FACULTY OF ECONOMICS AND
APPLIED ECONOMIC SCIENCES
CENTER FOR ECONOMIC STUDIES
ENERGY, TRANSPORT & ENVIRONMENT

KATHOLIEKE
UNIVERSITEIT
LEUVEN

WORKING PAPER SERIES
n°2003-7

The development and application of economic valuation techniques and their use in environmental policy – A survey

Ellen Moons
(K.U.Leuven-CES-ETE)

First version May 2003
Revised September 2003

secretariat:
Isabelle Benoit
KULeuven-CES
Naamsestraat 69, B-3000 Leuven (Belgium)
tel: +32 (0) 16 32.66.33
fax: +32 (0) 16 32.69.10
e-mail: Isabelle.Benoit@econ.kuleuven.ac.be
http://www.kuleuven.be/ete

KATHOLIEKE
UNIVERSITEIT
LEUVEN

THE DEVELOPMENT AND APPLICATION OF ECONOMIC VALUATION TECHNIQUES AND THEIR USE IN ENVIRONMENTAL POLICY – A SURVEY

Ellen Moons

11 September 2003

Abstract

This paper is concerned with the issue of how to introduce monetary valuation into public decision-making. This issue is closely related to introducing rational procedures into public decision-making (Pearce, 2001). All public decision-making involves choice. To economists, rational choice means making the 'best' use of available resources, i.e. choose that option that has the lowest opportunity cost or the lowest value to be sacrificed. Costs and benefits of any project should therefore be weighed as well as compared to cost and benefits of alternative projects. This implies that all impacts of these projects need to be expressed in the same unit to make comparison possible. Money seems to be the most obvious numéraire. We discuss some of the most popular economic valuation techniques and their potential role in public decision-making. Due to the high cost and time that is needed to perform original valuation studies and the limited knowledge of decision-makers with these techniques, we recommend that the Flemish Administration primarily invests in a limited number of primary studies on key topics on the one hand and performing high-quality transfer studies on the other hand.

Keywords: Valuation, Cost-benefit Analysis, Travel Cost Method, Contingent Valuation Method

JEL-classification:

Corresponding Address: Naamsestraat 69
B – 3000 Leuven
Tel: +32 16 32 66 37
Fax: +32 16 32 69 10
E-mail: Ellen.Moons@econ.kuleuven.ac.be

ENERGY, TRANSPORT AND ENVIRONMENT
CENTER FOR ECONOMIC STUDIES
Naamsestraat 69 B-3000 LEUVEN
BELGIUM

The development and application of economic valuation techniques and their use in environmental policy – a survey

1. INTRODUCTION

During the past two decades, public concern regarding environmental issues has risen in line with awareness of increasing pollution levels, loss of natural habitat and other natural resources, and the effects of environmental degradation upon human health and well being (Bonnieux and Rainelli, 1999). These concerns about protection, conservation and fighting pollution are more and more translated into specific legislation.

Public intervention is needed since the market mechanism is not able to capture the total value of natural goods and services due to the public character of goods such as landscape amenity and other non-use values.

This paper is concerned with the issue of how to introduce monetary valuation into public decision-making. This issue is closely related to introducing rational procedures into public decision making (Pearce, 2001). All public decision-making involves choice. As available resources (e.g. public funds) are scarce, resources allocated to one project cannot be allocated to other projects. Hence, trade-offs have to be made. To economists, rational choice means making the 'best' use of available resources, i.e. choose that option that has the lowest opportunity cost or the lowest value to be sacrificed.

There are two main contexts for expressing costs and benefits in monetary terms: regulation and liability. In the regulation context, it is Cost-Benefit Analysis (CBA) that is relevant, in the liability context only damages are relevant so money values of damages are the relevant measure.

Have public authorities in the United States and Europe actually used environmental benefit estimates in their policy decisions? For which types of decisions have they used them and which purposes did they serve? What are the main obstacles to their use? What is the role for benefit estimates in future decision-making processes? We will provide answers to all of these questions, though we do not claim to have written a complete literature review.

Concrete examples of valuation studies will specifically deal with air and water quality issues, in view of their potential use in the 'Milieukostenmodel[1]'.

2. ENVIRONMENTAL GOODS AND SERVICES

Costanza et al. have made a comprehensive list of ecosystem functions and services in their well-known article "The value of the world's ecosystem services and natural capital", published in Nature in 1997. Ecosystem services are defined as *"flows of materials, energy and information from natural capital stocks which combine with manufactured and human capital services to produce human welfare"* (Costanza et al., 1997). We extend their overview by adding recreation, non-use, option and other values (Table 1).

[1] Milieukostenmodel = environmental costing model for Flanders: the Flemish government aspires the development of a tool to (i) determine the costs of environmental policy and (ii) to contribut to a more efficient environmental policy by indicating how environmental targets can be realised in a cost effective way (Meynaerts et al., 2003).

Table 1: Overview of the values of environmental goods and services

Value category	Service/function	Examples
Ecosystem (indirect use)	Gas regulation: regulation of atmospheric chemical composition	CO2/O2 balance, O3 for UVB protection, and SOX levels
	Climate regulation: regulation of global temperature, precipitation and other biologically mediated climatic processes at global or local levels	Greenhouse gas regulation, DMS production affecting cloud formation
	Disturbance regulation: capacitance, damping and integrity of ecosystem response to environmental fluctuations	Storm protection, flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structure
	Water regulation	Provision of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation
	Water supply: retention and storage of water	Provision of water by watersheds, reservoirs and aquifers
	Erosion control and sediment retention	Prevention of loss of soil by wind, runoff, or other removal processes, storage of stilt in lakes and wetlands
	Soil formation	Weathering of rock and the accumulation of organic material
	Nutrient cycling	Nitrogen)fixation, N, P and other elemental or nutrient cycles
	Waste treatment	Waste treatment, pollution control, detoxification
	Pollination: movement of floral gametes	Provision of pollinators for the reproduction of plant populations
	Biological control: tropic dynamic regulations of populations	Keystone predator control of prey species, reduction of herbivory by top predators
	Refugia: habitat for resident and transient populations	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or overwintering grounds
	Food production	Production of fish, game, crops, nuts, fruits by hunting, gathering subsistence farming or fishing
	Raw materials:	The production of lumber, fuel or fodder
	Genetic resources: unique biological materials and products	Medicine, products for material science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants)
Recreation (direct use)	Providing opportunities for recreational activities	Eco-tourism, sport fishing, and other outdoor recreational activities
Non-use	Existence value: value from knowledge of continued existence	Habitats, species, genetic, ecosystem
	Bequest value: use and non-use value of environmental legacy; value accruing to a person from knowing that the good will be available in its current condition for future generations	Habitats, prevention of irreversible change
Option	Potential benefits from the direct and indirect use of an environmental good	Potential visit to a natural area; biodiversity; conserved habitats
Other	Cultural: providing opportunities for non-commercial uses	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems

3. HISTORY

3.1. International level

Internationally the use of monetary valuation techniques in project appraisal has increased significantly. During the past 40 years economists have developed techniques to assess the value of environmental goods (Adamowicz (1991), Arrow et al. (2000), Bockstael et al. (2000), Carson (2000)). Techniques such as the travel cost method to value natural areas for visitors and the contingent valuation method, which can both estimate the value for users as non-users, are being used intensively and are being constantly refined and improved.

In the United Stated the "National Environmental Policy Act" of 1969 obliges the draft of an environmental impacts report for projects with a potentially important repercussion on the quality of the environment. This law recognizes the interactions between all components of the natural environment and the rest of society. In 1980 the "Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)" came into force. This law provides regulations for the compensation of public resource values that are lost, temporarily or permanently, following poisonous waste dumps and hazardous waste disasters. These and related laws lead to a quick dispersion and frequent use of monetary valuation techniques such as the hedonic pricing method, the travel cost method and the contingent valuation method. The latter is being used more and more for the assessment of large-scale projects. The Executive Order 12991 of the Reagan Administration requires the execution of a cost-benefit analysis of important regulations. In 2000 the U.S. Environmental Protection Agency published the "Guidelines for preparing economic analyses" for the economic analyses of all costs and benefits (including social costs and benefits) of regulations.

In 1979 the "1979 U.S. Water Resources Council Cost-Benefit Regulations for Water related Federal Agencies" recommended the travel cost method and contingent valuation method as most appropriate techniques to quantify recreation benefits. These techniques have also been used by the U.S. Forest Service since the beginning of the eighties and by other federal institutions such as the U.S. Fish and Wildlife Service (Loomis, 1999, in: Bateman and Willis).

In the European Union too public attention for environmental problems has increased during the past two decades. In the eighties the first contingent valuation studies for the valuation of non-marketable values were executed in the United Kingdom, Norway and Sweden. In the beginning of the nineties the first monetary valuation studies appeared in France and Denmark (Bonnieux and Rainelli, 1999, in: Bateman and Willis). For the time being however, there are no legal regulations regarding the obliged use of social cost-benefit analyses within the European Union's environmental policy.

In the United Kingdom, the Department of the Environment, Transport and the Regions provides clear policy guidelines for assessment studies of the environmental policy (http://www.environment.detr.gov.uk/appraisal/index.htm). These guidelines clearly state that both costs and benefits need to be quantified and magnetised. The first important example of cost-benefit analyses is the localisation of the third London airport (Roskill, 1971). This

study took into account the monetary value of noise nuisance and national heritage impacts. Despite many criticisms, cost-benefit analysis is now the most important and most used technique for the assessment of government projects (Bonnieux and Rainelli, 1999, in: Bateman and Willis).

Norway has no legal regulations for the use of cost-benefit analyses, but there are government guidelines regarding costs-benefit analyses recommending the valuation of non-price effects. These non-price effects are often assessed using the contingent valuation method.

In Sweden too some contingent valuation studies with regard to land use conflicts were executed during the eighties. The social cost-benefit analysis of the Vaalaa Valley for example has partially contributed to the indication of this area as a National Nature Reserve (Bonnieux en Rainelli, 1999, in: Bateman and Willis).

3.2. National level

In Flanders, an Environmental Impact Report (MER) is obligatory for "public and private projects that could have considerable impacts on the environment", as well as for certain plans or programs that have a considerable impact on the environment. The possible consequences for "public health; plants, animals and ecosystems; soil quality; ground water and surface water quality; air quality; (micro-) climate; cultural and historical monuments and the landscape; the pressure on the environment of waste products and of noise nuisance". The goal is to "give the environment an equivalent place next to social, economic, technical, … interests" (http://mina.vlaanderen.be/regelgeving/mer_wetgeving/alg_info/rapport/index.htm).

All these impacts, however, are measured in their respective physical units, which makes it impossible to objectively compare and weigh positive (benefits) and negative (costs) impacts.

4. A SHORT INTRODUCTION TO MONETARY VALUATION TECHNIQUES

Several techniques are available but differ in the data demands, assumptions regarding economic agents and physical surroundings, and in the values they are able to capture.

In general, one distinguishes between monetary and non-monetary valuation techniques. Non-monetary valuation techniques include the dose-response function and the damage function (a.o.). They both assume a specific technical or biological relationship between the environmental good or service on the one hand and the consumer on the other hand (Mitchell and Carson, 1989). A dose-effect relationship, e.g. measures the relationship between the presence of forestland and the concentration of some pollutant in a region. However, these techniques are purely non-monetary. They can serve at the most as an aid in a monetary valuation study.

Monetary valuation techniques are divided into revealed and stated preference techniques. Revealed preference techniques include the travel cost method and the hedonic pricing method[2]. Contingent valuation is by far the most popular stated preference technique.

Apart from these special techniques that are able to capture non-tangible benefits, marketable benefits are valued by simply using actual market prices and changes in demand.

Table 2 provides an overview of the different values of environmental goods and services and their preferred valuation techniques.

Table 2: Values of environmental goods and services and their preferred valuation techniques

Value	Preferred valuation technique
Direct use - recreation	Travel cost method Contingent valuation method
Direct use – hunting, timber	Market prices/demand
Indirect use – ecosystem functions	Production cost method dose-response function damage function contingent valuation method
Option value	Contingent valuation method
Non-use values	Contingent valuation method

4.1. Travel cost method

The travel cost method (TCM) was first mentioned by Hotelling in 1947 but was only formally used in the literature several years later by Wood and Trice (1958) and Clawson and Knetsch (1966). It is based on observed market behaviour of a cross section of users and is therefore the preferred method for outdoor recreation modelling for most economists (Loomis and Walsh, 1997). It is considered to be an empirical application of the household production approach pioneered by Becker (1965).

4.1.1. The basic method

The TCM seeks how the visit frequency of users responds to changes in the price of a visit. The costs of travelling to the site, both direct monetary and time costs, and on-site costs, such as entry fees, are used as a proxy for price (Hanley and Spash, 1993). The basic premise of the approach is that the number of visits to the site decreases with increases in the travel costs, to a major extent determined by distance travelled.

We can formally represent travel costs (TC) to a given site 'j' as follows:

$$TC_{ij} = TC\left(DC_{ij}, TTC_{ij}, F_i\right) \qquad i = 1...n; j = 1...m \tag{1}$$

[2] Since the hedonic pricing method is not as frequently used as the travel cost method, we limit the discussion of revealed preference methods to the travel cost method. The hedonic pricing method uses differences in prices of related goods (e.g. housing prices) to estimate willingness to pay for an environmental good, taking into account other relevant factors that determine the price of the related good market good.

where DC are distance costs for each individual 'i', dependent on the distance travelled and the cost per kilometre[3]. TTC are time costs. These depend on how long it takes individual 'i' to get to the site and on the valuation of that individual's time. F stands for on-site costs including an entrance fee that is charged for some sites[4].

These travel costs are one of the independent variables that are used to explain the dependent variable, some form of quantity of recreation. Usually, one takes the number of visits taken by a person over a year or visits per capita from a specific zone to a recreation site (Loomis and Walsh, 1997)[5].

Other variables that influence visit frequency are socio-economic characteristics such as income, education and age level, family composition, gender, as well as variables giving information on the type of trip. The latter include mainly forest characteristics in the case of forest recreation. The last factor that influences visit frequency is the price and availability of substitutes. Substitutes are, in the case of forest recreation, other forests an individual could visit. The more substitutes a visitor has, or the closer by substitutes are, the lower the number of visits to the studied site.

4.1.2. Recreation demand function

We now have all the ingredients to specify a recreation demand function[6] that explains the quantity of recreation in terms of the price and other explanatory variables. This can formally be stated as follows:

$$V_{ij} = V(TC_{ij}, SC_{ij}, FC_i, S_i) \qquad i = 1...n, j = 1...m \tag{2}$$

where V are visits of individual 'i' to site 'j', TC are travel costs, SC are socio-economic characteristics, FC are forest characteristics and S is the price of visiting other sites.

This demand function, sometimes also referred to as 'trip generating function' (Hanley and Spash, 1993), is estimated using multiple regression techniques. Using the statistical coefficients from the regression, a demand curve or willingness to pay curve representing the relationship between the number of visits and the cost (price) of a trip can be traced out with increments in costs starting from the current cost of each individual.

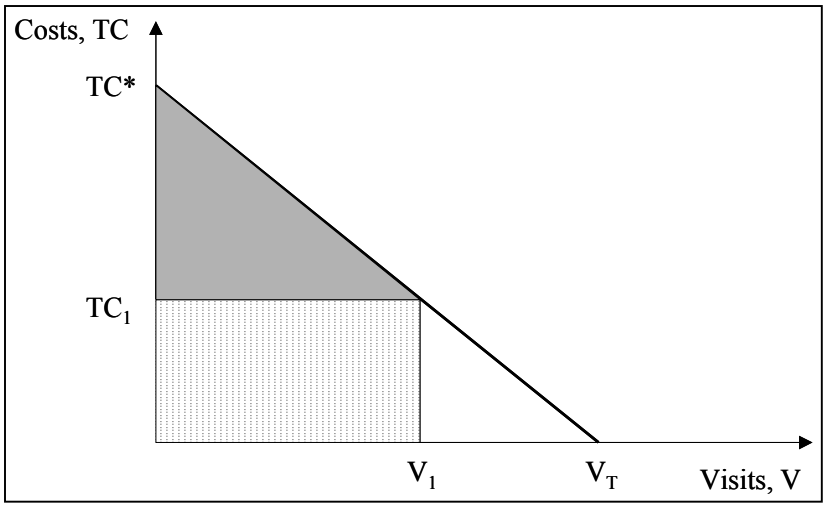
3 The cost per kilometre consists of variable costs such as fuel costs as well as fixed costs such as insurance, taxes, acquisition costs etc.

4 Entrance fees are unusual for forests with public access.

5 Two types of TCM's can be distinguished based on the definition of the dependent variable (visit frequency). Either it is defined as the number of trips per year per individual user (individual TCM) or it is defined as the total number of visits of an origin zone (zonal TCM). Although several empirical studies[5] show that the individual TCM scores better in terms of accuracy, Hellerstein (1995) has proven the zonal TCM is more robust, i.e. less sensitive to functional form or distributional assumptions.

6 From this point forward we will limit the discussion to the individual TCM.

Figure 1: Demand curve and consumer surplus



The key assumption behind the demand curve is that as travel costs increase, the number of visits falls. This is shown on Figure 1. There exists a cost TC* at which no more visits will be made. This is called the 'choke price'. On the other hand, when costs are zero, the number of visits will be highest (V_T). At any price higher than zero, the number of visits will drop, e.g. at a positive price TC_1 visits will trop to V_1.

4.1.3. Consumer surplus

The area under the demand curve measures the visitor's net willingness to pay or consumer surplus attributed to the site (Loomis and Walsh, 1997). It is the surplus benefit (grey triangle) over and above the cost (dotted rectangle). From Figure 1 we know that at a cost TC_1 an individual would make V_1 visits. However, the individual is willing to pay almost TC* for the first visit and any amount between TC* and TC_1 for the following trips (up to V_1). From that point onwards, the cost of a visit is higher than what the individual is willing to pay for the trip.

The consumer surplus is the value the visit is worth to the visitor over and above the price he already pays. The recreational value of the natural area can then be deducted by aggregating the consumer surplus per visit per visitor over all visitors. This is what would be lost when the natural area disappears or is closed for recreation.

4.1.4. Issues with the travel cost method

a) Multipurpose trips vs. single destination trips

If an individual leaves home and drives directly to the recreation site and returns home directly afterwards, costs of making the trip can be exclusively attributed to the site visit. This type of visitors is often referred to as 'purposeful visitors' (Hanley and Spash, 1993). Those visitors for whom a visit to the site is only part of the purpose of their trip are called 'meanderers'. In the latter case, taking into account the full cost of the trip will lead to an overestimation of benefits attributable to the recreation area (Loomis and Walsh, 1997).

There is not a theoretically correct way to allocate the trip costs among multiple destinations. Either these observations are dropped from the analysis or the visitors are asked to subjectively attribute a proportion of trip costs to visiting each destination.

b) Distance costs

Increases in distance are converted to the monetary amounts visitors would pay if they were required to travel the additional distance. There are basically two options to calculate a price per kilometre: (1) use fuel costs only as an estimate of marginal cost or (2) use full costs including an allowance for depreciation, insurance, etc. as an estimate of average cost. Consumer surplus measures will depend on the choice.

c) Travel time costs

Travel time costs are calculated by multiplying the duration of the trip (depending on distance and transport mode) by the value of travel time.

The value of travel time is the opportunity cost of that time. The time spent on the trip[7], which is assumed to create no benefits, cannot be spent on other time consuming and benefit creating activities such as working or alternative recreational activities.

Saving time in travelling to the site clearly has a positive value, or, time spent travelling in itself has a negative value. If the individual is giving up working time in order to visit a site, the wage rate is the correct opportunity cost of time travelled. However, most individuals are restricted by fixed working hours and will therefore make the trip in their leisure time. The travel time to a site would alternatively be spent on other leisure activities. No labour income is foregone and the correct opportunity cost here is the value, at the margin, of the other recreation activities foregone.

d) Statistical problems

Several statistical problems can occur when estimating a (recreation) demand function. First, there are problems related to the independent variables in the regression equation. All relevant variables affecting visit behaviour need to be included. Omission of variables will bias the coefficient estimates and therefore bias the consumer surplus estimates. However, it is not necessary to include variables that do not vary among individuals or according to distance travelled as these variables will not change the slope or the area under the demand curve.

Second, the dependent variable is subject to both truncation and endogenous stratification (Hellerstein, 1992). The dependent variable – visit frequency - is the variable we want to be able to explain and predict with the travel cost method. Truncation occurs when observations are only available greater than (or less than) some lower (or upper) bound. This is the case for most TCM studies when observations originate from on-site surveys and all respondents make at least one visit to the site. The dependent variable (visits) is said to be truncated at one. Endogenous stratification occurs when the probability of being sampled is a function of the value of the dependent variable. When interviewing visitors at specific checkpoints on site, people with higher visit frequencies have a higher chance of

7 Here we assume time spent on site has no value, although we are aware of the debate in the literature regarding this aspect of TCM applications.

being interviewed. Truncation and endogenous stratification require the functional form of the recreation demand function to be chosen with care. A good choice seems to be using count data models that are based on probability distributions that are defined for nonnegative integers only (Hellerstein, 1992).

4.1.5. Extensions of/alternatives for the basic TCM

Travel cost models in their basic form are also referred to as continuous recreation demand models as opposed to discrete choice approaches (Bockstael et al., 1991). The discrete choice models are based on McFadden's random utility models (RUM) (1981) that focus on the individual's decision of which recreation site to visit on any given choice occasion. For this reason, they are also known as site selection models. A second step is needed however to estimate the relationship between price, quality and the number of visits individuals make. Separate demand equations that predict the number of trips are estimated as a function of inclusive values computed from the site selection model as well as socio-economic characteristics (see e.g. Bockstael et al., 1987). Recently, continuous and discrete models have become more similar with each approach attempting to capture elements of the other (Kling and Crooker, 1999).

Another trend is the combining of recreation demand models (TCM or RUM) with contingent valuation models and data (see e.g. Cameron, 1992).

4.2. Valuation of non-use values: the contingent valuation method

4.2.1. Some historical notes

A procedure to convert changes (qualitative or quantitative) in environmental goods into monetary terms (Willingness To Pay or WTP) is the contingent valuation method (CVM). CVM uses survey questions to elicit people's preferences for public goods by finding out what they would be willing to pay for specified changes in them (Mitchell and Carson, 1989). Constructing a hypothetical yet detailed and realistic market in which consumers have the opportunity to buy the good circumvents the problem of missing markets for many environmental goods. Because valuation is contingent upon the particular hypothetical market, this approach is called the contingent valuation method (Brookshire and Eubanks, 1978; Brookshire and Randall, 1978; Schulze and d'Arge, 1978). The hypothetical nature of the method and the size of the values obtained by CVM-studies have given the method a rather controversial status.

Ciriacy-Wantrup (1947) was the first economist that stated the fact that information about people's preferences can be obtained by appropriately constructed interviews (Kriström, 1999 in van den Bergh). The first empirical study can be traced back to 1958[8] and more

8 It concerns a contingent valuation study undertaken by a consulting company, where people visiting the Delaware Basin (U.S.A.) were asked their willingness to pay for entering national parks (Mack and Myers, 1965).

studies were done since the 1970s (e.g. Davis, 1963; Bishop and Heberlein, 1979; Hanemann, 1984).

In the 1980s the method was being extensively employed in some countries outside the U.S.A. (Kriström, 1999 in van den Bergh). Navrud (1992) provides a survey of studies performed in Europe. Scandinavian countries have by far been the most active.

However, the method only became widely known and used since the Exxon Valdez oil tanker ran aground in Prince William Sound, Alaska (1989). Two groups of eminent economists were asked to undertake an extensive and thorough CV assessment of the non-use damages caused by this disaster (Bateman and Willis, 1999). One study was commissioned by the State of Alaska[9], the other by the Exxon Company because the latter questioned the validity of the CV technique (Hausman, 1993). As a consequence of the disagreement on the validity of the method, the National Oceanic and Atmospheric Administration (NOAA) commissioned an investigation of the CVM. This resulted in a set of explicit guidelines that should be followed in order to perform a valid CVM study (Arrow et al., 1993). The panel concluded that the CVM can be used as a starting point in a judicial process, provided the experiment follows these explicit guidelines. These guidelines include (a.o.) that the study design should be conservative in the sense that it is likely to underestimate willingness to pay; that people should have the option not to participate; that the binary valuation question (see 4.2.5 – dichotomous choice) should be used[10] (Kriström, 1999 in van den Bergh).

4.2.2. Survey structure

The CVM is solely dependent on survey data. The design of the survey is therefore a key element in determining the quality of the study. The survey has to be pretested in small discussion groups and in a small sample of respondents. This helps to determine whether respondents are likely to correctly interpret the questions, whether response categories are unambiguous and whether visual aids are clear and sufficient (Loomis and Walsh, 1997).

Respondents are best interviewed in person due to the complex nature of a CVM questionnaire.

The survey itself consists of three parts (Mitchell and Carson, 1989):

The first part gives a precise description of the good that has to be valued and of the hypothetical circumstances under which the public good is made available to the respondent. It also describes the baseline level of provision, the range of available substitutes and the method of payment.

The second part consists of questions intended to elicit the respondents' WTP for the defined change of availability of the environmental good. An alternative would be asking the respondents' WTA for a qualitative or quantitative change of the good. It is often desirable to ask respondents to specify the reasons for their reported choices, especially when respondents report they are not willing to pay anything. Adding questions about the

9 The results of this study can be found in Carson et al., 1992.

10 General findings in literature are, however, that using the dichotomous choice question format tends to give higher values (see e.g. Brown et al., 1996) although from economic theory alone, we would not expect to find any differences between open-ended and closed-ended question formats.

reason of their zero answer can identify whether their true valuation is zero or whether they protest against the hypothetical market or method of payment.

The third part of the survey asks for the characteristics of the respondents (e.g. income, age), their preferences relevant to the good being valued and their use of the good. This information is used to explain the WTP of the respondents and to determine the validity and reliability of the CVM as a measuring instrument of WTP for environmental goods.

The answers to the valuation questions provide information on the WTP of respondents. These amounts can then be used to develop an estimate of the benefit of the good.

4.2.3. WTP vs. WTA

Asking maximum WTP for an increase in quality of quantity of a good is the preferred approach for determining economic benefits (Loomis and Walsh, 1997). The alternative is to ask for an individual's minimum willingness to accept (WTA) compensation for a decrease in the quality or quantity of a resource. Since WTA is not directly constrained by income, chances are WTA is greater than WTP, which is constrained by income (Loomis and Walsh, 1997; Bishop and Heberlein, 1979) and therefore leads to an overestimation of benefits.

4.2.4. Method of payment

How people are asked to pay for a change in the provision of a good determines to a great extent the degree of honesty of their answers. Possibilities include taxes on income or property, voluntary or compulsory donations or contributions, entrance fees for visiting a nature area, hunting permits, … The NOAA-panel recommends the use of taxes because of their compulsory character.

4.2.5. Question format

There are several possibilities to ask for the WTP of a person. Techniques differ in the degree of accuracy, degree of non-response or 'don't know' answers, difficulty of statistical processing, etc.

The most straightforward way of asking is to ask directly what amount a person maximally would be willing to pay for the proposed change. This is called the *open-ended question format*. This is the simplest way to formulate the question and answers can be analysed without further data manipulation. The problem is that it is not straightforward for respondents to answer this question. They are simply not familiar with placing a value on a good that is not traded in a normal market. On the one hand, this leads to a high degree of non-response and protest answers, on the other hand, it creates incentives for strategic behaviour (i.e. stating a higher or lower WTP than the actual WTP) (Desvousges et al., 1983).

The disadvantages of this elicitation format have lead to the development of new techniques taking into account the difficulty for respondents to answer and the possibilities for strategic behaviour without losing valuable information.

The *bidding game* (Davis, 1964) is based on real-life situations in which individuals are asked to state a price for a specific good (cf. auctions). Respondents answer yes or no to an iteration of monetary amounts and this process goes on until the respondent changes his answer. The last (or first) price a respondent accepts is his maximum WTP. The advantage is that this elicitation format directly gives the highest WTP (Cummings et al., 1986). Moreover, due to the iterative character of the approach a respondent has more time to carefully consider his valuation (Hoehn and Randall, 1983). A disadvantage is the possibility of starting point bias implying that the starting bid influences to a great extent the value for the good (Roberts et al., 1985)

Another question format frequently used is the *payment card* (Mitchell and Carson, 1981, 1984). Respondents are shown a card with alternative values and are asked to select their maximum WTP from these values. Sometimes the card provides an indication of what the respondent is already spending on other public goods or services, although the answer can be influenced by these 'benchmarks'. Advantages are: (1) the answer does not depend on the starting bid and (2) respondents only have to answer one question.

The final important question format is the *dichotomous choice question format* (Bishop and Heberlein, 1979, 1980). There are two versions currently in use. The first is the *single bounded dichotomous choice*. The respondent is presented one of a list of previously determined values and is asked whether or not he would be willing to pay this amount for the proposed change. The major advantage of this approach is its simplicity for the respondent. Moreover, it has been shown (Hoehn and Randall, 1987) that this approach minimizes strategic behaviour. The primary drawback is inefficiency. A very large amount of observations is needed for a correct estimate of the WTP. Also, one has to make assumptions about the parametric specification of the valuation function to obtain mean WTP. Finally, the design of the bid amounts requires the greatest care.

A variation of the single bounded is the *double bounded dichotomous choice* (Carson et al., 1986). The respondent is presented with a follow up question with a bid that is dependent on his answer on the first dichotomous choice question. There is a list of several bid values and follow up values. This elicitation method increases the efficiency of the single bounded dichotomous choice and is the preferred format for the NOAA-panel. Studies have shown that the estimated WTP based on this format is lower than based on the single bounded dichotomous choice (Carson et al., 1999).

4.2.6. Possible biases of the WTP estimate

Due to the hypothetical nature of the CVM, the method of payment used and other factors, the estimated WTP can be biased. These biases should and can be avoided as much as possible by performing statistical tests during survey design (e.g. after pretesting).

A first possible bias is strategic behaviour of the respondent. This means the respondent 'lies' about his true WTP for the public good because he assumes that, although he states a low WTP, others will not answer strategically and the public good will be provided anyway. Once a forest is created, it is impossible to exclude those respondents that state a lower than their actual WTP. Strategic behaviour can be minimized by stressing the fact that everyone will have to pay, by not giving information on other respondents' WTP and

by making the provision of the good dependent on the WTP of the respondents (Mitchell and Carson, 1989).

Other problems are design and information biases. These problems are related to the design of the survey, the way information is presented and the amount and the kind of information that is given previously to the WTP question. Design bias also includes starting point bias (Hanley and Spash, 1993).

Another problem arises from the hypothetical nature of the CVM questionnaire. This implies that incorrect WTP assessments by the respondent will not be punished. The respondent will never actually have to pay his stated WTP and thus very often stated values will differ from true values systematically. The extent to which hypothetical market bias occurs seems to depend on how the questions are asked in the CVM questionnaire and on how realistic respondents feel the hypothetical market is (Hanley and Spash, 1993).

4.2.7. Issues for future research

According to Kriström (1999, in van den Bergh) it will not be in the field of econometric and statistical techniques that are applied to the data, nor in the field of experimental economics (laboratory experiments) that the marginal product will be highest in the future. It will probably be highest in research focusing on the scope of applicability. In theory, it can be applied to 'everything', but experiments comparing the CVM with real payments in realistic environments have shown that the effectiveness of the CVM can still be improved since too often one founds a considerable gap between real and hypothetical payments.

5. VALUATION AND PUBLIC DECISION MAKING

5.1. Purpose of benefit estimates: general framework

Environmental benefit estimates can be used in several ways in public decision-making (Kuik et al. in Navrud, 1992). First, a distinction may be made between decisions in environmental policy and decisions in other policy areas. Second, a distinction may be made between levels of policy (policies, regulation and projects). Valuation is relevant at each level, but may be used more extensively at one level than another. As for the policy level, a distinction can be made between environmental policy itself and decisions in other policy areas that may impose positive or negative side effects on the environment. At the regulations level, there could be a need for complete and comprehensive assessment of benefits as well as more cursory analyses. In the first case, one might use more controversial techniques such as CVM to capture all values including non-use values. On the projects level, there might be legal mandatory requirements to perform a full environmental impact assessment concerning large or specific projects. Third, a distinction may be drawn between different purposes for which benefit estimates are used in the areas mentioned. Monetary benefit estimates can serve four basic purposes (Bonnieux and Rainelli, 1999 in Bateman and Willis):

1. Contribute to public debate and awareness concerning specific (environmental) problems. Money serves as a readily understandable indicator of environmental damage or potential benefits;

2. Influence particular decisions by using a cost-benefit analysis or comparison of costs and benefits in another way
3. Identify the optimal alternative among competing options;
4. Support and justify decisions (ex ante or ex post) taken by government agencies.

Table 3 represents the possible objectives of benefit assessments for each decision level. Bonnieux and Rainelli (in Bateman and Willis, 1999) merge the 'identify decisions' and 'evaluate and justify' columns into a single vector relating to the trade-off of alternative options for environmental action.

Table 3: Level and purposes of benefit estimates

Purpose level	Stimulate awareness	Influence decisions	Identify decisions	Evaluate and justify
Policy	Yes	Possible	Unlikely	Unlikely
Regulations	Yes	Likely	Possible	Possible
Projects	No	Yes	Likely	Likely

Source: Kuik et al. (1992)

Regardless of the decision level and purpose, it is important that benefit estimates are made in a very early stage of the rule-making process (Kuik et al., in Navrud, 1992). This inevitably implies a trade-off between usefulness and accurateness of benefit estimates. In early stages of decision-making processes, not all results of other scientific research may be available. This may increase doubts about the correctness of the estimates as more scientific information is likely to increase their correctness. However, when monetary values are only available after the decision has been taken, they can only serve as an ex-post justification of the rule and cannot influence e.g. the choice among competing alternative options.

5.2. Cost-benefit analysis

Cost-benefit analysis (CBA) is a technique developed to evaluate investments from a social-economic point of view. It can be applied to any decision that involves a reallocation of resources within society (Hanley, 1999 in van den Bergh). It helps decision makers (1) to decide on the optimal level of the project; (2) to find the optimal mix of projects maximizing efficiency and (3) to choose among several alternative projects. A key factor of CBA is that the evaluation is made on the basis of *monetary* values.

The basic idea is very simple. If we have to decide whether to do investment A or not, the rule is: do A if the benefits exceed those of the next best alternative, and not otherwise. The 'benefits of the next best alternative' are referred to as the 'costs' of A (Layard and Glaister, 1994).

Six steps need to be carried out in order to complete a full CBA:

1. Definition of project/policy and of the relevant population
2. Identification of relevant impacts[11]
3. Valuation of relevant costs and benefits in money terms

[11] Based on the criterion of whether they constitute a change in resource availability or a change in prices (Hanley, 1999 in van den Bergh).

4. Aggregation of benefits and costs over time by discounting
5. Comparison of total discounted benefits with total discounted costs, to produce a net present value (NPV)
6. Sensitivity analysis on important parameters such as the discount rate, project life span and cost and benefit estimates.

A first question that needs to be answered once the project is defined in all its details is: what is the relevant society for which the change in welfare should be analysed? Either one takes on an international point of view or one limits the analysis to the population of the country undertaking the investment. In either case, costs and benefits to all members of society are included and not only the monetary expenditures and receipts of the project promoter.

Second, once an exhaustive list of all impacts is drafted, one needs to place a monetary value on all costs and benefits. In general, monetisation of costs and benefits is done following some specific rules. Assuming that only people matter, two (more theoretical) steps can be distinguished: first, find out how the investment affects the individual's welfare. This impact is measured by the individual's own valuation. Next, deduce the change in social welfare from these changes in individual welfare.

A thrid issue is the choice of the discount rate. This is a matter of great dispute (e.g. Pearce, 1994; Lind, 1982) as capital market imperfections drive a wedge between the social time preference rate and the social opportunity cost of capital (Hanley, 1999 in van den Bergh). An aggregate present value of the project is obtained by discounting costs and benefits in future years to make them commensurate with present costs and benefits. A high or low discount rate has a large impact on the final result (the net present value) when costs and benefits occur at different points in time.

A popular criticism of CBA is that it is unable to take into account equity concerns. Indeed, the underlying assumption in most CBA studies is that income is optimally distributed or that – in case of non-optimal distribution – there is some form of redistribution. Consequently, each person's 1 EURO has the same weight. However, as this is not true in real situations, one needs to value a poor person's 1 EURO higher than that of a rich person (Layard and Glaister, 1994).

CBA can be compared with alternative decision-making aids such as multi-criteria analysis (MCA) and environmental impact analysis (EIA). MCA has the advantage that it allows for multiple objectives to be considered, as opposed to the single objective of relevance in CBA (Hanley, 1999 in van den Bergh). A disadvantage of MCA is that it relies on a subjective specification of weights by the decision maker. EIA allows for much more detailed and disaggregated information on the environmental effects because it does not express all impacts in a single numéraire. However, it is by definition a less complete technique than CBA since it is not capable of including non-environmental impacts[12].

CBA has become an attractive and powerful decision-making tool that can be used to consider a wide range of environmental (management) problems in a rational and ordered way. Its use in policy making has greatly increased of the last few decades, especially in the UK and the US and it is very likely that the use of CBA will continue to increase in

[12] A complete overview of all pro's and con's of all available decision-making aids can be found in Pearce (2001).

both policy making and academic circles in the foreseeable future (Hanley, 1999 in van den Bergh).

5.3. Obstacles which influence the use of benefit estimates in decision making

The major obstacle which has limited the use of benefit estimates thus far is the uncertainty of the correctness (or low credibility) of the estimates. This uncertainty stems from different causes (Kuik et al. in Navrud, 1992):

1. Uncertainty about the most elementary physical dose-response relationships;
2. Preferences for environmental goods are not directly observable in the market place which implies the inevitable hypothetical character of the estimated money values;
3. Discounting costs and benefits which occur on different points in time to the present and the choice of the correct discount factor;
4. Transboundary pollution problems and the choice of the relevant population that is taken into account in valuation exercise

Apart from uncertainty, there are other obstacles to the use of benefit estimates in decision-making (Kuik et al., in Navrud, 1992 and Pearce, 2001). First, administrative obstacles have been and still are the major obstacles in most European countries. However, we are convinced that these can be rather easily overcome. Administrative obstacles are either statutory impediments which preclude the use of benefit assessment in decision-making (e.g. decisions must be based on pure financial calculations instead of welfare economic costs) or the lack of capability to perform benefit studies. Second, the lack of inter- or multidisciplinary research institutes which would make close collaboration between economists and scientists possible is also a major obstacle. This is called the academic obstacle. A third obstacle is of a more political nature: cost-benefit analysis forces politicians to reveal their (true) preferences and also, some decision makers feel that CBA compromises their flexibility of decision making. Fourth, there is often a moral 'hostility' towards using money as a measuring unit. This final criticism is often due to the fact that people misunderstand the role of money. It is nothing more than a numéraire and it could easily be replaced by any other good (e.g. breads, shoes, …).

5.4. Factors explaining different uses of benefit estimates in the U.S.A. and Europe (Pearce, 2001)

As was already reflected in section 3, the use of benefit estimates and rational decision-making techniques such as CBA, is by far more widespread in the U.S.A. According to Pearce (2001), there are several reasons for this. First, a strong tradition of efficiency in government as a philosophy is a necessity. This is both a political and cultural issue. In the U.S.A. the overall picture is that political parties are much more dedicated to free market principles and therefore perhaps more likely to believe in CBA. Second, the U.S.A. has very strong lobbying groups in favour of CBA, a trend that so far cannot be recognized in Europe. A third reason is the close link between academics and (policy) analysis institutes on the one hand and government on the other hand. It is a fact that in countries where this link is strong, CBA is used much more frequently in monitoring and appraising

government policy[13]. A final point is the difference in liability legislation. This legislation is much more elaborate and court cases dealing with liability issues occur much more often in the U.S.A. than in Europe. Liability legislation is a powerful impetus to the use of monetisation. Damages must be estimated. Moreover, liability forces monetisation into court so that monetary estimates of damage have to be credible because they will be debated and disputed by differing experts.

5.5. Some examples

5.5.1. EVRI-database

The Environmental Valuation Reference Inventory is an online database of recent published and unpublished valuation studies (http://www.evri.ca/)[14]. The following paragraphs are taken from the EVRI website.

"EVRI's goal in providing users with access to valuation study results is to promote defensible benefits transfers. Drawing on accepted criteria for benefits transfers, and the content of EVRI records, it remains the responsibility of the user to assess the suitability of an existing valuation study for a transfer and the challenges that must be addressed in making the transfer.

EVRI records provide information about the way in which the authors of existing valuation studies obtained their results. This includes information on the methods employed, the way in which the methods and models generated values, and the actual economic values that were estimated. The details of the EVRI records present additional information on the valuation studies. The sum of this information places users in a position to make their own assessment of the quality of the valuation study on which a record is based. "

The availability of databases such as EVRI improve the quality and cost-effectiveness of benefits transfers significantly. Reducing the time and cost involved in locating suitable studies for benefits transfer should be especially beneficial for those countries and organizations that have not previously had the ability to access the wealth of studies available in the literature.

The total number of valuation studies that is currently available in the EVRI-database is 970, of which 113 studies deal with "air" and 590 studies deal with "water"[15]. The following tables provide more details on the type and subject of the studies of the EVRI-database.

---

[13] We also have some examples of this in Europe. The Central Bureau of Statistics in Norway produces not only statistical and other support services for government but is an acknowledged source of strong economic research. Italy is another example of the strong role of academics in formulating government environmental policy.

[14] The use of the EVRI database is not free. Please visit the website for subscription information.

[15] For the time being, entries in the EVRI are concentrated in the area of water valuation studies. This is a consequence of the initial focus on water valuation in the Americas during the testing phases of the development of the database. The scope of the EVRI is being broadened to include valuation studies for many types of natural capital from all parts of the world.

Table 4: Studies dealing with air quality

Global	15
Local	46
Regional	52
Total	113

Table 5: Studies dealing with water quality

Canals	8
Drinking water	63
Estuaries	37
Fresh water	329
Ground water	66
Salt water	87
Total	590

There is a very large body of Northern American studies (70%) and Europe provides the second largest bulk of studies (22.5%). Asia comes third with 7% of available studies. African and Southern American contributions are negligible.

Nearly all valuation techniques that can be found in a representative sample of journal articles, are present in the EVRI-database. An overview is given in Table 6.

Table 6: Overview of valuation techniques applied in the studies available in EVRI

Count data	2
Actual expenditure/market price of output	117
Averting behaviour (preventing, defensive)	26
Change in productivity	17
Choice experiment	0
Combined revealed and stated preference	14
Conjoint analysis[16]	28
Contingent ranking	21
Contingent valuation – dichotomous choice	237
Contingent valuation – iterative bidding	90
Contingent valuation – open ended	226
Contingent valuation – payment card	121
Demand analysis	0
Experimental cash market value	5
Hedonic property	72
Hedonic wage	8
Replacement costs	13
Travel cost method – multi site – regional/hedonic	96
Travel cost method – random utility model	45
Travel cost method – single site	88

Although the EVRI-database does not contain all valuation studies that have been executed in the past, it can serve as an excellent starting point when you are thinking of doing a benefit transfer study, or when you need benefit or cost estimates to include in a cost-benefit analysis or other project appraisal studies. It gives an elaborate cross-section

[16] Conjoint analysis is defined as "any decompositional method that estimates the structure of a consumer's preferences (…) given his or her overall evaluation of a set of alternatives that are prespecified in terms of levels of different attributes" (Green and Srinivasan (1978: 104).

of studies that are described in journal articles as well as studies financed by government agencies of which only unpublished reports are available.

5.5.2. Water quality

In view of the transfer of results of valuation studies to the "Milieukostenmodel", we focus on studies dealing with the economic value of water quality and nitrate, sulphate and COD. A complete list of entries on these topics in the EVRI-database can be found in Appendices A, B and C. We will discuss the studies that are most relevant for Flanders in view of potential benefit transfers. We therefore only discuss studies performed in high-income countries such as European countries, United States and Canada, from 1990 onwards. To date, there are no Belgian studies on this topic.

a) Nitrates

The largest part of the literature on water quality valuation deals with nitrate (and other agricultural pesticides and fertilizers).

The first study in our selection is a U.K.-study specifically dealing with nitrates (Hanley, 1991). The study values a reduction of nitrate levels in drinking water supplies below European Commission and World Health Organisation upper limits of 50 mg/litre. It uses the contingent valuation technique, with an open-ended valuation question. The mean willingness-to-pay to reduce nitrate levels in drinking water to EU and WHO standards was estimated at 12.97 per household/annum (1991 British Pounds).

The second study of Poe and Bishop (1992) measures the benefits of groundwater protection from agricultural contamination in Wisconsin, U.S.A. The groundwater protection program they propose in their CVM-survey makes sure that nitrate levels in all (private) wells will definitely be kept below government health standards. Mean (median) WTP ranges from $257.1[17] ($253.3) to $414.8 ($400.3) per household per year, depending on the amount of information that is provided to the respondents.

In the same year (1992) Sun et al. report on the results of a CVM study on the ground water quality for drinking purposes in Georgia, U.S.A. the study's valuation question asks respondents about their WTP to support a program that would definitely keep pollution of groundwater by agricultural pesticides and fertilizers in Dougherty County at safe levels (i.e. below the EPA's health advisory levels) for drinking and cooking. The study reports an average annual household income of $42517 ($1989). The authors find a mean option price of groundwater pollution abatement annually per household of $641 with a 95% confidence interval of $493 to $890. The median option price was estimated at $636. They perform a thorough sensitivity analysis on the most important parameters. Two different payment vehicles were used: dichotomous choice and open ended.

Bergstrom and Dorfman (19941) executed a similar CVM study on the WTP for groundwater quality safe levels for drinking and cooking in Georgia, U.S.A. The specific type of pollution is the use of agricultural pesticides and fertilizers such as Aldicarb, Atrazine, Alachor, Carbofuran and Nitrates. The median household income reported is $23587 a year. Four different versions of the survey with varying amount of information

[17] All values are assumed to be in 1991 US dollars.

were distributed to the respondents. The payment vehicle used was the dichotomous choice. With the base information level, mean WTP varies from $320 to $1254, depending on the probability of contamination. With the most elaborate information level, mean WTP varies from $613 to $2360.

The study of Breaux et al. (1995) deviates from the previous studies with regard to the valuation technique used. This study investigates the savings arriving from a 570 acre plot of wetlands receiving municipal wastewater over traditional wastewater treatment in a sand filtration system (Louisiana, U.S.A.). The benefit in this instance is reduced pumping and engineering costs, annual operations and maintenance costs from sand filtration. Values for wetlands per acre for wastewater treatment range from $US 785[18] per acre to $2300 per acre in terms of savings over conventional wastewater treatment methods.

De Zoysa (1995) reports results of the evaluation of programs to enhance groundwater quality, surface water quality and wetland habitat in Northwest Ohio. The baseline of provision for groundwater quality is 0.5 to 3 mg/l nitrate concentration. The alternate level of provision is a program that would reduce nitrate concentrations to 0.5 to 1 mg/l. For surface water quality, the baseline level of provision in 10.3 million tons per year of sediment from soil erosion going into the river basin and lake. The alternate level of provision is a 15% reduction in soil erosion. A dichotomous choice CVM study lead to the following results: mean annual WTP values for improved groundwater, surface water and wetland quality are $52.78, $78.38 and $62.27 respectively (1994 $US).

A second European study is the one from Gren (1995) who estimates the value of wetland restoration in Gotland (Sweden), in terms of its impact on drinking water quality, the generation of secondary benefits (habitat provision, nitrogen abatement) and regional income and compares this with similar values for investment in sewage treatment plants and reduced fertiliser use in agriculture. Nitrate concentration is 40 mg/l and above 100 mg/l in some cases. Average application of nitrogen fertiliser is given as 100 kg N/ha/year. Nitrogen abatement capacity of restored wetlands is assumed to be 215 kg N/ha in the first year, rising to 500kgN/ha after ten years. Several valuation techniques were applied: actual expenditure/market price of output, replacement costs and contingent valuation (open ended). Total marginal abatement values of nitrogen abatement (1993 SEK) are 349 SEK/kg N for wetlands restoration, 82 SEK/kg N for sewage treatment plants and 2.7 SEK/kg N for agriculture. The marginal annual cost for investing in nitrogen abatement in sewage treatment plants ranges from 50 to 150 SEK/kg N, for investment in wetlands this is 93 SEK/kg N (opportunity cost).

Crutchfield et al. (1997) use 1994 data from the National Survey of Recreation and the Environment administered in several states (Indiana, Nebraska, Pennsylvania and Washington) to estimate WTP for improved drinking water. Monthly mean WTP to reduce nitrate concentrations in drinking water from a level exceeding the U.S.A. EPA standard by 50% to the EPA minimum safety standard ranged from $50.31 to $66.57 (1994 $US). Individuals were willing to pay an additional $0.09 to $9.95 to completely eliminate nitrates from their drinking water.

[18] All values are in $US 1985.

b) Sulphates

The only study we could find on valuation and sulphates is a study by Cho (1996). Cho uses the contingent valuation method to elicit Minnesota residents' WTP for reduced levels of iron, sulphate, hardness and copper in their community drinking water. Respondents were asked their WTP to reduce current levels to below the U.S.A. EPA standard levels. Average annual household WTP is $36 for sulphate. The author provides a detailed table with household WTP values for different amounts of sulphate reductions. We summarize the main results in Table 7.

Table 7: Annual WTP for reduced levels of sulphate (1995 $US)

Initial level of sulphate (mg/l)	Reduction (mg/l)	Average household WTP ($)
540	40	26.32
590	90	32.13
640	140	27.69
645	145	34.28
670	170	21.23
680	180	31.71
940	440	67.52
950	450	56.50
1100	600	56.50

c) COD: chemical oxygen demand

The most relevant studies on the value of COD water emissions are a cluster of Austrian studies performed in the late 1990s (Angst et al., 2001; ARGE GUA et al., 1998 and ARGE GUA et al., 2000) dealing with economic costs and benefits of waste management of Austrian households and facilities similar to households. Angst et al. (2001) studied the ecological advantages of collecting packaging materials (paper, glass, plastic materials, drink cartoons, metals) separately over their collection together with residual waste. The study was administered in view of the implementation of the packaging materials ordinance and of the steps for the further refinement and optimisation of the separate collection and recycling of individual packaging materials. Avoidance costs are taken to calculate the external costs and they amount to 712.19 EURO per tonne COD.

5.5.3. Air quality

In view of the transfer of results of valuation studies to the "Milieukostenmodel", we focus on studies dealing with the economic value of water quality and NOx, SOx and VOC's. A complete list of entries on these topics in the EVRI-database can be found in Appendices D, E and F. We will discuss the studies that are most relevant for Flanders in view of potential benefit transfers. We therefore only discuss studies performed in high-income countries such as European countries, United States and Canada, from 1990 onwards. To date, there are no Belgian studies on this topic.

a) NOx

The most relevant studies on the value of NOx air emissions are a cluster of Austrian studies performed in the late 1990s (Angst et al., 2001; ARGE GUA et al., 1998; ARGE GUA et al., 2000; Frühwirt et al., 2000, Kosz et al., 1996 and Schmid et al., 1998).

Angst et al. (2001) study the ecological advantages of collecting packaging materials (paper, glass, plastic materials, drink cartoons, metals) separately over their collection together with residual waste. They use the avoidance costs valuation technique. The studies from ARGE GUA (1998 and 2000) and Frühwirt report the same results. Kosz (1996) calculates external costs for emissions based on damage cost values to demonstrate the extensive benefit of thermal insulation measures under the assumption that these measures are implemented in all existing residential buildings in Austria. The study by Schmid et al. (1998) provides two values for emitted pollutants to provide a range of possible external costs. On the basis of an international survey of literature, the higher and lower values of external costs were chosen.

We can summarize the results for Austria as follows:

Table 8: External costs for air emissions - Austria

Air emissions	Costs, EUR per tonne			
	Angst et al. (2001); Frühwirt et al. (2000)	ARGE GUA/IFIP GUA (1998 and 2001)	Kosz et al. (1996)	Schmid et al. (1998)
CO2 (fossil)	63.23	25.44	25.44	25.41 – 50.87
CH4	1327.73	279.79	n.a.	
CO	76.31	76.31	130.81	10.90 – 21.80
SO2	2543.55	2543.55	2950.52	1780.48 – 2950.52
NOx,	2034.84	2034.84	5290.58	2696.16 – 5290.58
CxHy/NMVOC	2034.84	2034.84	4222.29	2034.84 – 4222.29
Pb in airborne particle	17804.84	17804.84	n.a.	n.a.
Particulate	508.71	508.71	3059.53	508.71 – 3052.26
FCKW	252901.46	252901.46	n.a.	n.a.
Cd in airborne particle	1780484.44	1780484.44	n.a.	n.a.
Hg in airborne particle	178048443.71	178048443.71	n.a.	n.a.

One American study could be found that dealt with the valuation of local and regional air emissions such as NOx, O3 and VOC's. The study of Brucato et al. (1990) evaluated the health and welfare effects resulting from a 10% reduction in ozone levels by estimating a damage function and a hedonic equation for California. The damage function estimated total benefits for the ozone change as a function of the point estimates from the concentration response function multiplied by the WTP estimate for the change and by the target population in the county. The sale price of owner-occupied single-family residences was modelled as a function of house, neighbourhood and community characteristics. The best estimate of the present value of marginal benefits was $316 million, over a 30-year period ($US1984) for the damage function approach. For the hedonic approach, the best estimate of the price differential aggregated over households affected by ozone levels in the area was valued at $430 million over a 30-year period.

b) SOx

We found only one relevant study for the valuation of reductions in SOx emissions. The U.S. Environmental Protection Agency published in 1998 a report on the external impacts

of fossil fuel generation by Ontario Hydro. A variety of air pollutants associated with fossil fuel production (SO2, SO4, O3, NO3, total suspended particles and trace metals) were taken into account. Using the damage function approach leads to the following results: $95.79 million total damage in 1992 ($Canadian 1993) and total magnetised impacts of 0.395 cents/kilowatt.

c) VOC: volatile organic compounds

One study dealing with air quality and VOC emissions has already been discussed under NOx (Brucato et al., 1990).

One other study that provides relevant data is Cifuentes and Lave (1993). The study deals with health effects associated with air pollution abatement. Specific environmental stressors taken into account are sulphur oxides, nitrogen dioxide, particulate matter and ozone. The authors use existing sources of data (ranging from 1979 up until 1992). And published studies for information. Ambient concentrations of various air pollutants were estimated as a function of emissions. Values of the health effects taken from the previously published studies were applied to the exposed population to estimate the national benefit of emission reductions. Depending on the pollutant, marginal pollutant benefits ranged from $287 to $1146 per ton of pollutant emissions reduced ($US 1991). Marginal morbidity benefits ranged from $77 to $845 per ton.

6. POTENTIAL USE OF VALUATION STUDIES: BENEFIT TRANSFER

For countries with limited experience in performing primary valuation studies, the benefit transfer technique might (in some instances) be the preferred valuation method. Especially in the field of practical policy analysis, transfer studies are normal practice as only rarely, policy analysts can afford to design and implement original studies (Desvousges et al., 1998).

The term *benefit transfer* was first used by Desvousges et al. (1992) to describe the transfer of monetary values for a natural area (the 'data site') to another natural area (the 'no data site'). Given the high costs and efforts of administering a valuation study, it is highly recommendable to use the results or at least the methodology of existing studies when valuing other environmental goods or services. A necessary and absolutely crucial condition is that the original study/ies is/are of excellent quality.

Other necessary conditions for performing a successful transfer study are (Desvousges et al., 1992):

1. The studied good/service of the original valuation study and the new study are similar to great extent;
2. the aspect to be valued in the new study is similar to that in the original study;
3. the socio-demographic characteristics of the relevant population groups are similar.

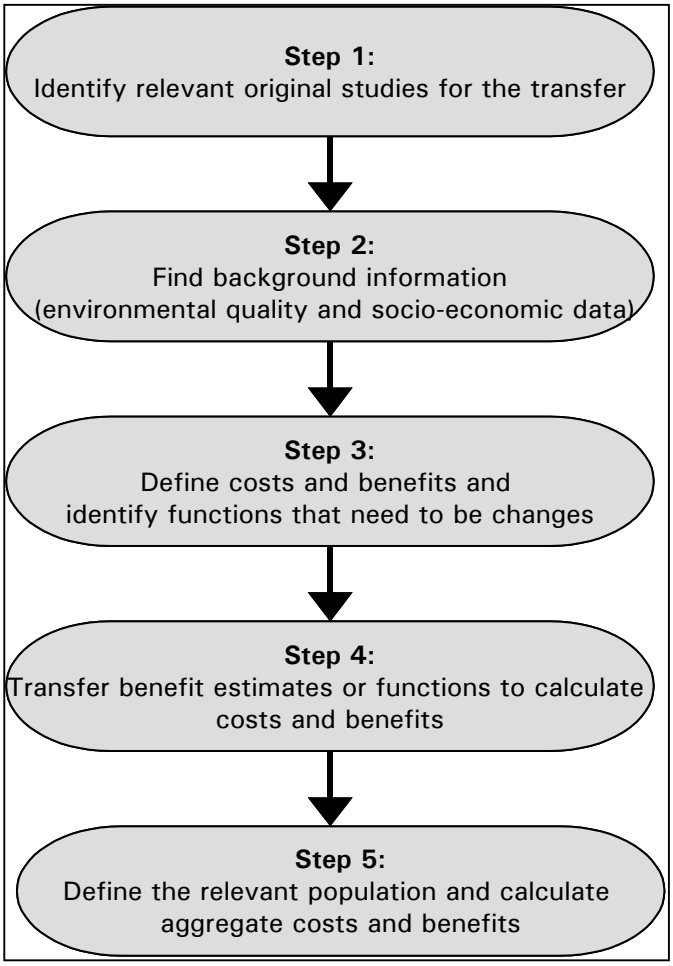
There are different ways in which transfer studies can be performed. A distinction can be made between a *benefit estimate transfer* and a *benefit function transfer*. The benefit estimate transfer refers to a transfer of aggregated benefit estimates or average benefit estimates per person/household. However, this method can at most perform reasonably well if corrections are made for possible biases in the original study and if the

characteristics of the valued good and of the relevant populations are not too different (Pearce et al., 1994).

The best results are obtained by transferring the methodology or benefit function instead of benefit estimates (Loomis, 1992). The original demand or valuation function in its original functional form and with the estimated parameters is transferred by filling in the relevant 'new' values for the independent variables and thus calculating the new value of the dependent variable (a quantity variable in case of a demand function, a value/bid variable in case of a valuation function).

In general, one can distinguish five different steps in the implementation of a transfer study (Desvousges et al., 1998). This is summarized in Figure 2.

Figure 2: The different steps of a transfer study



An example

To find the optimal location of new forest sites in East-Flanders (Belgium), the authors depended on GIS-automated benefit transfer techniques (see Moons et al., 2003) to determine the potential recreational value of these new sites. Only one relevant original study was available (Moons et al., 2000). GIS-based data on potential visitors (i.e. socio-economic characteristics of the East-Flanders population) were assembled, as well as site characteristics for the potential forest locations. Next, the individual TCM that was

estimated originally, was re-estimated on a zonal basis, using zonal population characteristics and visit rates rather than the individual observations. This function was then transferred to each potential new forest site. Visit rates were predicted by multiplying each estimated coefficient with the associated value of the variable and then added up to predict the visit rates. Total visit numbers, consumer's surplus and total recreational value were then derived.

7. CONCLUSIONS AND RECOMMENDATIONS

In this paper we explained some of the most popular economic valuation techniques and showed how they are used in rational political decision-making processes. The U.S.A. has a longstanding tradition of efficiency and thus rational decision-making.

Pearce (2001) formulates some recommendations of getting CBA into the process of decision-making. First, there must be a rational discourse about decision-making in general, which forces the issue of trade-offs to be recognized. Second, there must be external support in the forms of academic or research institutes who favour the procedures. Third, there must be an 'efficiency culture' for CBA to thrive. Fourth, there needs to be some tradition of 'senior ministries' such that a ministry of finance is regarded as the ultimate guide on what is and what is not the proper subject of public expenditure. Fifth, CBA must be explained and communicated in a comprehensible manner, in other words, it should be popularised. This way criticism based on limited understanding is avoided.

Apart from these recommendations, some legal or quasi-legal requirement that costs and benefits should be considered in (a) regulation and (b) damage liability would enhance a wider and better use of CBA in Europe.

Since it is required in a CBA that all relevant impacts are monetised, one will need to apply monetary valuation techniques such as the travel cost method and especially the contingent valuation method. The latter is in theory capable to capture all values of environmental goods and services. However, since the execution of an original valuation study is both costly and time-consuming and since it requires special knowledge that is not as widespread among political analysts as it is among academics, it is often more efficient to apply benefit transfer techniques using benefit estimates or benefit functions from studies about environmental goods and services that are similar to the good that you are looking at. This implies both a broad knowledge of decision-makers on valuation techniques and especially benefit transfer techniques as well as a close link between decision-makers and academics. Databases like EVRI are easily accessible ways to gather and locate interesting studies for a benefit transfer.

Nevertheless, regardless of the ongoing improvements in transfer techniques, original valuation studies designed to value one or a few specific environmental good(s) or service(s) provide without exception more accurate and credible benefit estimates. We therefore suggest that the Flemish Administration invests in a few selected valuation studies of those environmental goods and services in one specific region that will be the topic of future regulations. These few studies thus provide data for Flanders that can be transferred to other regions with more accuracy than when data from other European countries or the U.S.A. are used.

REFERENCES

- Adamowicz, W.L. (1991), "Valuation of environmental amenities", *Canadian Journal of Agricultural Economics*, 39, pp. 609-618.
- Arrow, K., G. Daily, P. Dasgupta, S. Levin, K-G. Mäler, E. Maskin, D. Starrett, T. Sterner en T. Tietenberg (2000), "Managing ecosystem resources", *Environmental Science and Technology*, 34(8), pp. 1401-1406
- Arrow, K.J., Solow, R., Portney, P.R., Leamer, E.E., Radner, R. and Shuman, E.H. (1993), Report of the NOAA panel on contingent valuation, Federal Register, 58, pp. 4602-4614.
- Bateman, I.J. and Willis, K.G. (1999), Valuing environmental preferences. Theory and practice of the contingent valuation method in the US, EU and developing countries, Oxford, Oxford University Pres, 645 p.
- Becker, G.S. (1965), " A theory of the allocation of time", *The Economic Journal*, 75, pp. 493-457.
- Bishop, R.C. and Heberlein, T.A. (1979), "Measuring values of extra-market goods: are indirect measure biased?", *American Journal of Agricultural Economics*, 61(5), pp. 926-930.
- Bishop, R.C. and Heberlein, T.A. (1980), "Simulated markets, hypothetical markets, and travel cost analysis: alternative methods of estimating outdoor recreation demand", *Staff Paper Series no. 187*, Department of Agricultural Economics, University of Wisconsin.
- Bockstael, N.E., A.M. Freeman, R.J. Kropp, P.R. Portney en V.K. Smith (2000), "On measuring economic values for nature", *Environmental Science and Technology*, 34(8), blz. 1384-1389.
- Bockstael, N.E., McConnell, K.E., Strand, I.E. (1991), "Recreation", in Braden, J. and Kolstad, C. (eds.), Measuring the demand for environmental quality, Amsterdam: North Holland.
- Bonnieux, F., Rainelli, P. (1999), "Contingent valuation methodology and the EU institutional framework", in Bateman, I.J. , Willis, K.G. (eds.), Valuing environmental preferences, Theory and practice of the contingent valuation method in the US, EU and Developing Countries, New York, Oxford University Press, 585-612.
- Brookshire, D.S. and Eubanks, L.S. (1978), Contingent valuation and revealing actual demand for public environmental commodities, manuscript, University of Wyoming.
- Brookshire, D.S. and Randall, A. (1978), "Public policy alternatives, public goods, and contingent valuation mechanisms", *Paper presented at the Western Economic Association Meeting*, Honolulu, Hawaii.
- Cameron, T. (1992), "Combining contingent valuation and travel cost data for the valuation of nonmarket goods", *Land Economics*, 68, 302-317.
- Carson, R.T. (2000), "Contingent valuation: a user's guide", *Environmental Science and Technology*, 34(8), blz. 1413-1418.
- Carson, R.T., Groves, T. and Machina, M.J. (1999), "Incentive and informational properties of preference questions", *Plenary Address, EAERE Conference*, Oslo, Norway.
- Carson, R.T., Hanemann, W.M. and Mitchell, R.C. (1986), Determining the demand for public goods by simulating referendums at different tax prices, manuscript, University of California, San Diego.
- Carson, R.T., Mitchell, R.C., Hanemann, W.M., Kopp, R.J., Presser, S. and Rudd, P.A. (1992), A contingent valuation study of lost passive use values resulting from the Exxon Valdez oil spill, Report to the Attorney General of the State of Alaska, Natural Resource Damage Assessment Inc., San Diego.
- Ciriacy-Wantrup, S.V. (1947), "Capital returns from soil-conservation practices", *Journal of Farm Economics*, 29, pp. 1181-1196.
- Clawson, M. and Knetsch, J. (1966), Economics of outdoor recreation, Baltimore, Johns Hopkins University Press.
- Costanza, R. et al. (1997), "The value of the world's largest ecosystem services and natural capital", *Nature*, 387, blz. 253-260.
- Cummings, R.G., Schulze, W.D., Gerking, S.D. and Brookshire, D.S. (1986), "Measuring the elasticity of substitution of wages for municipal infrastructure: a comparison of the survey and wage hedonic approaches", *Journal of Environmental Economics and Management*, 13(3), pp. 269-276.

- Davis, R.K. (1963), The value of outdoor recreation: an economic study of the Maine Woods, Ph.D. dissertation, Harvard University.
- Davis, R.K. (1964), "The value of big game hunting in a private forest", in Transactions of the 29th North American Wildlife and Natural Resources Conference (Washington, D.C., Wildlife Management Institute).
- Desvousges, W .H., Smith, V.K. and McGivney, M.P. (1983), "A comparison of alternative approaches for estimated recreation and related benefits of water quality improvements", EPA-230-05-83-001 (Washington, D.C., Office of Policy Analysis, U.S. Environmental Protection Agency).
- Desvousges, W.H., Johnson, F.R., Banzhaf, H.S. (1998), Environmental policy analysis with limited information. Principles and applications of the transfer method, Cheltenham, Edward Elgar, pp.244.
- Desvousges, W.H., Naughton, M.C., Parsons, G.R. (1992), "Benefit transfer: conceptual problems in estimating water quality benefits using existing studies", *Water Resources Research*, 28(3), pp. 675-683.
- Green, P.E., Srinivasan, V. (1978), "Conjoint analysis in consumer research: issues and outlook", *Journal of Consumer Research*, 5, 83-104.
- Hanemann, W.M. (1984), "Discrete-continuous models of consumer demand", Econometrica, 52, pp. 541-561.
- Hanley (1999), "Cost-benefit analysis of environmental policy and management" in van den Bergh (ed.), Handbook of Environmental and Resource Economics", Cheltenham, Edward Elgar.
- Hanley, N. and Spash, C.L. (1993), Cost-benefit analysis and the environment, Hants, Edward Elgar Publishing Limited.
- Hausman, J.A. (1993), Contingent valuation: a critical assessment, Amsterdam, Elsevier Science Publishers, BV.
- Hellerstein, D. (1992), 'The treatment of nonparticipants in travel cost analysis and other demand models", *Water Resources Research*, 28(8), pp. 1999-2004.
- Hoehn, J.P. and Randall, A. (1987), "A satisfactory benefit cost indicator from contingent valuation", *Journal of Environmental Economics and Management*, 14(3), pp. 226-247.
- Hotelling, H.H., 1947, Multivariate Quality Control Illustrated by the Air Testing of Sample Bombsights: Techniques of Statistical Analysis, New York, McGraw-Hill .
- http://mina.vlaanderen.be/regelgeving/mer_wetgeving/alg_info/rapport/index.htm
- http://www.environment.detr.gov.uk/appraisal/index.htm
- Kling, C.L., Crooker, J.R. (1999), "Recreation demand models for environmental valuation", in van den Bergh (ed.), Handbook of Environmental and Resource Economics", Cheltenham, Edward Elgar.
- Kriström, B. (1999), "Contingent valuation", in van den Bergh (ed.), Handbook of Environmental and Resource Economics, Cheltenham, Edward Elgar.
- Kuik, O., Navrud, S., Pearce D.W. (1992), "Benefit estimation and environmental decision-making", in Navrud, S. (ed.), Pricing the European Environment, Oslo, Scandinavian University Press; distributed by Oxford University Press, New York, 274-287.
- Layard, R. and Glaister, S. (eds.) (1994), Cost-benefit analysis, Cambridge, Cambridge University Press, 497 p.
- Lind, R. (1982), "A primer on the major issues relating to the discount rate" in R. Lind (ed.), Discounting for time and risk in energy policy, Baltimore, MD: Johns Hopkins Press.
- Loomis, J. B. (1999), " Contingent valuation methodology and the US institutional framework", in Bateman, I.J. , Willis, K.G. (eds.), Valuing environmental preferences, Theory and practice of the contingent valuation method in the US, EU and Developing Countries, New York, Oxford University Press, pp. 585-612.
- Loomis, J.B. (1992), "The evolution of a more rigorous approach to benefit transfer: benefit function transfer", *Water Resources Research*, 28(3), pp. 701-705.
- Loomis, J.B. (1999), "Contingent valuation methodology and the US institutional framework", in Bateman, I.J. and Willis, K.G. (eds.), Valuing environmental preferences. Theory and practice of the contingent valuation method in the US, EU and developing countries, Oxford, Oxford University Pres, 645 p.

- Loomis, J.B. and Walsh, R.G. (1997), Recreation Economic Decisions. Comparing benefits and costs (2nd edition), State College, Venture Publishing, Inc., 440 p.
- Mack, R.P., Myers, S. (1965), "Outdoor recreation", in R. Dorfman (ed.), Measuring benefits of government investments, Washington, DC: The Brookings Institution.
- McFadden, D.L. (1981), "Econometric models of probabilistic choice", in C.F. Manski and D.L. McFadden (eds.), Structural analysis of discrete data, Cambridge, MA: MIT Press.
- Mitchell, R.C., Carson (1981), "An experiment in determining willingness to pay for national water quality improvements", *draft report to the U.S. Environmental Protection Agency*, Washington, D.C.
- Mitchell, R.C., Carson, R.T. (1984), A contingent valuation estimate of national freshwater benefits: technical report to the U.S. Environmental Protection Agency (Washington, D.C., Resources for the Future).
- Mitchell, R.C., Carson, R.T. (1989), Using surveys to value public goods: the contingent valuation method, Washington, Resources for the Future, 463 p.
- Moons, E., Proost, S., Saveyn, B., Hermy, M. (2003), "Optimal location of new forests in a suburban area", paper presented at the XII Congress of the European Association of Environmental and Resource Economists – EAERE 2003.
- Moons, E., Eggermont, K., Hermy, M., Proost, S. (2000), Economische waardering van bossen – een case-study van Heverleebos-Meerdaalwoud, Garant, Leuven, 356 p.
- Navrud (1992), Pricing the Environment: The European Experience, Oxford: Oxford University Press.
- Pearce, D. (2001), Annex II: Integrating cost-benefit analysis into the policy process, in Howarth, A., Pearce, D.W., Ozdemiroglu, E., Seccombe-Hett, T., Wieringa, K., Streefkerk, C.M., de Hollander, A.E.M., RIVM report 481 505 024 Valuing the benefits of environmental policy: The Netherlands, Bilthover, RIVM.
- Pearce, D., Whittington, D., Georgiou, S., James, D. (1994), Transferring benefit estimates, chapter 10 in: Project and policy appraisal: integrating economics and the environment, OECD.
- Pearce, D.W. (1994), The environment: assessing the social rate of return from investment in temperate zone forestry, in: Layard, R. en S. Glaister (1994), Cost-benefit analysis – 2nd edition, Cambridge University Press, blz. 464-490.
- Roberts, K.J., Thompson, M.E. and Pawlyk, P.W. (1985), "Contingent valuation of recreational diving at petroleum rigs, Gulf of Mexico", *Transactions of the American Fisheries Society*, 114(2), pp. 214-219.
- Roskill, E.W.E.R. (1971), Commission on the third London airport, HMSO, London.
- Schulze, W.D. and d'Arge, R.C. (1978), "On the valuation of recreational damages", Paper presented to the Association of Environmental and Resource Economists, New York, December.
- Wood, S. and Trice, A. (1958), "Measurement of recreation benefits", *Land Economics*, 34, pp. 195-207.

APPENDICES

Appendix A : EVRI-database: Keywords 'water quality' and 'nitrate'

1. Bergstrom, J.C. and J.F. Dorfman, "Commodity Information and Willingness-to-Pay for Groundwater Quality Protection", Review of Agricultural Economics 16, no 3, 413-425 , 1994
2. Boyle, K.J., Poe, G.L. and J.C. Bergstrom, "What Do We Know About Groundwater Values? Preliminary Implications from a Meta Analysis of Contingent Valuation Studies", American Journal of Agricultural Economics 76, 1055-1061 , 1994
3. Breaux, Andree., Stephen Farber, and John Day., "Using Natural Coastal Wetlands to Wastewater Treatment: An Economic Benefit Analysis.", Journal of Environmental Management, Vol. (44), pp. 285-291. , 1995
4. Crutchfield, S.R., J.C. Cooper, and D. Hellerstein, "Benefits of Safer Drinking Water: The Value of Nitrate Reduction", Food and Consumer Economics Division, Economics Research Service, U.S. Department of Agriculture 1997 , 1997
5. De Zoysa, A.D.N., "A Benefit Evaluation of Programs to Enhance Groundwater Quality, Surface Water Quality and Wetland Habitat in Northwest Ohio", Dissertation, The Ohio State University , 1995
6. Edwards, S.E., "Option Prices for Groundwater Protection.", Journal of Environmental Economics and Management 15, 475-487. , 1988
7. Giraldez, C. and G. Fox, "An Economic Analysis of Groundwater Contamination from Agricultural Nitrate Emissions in Southern Ontario", Canadian Journal of Agricultural Economics 43, pp. 387-402 , 1995
8. Gren, I.M., "The Value of Investing in Wetlands for Nitrogen Abatement", European Review of Agricultural Economics 22 157-172 , 1995
9. Hanley, N., "The Economics of Nitrate Pollution in the UK", Hanley, N.D. Farming and the Countryside: An Economic Analysis of External Costs and Benefits, CAB, Oxford. , 1991
10. Jordan, J.L., and A.H. Elnagheeb, "Willingness to Pay for Improvements in Drinking Water Quality.", Water Resources Research 29, no. 2, 237-245. , 1993
11. Lee, L. and E.G. Nielsen, The Extent and Costs of Groundwater Contamination by Agriculture., Journal of Soil and Water Conservation, 42, no. 4, 243-248. , 1987
12. Loomis, H., P. Kent, L. Strange, K. Fausch, and A. Covich, "Measuring the Total Economic Value of Restoring EcoSystem Services in an Impaired River Basin: Results from a Contingent Valuation Survey.", Ecological Economics 33, p. 103-117 , 2000
13. Malone, P., and R. Barrows, Groundwater Pollution's effects on Residential Property Values, Portage County, Wisconsin., Journal of Soil and Water Conservation, March/April, 1990, 346-348. , 1990
14. Phillips, T.P. and B.A. Forster, "Economic Impacts of Acid Rain on Forest, Aquatic, and Agricultural Ecosystems in Canada", American Journal of Agricultural Economics 69, no. 5, 963-969 , 1987
15. Poe, G.L., and R.C. Bishop, Measuring the Benefits of Groundwater Protection from Agricultural Contamination: Results from a Two-Stage Contingent Valuation Study., University of Wisconsin-Madison Agricultural Economics Staff Paper No. 341, 1992. , 1992
16. Sun, H., J.C. Bergstrom, and J.H. Dorfman, Estimating the Benefits of Groundwater Contamination Control., Southern Journal of Agricultural Economics, 1992, 63-71 , 1992

17. Wright, C., "An Economic Assessment of Groundwater Pollution", Masters Thesis, Central Michigan University , 1988

Appendix B : EVRI-database: Keywords 'water quality' and 'sulphate'

1. Cho, Y., "Willingness to Pay for Drinking Water Quality Improvements: A Contingent Valuation Study for Southwestern Minnesota", Dissertation, University of Minnesota , 1996

Appendix C : EVRI-database: Keywords 'water quality' and 'COD'

1. Angst, G., Stark, W., Hutterer H., Pilz, H.,, Cost-benefit Analysis of material recycling of packaging, Federal Environment Agency - Austria , 2001
2. ARGE GUA/IFIP GUA: Gesellschaft für umweltfreundliche Abfallbehandlung GmbH; IFIP TU - Institut für Finanzwissenschaft und Infrastrukturpolitik, TU Wien, Overall economic costs and benefits of waste management of Austrian households and facilities similar to households, Federal Ministry of Agriculture, Forestry, Environment and Water Management Division IV/4 , 1998
3. ARGE GUA/IFIP GUA: Gesellschaft für umweltfreundliche Abfallbehandlung GmbH; IFIP TU - Institut für Finanzwissenschaft und Infrastrukturpolitik, TU Wien, Economic comparison of one-way systems and returnable systems, www.bmu.gv.at, Federal Ministry of Agriculture, Forestry, Environment and Water Management Devision IV/4 , 2000
4. Bockstael, N.E., W.M. Hanemann, and C.L. Kling, "Estimating the Value of Water Quality Improvements in a Recreational Demand Framework.", Water Resources Research 23, no. 5, 951-960. , 1987
5. Boyle, K.J., Poe, G.L. and J.C. Bergstrom, "What Do We Know About Groundwater Values? Preliminary Implications from a Meta Analysis of Contingent Valuation Studies", American Journal of Agricultural Economics 76, 1055-1061 , 1994
6. Edwards, S.E., "Option Prices for Groundwater Protection.", Journal of Environmental Economics and Management 15, 475-487, 1988
7. Frühwirt, W., Wöginger, H., Döberl, G., Huber, R., Eder, M., Pierrard, R., Evaluation of Waste Management Options in View of Long-Term Maintenance-Free Landfills, Federal Environment Agency - Austria , 2000
8. Kawabe, M. and T. Oka, "Benefit from Improvement of Organic Contamination of Tokyo Bay", Marine Pollution Bulletin 32, no. 11, 788-793 , 1996
9. Ping, Y., "The Pollution Charge System in China: An Economic Incentive?", Economy and Environment Program for Southeast Asia, International Development Research Centre , 1998
10. Tao, W., W. Yang and B. Zhou, "Tradable Discharge Permits System for Water Pollution of the Upper Nanpan River, China", Economy and Environment Program for Southeast Asia, International Development Research Centre 1998 , 1998
11. Wilman, E.A., "Hedonic Prices and Beach Recreational Values.", Greenwich, CT: JAI Press 1981 , 1981
12. Xu, Jintau, "Chinas Paper Industry: Growth and Environmental Policy during Economic Reform", Economy and Environment Program for Southeast Asia, International Development Research Centre , 2000
13. Zhang, F., "Marginal Opportunity Cost Pricing for Wastewater Disposal: A Case Study of Wuxi China", Economy and Environment Program for Southeast Asia, International Development Research Centre 1999 , 1999

Appendix D : EVRI-database: Keywords 'air' and 'NOx'

1. Angst, G., Stark, W., Hutterer H., Pilz, H.,, Cost-benefit Analysis of material recycling of packaging, Federal Environment Agency - Austria , 2001
2. ARGE GUA/IFIP GUA: Gesellschaft für umweltfreundliche Abfallbehandlung GmbH; IFIP TU - Institut für Finanzwissenschaft und Infrastrukturpolitik, TU Wien, Overall economic costs and benefits of waste management of Austrian households and facilities similar to households, Federal Ministry of Agriculture, Forestry, Environment and Water Management Division IV/4 , 1998
3. ARGE GUA/IFIP GUA: Gesellschaft für umweltfreundliche Abfallbehandlung GmbH; IFIP TU - Institut für Finanzwissenschaft und Infrastrukturpolitik, TU Wien, Economic comparison of one-way systems and returnable systems, www.bmu.gv.at, Federal Ministry of Agriculture, Forestry, Environment and Water Management Devision IV/4 , 2000
4. Brucato, P., J.C. Murdoch, and M.A. Thayer, "Urban Air Quality Improvements: a Comparison of Aggregate Health and Welfare Benefits to Hedonic Price Differentials", Journal of Environmental Management, vol. 30, no. 3, 265-279 , 1990
5. Chandrasiri, S., "Controlling Automotive Air Pollution: The Case of Colombo City", Economy and Environment Program for Southeast Asia, International Development Research Centre , 1999
6. Corpuz, C.F., "Pollution Tax for Controlling Emissions from the Manufacturing and Power Generation Sectors: Metro Manila", Economy and Environment Program for Southeast Asia, International Development Research Centre 1999 , 1999
7. Frühwirt, W., Wöginger, H., Döberl, G., Huber, R., Eder, M., Pierrard, R., Evaluation of Waste Management Options in View of Long-Term Maintenance-Free Landfills, Federal Environment Agency - Austria , 2000
8. Kosz, M., Madreiter, T., Schönbäck, W., Thermal Insulation: Profitability, effect on employment, climate protection. A micro and macro-economical analysis., SpringerWienNewYork, 1996 , 1996
9. Schmid, W. et al, Integrated Resource Planning in Austrian Production and Distribution Companies, www.eva.wsr.ac.at/projekte/irp.htm , 1998
10. Shiqui, Z. and D. Yanxin, "Marginal Cost pricing for Coal Fired Electricity in Coastal Cities of China: The Case of Mawan Electricity Plant in Shenzhen, Guandong Province", Economy and Environment Program for Southeast Asia, International Development Research Centre 1999 , 1999

Appendix E : EVRI-database: Keywords 'air' and 'SOx'

1. Corpuz, C.F., "Pollution Tax for Controlling Emissions from the Manufacturing and Power Generation Sectors: Metro Manila", Economy and Environment Program for Southeast Asia, International Development Research Centre 1999 , 1999
2. Orbeta, E. M., C. M. Rufo, Jr., and A. L. Indab, "Benefits and Costs of Controlling Emissions from Fossil-fired Power Plants: Region IV, Philippines", Economy and Environment Program for Southeast Asia, International Development Research Centre , 2000
3. Shiqui, Z. and D. Yanxin, "Marginal Cost pricing for Coal Fired Electricity in Coastal Cities of China: The Case of Mawan Electricity Plant in Shenzhen, Guandong Province", Economy and Environment Program for Southeast Asia, International Development Research Centre 1999 , 1999
4. U.S. Environmental Protection Agency, "Full-Cost Accounting for Decision-Making at Ontario Hydro," in "The Green Bottom Line," edited by Martin Bennet and Peter James., Sheffield, England: Greenleaf Publishing 1998 , 1998

Appendix F : EVRI-database: Keywords 'air' and 'VOC'

1. Brucato, P., J.C. Murdoch, and M.A. Thayer, "Urban Air Quality Improvements: a Comparison of Aggregate Health and Welfare Benefits to Hedonic Price Differentials", Journal of Environmental Management, vol. 30, no. 3, 265-279 , 1990
2. Chandrasiri, S., "Controlling Automotive Air Pollution: The Case of Colombo City", Economy and Environment Program for Southeast Asia, International Development Research Centre , 1999
3. Cifuentes, L.A., and L.B. Lave, "Economic Valuation of Air Pollution Abatement: Benefits from Health Effects", Annual Review of Energy and the Environment 18, no. 1, 319-342 , 1993
4. Corpuz, C.F., "Pollution Tax for Controlling Emissions from the Manufacturing and Power Generation Sectors: Metro Manila", Economy and Environment Program for Southeast Asia, International Development Research Centre 1999 , 1999

The Center for Economic Studies (CES) is the research division of the Department of Economics of the Katholieke Universiteit Leuven. The CES research department employs some 100 people. The division Energy, Transport & Environment (ETE) currently consists of about 15 full time researchers. The general aim of ETE is to apply state of the art economic theory to current policy issues at the Flemish, Belgian and European level. An important asset of ETE is its extensive portfolio of numerical partial and general equilibrium models for the assessment of transport, energy and environmental policies.

ETE WORKING PAPER SERIES 2003

n° 2003-07 Moons E., The development and application of economic valuation techniques and their use in environmental policy – A survey

n° 2003-06 Muys B., Deckmyn G., Moons E., Quijano J.G., Proost S. and Ceulemans R. (2003), An integrated decision support tool for the prediction and evaluation of efficiency, environmental impact and total social cost of forestry projects in the framework of the Kyoto protocol

n° 2003-05 Proost, S. and Van Regemorter, D. (2003), Climate change policy in European countries and its effects on industry

n° 2003-04 Willems, B. (2003), Should an incumbent generator be allowed to buy import transmission capacity?

n° 2003-03 Rousseau, S. and Billiet, C.M. (2003), Using emission standards under incomplete compliance

n° 2003-02 Calthrop, E., De Borger, B. and Proost S. (2003), Tax reform for dirty intermediate goods: theory and an application to the taxation of freight transport

n° 2003-01 Pepermans, G. (2003), Simulating the restructuring of the Flemish electricity distribution sector

ETE WORKING PAPER SERIES 2002

n° 2002-13 Willems, B. (2002), Barring consumers from the electricity network might improve welfare

n° 2002-12 Mayeres, I. And Proost, S. (2002), Reforming transport pricing: an economist's perspective on equity, efficiency and acceptability

n° 2002-11 Mayeres, I. (2002), Taxes and Transport Externalities

n° 2002-10 Franckx, L. and Kampas, A. (2002), A Note on "The Choice between Emission Taxes and Output Taxes under Imperfect Monitoring"

n° 2002-09 Eyckmans, J. (2002) International Environment Agreements And The Case Of Global Warming

n° 2002-08 Calthrop, E. Proost, S. (2002) Environmental Pricing in Transport Chapter for Handbook 4: Transport and the Environment