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Abstract:

Environmental valuation studies aim at the assessment of the social benefits or the social costs caused by some change in environmental quality (in the broadest sense). The most popular field of application of environmental valuation studies is project appraisal where the benefits arising from some environmental project (measured in terms of people's willingness to pay for that project) are assessed and confronted with the costs of the project or with the benefits from some alternative project if a choice has to be made between different projects. A closer look at the results of empirical valuation studies shows that in many surveys a negative correlation between the number auf household members and the willingness to pay (WTP) stated by a household for a project can be observed. These results are rather puzzling because in larger households more people are going to benefit from an environmental improvement than in small households. A plausible explanation for these results is that household budgets are tighter for large households than for smaller households with the same household income. Therefore, large households must state a smaller WTP for a project than smaller households with the same income and the same preferences. This might have consequences for the allocation of public funds in all cases where the realization of a specific environmental project depends on the absolute value of the aggregate social benefits it generates. In order to calculate the social benefits typically the WTPs of the different households affected by that project are added up. In this aggregation process the members of larger households have a lower weight and, therefore, their WTP has a smaller impact on the decision if a certain project is realized or not. The reason for this violation of the principle of horizontal equity is that for the computation of the social benefits not individual but household WTPs are aggregated. In this paper we suggest to use household equivalence scales for the evaluation of WTP data in order to reduce this discrimination of the members of large families. We demonstrate the effects of equivalence scales on the results of environmental valuation surveys using an empirical study carried out in Eastern Germany.

JEL-Class.: D61, D63, H43, Q51

1. Introduction

In many countries the economic valuation of changes in environmental quality, especially in the context of project evaluation, has become an important decision tool supporting the rational use of public funds in the environmental sector. Project evaluation aims at the assessment of the increase in social welfare generated by some environmental project in monetary terms, i. e. its social value, in order to compare this welfare gain to the costs of the project or to the welfare gain generated by other projects. Therefore, environmental valuation helps to substantiate the decision if some environmental project should be realized or not and it may also help to pick the best from a variety of alternative projects. In this application environmental valuation is primarily an instrument to enhance the efficiency of public

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spending.[1] Since the benefits accruing from different public projects affect different groups of the population differently the outcome of a valuation study has not only consequences for the efficiency of public spending but also for the distribution of the ensuing benefits. This paper deals with the equity aspects of environmental valuation.

One of the most popular methods for the economic valuation of public projects, especially in the environmental sector, is the contingent valuation method (CVM). It is an interview-based so-called direct valuation technique which aims at the assessment of people's Hicksian Compensating Variation (HCV) for a public project. The HCV is positive if a household's utility increases as a consequence of the project in question. In this case it equals the maximum amount of money a household could give up after the project has been carried out without being worse off than without that project. For utility decreases the HCV is negative and equals the minimum amount of money a household must be given after the project has been carried out so that it is not worse off than without the project. In the first case the HCV can be interpreted as people's maximum willingness to pay (WTP) for the realization of that project. In the second case the HCV is negative and interpreted as a household's minimum willingness to accept compensation (WTA) for the realization of that project. Much has been said about the theoretical deficiencies of the contingent valuation method [cf. e. g. Harrison (2007), Mathews et al. (2004), Carson / Hanemann (2005, p. 906 ff.), Bockstael / Freeman (2005), Diamond (1996a, b) or Diamond / Hausman (1994)]. But this has not impaired the dominant position of the CVM among environmental valuation techniques and still it holds that it "is hard to overestimate the central importance of contingent valuation to modern environmental economics" as Carson and Hanemann (2005, p. 826) put it. In this paper we focus on one point which has not received much attention until now, namely the aggregation method used in practical CVM studies and its consequences for equity.

In a CVM survey typically a representative random sample of households is drawn and the selected households are asked their WTP or WTA for a public project. For the computation of its social value the individual WTPs and/or WTAs have to be aggregated over all households. For this purpose, typically, the mean or median HCV of the interviewed households of the selected sample is multiplied by the total number of all households potentially affected by that project. Ideally (i. e. if the selected household sample is really representative) this is equivalent to adding up all household HCVs (positive and negative). The typical interpretation of CVM results is then that a positive sum of household HCVs signals a potential Pareto improvement in the sense of the Hicks (1939) – Kaldor (1939) criterion, so that the project in question can be recommended for realization. If two alternative projects are compared the one that yields a higher sum of household HCVs is considered more beneficial from a social welfare point of view and, therefore, stands a better chance of being realized.[2] This is problematic since the Hicks-Kaldor criterion is based on an individualistic

[1] Of course, there are other uses of environmental valuation studies, e. g. the assessment of damages to nature after environmental accidents [cf. Carson / Hanemann (2005, p. 827 ff.)] or the appraisal of the non-market production of the agricultural sector as an assessment basis subsidies in the EU [cf. Ahlheim / Frör (2003)].

[2] Since not only the CVM but also most of the other environmental valuation methods use this kind of household-based aggregation the resulting plausibility problems are, of course, not confined to the CVM which is just used as an example here.

view of society and not a household view, i. e. the theoretical foundations of the Hicks-Kaldor criterion require to add up individual and not household WTPs and WTAs.

Empirical studies show that the household-based aggregation of preferences by adding-up the unweighted household WTPs leads to counterintuitive results. When, for example, projects causing environmental improvements are valued one would expect that the WTP for such a project increases with household size since in many-person households more people will benefit from that project than in single-person households. Contrary to this hypothesis empirical studies yield results where stated WTP for one and the same project decreases with household size [see e. g. Ahlheim et al. (2004), Roschewitz (1999) or Whittington et al. (1992)]. Also Chambers et al. (1998) obtain the result that "Family size has a negative effect ..." on the stated WTP and they conclude: "This result might be related to ability to pay; as family size increases, budgets tighten, and WTP falls." [Chambers et al. (1998, p. 149)].

From a financial point of view, however, it is plausible that stated WTP for public projects has to decrease as household size increases other things being equal. An increase in family size means an increase in the fixed costs necessary to secure the subsistence minimum of a household so that the freely disposable rest of the household budget (from which potential payments for environmental projects would have to come) decreases. Therefore, households' WTPs for an environmental project have to decrease as family size increases. Therefore, the aggregation of households' instead of individuals' WTPs which is common practice in applied environmental valuation studies is not compatible with the interpretation of the results according to the Hicks-Kaldor criterion that is based on individual WTPs. Since budgets are tighter for households with more members (other things being equal) this aggregation leads to a discrimination of the members of large families as compared to the members of small families with the same household income and the same preferences of household members. The fact that households with equal preferences and equal household income are treated differently in such valuation studies violates the principle of horizontal equity according to which equals have to be treated equally [cf. e. g. Slemrod / Yitzhaki (2002, p. 445)].

In order to reduce this household size bias of valuation results we suggest considering household size explicitly in valuation studies by using household equivalence scales for the aggregation of household WTPs. The use of household equivalence scales makes the WTP stated by households with the same household income and the same preferences but different household size compatible with each other as will be shown below. The aggregation of household WTPs according to the Hicks-Kaldor criterion is then equivalent (or at least closer) to an individual-based aggregation. Using an empirical study carried out in Eastern Germany we demonstrate this approach and the resulting effects on valuation results.

The rest of the paper is organized as follows. In the second section we highlight the theoretical background of aggregation in environmental valuation analyses and show that WTP has to decrease with freely disposable income which is the source of implausible results if household WTPs instead of individual WTPs are aggregated. In section 3 we discuss the theoretical concept of equivalence scales and their possible integration in environmental valuation studies. In section 4 we illustrate the practical application of equivalence scales in a contingent valuation study carried out in Eastern Germany. Section 5 contains some concluding remarks.

2. Environmental valuation

In this section we first give a short summary of the theoretical background of environmental valuation and then we contrast it with the practice of environmental valuation to show where the common aggregation procedure leads to a deviation from what theory demands.

Theory

The economic assessment of changes in environmental quality caused by a public project typically aims at the question whether or not society as a whole is better off after that project has been performed. To answer this question one has to assess the changes of individual welfare of all persons affected by that project first and then to aggregate these individual welfare changes to compute the gain or loss in social welfare caused by this project.

The individual assessment problem aims at the identification of the individual utility changes caused by an environmental project

(1) $$\Delta U_j = U_j^1 - U_j^0 = u_j(x_j^1, z^1) - u_j(x_j^0, z^0)$$

where the index j denotes individuals $j \in \{1, 2, ..., J\}$ and U_j^0 and U_j^1 denote the utility levels attained by an individual j before (situation 0) and after (situation 1) the project. The function $u_j(\cdot)$ is the individual's direct utility function, $x_j \in \Re^N$ is the vector of market commodities consumed in the different situations and $z \in \Re^M$ is a vector of parameters describing the state of the environment, i. e. environmental quality.

Since utility changes cannot be observed directly ΔU_j is typically measured by the Hicksian Compensating Variation (HCV). If we concentrate on the environmental quality effects of public projects and assume that commodity prices $p \in \Re^N$ and incomes I_j are not affected and therefore constant the Hicksian Compensating Variation for an individual j can be described by

(2) $$HCV_j(p, z^1, U_j^0, U_j^1) = e_j(p, z^1, U_j^1) - e_j(p, z^1, U_j^0)$$

where $e_j(\cdot)$ is the j^{th} individual's expenditure function.

An important point in our argumentation is that under the assumption of decreasing marginal utility of income the Compensating Variation decreases with income. This can be seen if we substitute the household's indirect utility function $v_j(p, z, I_j)$ for the utility levels U_j in (2) so that we obtain the indirect version of the Hicksian CV as a function of p, z and I according to

(3) $$HCV_j^{ind}(p, z^0, z^1, I_j) \equiv e_j\left(p, z^1, v_j\left(p, z^1, I_j\right)\right) - e_j\left(p, z^1, v_j\left(p, z^0, I_j\right)\right).$$

If we take into account the duality identity

(4) $$e_j\left(p, z, v_j\left(p, z, I_j\right)\right) \equiv I_j$$

we obtain that

(5) $$HCV_j^{ind}(p,z^0,z^1,I_j) \equiv I_j - e_j\left(p,z^1,v_j\left(p,z^0,I_j\right)\right)$$

Taking the first-order derivative w. r. t. income yields

(6) $$\frac{\partial\, HCV_j^{ind}}{\partial\, I_j}(p,z^0,z^1,I_j) \equiv 1 - \frac{\partial e_j\left(p,z^1,U_j^0\right)}{\partial U_j} \cdot \frac{\partial v_j\left(p,\, z^0,\, I_j\right)}{\partial\, I_j} \quad .$$

From (4) it follows that the derivative of the expenditure function w. r. t. income is reciprocal to the derivative of the indirect utility function w. r. t. income, i. e.

(7) $$\frac{\partial e_j\left(p,z,v_j\left(p,z,I_j\right)\right)}{\partial U_j} \equiv \frac{1}{\dfrac{\partial v_j\left(p,z,I_j\right)}{\partial I_j}} \quad ,$$

so that (6) can be expressed as

(8) $$\frac{\partial\, HCV_j^{ind}}{\partial\, I_j}(p,z^0,z^1,I_j) \equiv 1 - \frac{\dfrac{\partial e_j}{\partial U_j}\left(p,z^1,U_j^0\right)}{\dfrac{\partial e_j}{\partial U_j}\left(p,z^0,U_j^0\right)} \quad .$$

Since the expenditure function is strictly monotonically decreasing in environmental quality, for an environmental improvement $z^1 > z^0$ it holds that

$$e_j\left(p,\, z^1,\, U_j^0\right) < e_j\left(p,\, z^0,\, U_j^0\right) \quad .$$

Under the assumption of a decreasing marginal utility of income its reciprocal, the marginal cost of utility $\partial e_j / \partial U_j$, must be greater for $e_j\left(p,\, z^0,\, U_j^0\right)$ than for $e_j\left(p,\, z^1,\, U_j^0\right)$ because of (7). Therefore $\dfrac{\partial\, HCV_j^{ind}}{\partial\, I_j}(p,z^0,z^1,I_j)$ must be positive for a decreasing marginal utility of income according to (8). As a result of these considerations we obtain that under the conventional assumption of a decreasing marginal utility of income the Hicksian Compensating Variation increases with disposable income.

For the (political) decision if an environmental project should be carried out or not it is not enough to assess the individual utility effects of that project as measured by HCV according to (2) but it is also necessary or at least desired by politicians that these individual HCVs are aggregated. From Arrow's (1950, 1963) Impossibility Theorem it is well-known that within the framework of ordinal utility theory an "objective", i. e. a non-normative aggregation of individual preferences is not possible under fairly plausible conditions. Nevertheless, the already mentioned Hicks-Kaldor criterion is widely accepted as a social decision criterion, especially, in the framework of cost-benefit analysis. It says that a public project should be accepted as socially beneficial if the sum of the individual Compensating Variations over all individuals

$$(9) \qquad \sum_{j=1}^{J} HCV_j = \sum_{j=1}^{J} \left(e_j\,(p, z^1, U_j^1) - e_j\,(p, z^1, U_j^0\,) \right)$$

is positive. Since for constant p and constant z the expenditure function is a (money-metric) utility function the aggregation of individual utility changes by summing up the Compensating Variations over all individuals is compatible with the postulation of a utilitarian welfare function $W = \sum_j U_j$ for which changes in individual utility would lead to $\Delta W = \sum_j \Delta U_j$ (see e. g. Sen (1986, p. 1074)). Of course, a utility aggregation according to (9) is not an objective form of aggregation but corresponds to a specific (and in a way arbitrary) distributional norm.

Summing up, according to the generally accepted theoretical standards of environmental valuation in the course of a valuation study first the Compensating Variations of all individuals affected by a project are assessed and then these individual HCVs are added up over all individuals. Under the assumption of a decreasing marginal utility of income the HCV decreases as income decreases, other things being equal. The sum of individual HCVs is interpreted as an indicator of the change in social welfare caused by the project in question. Its sign as well as its absolute value (in the case of several alternative projects) can be decisive for the realization of a project.

Practice

As already mentioned the most popular technique for the practical valuation of public projects in the environmental sector is the contingent valuation method. It is an interview technique that aims at the assessment of people's Hicksian Compensating Variation in terms of their willingness to pay for a public project. In the centre of a CVM interview is the so-called elicitation question where the respondents' WTP for the project is assessed. In most studies a representative random sample of all households potentially affected by the project is drawn and their WTP is assessed in CVM interviews. It is important to note that these interviews are typically conducted on a household basis, i. e. one member of a household is interviewed and she or he is asked (among other things) the household's WTP for the project in question. That means that unlike the theoretical HCV measure explained above practical valuation does not focus on individual WTP but on household WTP instead. As we showed in the last section the Hicksian Compensating Variation decreases as income decreases where "income" means the freely disposable part of income, i. e. total income after taxes and after the fixed costs that have to be incurred in order to secure the basic needs, i. e. the subsistence, of all household members. This freely disposable part of income decreases as the number of household members increases, other things being equal. As a consequence a household's stated WTP for some public project has to decrease as household size increases, too.

Equity considerations

As explained above the decision if a public project is realized or not depends on the sign and on the absolute value of the sum of individual Compensating Variations with respect to this project according to (9). In practical valuation surveys both, sign (if there are losers and winners of the same project) and absolute value of Σ HCV, depend on the absolute values of the WTPs stated by the interviewed households, not individuals. As shown in the preceding section household WTP decreases with increasing household size other things (income and preferences) being equal. Taken together these facts imply that the chances for the realization of a project are the worse the more large size households are among the supporters of the project and the more small size households are among the opponents. Especially in the case of environmental improvements this is not plausible and does not seem to be a good decision criterion.

If the decision is between two alternative projects (where Σ HCV is positive for both) the project with a higher number of small size households (other things being equal) stands a better chance of being chosen even if a smaller number of people might be concerned by this project. Again this does not seem to be a satisfactory decision criterion. Therefore, with the aggregation mode (9) which is typically used in environmental valuation studies large scale households have more problems to get projects realized which are in their interest than small size households with the same income and preferences. Empirical findings support this hypothesis [cf. Ahlheim et al. (2004), Roschewitz (1999), Chambers et al. (1998), Whittington et al. (1992)].

The question whether this fact constitutes a problem or not is a political as well as an ethical question. Environmental valuation studies provide the scientific basis for political decisions regarding the allocation of public funds. Since these allocation decisions are also decisions with respect to the distribution of the benefits accruing from these public funds questions of equity and distributional justice are to be addressed here. For consistency as well as distributional justice reasons we would like to propose to include equity considerations with respect to family size explicitly in the decision on the realization of public projects, especially in the environmental sector. Since environmental decisions are oriented towards the future and the wellbeing of future generations, especially in this context a discrimination of families with many children seems to be rather unfortunate. Therefore we propose to use family equivalence scales for a weighted aggregation of individual Hicksian Compensating Variations in environmental valuation studies in order to realize an equal treatment of households differing in size only. Our suggestion is that the household WTPs should not be added up without any weighting as in (9) but, instead, each WTP should be weighted by a suitable equivalence scale before entering the aggregation process. This weighting of household WTPs would make up for the consequences of differences in household size on the results of environmental valuation studies.

3. Equivalence scales and environmental valuation

The concept of equivalence scales has proved to be very useful for the assessment of poverty lines and welfare payments and its use has a long tradition there [cf. Dagum / Ferrari (2004) or Browning (1992)]. Equivalence scales are also considered in the context of taxation because they are regarded suitable to meet the requirements of horizontal equity there [cf. e. g. Lambert (2004)]. Horizontal equity in taxation refers to "…the idea that equals should be treated equally by the tax system, or that tax liability should not depend on any of a set of irrelevant characteristics" [Slemrod / Yitzhaki (2002, p. 445)]. Lambert (2004, p. 76) states: "It has become conventional to apply an equivalence scale to determine the equals at the family level". This is exactly what is needed for an adequate aggregation of household WTPs: identifying "equals" and giving them equal opportunities to feed their preferences for a public project into the decision process regarding the realization of that project. "Irrelevant characteristics" [Slemrod / Yitzhaki (2002, p. 445)] like the size of the family they happen to be born into should not be an obstacle to their influence on that decision. Equity in the context of environmental valuation, therefore, refers to people's influence on the decision if a specific environmental project should be realized or not, or which of several alternative projects should carried out. Our suggestion is to give households with equal preferences and equal household income but different size the opportunity to state equal WTPs for a specific environmental project. For this purpose the households' stated WTPs should be weighted by suitable equivalence scales in order to make their stated WTPs compatible with each other. This aggregation procedure is, of course, more sophisticated and more complicated than the standard aggregation according to (9).

Studies on the different "welfare potential" of the same income for different households with different socioeconomic characteristics have a long tradition which goes back as far as the end of the nineteenth century to the work of Engel (1883 and 1895). The papers of Prais (1953), Prais and Houthakker (1955), Barten (1964), Kapteyn and van Praag (1976), Lewbel (1989), Blundell and Lewbel (1991), Muellbauer (1974, 1977, 1980) set further landmarks in this field of research. Several concepts of equivalence scales have emerged over the years [for an overview see e. g. Dagum / Ferrari (2004), Muellbauer (1980) or Deaton / Muellbauer (1980)]. The extensive literature on the empirical measurement of equivalence scales covers a variety of approaches (Ray (1986). Recent definitions follow, among others, van Praag (1968, 1991) and Kapteyn (1994), for Dutch data see Melenberg / van Soest (1995) and for an application to German data Charlier (2002). Based on these concepts we have to construct an equivalence scale which is suited for the correction of stated WTP for household size and composition.

The general idea which is common to the various concepts of household equivalence scales is that the material needs of a household depend, among other things, on its demographic characteristics, especially on its size and composition. Households with different demographic characteristics need different amounts of income to attain a certain utility level or standard of living, while the same income generates different degrees of satisfaction for households with different demographic characteristics. A household equivalence scale is "... a budget deflator which reflects household needs", as Muellbauer (1980, p. 154) puts it. Or, more precisely: "Equivalence scales are to welfare comparisons across households with different characteristics what cost of living indices are to welfare comparisons for a given household facing different prices" (Muellbauer, 1980, p. 155).

In analogy to the individual expenditure function used in (2) we may define a household conditional expenditure function [see e. g. Pollak / Wales (1979), p. 217] as

$$(10) \qquad e(p, z, W, \delta) \;\equiv\; \min p \cdot x \quad , \quad \text{s. t. } w(x, z, \delta) \geq W$$

where W is the household utility level defined by the household utility function $W = w(x,z,\delta)$ $\left(\equiv \tilde{w}\left(u_1(x_1,z), u_2(x_2,z), ..., u_F(x_F,z), \delta\right)\right)$ with $x = \sum_{f=1}^{F} x_f$. The number of family members is F and δ is a vector of demographic household parameters like the number of adults, number of children etc. This leads us to the definition of conditional equivalence scales.[3] A standard or reference household with two adults and no kids is defined and all other households are regarded in relation to this reference household. Then an equivalence scale S_h for a demographic household group h expresses the ratio between the minimum expenditure a household from this group has to undergo to realize a certain level of satisfaction on the one hand and the respective expenditures of the reference household on the other [cf. also Deaton / Muellbauer (1980, p. 205):

$$(11) \qquad S_h = S(p, z, W, \delta^h, \delta^r) \equiv \frac{e(p, z, W, \delta^h)}{e(p, z, W, \delta^r)} \qquad (h \in \{1, 2, ..., H\})$$

where the functional forms of the expenditure functions for household h and for the reference household r are the same since, typically, all households are assumed to have the same preference ordering[4] and differ only in the demographic parameters δ. Obviously, for the reference household r it holds that $S_r = S\ (p, z, W, \delta^r, \delta^r) \equiv 1$.

Since the household utility level W cannot be assessed directly it is typically expressed by the indirect household utility function v(p,z,I) so that the equivalence scale S_h becomes

$$(12) \qquad S_h = \hat{S}\left(p, z, I_h, \delta^h, \delta^r\right) \equiv S\left(p, z, v\left(p, z, I_h\right), \delta^h, \delta^r\right) \quad , \quad (h \in \{1, 2, ..., H\})$$

The dependence of the equivalence scale on prices and income is usually interpreted as a dependence on real income $\hat{I}_h = I_h / \hat{p}$ where $\hat{p}$ is some cost-of–living index.

For practical applications the literature often proposes the use of expert scales or – more recently – survey approaches [for the latter see Charlier (2002) or Schwarze (2003)]. Survey-based approaches were popular in the 1970s with the so-called Leyden School (van Praag and Kapteyn 1973) using the income equivalence question. A typical question would read: “What income would you consider to be “very bad”… “very good” given your household’s circumstances?”. The problem with this approach is that households often will not understand the qualitative scale in an absolute way, but will, instead, implicitly compare the respective situation to that of an unrevealed reference household. The results of the Leyden school approach were equivalence scales that turned out flatter than the results from other measurement approaches. The income satisfaction approach is based on a question of the following type: ”How satisfied are you today with your household income? Please indicate on a scale from 0 (totally unhappy) to 10 (totally happy).” (Socio-economic panel of Germany). This approach also yields rather flat equivalence scales. One reason that has been suggested in the literature is that people tend to adjust to new income situations and after a while are as happy as they were before [Schulte (2007)]. Expert scales are the most widely used scales in practical applications, and the OECD scales the most prominent examples where the first adult in the household is given a value of 1, each additional adult is attributed a value of 0.5 and each child 0.3. Eurostat for instance uses this scale in its “Statistics in

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[3] As mentioned before there are many different definitions and concepts of equivalence scales in the literature. For an overview see e. g. Dagum / Ferrari (2004).

[4] The implications of the assumption of identical preferences across all households have been extensively analyzed by Fisher (1987).

Focus” summaries based on data from the first and second Wave of the European Commission Household Panel (ECHP). Another example is the OECD scale, which simply uses the square root of household size [Biewen (2000)]. In the sixties and seventies several suggestions have been made for equivalence scales for Germany, but they will not be considered any further. Table 1 gives an overview over the range of equivalence scales for Germany and compares them to the OECD scales.

Table 1: Equivalence scales for Germany

Number of household members	1	3	4	5	6
Charlier	0.7	1.2	1.3	1.42	1.54
Missong	0.6	1.28	1.43	1.54	
OECD (modif.)	0.67	1.2	1.4	1.6	1.8
OECD (old)	0.59	1.29	1.59	1.88	2.18
Praag	0.83	1.12	1.21	1.29	1.35
Schröder	0.67	1.15	1.28	1.41	
Schwarze	0.79	1.15	1.26	1.37	
Social Assistance	0.56	1.36	1.72	2.08	2.44

A childless couple is the reference household with an equivalence scale of 1.00. Source: Schulte 2007

Assuming that the WTP stated by the reference household r is a reliable indicator for its utility gain resulting from an environmental project we propose to correct the WTP stated by other households with different household sizes using an appropriate equivalence scale S_h in order to assess their "true" benefits B_h received from the project in question:

$$B_h = S_h \cdot WTP_h \qquad \left(h \in \{1, 2, ..., H\}\right) \tag{13}$$

This up- or down-scaling of the WTP stated by a household h corresponds to endowing this household with a virtual income that would enable this household to state the same WTP as the reference household r [cf. Ahlheim (1998)]. Correcting WTP through equivalence scales which leads to scale-corrected household benefits B_h is a pragmatic way of avoiding the (scarcely solvable) problems associated with the empirical assessment of virtual incomes.

The assessment procedure for a scale-corrected CVM study is similar to that for a traditional one: First a random sample of households potentially affected by the project in question is drawn and then one household member is chosen for the interview. In the course of a CVM interview the respondent is asked among other things the household's WTP for the environmental project in question. In traditional CVM studies the average willingness to pay of the households in the sample $\overline{WTP}$ is determined and multiplied by the number of all households affected by the project in question H to obtain the overall social benefits generated by this project, i. e. $WTP^{social} = H \cdot \overline{WTP}$.

Since the questionnaire of a CVM survey typically contains questions with respect to the demographic characteristics of the households, we know how many one-person, two-person, three-person etc. households we have in our sample and can correct the WTP stated by different households for household size. If there are K different demographic groups k (k = 1, 2, ..., K) in a sample of $\overline{H}$ households we can assign suitable equivalence scales S_k to each group k, so that all households in a demographic group k obtain the same equivalence scale S_k. If the number of households in a demographic group k is N_k we obtain the sum of the corrected $\overline{WTP} \cdot S_k$ of all households in our sample (which equals the sum of the scale-corrected household benefits B_h) as

$$(14) \qquad B^{sample} = \sum_{k=1}^{K} \overline{WTP} \cdot S_k \cdot N_k \quad , \quad \text{where} \quad \sum_{k=1}^{K} N_k = \overline{H} \quad .$$

If we take for granted that the distribution of the different demographic household characteristics in our random sample is the same as in the set of all households we can generalize B^{sample} from the $\overline{H}$ households in the sample to all H households by multiplying B^{sample} by the factor H / $\overline{H}$. The social benefit of the project under consideration is then

$$(15) \qquad B^{social} = \frac{H}{\overline{H}} \cdot B^{sample} \quad \left(= H \cdot \sum_{k=1}^{K} \overline{WTP} \cdot S_k \cdot \frac{N_k}{\overline{H}} \right).$$

A comparison between the traditional aggregate welfare measure $WTP^{social} = H \cdot \overline{WTP}$ and (15) illustrates the improvement that is attained by using equivalence scales for aggregation. In (15) the WTPs stated by the different households are corrected for household size in that not one single average $\overline{WTP}$ is generalized to the whole society but instead many different up- or down-scaled willingness to pay terms $\overline{WTP} \cdot S_k$ for the different demographic household groups k are weighted by their relative frequency $N_k / \overline{H}$ in the household sample and then aggregated to the number of all households affected by the project. This means a break with the simplifying "a dollar is a dollar"-principle prevailing in traditional cost-benefit analysis and a step towards a more sophisticated valuation of environmental changes where the different demographic characteristics of households are considered explicitly and the discrimination of the members of large households is reduced. Scale correction of household WTP in environmental valuation does not mean the solution to all our problems but it constitutes an important step in the right direction.

4. Results from an empirical study

In this section we illustrate the working of the proposed scaling mechanism in the context of an empirical example. We apply this scale correction procedure to stated household WTP in a contingent valuation study carried out in Eastern Germany and show how the results of the study respond to the use of equivalence scales [for details of the study see Ahlheim et al. (2004)]. The aim of the study was to assess the social benefits accruing from the reclamation of a former open-pit mining area close to the city of Cottbus, which lies 120 kilometers southeast of Berlin. In a still active lignite pit near Cottbus mining activities will end by the year 2015. At this time the mining company will stop pumping off the groundwater so that it will rise to its original level and the former pit is turned into a lake. The embankment of the lake as well as the whole area has to be reinforced so that public security is ensured. Further, it is envisaged to design the edge of the lake to embrace several beaches, partly with artificially created dunes, camping grounds, sports fields and to provide even a small marina. Swimming, fishing, boating, windsurfing will be possible, new forests with hiking trails will be laid out. A part of the lake and its shores will be reserved for natural conservation to provide habitat for endangered species.

For the assessment of the benefits resulting from this reclamation project a contingent valuation study was carried out in 2003. In this study 1012 households were contacted. In the course of personal interviews households were asked in a double-bounded referendum format, if they would vote for the reclamation project if their average costs of living[5] increased by a certain Euro amount per year. From the survey we obtained all information necessary to estimate the WTP of the respondents in the intervals given in Table 1. Based on a logit model, we estimate an average household willingness to pay for the Cottbus Lake of 4.39 Euro per month. Confidence intervals can be obtained by the bootstrap method [cf. Park et al. (1991), Cooper (1994), Krinsky and Robb (1986)]. A 95 % confidence interval based on the bid amount as only explanatory variable results in 3.45 to 5.23 Euro per month.

The city of Cottbus and the surrounding communities have roughly 100,000 people that live in 50,899 households. Using the estimates derived from the closed-ended data yields an aggregate willingness to pay for the population affected by the proposed design of the Cottbus Lake of ca. 223,000 Euro per month or 2.68 mill. Euro per year. The payment vehicle “increasing cost of living” assumes that this amount will be paid “forever”. Almost 2.7 mill. Euro per year will therefore be an estimate of the benefits created by the suggested design of the Cottbus Lake each year.

Table 2: Average household WTP and aggregate WTP for the “Cottbus Lake”

	Logit Model
Avg. household WTP	4.39 Euro / month
Aggregate WTP	2.68 mill. Euro / year

Own calculations.

However, this estimate considers neither household sizes nor any adjustment for it. The data on willingness to pay from the survey exhibit a negative influence of household size on willingness to pay. Table 2 gives an overview over the signs of the coefficients for some covariates with household size as one of them [for more details s. Ahlheim et al. (2004)].

[5] This rise in the cost of living can explained to the participants as a consequence of the fact that the project has to be financed by the communities in this area who in turn will raise their communal taxes, fees etc. These increases in costs are be passed on by shop owners or house owners to their customers or tenants giving rise to a general increase in prices in the end.

While education level and household income have a positive effect on the estimated willingness to pay, age and distance to the lake have a negative effect. Also household size can be found to have a negative effect on willingness to pay.

Table 3: Effect of covariates

	sign	p-value
Age	-	0.028
Monthly income	+	0.000
Education level	+	0.195
Household size	-	0.025
Distance to the lake (in travel time classes)	-	0.006
Gender (1=female, 0=male)	+	0.041
Constant	+	0.029
Bid	-	0.000

Own calculations.

Historically, the average family size in the East tended to be larger than in West Germany. Table 4 gives the distribution of the family sizes in Cottbus in comparison to the German averages. The number of households with only one person is in Cottbus only half as large as in Germany, more than 36% of all households in Cottbus households have at least one child as opposed to more than 29% in Germany.

Table 4: Distribution of family size in Germany and Cottbus (2004, in percent)

Number of household members	1	2	3	4	5
Germany	36.74%	33.73%	14.17%	11.14%	4.22%
Cottbus	18.44%	46.25%	20.32%	12.33%	4.25%

Source: Statistical yearbook of Germany 2005, own calculations.

In table 5 the equivalence scales discussed in section 3 are used to correct the stated WTP of the different household groups of the reclamation project in Cottbus for household size. The results show that the use of equivalence scales changed the original non-scaled results substantially. Especially in a region with many households with children and tight budgets like Eastern Germany the adjustment of WTP to household size leads to considerable changes in the total social value of a project assessed by environmental valuation studies.

Table 5: Mean willingness to pay adjusted with equivalence scales in €

Scale	WTP/ average household	Total WTP
Charlier	4,58	2.800.614
Missong	4,61	2.816.776
OECD (modif.)	4,64	2.835.498
OECD (old)	4,80	2.934.793
Praag	4,55	2.777.772
Schröder	4,45	2.721.712
Schwarze	4,53	2.771.584
Social Assistance	4,94	3.020.152

Own calculations.

In our study the use of equivalence scales boosted the total benefits from the reclamation of the former open-pit mining area near Cottbus up to over 3 million Euro per year. The increase of the social value of the project of more than 300,000 Euro per year as compared to the unscaled result can be crucial in the political decision making process, when the costs and the benefits of a project are weighed against each other or when the benefits accruing from different alternative projects are compared to each other to decide which of them is most profitable and should be realized.

5. Concluding remarks

In this paper we showed that in practical environmental valuation studies an equity problem arises from the aggregation method used to calculate social benefits from the respective household benefits accruing from a public project. In practical valuation studies the social benefits from a project are calculated by just adding up the willingness to pay for that project stated by households instead of the willingness to pay of individuals as welfare theory would demand. In the second section of the paper it was shown theoretically that under realistic assumptions stated WTP for a project has to decrease as household size increases. That means that the WTP for a project stated by large households in a valuation survey has to be smaller than the WTP stated by small households with the same household income and the same preferences of the household members. This fact which is supported by empirical studies implies that the impact of the preferences of large-household members on the decision process regarding the realization of some public project is smaller than that of the members of small households.

This discrimination of large households constitutes not only an ethical or equity problem but is also counterintuitive from a practical view, since in large households more people benefit (at least potentially) from an environmental project than in small households. Therefore, the overall benefits accruing to large households should be greater than for small households.

Accordingly, one would expect their WTP for the project to be greater than the WTP stated by small households. If empirical studies yield the opposite result, as it is in fact the case, something must be wrong with the assessment techniques employed. As a solution to this problem we propose to correct the willingness to pay assessed in valuation surveys for household size by using household equivalence scales. This adjustment of stated WTP and, thereby, of the influence of households of different size on the results of valuation studies serves also the principle of horizontal equity.

Using an empirical study carried out in Eastern Germany we illustrate how equivalence scales can be integrated in practical valuation surveys. In our example this modification leads to an increase of the previously calculated social benefits by up to ten percent. This shows that the problem of observing household size and including the unrestricted preferences also of large families in cost-benefit analyses is not trivial and its magnitude is far from negligible. Integrating equivalence scales into environmental valuation serves not only the objective of horizontal equity but leads also to more plausible results in the sense that after this modification households' willingness to pay does not necessarily decrease as the number of household members increases.

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