Equity in welfare evaluations
Örebro Studies in Economics 10

GUNNEL BÅNGMAN

Equity in welfare evaluations
– The rationale for and effects of distributional weighting
Title: Equity in welfare evaluations – The rationale for and effects of distributional weighting.

Publisher: Universitetsbiblioteket 2006
www.oru.se

Publications editor: Joanna Jansdotter
joanna.jansdotter@ub.oru.se

Editor: Heinz Merten
heinz.merten@ub.oru.se

Printer: DocuSys, V Frölunda 2/2006
ISSN 1651-8896
**Author:** Gunnel Bångman. **Title:** Equity in welfare evaluations – The rationale for and effects of distributional weighting.

**Abstract**
This thesis addresses the issue of weighted cost-benefit analysis (WCBA). WCBA is a welfare evaluation model where income distribution effects are valued by distributional weighting. The method was developed already in the 1970s. The interest in and applications of this method have increased in the past decade, e.g. when evaluating of global environmental problems. There are, however, still unsolved problems regarding the application of this method. One such issue is the choice of the approach to the means of estimating of the distributional weights. The literature on WCBA suggests a couple of approaches, but gives no clues as to which one is the most appropriate one to use, either from a theoretical or from an empirical point of view. Accordingly, the choice of distributional weights may be an arbitrary one. In the first paper in this thesis, the consequences of the choice of distributional weights on project decisions have been studied. Different sets of distributional weights have been compared across a variety of strategically chosen income distribution effects. The distributional weights examined are those that correspond to the WCBA approaches commonly suggested in literature on the topic. The results indicate that the choice of distributional weights is of importance for the rank of projects only when the income distribution effects concern target populations with low incomes. The results also show that not only the mean income but also the span of incomes, of the target population of the income distribution effect, affects the result of the distributional weighting when applying very progressive non-linear distributional weights. This may cause the distributional weighting to indicate an income distribution effect even though the project effect is evenly distributed across the population.

One rational for distributional weighting, commonly referred to when applying WCBA, is that marginal utility of income is decreasing with income. In the second paper, this hypothesis is tested. My study contributes to this literature by employing stated preference data on compensated variation (CV) in a model flexible as to the functional form of the marginal utility. The results indicate that the marginal utility of income decreases linearly with income.

Under certain conditions, a decreasing marginal utility of income corresponds to risk aversion. Thus the hypothesis that marginal utility of income is decreasing with income can be tested by analyses of individuals’ behaviour in gambling situations. The third paper examines of the role of risk aversion, defined by the von Neumann-Morgenstern expected utility function, for people’s concern about the problem of ‘sick’ buildings. The analysis is based on data on the willingness to pay (WTP) for having the indoor air quality (IAQ) at home examined and diagnosed by experts and the WTP for acquiring an IAQ at home that is guaranteed to be good. The results indicate that some of the households are willing to pay for an elimination of the uncertainty of the IAQ at home, even though they are not willing to pay for an elimination of the risks for building related ill health. The probability to pay, for an elimination of the uncertainty of the indoor air quality at home, only because of risk aversion is estimated to 0.3–0.4. Risk aversion seems to be a more common motive, for the decision to pay for a diagnosis of the IAQ at home, among young people.

Another rationale for distributional weighting, commonly referred to, is the existence of unselfish motives for economic behaviour, such as social inequality aversion or altruism. In the fourth paper the hypothesis that people have altruistic preferences, i.e. that they care about other people’s well being, is tested. The WTP for a public project, that ensures good indoor air quality in all buildings, have been measured in three different ways for three randomly drawn sub-samples, capturing different motives for economic behaviour (pure altruism, paternalism and selfishness). The significance of different questions, and different motives, is analysed using an independent samples test of the mean WTPs of the sub-samples, a chi-square test of the association between the WTP and the sample group membership and an econometric analysis of the decision to pay to the public project. No evidence for altruism, either pure altruism or paternalism, is found in this study.

**Key words:** weighted cost-benefit-analysis, equity, distributional weights, social welfare, income distribution, risk aversion, social marginal value of income, altruism, paternalism, marginal utility of income, social inequality aversion, stated preferences
Acknowledgements

The road to this dissertation has been a long and winding one, due to factors such as chance, bad luck, fate or whatever. The journey has only been completed thanks to all the people lining the route or following me on a part of the way, sharing their expert knowledge, giving good advice and being supportive. Because of the large number of people involved and the limited space available here, I cannot mention each and every one of them. So, all of you who are not mentioned here, please do not feel neglected. I do remember all of you and I am truly grateful for your contributions.

However, I wish to mention some of those to whom I owe much thanks: First of all, I want to thank the two persons who have contributed most to this thesis, my supervisors Lars Hultkrantz, at ESI, Örebro University, who led my way during the first part of the journey and through the flying finish, and Thomas Aronsson, at the Department of Economics at Umeå University, who was my path-finder during the period in between. Both of them have given much constructive help and all the time believed in my capacity to work my way to the end of the journey (which was invaluable help during my periods of despair).

Thanks are also due to Sören Wibe, at the Department of Forest Economics, SLU, Umeå, for being an enthusiastic and inspiring manager of the project for evaluation of the Mid-Sweden Line - the very starting point for my interest in weighted CBA and this thesis; Linda Andersson, Bengt Hanes, Jonas Nordström, Thomas Sjögren and Magnus Wikström, at the Department of Economics at Umeå University, and Peter Fredman at ETOUR, Östersund, for good advices and helpful comments on my work in progress; Li Chuan-Zhong, at Uppsala University, Reza Mortazavi and Lena Nerhagen, at Högskolan Dalarna, and Henrik Andersson, at VTI, Solna, and Per-Olov Johansson, at Stockholm School of Economics, for giving helpful comments on the final versions of my papers; Mid Sweden University (MIUN) for the grants that made my doctoral studies possible; my former colleague at MIUN, Sven-Olov Larsson, for reading my papers and digging out articles on welfare economics for me; Anita Lundin, at MIUN, and Marie Hammarstedt, at Umeå University, for administrative services and their personal support; Dag Wassdal, at MIUN, for keeping the computers in top shape; the staff at the MIUN University Library for their excellent service.

Last, but not the least, thanks to my husband Dennis for putting up with me during the periods when I was totally absorbed in welfare economics and weighted cost-benefit analysis, and to my parents (my late father Bror and mother Lisa) for giving me my curiosity and commitment to social issues and hard work.
The shortcomings of this thesis, in spite of all the help I have received, are entirely my own responsibility.

Östersund, January 8, 2006

Gunnar Bångman
Contents

1. Introduction
2. The rationale for and practical use of distributional weights
3. Contingent valuation data as a basis for analyses of the rationale for weighted CBA
4. Summary of the papers

References

Paper 1: The choice of distributional weights and project decisions
Paper 2: Marginal utility of income estimated on stated preference data
Paper 3: Risk aversion and concerns about the problems of sick buildings
Paper 4: Motive for valuing good indoor air quality: Altruism or self-interest?
1 Introduction

In the 19th century Jeremy Bentham described social welfare as “the greatest good for the greatest number” (Brent 1984b). This objective was later formulated as a social welfare function (SWF for short) where welfare was determined by the sum (arithmetic or weighted) of all individual utilities (Sen 1986, Johansson-Stenman 1998 or Mas-Colell et al. 1995). The problem of the measurement and interpersonal comparison of utilities was not recognised, as utilities were assumed to be cardinal. In the 1930’s, however, the “ordinalist revolution” pointed out the ordinal nature of utilities and the difficulty to make accurate interpersonal comparisons of utilities (Mishan 1981). The New Welfare Economics (NWE) was born and with it the realisation that utilitarian social welfare functions could not be used in practice as an instrument for welfare evaluations (Just et al. 2004). The only non-controversial principle for resource allocation available was the Pareto-principle; a criterion concerned with the attainment of economic efficiency but which leaves the world helpless with regard to the problem of income distribution. Arrow tried to circumvent the problem by searching for a way to form a social welfare functional that could rank different social states (different sets of resources, distributed in different ways) in a way that was Paretian and compatible with the preferences of all individuals. Unfortunately, Arrow’s search for a solution ended in an impasse in the shape of Arrow’s Theorem of Impossibility (Sen 1995). Because of this, welfare evaluations have been conducted using the traditional social cost-benefit analysis (CBA for short), based on the Hicks/Kaldors principle of compensation (i.e. potential Pareto improvements).

In the 1970s, however, a reaction started against the NWE and its avoidance of matters of income distribution. The “New, New Welfare Economy” (NNWE) gradually developed (Johansson-Stenman 1998). The advocates of this school, while recognising the ordinal nature of utilities and the problem of making accurate interpersonal comparisons of utilities, claim that if policy recommendations are to be made, conflicts in interests between individuals had to be solved. Therefore, aggregations of individual utilities have to be made in one way or another, no matter how difficult (Johansson-Stenman 1998). If welfare economics do not provide decision-makers with analytical methods for the evaluation of income distribution effects, then informal and casual methods will be used (Williams 1993). The NNWE acknowledges that social welfare evaluations, which embrace equity, still have to rely on
à priori assumptions and/or value judgements regarding individual and social utilities (such as risk aversion or social inequality aversion). The point made is, however, that making an analysis based on explicitly declared assumptions and value judgements is better than making no analysis at all. As long as assumptions and value judgements are explicitly declared, decision-makers and others have the opportunity to make their own judgements about the significance and reliability of the welfare evaluation. Besides, welfare evaluations à la Hicks-Kaldor are not completely objective and free from value judgements either. As the Hicks-Kaldor criterion only demands compensation to be possible, not carried out, the practical procedure of the CBA consists of an aggregation of gains and losses of different individuals, measured by the willingness to pay of the individuals concerned. Thus, an interpersonal comparison of changes in utility is actually made, although implicitly. As the willingness to pay for a good is dependent on preferences as well as on the ability to pay (i.e. income), efficiency shadow prices in the traditional CBA are dependent on income distribution. Thus, by not explicitly treating income distribution aspects in a social CBA one makes the implicit judgement that the initial income distribution is the fair one (Battiato 1993). In addition, because of the Scitovsky reversal paradox, welfare evaluations using traditional CBA may not even be consistent (Just et al. 2004). If income distribution is changed, due to the project evaluated, this may affect the monetary value of the effects of the project with the result that the project produces a net gain when evaluated ex ante and a net loss when evaluated ex post, or vice versa. Thus the problem of income distribution, and its effect on social welfare, simply cannot be avoided.

In the 1970s, the need for a model for welfare evaluations embracing both efficiency and equity objectives led the World Bank (Little and Mirrlees 1974) and the UN (UNIDO 1972) to develop weighted cost-benefit analysis (WCBA for short). WCBA is a welfare evaluation model where effects on income distribution (or other aspects of equity) are taken into account, by the weighting of the effects of a project through distributional weights. The application of WCBA did not spread outside the World Bank and its use in project appraisal in developing countries during the 1970s and 1980s. In the 1990s, however, the NNWE seems to have been adopted by environmental economists. Several welfare evaluations of global environmental problems, such as global warming and the greenhouse effect, have been made using WCBA (e.g. Nordhaus 1993, Azar and Sterner 1996, Fankhauser et al. 1997 and Tol 1999). The problem of an uneven global distribution of incomes and consumption cannot be ignored.
when seeking international political solutions to global environmental problems. Therefore it has to be taken into account also in economic evaluations.

One reason that WCBA has not been commonly accepted as a method of social evaluation may be a resistance from NW economists to the treatment of utilities as if they were cardinal. Another reason may be the idea that distributional matters should be dealt with by taxation, not by the design and implementation of public projects. Hylland and Zeckhauser (1979) have shown that if it is possible to find an optimal tax scheme in an economy without public projects then, under certain conditions, an optimal tax scheme can also be found in the presence of public projects with income-related benefits. An optimal social welfare level can be achieved by applying traditional CBA when designing and choosing public projects, combined with an adjustment of income distribution effects by taxes (the effects are “taxed away”). One of the requisites, for this optimal solution to be feasible, is that individuals have identical utility functions where the labour supply is weakly separable from the demand for goods (Christiansen, 1981). Another condition is that project benefits do not differ among members within an income group (Hylland and Zeckhouser 1979). On the other hand Johansson – Stenmann (2005) has shown that if public goods are weakly separable from the demand for private goods, instead of labour supply, then distributional weighting is needed, regardless of whether taxation is optimal or not. Besides, in real life the problem of finding an optimal tax scheme is not an easy one. Furthermore, dealing with the income distribution effects of public projects through optimal taxation requires tax schemes and public projects to be determined simultaneously (Hylland and Zeckhauser 1979). All-in-all, the application of WCBA seems to be justified, at least in some contexts, even though income is redistributed through taxation.

2 The rationale for and practical use of distributional weights

In distributional weighting, the weights are related to the initial income of individuals affected by the project and are supposed to mirror the social marginal value of the income distribution effects of the project. The distributional weights may be determined in different ways depending on which objectives society has and the nature of the SWF. As we still have no definite knowledge about the nature of individual preferences and utilities, the distributional
weights cannot be determined with any certainty. We have to rely on different kinds of indirect methods to derive and empirically estimate the values of the distributional weights. One approach is to make an à priori assumption about the nature of the SWF (the SWF approach, Nordhaus 1993, Tol 1999) or the marginal utility of income (the MUI approach, Brent 1984a or 1996). One can assume political preferences for equity to be compatible with those of the SWF (the decision-maker approach, DM, Weisbrod 1968, Tresch 1981, Pearce and Nash 1981) or assume the opportunity-cost-of-taxes to reflect the social marginal value of income (the OCT approach, Harberger 1978, Ray 1984, Brent 1990 or 1996). Yet another approach is to give the preferences of individuals equal weight by adjusting prices and/or consumer surpluses with respect to variations in individual incomes (the One-Person-One-Vote (OPOV) approach, Pearce and Nash 1981 or Boardman et al. 2001)¹.

The technical formulation of the distributional weights used in the SWF/MUI and the OPOV approaches is that of a continuous weighting function having a constant elasticity in relation to income and calibrated so as to be equal to one for average income (Pearce and Nash 1981, Brent 1996, Ray 1984):

\[ w_i = \frac{y_i^{-\theta}}{y_a^{-\theta}} = \left( \frac{y_a}{y_i} \right)^\theta \]  

(1)

\[ w_i = \] distributional weight for individual \( i \)

\[ y_i = \] actual income of individual \( i \)

\[ y_a = \] average income

\[ \theta = \] elasticity of the weights (representing constant relative risk aversion, inequality aversion or income elasticity of willingness-to-pay)

The distributional weights in the DM approach may be continuous weighting functions or a couple of discrete weights. No particular technical formulation is advocated. The weights corresponding to the OCT approach form a discontinuous set of numbers.

¹ Somanathan (2003) has suggested distributional weights that are proportional to the reciprocals of the value of statistical lives. As this approach is only recently proposed and yet not mentioned in text-books on CBA it is not included in my study.
The objective of distributional weighting is to increase the net efficiency value of a project making income distribution more even. All WCBA approaches are constructed so as to increase the income distribution effects that affect persons with low incomes, and vice versa. The sets of weights may however differ substantially in amplitudes. If all approaches resulted in the same numerical sets of weights, then it would be of no practical importance that the most accurate one (from a theoretical point of view) still cannot be appointed. As the sets of weights differ in size and structure, we can expect the approaches to lead to different results of the WCBA. Accordingly, the choice of approach when estimating the weights may be of importance when making project decisions.

The WCBA model has not been used very much in practice, and even less subject to analysis regarding the consequences of the choice of approach for the derivation of distributional weights. In some applications of WCBA in environmental economics, sensitivity analyses have been made regarding changes in the net value of a project due to changes in numerical values of the distributional weights (Macarthur 1978, Hau 1986, Azar and Sterner 1996, Fankhauser et al. 1997 and Tol 1999). No other analysis of the way WCBA works in practice, and the consequences of the choice of approach for the derivation of weights, has been found.

The use of distributional weights is often justified by the assumption of a Bergsonian SWF (Ray 1984, Tresco 1981 or Mas-Colell et al. 1995):

\[ W = W(V_1(y_1), V_2(y_2), \ldots \ldots , V_i(y_i), \ldots \ldots , V_n(y_n)) \quad i = 1 \ldots n \]  

\[ W = \text{social welfare} \]

\[ V_i = \text{the indirect utility function of individual } i \]

\[ y_i = \text{disposal income (or the value of consumption) of individual } i \]

The welfare function is assumed to be concave in indirect utilities, implying aversion to social inequality, and/or the indirect utilities to be concave in income, implying aversion to risk, i.e.:

\[ \frac{\partial^2 W}{\partial V_i^2} \leq 0 \quad \text{and} \quad \frac{\partial^2 V_i}{\partial y_i^2} \leq 0 \quad \forall \ i \]  

\[ 3 \]
A Bergsonian SWF concave in utilities describes a society where redistribution of incomes is motivated because of a social equity objective. If, on the other hand, the SWF is a Benthamite one and the indirect utility functions are concave in income, then redistribution of income is motivated for reasons of efficiency (the sum of all individual utilities is maximised only when the income distribution is even).

If the nature of marginal utilities of income or social inequality aversion were clearly demonstrated and proved, then the MUI or SWF approach would, certainly, be an accurate one. Marginal utility of income has been estimated in a number of studies. Most studies have relied on the hypothesis of people having aversion to risk and utility functions being defined as CRRA\(^2\) functions. These studies have estimated the constant elasticity of marginal utility of income, in relation to income. Various methods have been used to estimate the presumed iso-elasticity of the marginal utility, resulting in estimates from plus infinity to minus infinity with a concentration in the interval 0-3 (Stern 1977, Auerbach and Kotlikoff 1987, Dasgupta 1998). Jara-Diaz and Videla (1989) and Johansson and Mortazavi (1999) have analysed the marginal utility of income without testing any specific functional form. The former study did detect signs of a decreasing marginal utility of income, while the latter did not. Blue and Tweeten (1997) have found empirical support for quadratic utility functions, and thus linear marginal utility functions, although the statistical test values indicated weak support. As the results are still ambiguous, the subject cannot be regarded as fully and finally explored.

The existence of social inequality aversion is a matter that has not been explored to any extent empirically. The reason is, I assume, the difficulty of finding methods for the measurement and analysis of such preferences. Now, developments in experimental techniques have facilitated studies of the motives for people’s preferences. By the use of simple experimental games the assumed existence of altruism and envy, social inequality aversion or intention-based reciprocity has been investigated (Fehr and Schmidt 2001). Studies of social inequality aversion, for example, have been made by the analyses of choices, behind a veil of ignorance, among different hypothetical future societies (Johansson-Stenman et al. 2002, Carlsson et al. 2003, 2005). In some of these studies (Johansson-Stenman et al. 2002 and Carlsson et al. 2003) individual relative risk aversion is interpreted as a measurement of social inequality aversion. The results achieved in these studies indicate that a majority of individuals have

\(^2\) CRRA = Constant Relative Risk Aversion
inequality aversion. In ‘Dictator Games’ and ‘Public Goods Games’ individual behaviour has been observed (propensity to give and voluntary contributions) which is compatible with altruism, but not with selfishness (Fehr and Schmidt 2001). Another result from experimental studies is that people appear to be heterogeneous with regard to their motives for economic behaviour. Some people seem to be altruistic while some seem to be selfish or have other motives, and some people may behave in an apparently altruistic fashion in some situations but not in others (Fehr and Schmidt 2001). In addition, the economic context may be of importance for selfless behaviour (Andreoni 1994). Thus, many interesting studies have been made, within this field in recent years, but still the results are highly varied and somewhat inconclusive and the field of research largely unexplored.

3 Contingent valuation data as a basis for analyses of the rationale for weighted CBA

Stated preference data in the shape of contingent valuation data are useful for at least two reasons. First of all, willingness to pay (WTP) data, collected by the contingent valuation method (CVM), represent Hicksian monetary measures of utility (equivalent variation or compensating variation, see e.g. Johansson (1993)). These measures are more accurate measurements of welfare than consumer surplus derived from market data and Marshallian demand curves (Slesnick 1998, Just et al. 2004). Hicksian welfare measures can be indirectly inferred from revealed preference data. This is done by the derivation of implicit indirect utility functions from expenditure functions or demand functions (backward integration from demand to utility) (Slesnick 1998, Mc Fadden and Leonard 1993). Measuring utility indirectly from demand or expenditure systems can, however, be technically complicated unless the demand or expenditure systems are linear. Contingent valuation, on the other hand, is a direct, straightforward and fairly uncomplicated method that can be used to register Hicksian utility measures. Because of these qualities, contingent valuation data is of interest for the analysis of the marginal utility of income, although there are several other methods available based on revealed preference data (for example the methods based on expenditure or demand systems). Secondly, WTP data are the only utility measures available when

3 There are other kinds of stated preference data as well, e.g. data from conjoint analyses (McFadden and Leonard 1993) or experimental games.
evaluating the welfare effects of non-market goods. Thus, this kind of data is necessary for the evaluation of environmental amenities and public projects etc. The rapid growth of empirical studies of issues related to social choice, social preferences and underlying motives for individual economic behaviour in the past decade is not only a result of the development of the NNWE but also a result of the development and refinement of methods to collect and analyse WTP data.

There are, however, also drawbacks to the use of stated preference data. The fact that WTP data from contingent valuation give exact welfare values in theory does not necessarily mean they are exact and reliable in practice. There are several sources of distortion of the WTP values connected to the practical procedure of collecting such data. The fact that payments are made only in words, not in effect, i.e. hypothetical bias, may lead to overestimations of WTPs (Blumenschein et al. 1998, 2001 and 2005, Botelho and Pinto 2002, Johannesson et al. 1998). The means by which the hypothetical payments are made may also affect the stated WTPs (vehicle bias). Some people may, for example, have preferences against paying taxes and may report stated WTPs for public goods where the negative utility effect of having to pay taxes is included. Strategic behaviour is yet another source of bias in WTP data. The best-known form of strategic behaviour is free-riding, where individuals, in order to gain at the expense of others if the hypothetical situation in the contingent valuation were to come true, make statements that do not truly reflect their preferences. Such behaviour may lead to either underestimation or overestimation, depending on individuals’ expectations about the way the project under evaluation will be implemented. The choice between open-ended and dichotomous WTP questions may also affect the quality of the WTP data. Open-ended questions are, for example, more open to strategic behaviour such as free-riding. Dichotomous WTP questions, on the other hand, may cause problems with anchoring i.e. the WTP bids offered might implicitly affect the statements of the respondents (Green et al. 1998).

Knowledge about causes of bias in WTP data and methods to deal with or circumvent such problems are under continuous development. As our knowledge today is imperfect, the analyst should be aware of the shortcomings of stated preference data and cautious when analysing and interpreting the results.
4 Summary of the papers

Paper (1) The choice of distributional weights and project decisions

The purpose of this study is to analyse the consequences for project decisions of the choice of distributional weights. Because useful data on actual projects is not available, the study is based on a simulation of projects, strategically chosen to embrace a large span of likely empirical situations. The kinds of projects analysed are typical public projects providing a certain target population with a good or service, generating a consumer surplus and an income distribution effect. The distributional weights compared are the ones commonly suggested in literature on WCBA, i.e. constant elasticity weighting functions corresponding to the Marginal-Utility-of-Income (MUI), the Social-Welfare-Function (SWF) and the One-Person-One-Vote (OPOV) approaches, discrete weights derived from the Opportunity-Cost-of-Taxes (OCT) approach and discrete weights corresponding to the Decision-Maker (DM) approach.

According to the results, the choice of distributional weights is likely to be of importance when project decisions are unconstrained, particularly when the target populations of the projects have low incomes. On the other hand, when project decisions are constrained, the choice of distributional weights seems to be of little consequence. At very high average incomes of the target groups, the different sets of distributional weights produce identical rankings of the projects, and the choice of weights will have no effect on the project decision. At low or medium average incomes, the different sets of weights do not produce identical rankings. Yet, the rankings are contradictory only in rare cases, making it quite possible that, also in this case, the choice of weights has no effect on project decisions. The main finding is that very progressive weights (e.g. iso-elastic weights based on large elasticity values) have the potential to produce a more complete ranking of projects, as to their income distribution effects. Less progressive weights, such as the OCT weights, grade income effects very crudely and therefore have little effect on the rank of projects.

4 Here, unconstrained project decisions refers to situations with no financial or other constrains limiting the number of projects to be carried out, and only the sign of the net social value of the projects matters for the decisions.

5 When project decisions are constrained, for financial or other reasons, and the number of projects to be carried out is limited, then the rank of projects is of importance.
An indirect effect of using very progressive non-linear weights is that the span of initial incomes, of the target population of the project, does affect the total effect of the distributional weighting. This indirect effect works as a numbers effect, if the increase in the span of incomes is due to an enlargement of the target population. This effect is significant only when the target populations have low incomes. One consequence of this effect is the possibility that the distributional weighting erroneously indicates the value of an income distribution effect even though a project is neutral as to income distribution (the project benefit or cost is evenly distributed over the national population).

**Paper (2) Marginal utility of income estimated on stated preference data**

In this study, I have made an estimation of the marginal utility of income, based on stated preference data that represents the Contingent Valuation (CV) of improved travel comfort. The hypothesis tested is that marginal utility of income decreases with income. The estimated model differs from other estimations of marginal utility of income in that it is based on stated preference data, instead of revealed preference data. The model does not follow the common practice of assuming marginal utility to have constant elasticity with respect to income, but allows it to take any functional form. Basically, it follows the non-linear Random Utility Model (RUM) of Hultkrantz and Mortazavi (1999), analysing the value of travel-time changes. The model is estimated by the application of the binary Logit to discrete choice data on the willingness to pay for an increase in travel comfort. The results indicate that the marginal utility of income decreases linearly with income. The results also indicate that the probability that an individual will pay for travel comfort is negatively related to his/her age. The effect of age on the willingness to pay for travel comfort may be related either to the preferences for travel comfort or to the marginal utility of income.
The objective of this study is to analyse if risk aversion is of significance for the concern people show for problems of ‘sick’ buildings. The analysis is based on an estimation of the WTP for having the indoor air quality (IAQ) at home examined by experts and diagnosed, which is a measurement of the value of an elimination of uncertainty about the indoor air quality (IAQ) at home. The WTP for acquiring good IAQ is also estimated. It is used to derive the value of an elimination of risks of building-related ill health and to be able to make a distinction between the concerns about the problems of ‘sick’ buildings arising from risk aversion and the concerns because of preferences for good indoor environment and good health. The model is based on the assumption that individuals have von Neumann-Morgenstern expected utility functions. The prediction of the model is that a person who has a positive WTP for a diagnosis of the IAQ at home, even though he/she have no preferences for good IAQ at home, have risk aversion. The model is tested by a non-parametric test and an econometric estimation is made, of the probability to pay for a diagnosis of the IAQ at home because of risk aversion.

The results indicate that a considerable portion of the population may have risk aversion. About 80% have a positive WTP for an elimination of the uncertainty of the IAQ at home, even though only about 45% have a demand for good IAQ at home. The non-parametric test confirms that the decisions, to pay for a diagnosis of the IAQ at home even though not demanding good IAQ at home, are not random. Thus, the hypothesis that the motive is risk aversion has not failed. The estimated probability to pay to have the IAQ at home diagnosed, because of risk aversion, is about 0.3 – 0.4 at sample means. The probability to pay because of risk aversion is, according to the estimation, significantly associated to age; it is larger for young people.
Paper (4) Motive for valuing good indoor air quality: Altruism or self-interest?

This study aims at discovering the motives behind individuals’ preferences for good indoor air quality (IAQ). The economic behaviour of individuals can be motivated by self-interest, pure altruism or paternalism. This hypothesis is tested using a model established by Jones-Lee (1991, 1992), for the analysis of the value of a statistical life, and further developed by Johansson (1994, 1995). The model consists of three differently formulated WTP questions, capturing different kinds of preferences (egoistic or altruistic preferences). The model is applied in a CVM survey on the WTP for a public project ensuring good IAQ in all buildings. In the survey the three different WTP questions have been posed to different sample groups. The survey also includes a WTP question on the value of the private good of acquiring good IAQ at home. The latter value is used as a measure of the demand for consumption of good IAQ and a point of reference when analysing the WTP for the public project. The significance of posing different WTP questions to different sample groups, in order to capture altruistic preferences, has been tested using two kinds of methods. One method is samples tests (t-tests and chi-square tests). The other is an econometric estimation of a binary choice model of the decision to pay for the public good of acquiring good IAQ in all buildings.

The results give no evidence for the existence of altruistic preferences. Posing the WTP questions in different ways in order to capture altruistic preferences did not give a significant effect, either in the samples tests or in the econometric estimations. An unexpected result is that the mean level of the WTP for the private good of acquiring good IAQ at home is much larger than the mean WTP for a public project ensuring good IAQ in all buildings (about eight times larger). This may be because of strategic behaviour when stating the WTPs. Vehicle bias (a dislike of paying taxes), or a dislike of or distrust in public projects are factors that may make people more willing to pay for private solutions than for public ones. Another explanation could be free riding. Such behaviour is compatible with selfishness but not altruism.
References


THE CHOICE OF DISTRIBUTIONAL WEIGHTS AND PROJECT DECISIONS

Gunnel Bångman

E-mail: gunnel.bangman@home.se
Tel: 063 – 10 74 16, 070 – 343 75 74

Abstract

This study analyses the implications of the choice of distributional weights for project decisions. The study is based on a simulation of projects that are identical in efficiency costs and benefits but which differ in income distribution effects. The distributional weights compared are iso-elastic weighting functions, implicit governmental preferences for equity and weights determined by the opportunity-cost-of-taxes. According to the results, more progressive weights produce more elaborated and complete rankings of projects. However, the rankings of projects are contradictory only in rare cases when projects affect target populations with low incomes. The choice of distributional weights seems to be of little importance when evaluating projects affecting target populations with medium or high initial incomes. The results also disclose the occurrence of an indirect numbers effect when applying iso-elastic weights based on a large value of elasticity.
1 Introduction

Weighted cost-benefit analysis (WCBA) is a method for welfare evaluation where the social objective of equity is taken into account by means of distributional weights reflecting the social marginal value of income or consumption. WCBA was developed by the UN and the World Bank for project appraisal in developing countries (UNIDO 1972, Little and Mirrlees 1974, Brent 1990, 1998). In recent years the method has been used in evaluations of global environmental problems, such as global warming and the greenhouse effect (see for example Nordhaus 1993, Azar and Sterner 1996, Fankhauser et al. 1997, Tol 1999). The method could be of interest as an instrument for the evaluation of public projects and project decisions also in other contexts. In the European Union, for example, the main political objectives are both economic efficiency and equity, formulated in terms of full employment, economic dynamism and greater social cohesion and fairness (CEC 2000). Another example of a possible field of application is investment in infrastructure in Sweden where equity, in terms of regional balance of the economy, has to be considered when making project decisions.

In the theoretical framework, distributional weights are derived from a social welfare function. In practice there are several methods suggested for indirect and/or approximate empirical estimations of distributional weights. The commonly suggested methods are:

i) The SWF/MUI approach, where weights reflect social inequality aversion or marginal utility of income, or both (Brent 1984a, 1996, 1998, Perkins 1994, Ray 1984),

ii) The decision-maker (DM) approach, based on weights derived by stated or revealed governmental preferences for equity (Weisbrod 1968, Tresch 1981, Pearce and Nash 1981),

iii) The OCT approach, where weights are derived from the opportunity-cost of taxation (Musgrave 1969, Harberger 1978, Ray 1984, Brent 1990, 1998),

iv) The One-Person-One-Vote (OPOV) approach, where weights are determined by income elasticities of demand (Pearce and Nash 1981, Boardman et al. 2001).

1 The normative problem of whether taxation or the design and choice of public projects is the most efficient way of dealing with income distributional effects is disregarded here. The point of departure for this study is the current real life situation, in which public projects may be used for attaining efficiency as well as equity.
No guidance is given by the literature as to which WCBA approach to choose. The approaches differ in an economic sense, but so far, none of them has been proclaimed as the best from a theoretical point of view. However, the choice of the WCBA approach is important only if the suggested approaches produce different outcomes and imply different project decisions.

The purpose of this study is to analyse the consequences for project decisions of the choice of distributional weights among the four approaches mentioned above. The study is based on a comparison of applications of different kinds of distributional weights on simulated projects that differ in income distribution effects. The effect of distributional weighting is determined by three components: the distributional weights, the project effects (costs and benefits) and the distributional profile of these effects. In order to make the analysis short and comprehensible the study is limited to the analysis of variations in two of the determinants, distributional weights and the distributional consequences of the project. Holding project costs and benefits constant does not restrict, in any major sense, the universality of the analysis. On the contrary, it helps to isolate and reveal the effects of distributional weighting and may reveal interesting matters not easily guessed at when simply looking at the sets of weights. The income distribution effects are chosen so as to include a broad variety of different distributional aspects. Thereby, the analysis will cover the most common project situations and allow for some general conclusions.

I have found only one application where the choice of the WCBA approach is discussed (Macarthur 1978). Analyses of the implications of the choice of distributional weights are very few. They are also limited in scope, in that they consist only of sensitivity analyses of the SWF/MUI approach and regard the evaluation of only a single project (see e.g. Macarthur 1978, Hau 1986, Azar and Sterner 1996, Fankhauser et al. 1997, Tol 1999). Therefore, this study is a step towards a more elaborate picture of the consequences of the choice of distributional weights.

The outline of the paper is as follows: Section 2 contains a short presentation of the four WCBA approaches suggested in the literature and the corresponding distributional weights, the procedure of distributional weighting and the expected effects of the choice of

---

2 Somanathan (2003) have suggested distributional weights that are proportional to the reciprocals of the value
distributional weights. The distributional weights and income distribution effects forming the basis of my analysis are presented in section 3 and the results in section 4. The study is concluded in section 5.

2 Distributional weights, weighting and the effects on project decisions

This section starts with a presentation of the four different approaches for deriving distributional weights. Then follows the procedure for distributional weighting. The section ends with the expected effects of the choice of distributional weights on project decisions.

2.1 Approaches to the empirical estimation of distributional weights

WCBA is commonly based on a Bergsonian (or Bergson-Samuelson) social welfare function (SWF) (Ray 1984 or Tresch 1981) having two objectives, efficiency and equity:

\[ W = W(V_1(y_1), V_2(y_2), \ldots, V_i(y_i), \ldots, V_n(y_n)) \]

where

- \( W \) = social welfare
- \( V_i \) = the indirect utility function of individual \( i \)
- \( y_i \) = disposal income, or the money metric value of consumption, of individual \( i \)

In rare cases, other formulations of the SWF are used. One such case is the three-objective SWF, suggested and empirically tested by Brent (1984b). In this SWF the number of individuals, whose income/consumption is changing, is of importance, in addition to the traditional social objectives of efficiency and equity. The rationale for the numbers objective is, according to Brent (1984b), Jeremy Bentham’s definition of welfare as “the greatest good for the greatest number”.

---

of statistical lives. This approach is only recently proposed and yet not applied, and therefore not included here. 3 In WCBA contexts the SWF function is usually simplified in the sense that prices are not explicitly included as arguments in the individual indirect utility functions, and that income equals total consumption.
In the commonly used two-objective Bergsonian SWF, the net social benefit from changes in incomes is (Ray 1984, Tresch 1981):

\[
\text{Net social benefit} = dW = \sum_{i=1}^{n} \frac{\partial W}{\partial y_i} dy_i = \sum_{i=1}^{n} \frac{\partial W}{\partial V_i} \frac{\partial V_i}{\partial y_i} dy_i = \sum_{i=1}^{n} w_i dy_i \tag{2}
\]

\[w_i = \text{distributional weight of individual } i\]

In the **SWF approach** distributional weighting is motivated by social inequality aversion. The weights are defined by \(\frac{\partial W}{\partial V_i}\), in equation (2), which is assumed to be decreasing with increases in utility, and indirectly also with increases in income. The **MUI approach**, on the other hand, is motivated by risk aversion, i.e. defined by \(\frac{\partial V_i}{\partial y_i}\) in equation (2). In the MUI approach, the SWF is assumed to be a purely utilitarian one based on marginal utilities of income that are decreasing with income, making an even income distribution optimal for the reason of efficiency\(^4\). In the WCBA context marginal utilities of income and/or social marginal values of utility are commonly assumed to have constant elasticities, regarding income and utility respectively\(^5\), i.e.:

\[
\frac{\partial V_i}{\partial y_i} = y_i^{-\sigma} \quad \text{and/or} \quad \frac{\partial W}{\partial V_i} = [V_i(y_i)]^{-\rho} \quad \text{where } \sigma \geq 0 \text{ and/or } \rho \geq 0 \tag{3}
\]

\(\sigma, \rho = \text{elasticities, regarding income and utility respectively}\)

When applying distributional weighting, the scale of the weights is usually calibrated so as to give the value 1 at average income. The distributional weights of the SWF/MUI approach then becomes (Brent 1990, 1998, Pearce and Nash 1981, Ray 1984):

---

\(^4\) Decreasing marginal utility of income is not a sufficient condition for an even income distribution to be efficient. It is however a necessary condition. The sufficient condition is that individuals should have identical (at least approximately) concave marginal utility functions. If individuals’ utility functions are concave but not identical then some kind of redistribution of incomes might be motivated, but not necessarily one giving people more equal incomes (Layard and Walters 1994).

\(^5\) The marginal utility function is derived from the CRRA utility function. See e.g. Blanchard and Fischer (1989).
\( w_i = \left( \frac{y_i}{y_a} \right)^\theta \)  

\( \theta = \) the elasticity of the distributional weights = \( \sigma \) or \( \rho \) or a combination of both  
\( y_i = \) income of individual \( i \)  
\( y_a = \) average income of the national population

A problem with the SWF/MUI approach has been to empirically verify the marginal utility or social marginal value functions in equations (3). Estimations of the marginal utility of income have produced various results. In the 1970s elasticity values for the marginal utility of income ranging from 0 to 10 (absolute value) or even from minus infinity to plus infinity (different intervals corresponding to different methods of estimation) where reported (Stern 1977). Later, the estimated elasticity values were narrowed down to 0-3 (Auerbach and Kotlicoff 1987). One way of estimating the marginal utility of income is to study risk behaviour. Under certain assumptions, a marginal utility of income that is decreasing with income corresponds to risk aversion. Dasgupta (1998) claims (without referring to any particular sources) that estimations of risk aversion usually give an elasticity value slightly larger than 2. This is confirmed by the studies of Johansson-Stenman et al (2002) and Carlsson et al (2003, 2005), reporting medium relative risk aversions parameters in the interval 2-3. On the other hand, Dalal and Arshanapalli (1993) and Belzil and Hansen (2002) have reported much lower estimates of relative risk aversion, about 1.3 and 0.9 respectively. The World Bank has recommended the use of elasticity values within the range 0-2, preferably the value 1 (Brent 1990 or 1998). This recommendation has been followed by e.g. Macarthur (1978), Tyler (1979), Loury (1983) and Fankhauser et al. (1997).

The social marginal value of utility has so far been based on à priori estimations of social inequality aversion (e.g. Nordhaus 1983 and Tol 1999), by using, for example, benchmark models such as the Rawlsian, the Benthamite (purely utilitarian) and the Bernouilli-Nash SWF (Hau 1986, Fankhauser et al. 1997). As to empirical studies of social preferences, relative risk aversion has sometimes been interpreted as social inequality aversion (e.g. Johansson-Stenman et al. 2002 and Carlsson et al. 2003). However, Carlsson et al (2005) have made an estimation of the social inequality aversion separated from risk behaviour. They
found that the majority of individuals are willing to pay for a more equal income distribution, although the size of the payment varies.

An alternative approach is the One-Person-One-Vote approach (OPOV). The weights of OPOV appear the same as the SWF/MUI weights, but have an essentially different import. Technically they differ from the SWF/MUI weights in that the elasticity ($\theta$) reflects the income elasticity of demand for the good generating the project benefit (Pearce and Nash 1981). The weights are supposed to convert costs and benefits to values reflecting the costs and benefits that would be the case if individuals had average incomes instead of the actual ones (Pearce and Nash 1981). Because of budget constraints, the preferences of rich consumers generally have more influence on demand and prices than the preferences of the poor. The objective of the OPOV approach is to give equal weight to the preferences of all individuals (Boardman et al. 2001). In this respect, the OPOV approach differs from the other WCBA approaches. It does not make an assessment of the distributional effects of projects. Instead, eliminates some of the consequences of an uneven income distribution, by giving individuals more equal opportunities to influence project decisions by their “economic voting”.

A third method of deriving distribution weights is the decision-maker approach (DM), where the weights are determined by the stated or revealed preferences of the government (according to Brent (1984a, 1996) also denoted "the imputational school" or "the revealed preference approach"). One method of disclosing preferences of decision-makers is the Weisbrod approach (Weisbrod 1968, Tresch 1981) where implicit distributional weights are derived from past political decisions. When applying the Weisbrod method it is possible to estimate weights that discriminate not only between differences in income levels but in age, gender, race etc. Another method is the Eckstein approach (Pearce and Nash 1981) where income taxation is assumed to reflect social inequality aversion and provide us with implicit distributional weights. However, there are reasons to doubt that political decisions fully mirror the social value of distributional effects (Tresch 1981). Even if politicians do know the preferences of individuals, there may be political constraints (powerful social groups to consider, political or other traditions etc.) affecting political objectives and decisions (Myles 1995). On the other hand, if the ambition is to catch underlying basic ethical preferences in society, instead of making an exact aggregation of individual preferences, this approach may
work well. At least, the decision-maker approach works well as an instrument for attaining political targets in a systematic and consistent manner (Sugden and Williams 1978).

A fourth method is the **Opportunity-Cost-of-Taxes approach (OCT)** (also named the **administrative cost argument**), originally proposed by Musgrave (1969) and strongly recommended by Harberger (1978). According to this approach, the possibility of the redistribution of income by taxes and transfers makes the excess burden of taxation a relevant basis for the evaluation of income distribution effects. Harberger (1978) suggested a 10% - 20% premium to be added to favourable income distribution effects, representing the opportunity cost of redistribution by taxation. Ray (1984) has reformulated and formalized the opportunity-cost-of-taxes argument by stating that the distributional weights have to comply with the following condition\(^6\):

\[
\frac{w_p}{w_r} = \frac{T + (1 - \psi)S}{T - \psi S} = \frac{1 + (1 - \psi)S}{1 - \psi S} > 1 \quad 0 \leq \psi \leq 1
\]  

\[ (5) \]

\( w = \) distributional weight  
\( p = \) subscript denoting poor  
\( r = \) subscript denoting rich  
\( T = \) the transfer from the rich to the poor  
\( S = \) the excess burden of the transfer  
\( s = \) the excess burden per unit of the transfer  
\( \psi = \) the proportion of the excess burden borne by the poor

The OCT approach seems to rely on the same basic assumptions as the SWF/MUI approach\(^7\), except for the assumption that incomes are or may be redistributed by taxation. One condition for income distribution effects of projects (redistribution-in-kind) to be socially efficient is that the benefit of the redistribution of incomes is higher than the cost of attaining it. Another condition is that the cost of attaining the income distribution effect by redistribution-in-kind is lower than the cost of attaining the same effect by using taxation, i.e. the excess burden of

\(^6\) If the excess burden is borne only by the rich then \( \psi = 0 \) and \( v_p/v_r = (T+S)/T \). If it is borne only by the poor then \( \psi = 1 \) and \( v_p/v_r = T/(T-S) > 1 \). \( T/(T-S) > (T+S)/T \) (Ray 1984).

\(^7\) Either marginal utility of income decreases with income or the social marginal value of utility decreases with utility, or both.
taxation (Zerbe Jr and Dively 1994). Because of this, the opportunity-cost-of-taxes works as an upper limit for the maximum value of the ratio of the distributional weights when income is redistributed from the richest to the poorest.

A problem with the OCT approach is that the ratio in equation (5) only tells us the relation between the weights assigned to the richest and the poorest. It does not tell us what the limits are for being considered rich or poor, or which weights to apply to people having incomes in between these limits. Equation (5) only puts a constraint on the extreme values of the weights, it does not define the entire set of weights.

2.2 Distributional characteristics – the effects of distributional weighting

The total effect of distributional weighting on the net social value of a project can be illustrated and analysed using the distributional characteristic of the project (Feldstein 1972, Boadway 1976 or Hau 1986). The distributional characteristic ($d^c$) is the weighted average of distributional weights applied at different levels of initial incomes, where the weighting is determined by the distribution of the project effect across the population ($\beta_1, \ldots, \beta_n$).

The weighted value of a certain project benefit is:

$$B = \left[1 + \sum_{i=1}^{n} (y_i - \bar{y}) (\Delta y_i - \Delta y_a) / w_a (\Delta y_a) \right] B$$

$$= \left[1 + \sum_{i=1}^{n} (y_i - \bar{y}) (\Delta y_i - \Delta y_a) / w_a (\Delta y_a) \right] B$$

$$= \left[1 + \sum_{i=1}^{n} (\Delta y_i - \Delta y_a) / \bar{y} \right] B$$

where $\delta$ is Sandmo’s indirect measure of the distributional characteristic, $w_a$ is the distributional weight corresponding to the national average income ($w_a = 1$), $y_i$ is the initial income of individual $i$, $w(y_i)$ the distributional weight corresponding to the initial income of individual $i$, $\Delta y_i$ the average project benefit received by the population, $\Delta y_i$ the project benefit received by individual $i$ and $\beta_a$ the average proportion of the project benefit received by the population, $\beta_i$ the proportion of the project benefit received by individual $i$.  

8 The concept was originally defined by Feldstein (1972) but applied to distributional effects of policy decisions by, among others, Boadway (1976) and Hau (1986).

9 Following Sandmo (1998), an alternative way of expressing the distributional characteristic is: 

$$B = \left[1 + \sum_{i=1}^{n} (y_i - \bar{y}) (\Delta y_i - \Delta y_a) / w_a (\Delta y_a) \right] B$$

$$= \left[1 + \sum_{i=1}^{n} (\Delta y_i - \Delta y_a) / \bar{y} \right] B$$

where $\delta$ is Sandmo’s indirect measure of the distributional characteristic, $w_a$ is the distributional weight corresponding to the national average income ($w_a = 1$), $y_i$ is the initial income of individual $i$, $w(y_i)$ the distributional weight corresponding to the initial income of individual $i$, $\Delta y_i$ the average project benefit received by the population, $\Delta y_i$ the project benefit received by individual $i$ and $\beta_a$ the average proportion of the project benefit received by the population, $\beta_i$ the proportion of the project benefit received by individual $i$.  

8 The concept was originally defined by Feldstein (1972) but applied to distributional effects of policy decisions by, among others, Boadway (1976) and Hau (1986).

9 Following Sandmo (1998), an alternative way of expressing the distributional characteristic is:
\[ B^* = \sum_{i=1}^{n} w_i(y_i) \Delta y_i = \sum_{i=1}^{n} w_i(y_i) \frac{\Delta y_i}{B} = \sum_{i=1}^{n} w_i(y_i) \beta_i B = d^* B \quad (7a) \]

and \[ d^* = \sum_{i=1}^{n} w_i(y_i) \beta_i \quad (7b) \]

\( B^* \) = the weighted project benefit
\( y_i \) = the initial income of individual \( i \)
\( w_i(y_i) \) = the distributional weight corresponding to the initial income \( y_i \)
\( i \) = individuals \( (1, \ldots, n) \)
\( \Delta y_i \) = the part of the project benefit received by individual \( i \)
\( B = \sum_{i=1}^{n} \Delta y_i \) = the unweighted project benefit
\( \beta_i \) = the proportion of the project benefit received by individual \( i \)
\( d^* \) = the distributional characteristic of the benefit

Equation (7) cannot be applied empirically, as it is impossible in practice to compute the weighted project effects of each and every individual. Equation (7) become empirically useful only if redefined so as to base the distributional characteristic on groups of individuals at a certain income level, i.e.:

\[ d^* = \sum_{j} \alpha_j w_j(Y_j) \quad (8) \]

\( j \) = \( (1, \ldots, m) \) = group of individuals having the same initial income
\( Y_j \) = the level of initial income of group \( j \), \( (Y_1 > Y_2 > \ldots > Y_j > \ldots > Y_m) \)
\( \alpha_j \) = the portion of the project benefit received by the group of individuals having income level \( Y_j \). Belongs to the distribution \( (\alpha_1, \alpha_2, \ldots, \alpha_m) \).
\( w_j(Y_j) \) = the distributional weight corresponding to the income level \( Y_j \)

Thus, in practice the distribution \( (\beta_1, \ldots, \beta_n) \) is replaced by the distribution \( (\alpha_1, \ldots, \alpha_m) \).
2.3 Consequences of the choice of distributional weights for project decisions

In this section the effect of the choice of weights, on the net value and the rank of projects and thus on project decisions, is modelled. Throughout the analysis decision-makers are assumed to be economically rational, i.e. they will chose projects so as to maximise the sum of the net welfare effects of the chosen projects.

Normally, the distributional weighting aims at levelling out incomes, i.e. to increase the value of project effects that contribute to a more even income distribution, and vice versa. Therefore, all kinds of distributional weights, suggested in literature, have values larger than one for incomes below average and values less than one for incomes above average. However, the effect of distributional weighting may still vary among the different kinds of distributional weights.

The projects analysed have net efficiency and net social values determined as follows:

\[ \pi_e = B - C \]  \hspace{1cm} (9)
\[ \pi_w = B^* - C = d^*B - C \]  \hspace{1cm} (10)

\( \pi_e \) = the net efficiency value of traditional CBA
\( \pi_w \) = the net social value of WCBA
\( B \) = project benefit
\( C \) = project cost

Equation (9) and (10) describe, for example, a public project providing a free good or service to a particular target population. The project has one benefit producing a consumer surplus for the beneficiaries and thereby affecting the distribution of incomes, total consumption (real income) and welfare. The project cost is paid for out of taxation. To keep the analysis simple and straightforward, with regard to the effects of distributional weighting, taxation is assumed to be neutral as to income distribution, and thus the project cost do not have to be weighted.
If project decisions are unconstrained, i.e. all projects having a non-negative net value will be carried out, then the number of projects carried out can be affected by the choice of distributional weights. The effect of distributional weighting on project decisions is then determined by the change in net value due to the weighting. Using equations (9) and (10) we get:

$$\pi_w = (d^c - 1)B + \pi_e$$

(11)

Large weights have the potential to change a negative net efficiency value into a positive net social value. Small weights, making the distributional characteristic less than 1, have the potential to change a positive net efficiency value into a negative net social value.

Constrained project decisions are more common than unconstrained ones, at least in the public sector. The number of projects to carry out may be limited by financial or other constraints. In such cases the rank of projects is of interest. Different sets of distributional weights will produce the same ranking of projects if the net social value of projects computed by one set of weights is a monotonic transformation of the net social value computed by the other set of weights, i.e. if

$$\pi^*(w(Y)) = f(\pi_w(v(Y))), \quad \frac{\partial f}{\partial (\pi_w)} > 0 \text{ for all } d\pi_w$$

(12)

\[w(Y) = \text{one set of distributional weights} \]
\[v(Y) = \text{another set of distributional weights} \]

If one of the sets of weights is a continuous function of the other one, i.e. \( w(Y) = g(v(Y)) \), what properties of the function \( g(\bullet) \) are necessary and/or sufficient to make \( \pi_w^* \) a monotonic transformation of \( \pi_w \)? As the welfare change of a project is the sum of all changes in utilities, the only possible property is that \( w(Y) \) is a multiplicative transformation of \( v(Y) \) (which does not hold for the different sets of weights tested in this study). This property is a sufficient condition when there is only one project effect (a benefit or a cost). When there are several project effects and only some of them are weighted not even weights that are multiplicative
transformations of each other can produce net social values that are monotonic
transformations of each other. This is easy to see by letting inserting (8) and (10) in
equation (12):

\[ 
\pi^*_w = \left( \sum_j \alpha_j w(Y_j)B \right) - C = f(\pi_w) = f(\left( \sum_j \alpha_j v(Y_j)B \right) - C) 
\]  
(13)

In equation (13), \( \partial f/\partial \pi_w > 0 \) for all \( d\pi_w \) (for sure) only if \( w(Y) = v(Y) \). Thus, the choice of
distributinal weights can be expected to affect the ranking of projects and project decisions.

3 Projects and distributional weights examined

Empirical data on projects, which are identical from an efficiency point of view but which
differ in income distribution effect, have not been available. Therefore, the analysis is based
on 20 hypothetical projects, arbitrarily named A-T. Because the project benefits and costs are
constant for all projects, and only the differences among the projects are of interest, they need
not be specified. The income distribution effects of project A-T, i.e. the distributions of the
project benefits among people at different levels of initial incomes, denoted A-T like the

The profiles of the distributional effects of projects A-J are truncated normal distributions (at
both ends, so that the distribution is still symmetric). These distributions represent a situation
where the benefit of the project is intended for individuals in a certain income class. However,
the benefit need not necessarily go to all people in that particular income class. Because of the
lack of precision in the implementation of political decisions, there is a spill-over to
individuals at income levels just above and below. The benefits of projects K-T are evenly
distributed among all individuals within a certain income interval. Because the benefit per
capita is constant the distributions of the benefits have the same profile as the national income
distribution, for the relevant income interval. The distributions A-J are constructed from data on normal density functions (Maddala 1992) and distributions K-T from the distribution of incomes in Sweden in 2001 (table A2 in appendix). The means of the distributions vary between SEK 8,000/month and SEK 48,000/month. The spans of the distributions vary from SEK 5,000 to SEK 85,000.

The distributional weights used in the analysis are the following (all prices in SEK, in 2001):

**Iso-elastic weights of the SWF/MUI/OPOV approach:** The iso-elastic weights are the ones defined in equation (4), and have elasticity values of 0.5, 1 and 2. The reasons for using these elasticity values are the recommendation of the World Bank (Brent 1990), the results from empirical estimations and the values commonly used in applications. These elasticity values are reasonable also for the OPOV approach. The point of reference for the distributional weights is SEK 17,100/month. Because the income interval is cut at SEK 85,000/month, the average income used is slightly lower than the national average before-tax income (SEK 17,300/month; see Swedish Statistics 2004). The income distributions are based on discrete income intervals and each distributional weight computed using the mean of the income interval (see table 3.2).

**The OCT approach:** In Sweden the average excess burden of taxation has been assumed to be about 30% of the amount of taxation (ASEK 1999). This may be an underestimation of the relevant measure of $s$ in equation (5), which is the marginal excess burden of net transfers (Layard 1999). This being the only estimate available, I will use it for the OCT approach. In my computations, the definition of poor people follows the practice of the EU Commission (EESC 1998), i.e. people classified as poor are those who have less than 50% of the national average income per capita. In this case, it means people who earn less than SEK 8,600/month. This represents the 20% of the population having the lowest incomes (see table A2 in appendix). I have, somewhat arbitrarily, defined rich people as the 10% of the population having the largest incomes, i.e. people earning more than SEK 28,000/month in 2001. I have used 3 weights: 1.2 for the poor, 0.9 for the rich (making up the maximum ratio 1.33) and 1.00 for the others (see table 3.2).
The DM approach: In the decision-maker approach there is no particular technical formulation advocated for the distributional weights. Distributional weights reflecting implicit political preferences have been estimated either as continuous weighting functions (e.g. implicit weights in Norwegian taxation by Christiansen and Jansen 1978, or local government preferences in Baltimore by Behrman and Craig 1987) or as sets of discrete weights (e.g. implicit weights in British railway closures by Brent 1979 or 1984b). No Swedish estimations of implicit distributional weights, derived from political decisions or taxation, have been found. Therefore, I have made a rough estimation of such weights based on the relation between earned incomes and disposal incomes (redistributed incomes) in Sweden. In table 3.1 the distribution of before-tax-incomes across deciles is presented in column B and the distribution of disposal income across deciles in column C. The ratio C/B is the actual disposal income related to the income earned by employment or business, for each decile.

<table>
<thead>
<tr>
<th>Deciles</th>
<th>Earnings, taxable income</th>
<th>Earnings, taxable income</th>
<th>Disposal income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. Income interval, SEK 1,000/month</td>
<td>B. Distribution, %</td>
<td>C. Distribution, %</td>
</tr>
<tr>
<td>First</td>
<td>0</td>
<td>0.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Second</td>
<td>0 - 2.9</td>
<td>1.0</td>
<td>6.1</td>
</tr>
<tr>
<td>Third</td>
<td>3.0 - 7.1</td>
<td>3.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Fourth</td>
<td>7.2 - 9.9</td>
<td>6.4</td>
<td>7.7</td>
</tr>
<tr>
<td>Fifth</td>
<td>10.0 - 12.2</td>
<td>8.3</td>
<td>8.5</td>
</tr>
<tr>
<td>Sixth</td>
<td>12.3 - 14.7</td>
<td>10.1</td>
<td>9.5</td>
</tr>
<tr>
<td>Seventh</td>
<td>14.8 - 17.0</td>
<td>11.9</td>
<td>10.6</td>
</tr>
<tr>
<td>Eighth</td>
<td>17.1 - 19.7</td>
<td>13.7</td>
<td>12.0</td>
</tr>
<tr>
<td>Ninth</td>
<td>19.8 - 24.7</td>
<td>16.4</td>
<td>14.0</td>
</tr>
<tr>
<td>Tenth</td>
<td>24.8 -</td>
<td>28.3</td>
<td>20.8</td>
</tr>
</tbody>
</table>

Sources: Data and processing of data from Statistics Sweden (2003a) (column A and B) and data from Statistics Sweden (2003b) (column C).

Provided the actual redistribution is the ideal one from the government’s point of view, the ratio C/B may be regarded as a measurement of the inequality aversion of the government and thus a basis for distributional weights. I have used the ratios C/B in table 3.1 to compute the distributional weights of the DM approach (see table 3.2). This estimation of DM weights is
very simple and crude. But, even though the reliability of these weights can for good reasons be questioned, they do serve their purpose in this study by being middle-of-the-road, compared to the iso-elastic weighting functions and the discrete OCT weights.

### Table 3.2 Distributional weights.

<table>
<thead>
<tr>
<th>Income SEK1,000/month</th>
<th>Iso-elastic weights(^1)</th>
<th>Other weights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>w (0.5)</td>
<td>w(1)</td>
</tr>
<tr>
<td>1 - 5</td>
<td>2.39</td>
<td>5.70</td>
</tr>
<tr>
<td>6 - 10</td>
<td>1.46</td>
<td>2.14</td>
</tr>
<tr>
<td>11 – 15</td>
<td>1.15</td>
<td>1.32</td>
</tr>
<tr>
<td>16 – 20</td>
<td>0.97</td>
<td>0.95</td>
</tr>
<tr>
<td>21 – 25</td>
<td>0.86</td>
<td>0.74</td>
</tr>
<tr>
<td>26 - 30</td>
<td>0.78</td>
<td>0.61</td>
</tr>
<tr>
<td>31 – 35</td>
<td>0.72</td>
<td>0.52</td>
</tr>
<tr>
<td>36 – 40</td>
<td>0.67</td>
<td>0.45</td>
</tr>
<tr>
<td>41 – 45</td>
<td>0.63</td>
<td>0.40</td>
</tr>
<tr>
<td>46 – 50</td>
<td>0.60</td>
<td>0.36</td>
</tr>
<tr>
<td>51 – 55</td>
<td>0.57</td>
<td>0.32</td>
</tr>
<tr>
<td>56 – 60</td>
<td>0.54</td>
<td>0.29</td>
</tr>
<tr>
<td>61 – 65</td>
<td>0.52</td>
<td>0.27</td>
</tr>
<tr>
<td>66 – 70</td>
<td>0.50</td>
<td>0.25</td>
</tr>
<tr>
<td>71 – 75</td>
<td>0.48</td>
<td>0.23</td>
</tr>
<tr>
<td>76 – 80</td>
<td>0.47</td>
<td>0.22</td>
</tr>
<tr>
<td>81 – 85</td>
<td>0.45</td>
<td>0.21</td>
</tr>
</tbody>
</table>

\(^1\) The iso-elastic weights are based on an average income of SEK 17,100/month.

### 4 Analysis

A reasonable expectation, after looking at the sets of distributional weights in table 3.2, is that the choice of distributional weights ought to be of great significance for project decisions. The distributional characteristics of the projects A-T are shown in table 4.1. The most progressive set of weights (iso-elastic weights with elasticity 2) can give very large values of the distributional characteristics. The OCT weights, on the other hand, do not induce much variation in the distributional characteristics. Nevertheless, the distributional characteristics seem to be somewhat less dispersed than the values of the distributional weights they are based on.
### Table 4.1 Distributional characteristics of project effects (d^c)

<table>
<thead>
<tr>
<th>Projects and distributions</th>
<th>Monthly incomes</th>
<th>Distributional characteristics</th>
<th>Iso-elastic weights^1</th>
<th>Other weights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Interval SEK 1,000</td>
<td>Mean SEK 1,000</td>
<td>w(0.5)</td>
<td>w(1)</td>
</tr>
<tr>
<td>Truncated normal distributions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>6 - 10</td>
<td>8</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>B</td>
<td>1 - 15</td>
<td>8</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>C</td>
<td>6 - 20</td>
<td>13</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>D</td>
<td>1 - 25</td>
<td>13</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>E</td>
<td>11 - 25</td>
<td>18</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>F</td>
<td>6 - 30</td>
<td>18</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>G</td>
<td>21 - 35</td>
<td>28</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>H</td>
<td>16 - 40</td>
<td>28</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>I</td>
<td>36 - 60</td>
<td>48</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>J</td>
<td>1 - 65</td>
<td>48</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Constant benefit/capita</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>1 - 15</td>
<td>8</td>
<td>1.7</td>
<td>3.0</td>
</tr>
<tr>
<td>L</td>
<td>6 - 20</td>
<td>13</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>M</td>
<td>1 - 25</td>
<td>13</td>
<td>1.3</td>
<td>2.0</td>
</tr>
<tr>
<td>N</td>
<td>1 - 85</td>
<td>17.1</td>
<td>1.2</td>
<td>1.7</td>
</tr>
<tr>
<td>O</td>
<td>11 - 30</td>
<td>17.1</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>P</td>
<td>6 - 40</td>
<td>18</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Q</td>
<td>21 - 35</td>
<td>25.7</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>R</td>
<td>16 - 40</td>
<td>22.5</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>S</td>
<td>40 - 60</td>
<td>48</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>T</td>
<td>36 - 70</td>
<td>48</td>
<td>0.6</td>
<td>0.4</td>
</tr>
</tbody>
</table>

^1 For the distributional weights w(θ), θ = elasticity of iso-elastic distributional weights.

According to the results in table 4.1, all sets of weights comply with the objective of WCBA as the distributional characteristic decreases with the mean income of the target population. However, for iso-elastic weights the distributional characteristic may increase with the span of the distribution, given a constant mean of distribution (compare the pairs of projects A-B, C-D etc). The implication of this effect is that a project benefiting many people within a broad range of initial incomes may be preferred to a project benefiting only few people within a narrow range of initial incomes, although the mean income of the target populations is the same. In other words, this effect may work as a numbers effect. It appears only when the mean income of the target population is low (lower than the national average) and is
dependent on the elasticity of the iso-elastic weights. This is because the effect is due to the non-linearity of the weights. (The effect appears also when using the discrete DM weights, as they form a non-linear pattern at extremely low incomes).

The iso-elastic weights are determined by \((1/y_i)\) over \(y_i\) (see equation (4)). Because of this, the marginal effect of the distributional weighting, if the span of incomes of the target population increases, is larger at the low end of the income scale than at the high end of it, resulting in a net effect on the distributional characteristic. As the indirect numbers effect is due to the sharpness of the curvature of \((1/y_i)\) it increases with elasticity value and decreases with the mean income of the target population. The effect is also more prominent for skewed distributions than for the symmetric ones (compare projects L-M and C-D). In the three-objective SFW suggested by Brent (1984b) a numbers effect is considered to increase social welfare. However, in a WCBA based on the commonly assumed two-objective SWF (equity and efficiency) it is not quite clear how this indirect numbers effect should be interpreted.

An odd consequence of the numbers effect is that a project benefit (or cost) evenly distributed over the entire national population will have a distributional characteristic larger than 1 (project N) although such an effect is neutral with regard to income distribution. The fact that the distributional characteristic in this case erroneously indicates an income distribution effect is due to the non-linearity of the weights combined with the weighting procedure used in practice (the weighting and aggregation of groups of individuals instead of single individuals). This is easily demonstrated by inserting distributional weights, corresponding to equation (4), into equation (8):

\[
d^* = \sum \alpha_j \left( \frac{Y_j}{Y_j} \right)^\theta = Y_a^\theta \sum \alpha_j Y_j^{-\theta} = \left( \sum \rho_j Y_j \right)^\theta \sum \alpha_j Y_j^{-\theta}
\]  

(14)

\(\alpha_j = \) the portion of the project benefit acquired by the group of individuals having the initial income \(Y_i\)

\(Y_a = \) the average income of the national population

\(\rho_j = \) the proportion of the population having the level of initial income \(Y_j\)
When the distribution of the project effect is identical to the income distribution of the population, i.e.

\[ \alpha_j = \rho_j \quad \text{for all } j, \quad \text{and } \sum_j \alpha_j Y_j = \sum_j \rho_j Y_j = Y_a \]  

equation (14) becomes:

\[ d^c = \left( \sum_j \alpha_j Y_j \right)^\theta \sum_j \alpha_j Y_j^{-\theta} \]  

According to equation (16), when using non-linear iso-elastic weights \( d^c = 1 \) if and only if the elasticity of the weights is zero (all weights are 1) or the initial income is evenly distributed (there is only one income level and \( \rho = \alpha = 1 \) for the one and only \( Y \)).

When project decisions are unconstrained, i.e. only the net social value of the projects is of interest, then the absolute size of the distributional characteristic is of importance. According to the results in table 4.1, the choice of distributional weights must have significant effect on project decisions, particularly when the target population has low incomes. However, in the real world constrained project decisions are more common (financial constraints ought to be the most common ones to consider) and thus the effect of the choice of weights on the ranking of the projects is of greater interest. Table 4.2 presents the ranking of projects when applying distributional weighting and, as a point of reference, the ranking based on the mean income of their target populations. The latter is a likely outcome if income distribution effects of the projects are considered “manually”, i.e. no method of analysis is used for integrating the equity objective.

---

10 If Sandemo’s formulation of the distributional characteristic, in footnote 9, were used, which it unfortunately cannot because individual data would not be available, the indirect numbers effect would not occur. As the project effect is evenly distributed over all individuals \( \Delta y_i \) is equal to \( \Delta y_a \) for all \( i \)’s (and \( \beta_i \) is equal to \( \beta_a \) for all \( i \)’s) and thus \( \delta \) must be equal to zero and \( d^c \) equal to 1.
Table 4.2  The ranking of projects by distributional weighting ($d^i$)\(^1\).

<table>
<thead>
<tr>
<th>Rank</th>
<th>No weighting(^2)</th>
<th>w(0.5)</th>
<th>w(1)</th>
<th>w(2)</th>
<th>OTC</th>
<th>DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A, B, K</td>
<td>K</td>
<td>K</td>
<td>K</td>
<td>A, B</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>A, B</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td></td>
<td>K</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>M</td>
<td>K, L, M, N</td>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>C, D, L, M</td>
<td>M</td>
<td>M</td>
<td>N</td>
<td></td>
<td>M</td>
</tr>
<tr>
<td>5</td>
<td>C, D, L, N</td>
<td>N</td>
<td>A</td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>6</td>
<td>L</td>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>C, D</td>
<td>D</td>
<td>C, D, E, F, G, H, O, P, Q, R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>N, O</td>
<td></td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>E, F, O, P</td>
<td>O, P</td>
<td>P</td>
<td>O, P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>E, F, P</td>
<td></td>
<td>O</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>E, F</td>
<td>E, F</td>
<td>E, F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>Q, R</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Q</td>
<td>G, H, Q</td>
<td>Q</td>
<td>Q</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>I, J, S, T</td>
<td>I, J, S, T</td>
<td>I, J, S, T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Before the distributional weighting all projects have the same net efficiency value $\pi_e$ and the same rank.
\(^2\) The projects are ranked by the mean income if the target group.

There is very little difference between the rankings of the projects. At very high incomes (projects I, J, S and T) the rankings, based on different sets of distributional weights, are identical. Furthermore, at very high incomes none of the sets of distributional weights do discriminate between projects because of differences in distributional profiles and span of incomes of the target group. At low or medium incomes, the rankings are not identical but only rarely contradictory and could in many instances lead to the same project decisions. The most obvious difference is that more progressive weights (e.g. $w(2)$) gives a more elaborated and complete ranking of the projects. Less progressive weights, such as $w(0.5)$, produce an incomplete ranking similar to the “manually” made ranking based only on the mean income of the target groups. The OCT weights are even less progressive and only divide the projects into 3 groups. If using the OCT approach, the decision maker still has to make his own priority among most of the projects, and much of the point in using WCBA is lost.
The more elaborate ranking of the progressive weights is because of the indirect numbers effect, differentiating between the widths of income spans. Thus, whether or not the more elaborated ranking of the progressive weights is advantageous, depends on whether or not the indirect numbers effect is relevant from an equity point of view.

5 Conclusions

The ranking of projects is the same for the different sets of distributional weights when the mean incomes of the targets groups are very high. At low or medium levels of the mean incomes of the target groups the ranking of projects is not identical for different sets of distributional weights, but contradictory only in rare cases. Therefore, the choice of distributional weights need not necessarily affect project decisions, when a fixed number of projects have to be chosen.

The rankings differ mainly in that they are more elaborated when based on more progressive weights. The more elaborated and almost complete ranking, when using very progressive iso-elastic weights, is due to the indirect numbers effect disclosed in this analysis. Because of the non-linearity of the weights, the effect of distributional weighting increases with the span of incomes when the target population is at the low end of the income scale. The effect works as a numbers effect if the increase in income span is due to an increase in the size of the target population. The indirect numbers effect may even make non-linear weights erroneously indicate a positive income distribution effect if the project benefit is evenly distributed over the national population, and thus is neutral from an income distribution point of view. As the relevance of this effect is unclear, the value of the almost complete ranking of projects is also unclear.

The OCT weights have little effect on the social net value of projects. They produce a very incomplete ranking of the projects. By having so little effect, the OCT weights could be considered either safe to use or ineffective.
All in all, the effect of the choice of distributional weights differs depending on which target populations the projects will affect and if the decision-making is constrained or unconstrained. The choice of weights is of great significance only in evaluations of projects affecting target populations with very low incomes. The choice of weights is of less importance than expected for constrained project decisions where the ranking of projects is of interest. A safe strategy, when conducting WCBA, may be to make sensitivity analyses based on several different sets of weights whenever evaluating projects affecting target populations with low incomes.

References


Table A1  Distributions of project benefits for projects A-T.

Distributions B – J are normally distributed and constructed from data on ordinates of the normal density function (table A.1 in Maddala, 1992). Distributions K - T correspond to the actual distribution of income in, Sweden in 2001, within the relevant intervals of incomes. Incomes are in SEK 1,000/month and distributions in %.

<table>
<thead>
<tr>
<th>Income</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>11.80</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-10</td>
<td>100.00</td>
<td>76.40</td>
<td>11.80</td>
<td>19.40</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-15</td>
<td>11.80</td>
<td>76.40</td>
<td>59.80</td>
<td>11.80</td>
<td>19.40</td>
<td>0.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-20</td>
<td>11.80</td>
<td>19.40</td>
<td>76.40</td>
<td>59.80</td>
<td>6.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-25</td>
<td>0.70</td>
<td>11.80</td>
<td>19.40</td>
<td>11.80</td>
<td>24.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26-30</td>
<td>0.70</td>
<td>76.40</td>
<td>38.20</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31-35</td>
<td>11.80</td>
<td>24.20</td>
<td>0.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36-40</td>
<td>6.10</td>
<td>0.70</td>
<td>6.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41-45</td>
<td>0.60</td>
<td>19.40</td>
<td>23.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46-50</td>
<td>59.80</td>
<td>38.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51-55</td>
<td>19.40</td>
<td>23.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56-60</td>
<td>0.70</td>
<td>6.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>61-65</td>
<td>0.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66-70</td>
<td>0.20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71-75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76-80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>81-85</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
<th>O</th>
<th>P</th>
<th>Q</th>
<th>R</th>
<th>S</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>33.00</td>
<td>14.90</td>
<td>10.97</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-10</td>
<td>33.85</td>
<td>33.25</td>
<td>20.83</td>
<td>15.88</td>
<td>16.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-15</td>
<td>33.15</td>
<td>33.95</td>
<td>26.54</td>
<td>23.01</td>
<td>42.77</td>
<td>25.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-20</td>
<td>32.80</td>
<td>24.31</td>
<td>22.55</td>
<td>36.85</td>
<td>25.36</td>
<td>48.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-25</td>
<td>13.42</td>
<td>13.31</td>
<td>15.37</td>
<td>16.56</td>
<td>59.90</td>
<td>28.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26-30</td>
<td>5.83</td>
<td>5.01</td>
<td>7.81</td>
<td>26.24</td>
<td>12.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31-35</td>
<td>3.08</td>
<td>4.60</td>
<td>13.86</td>
<td>6.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36-40</td>
<td>1.90</td>
<td>3.22</td>
<td>4.07</td>
<td>36.39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41-45</td>
<td>0.72</td>
<td>42.92</td>
<td>15.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46-50</td>
<td>0.46</td>
<td>26.64</td>
<td>11.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51-55</td>
<td>0.41</td>
<td>17.03</td>
<td>9.93</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56-60</td>
<td>0.36</td>
<td>13.41</td>
<td>8.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>61-65</td>
<td>0.36</td>
<td>8.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66-70</td>
<td>0.36</td>
<td>8.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71-75</td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76-80</td>
<td>0.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>81-85</td>
<td>0.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table A2  Distribution of taxable income (earnings and capital incomes) of the Swedish population, \( \geq 20 \) years old, in 2001.
Distribution in % and incomes in SEK 1,000.
Source: Swedish Statistics 2004

<table>
<thead>
<tr>
<th>Annual income</th>
<th>≈ Monthly income</th>
<th>Distribution of the Swedish population</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0 – 1.7</td>
<td>2.65</td>
</tr>
<tr>
<td>1 – 19.9</td>
<td>1.7 – 3.3</td>
<td>2.10</td>
</tr>
<tr>
<td>20.0 – 39.9</td>
<td>3.3 – 5.0</td>
<td>4.39</td>
</tr>
<tr>
<td>40.0 – 59.9</td>
<td>5.0 – 6.7</td>
<td>5.08</td>
</tr>
<tr>
<td>60.0 – 79.9</td>
<td>6.7 – 8.3</td>
<td>4.54</td>
</tr>
<tr>
<td>80.0 – 99.9</td>
<td>8.3 – 10.0</td>
<td>5.29</td>
</tr>
<tr>
<td>100.0 – 119.9</td>
<td>10.0 – 11.6</td>
<td>6.62</td>
</tr>
<tr>
<td>120.0 – 139.9</td>
<td>11.6 – 13.3</td>
<td>7.65</td>
</tr>
<tr>
<td>140.0 – 159.9</td>
<td>13.3 – 15.0</td>
<td>7.61</td>
</tr>
<tr>
<td>160.0 – 179.9</td>
<td>15.0 – 16.7</td>
<td>8.01</td>
</tr>
<tr>
<td>180.0 – 199.9</td>
<td>16.7 – 18.3</td>
<td>7.73</td>
</tr>
<tr>
<td>200.0 – 219.9</td>
<td>18.3 – 19.9</td>
<td>6.79</td>
</tr>
<tr>
<td>220.0 – 239.9</td>
<td>20.0 – 21.7</td>
<td>5.71</td>
</tr>
<tr>
<td>240.0 – 259.9</td>
<td>21.7 – 23.3</td>
<td>4.62</td>
</tr>
<tr>
<td>260.0 – 279.9</td>
<td>23.3 – 24.9</td>
<td>3.57</td>
</tr>
<tr>
<td>280.0 – 299.9</td>
<td>25.0 – 28.3</td>
<td>4.68</td>
</tr>
<tr>
<td>300.0 – 339.9</td>
<td>28.3 – 33.3</td>
<td>3.85</td>
</tr>
<tr>
<td>340.0 – 399.9</td>
<td>33.4 – 41.6</td>
<td>3.06</td>
</tr>
<tr>
<td>400.0 – 499.9</td>
<td>41.7 – 83.3</td>
<td>2.93</td>
</tr>
<tr>
<td>500.0 – 999.9</td>
<td>83.4 -</td>
<td>0.51</td>
</tr>
<tr>
<td>1 000.0 -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Abstract
In this study the hypothesis of marginal utility of income decreasing with income is tested within a binary choice model flexible as to the functional form of the marginal utility of income. The analysis differs from other analyses of marginal utility of income in that it is based on stated preference data. The results indicate that marginal utility of income is a linearly decreasing function of income.
1 Introduction

The conjecture that marginal utilities of income decrease with increases in income and consumption is one of the most common motives for applying distributional weights in welfare evaluations (see e.g. Pearce and Nash 1981, Brent 1984, 1996 or 1998, Perkins 1994, Ray 1984 or Azar and Sterner 1996). In this study the hypothesis of individual marginal utilities of income decreasing with income is tested. The marginal utility of income is analysed using a non-linear model, flexible as to functional form, based on Contingent Valuation data on travel comfort (Bångman 1994).

In previous studies, utility functions have often been assumed to be of the CRRA\(^1\) type and marginal utility has been defined as a continuous function of income having constant elasticity with respect to income. Studies made in the 1970s, based on linear or non-linear expenditure systems reported elasticities ranging from 0 to 10 with a concentration around 2 (Stern 1977). A recent study by Jacobs (2002), using consumption data, estimated the relative risk aversion in the range of 2 - 8. Studies of the savings behaviour of individuals and the inter-temporal distribution of incomes have resulted in estimated elasticity values ranging from 0 to 10, with a concentration around 4 – 5 (Stern 1977). Analyses of risk behaviour in gambling experiments have indicated both convex and concave segments of the utility function, and elasticity values ranging from minus infinity to plus infinity (Stern 1977). According to Dasgupta (1998), empirical studies of choices under conditions of uncertainty have revealed utility functions implying an elasticity of the marginal utility of about 2. More recently, Johansson-Stenman et al. (2002), Carlsson et al. (2005) and (2003) have studied individual risk aversion by experimental studies based on the choices of lotteries which will determine the future income of hypothetical grandchildren. These studies found the relative risk aversion (i.e. the elasticity of marginal utility of income) to vary among individuals, having median values in the interval 2-3. In a study of the demand for risky assets in the US 1946-85, the aggregate household behaviour was found to be consistent with a relative risk aversion of approximately 1.3 (Dalal and Arshanapalli 1993). Also, in a model of schooling decisions the relative risk aversion was found to be fairly low; about 0.9 (Belzil and Hansen 2002).

---

\(^1\) CRRA stands for constant relative risk aversion, and gives a marginal utility function of the form: \(dU/dy = y^\rho\), where \(\rho\) is the constant elasticity, regarding income (see e.g. Blanchard and Fischer 1989).
A possible reason for the great variety in the results could be that, after all, a constant elasticity function may not be the proper functional form for the marginal utility of income. Blue and Tweeten (1997), for example, have, in tests of different functional forms, found a quadratic utility function and thus a linear marginal utility of income function to be the best. Thus, analyses of the marginal utility of income that allow for more flexible functional forms could provide valuable insights into this issue.

Estimations of the marginal utility of income without constrains regarding the functional form have been made in some studies in transport economics. Jara-Diaz and Videla (1989) have, using of Chilean revealed preference data on travel mode choices, tried to detect both the income elasticity of demand and the marginal utility of income. In this study, changes in the marginal utility of income have been detected by estimating a model of travel mode choices on sub-samples segmented by different intervals of incomes. Their results support the hypothesis that the marginal utility of income decreases with increases in income. Johansson and Mortazavi (1999) have estimated the marginal utility of income in a similar way, in an analysis of travel mode choices and the value of travel time for non-business trips in Sweden. The results obtained by Johansson and Mortazavi (1999) do not show a significant difference between marginal utilities at different income intervals.

Stated preferences and Hicksian welfare measures have been used to analyse the effect of income on consumption and individual utilities also within the area of environmental economics (Kanninen and Kriström 1993, Kriström and Riera 1996). These analyses are, however, concentrated on the income elasticity of the willingness to pay for environmental improvements, not the marginal utility of income. Hultkrantz and Mortazavi (1999) have studied the value of travel time changes using a random non-linear utility model based on stated preference data. Indirectly this model also captures the effects of income on utility. Unfortunately, this model embraces income effects of changes in travel cost as well as income as a socio-economic interaction term. Because of this the results are difficult to interpret as to the nature of the marginal utility of income.

---

2 Blue and Tweeten (1997) have analysed the effect of income on a proxy measure of utility (a quality-of-life index, QLI) constructed by an aggregation of socio-psychological measures.
This study relies on basically the same kind of data (binary stated choices) and model as Hultkrantz and Mortazavi (1999), only that the model has been modified so as to demonstrate possible changes in the marginal utility of income in a straightforward and unambiguous way. An advantage of using stated preference data, instead of revealed preferences, for the present purpose, is the availability and completeness of data. Household expenditure data may be available but they rarely contain the prices paid for the goods or services purchased. Data on prices will have to be obtained from other sources and may, because of local or temporal variations in prices, differ from the real prices paid by the households in question (Slesnick 1998). Stated preference data are computationally uncomplicated and provides the model with all the data needed for the analysis. However, they can be criticised for being hypothetical.

The outline of the report is as follows: In section 2 the economic and econometric models are specified. In section 3 and 4 data and results are presented. Section 5 presents the conclusions.

2 The economic and econometric model

Because the model relies on Contingent Valuation data, the setting of the economic model is a situation where a non-market good is hypothetically paid for, under the condition that utility is maximized. In this particular case the non-market good is improved travel comfort when travelling by train. Let us assume that a representative train passenger with inelastic demand for train service consumes a bundle of market goods and also receives utility from the quality of travel comfort when travelling by train. In contrast to the model of Hultkrantz and Mortazavi (1999), all individuals are assumed to have equal utility functions. Preferences for single goods are conditional on individual characteristics, but not the functional form of utility.

---

3 Travel comfort is normally treated as a part of a travel package and one of several factors determining total travel cost (lack of comfort is one, travel time and the fare are the others). In the CV measurement, however, travel comfort is treated as a distinct good, just as any other environmental amenity is when evaluated by CV.
The individual maximizes utility subject to the budget constraint, i.e.:

\[
\text{Max } U = U(X, c) \quad \text{subject to } \quad pX \leq y \quad \text{and } \quad c \text{ given} \tag{1}
\]

\[
X = (x_1, x_2, \ldots, x_K) = \text{a vector containing the consumption of } K \text{ market goods}
\]

\[
c = \text{quality of travel comfort}
\]

\[
p = (p_1, p_2, \ldots, p_K) = \text{a vector of prices of market goods}
\]

\[
y = \text{the income of the individual}
\]

Utility maximization produces the restricted indirect utility function (Cornes and Sandler 1996):

\[
V = V(y, p, c) \tag{2}
\]

The Compensating Variation (CV) is the maximum willingness to pay for an improvement in travel comfort\(^4\). However, the CV is not measured directly, only indirectly through discrete choices. Individuals choose between the initial level of travel comfort \((c^0)\) or improved travel comfort \((c^{'})\) on their journey by train, under the condition that an extra fee \((\Delta y)\) has to be paid in addition to the fare. If the CV is larger than the fee \((CV > \Delta y)\), improved travel comfort will be chosen and the following condition hold:

\[
\Delta V = V((y - \Delta y), p, c^{'}) - V(y, p, c^0) > 0 \tag{3}
\]

In order to make equation (3) tractable, and to allow for non-linear functional forms, the change in utility \(\Delta V\) is transformed into a polynomial form, more specifically a quadratic approximation using Taylor’s theorem (Hultkrantz and Mortazavi 1999). A 2\(^{nd}\) order Taylor approximation of \(\Delta V\) at the point \((y^0, p, c^0)\), where \(y^0\) and \(c^0\) are the initial income and level of travel comfort, converts equation (3) to:

---

\(^4\) The formal definition is (see Johansson 1993): \(\Delta V = V(y - CV, p, c^{'}) - V(y, p, c^0) = 0\) where \(c^0\) and \(c^{'})\) are the initial level of travel comfort and the improved quality of the travel comfort respectively.
\[ \Delta V = \left( (y^0 - \Delta y) - y^0 \right) \frac{\partial V}{\partial y^0} + (c^1 - c^0) \frac{\partial V}{\partial c^0} + \frac{1}{2} \left( (y^0 - \Delta y) - y^0 \right)^2 \frac{\partial^2 V}{\partial (\Delta y)^2} \]
\[ + (c^1 - c^0)^2 \frac{\partial^2 V}{\partial c^0 \partial y^0} + 2 ((y^0 - \Delta y) - y^0)(c^1 - c^0) \frac{\partial^2 V}{\partial c^0 \partial y^0} \]
\[ = -\Delta y \frac{\partial V}{\partial y^0} + (c^1 - c^0) \frac{\partial V}{\partial c^0} + \frac{1}{2} (-\Delta y)^2 \frac{\partial^2 V}{\partial y^0} + \frac{1}{2} (c^1 - c^0)^2 \frac{\partial^2 V}{\partial c^0} \]
\[ - \Delta y (c^1 - c^0) \frac{\partial^2 V}{\partial c^0 \partial y^0} > 0 \] (4)

The scale of the measurement of travel comfort is calibrated so as to make the change in travel comfort equal to one. Equation (4) then becomes:

\[ \Delta V = \left( \frac{\partial V}{\partial y^0} \Delta y + \frac{\partial V}{\partial c^0} + \frac{1}{2} \frac{\partial^2 V}{\partial (\Delta y)^2} \Delta y \right) - \frac{\partial^2 V}{\partial c^0 \partial y^0} \Delta y + \frac{1}{2} \frac{\partial^2 V}{\partial c^0} > 0 \] (5)

The first two terms in equation (5) describe the increase in utility owing to a more comfortable journey and the decrease in utility due to the loss of money when paying for the improved travel comfort. The third and fifth term capture possible adjustments of the marginal utility of travel comfort and the marginal utility of income as travel comfort increases and the amount of money (available for buying other goods) decreases when the individual buys a more comfortable journey. These two second-order derivatives are negative, if the marginal utility of income and comfort decrease with income and comfort, respectively. Thus, the third term is the crucial one when testing the hypothesis that marginal utility decreases with income. The fourth term is the mixed partial derivative that determines the effect of marginal utility of comfort on marginal utility of income and vice versa. If there is a correlation between the preferences for travel comfort and the marginal utility of income, this second-order derivative will have a non-zero value.
If the hypothesis of the decrease in marginal utility of income, with increases in income, is true, then:

\[
\frac{\partial V}{\partial y^0} = f(y) \quad \text{and} \quad \frac{\partial^2 V}{(\partial y^0)^2} < 0 \quad (6)
\]

The utility model has been estimated using a binary Logit model (see e.g. Hanemann 1984, Ben-Akiva and Lerman 1985, Maddala 1992 or Greene 1997). This discrete choice model estimates the probability to accept the offer of improved travel comfort, i.e.:

\[
P_1 = \text{Prob} (\psi = 1) = \text{Prob} (\Delta V + \varepsilon > 0) = F(\Delta V) \quad (7)
\]

where \( \psi^* = \Delta V + \varepsilon \quad \psi = 1 \quad \text{if} \quad \psi^* > 0 \quad \text{and} \quad \psi = 0 \quad \text{if} \quad \psi^* \leq 0 \)

\( P_1 \) = the probability to pay for improved travel comfort

\( \psi_i \) = the discrete choice dependent variable, to pay (1) or not to pay (0)

\( \varepsilon \) = disturbances, standard logistic distribution with mean 0 and variance 1.

\( F \) = the cumulative distribution function of the disturbances

In a binary choice model any monotonic transformation of the underlying utility function \( V \) results in a multiplication of \( \Delta V \) but no change in the discrete choice variable \( \psi^* \).

With no assumptions made as to the form of the marginal utility function, the index function corresponding to equation (5), is\(^6\):

\[
\Delta V = -\frac{\partial f}{\partial V} \frac{\partial V}{\partial y^0} (\Delta y) + \frac{\partial f}{\partial V} \frac{\partial V}{\partial \varepsilon^0} + \frac{1}{2} (\Delta y)^2 \frac{\partial^2 f}{\partial V \partial \varepsilon^0 \partial \varepsilon^0} - (\Delta y) \frac{\partial f}{\partial V} \frac{\partial^2 V}{\partial \varepsilon^0 \partial \varepsilon^0} + \frac{1}{2} \frac{\partial f}{\partial V} \frac{\partial^2 V}{\partial \varepsilon^0 \partial \varepsilon^0} = \frac{\partial f}{\partial V} (\Delta V)
\]

\(^5\) If \( V \) is a monotonic transformation of the function \( V \), then \( \frac{\partial f}{\partial V} > 0 \) for all \( V \) and

\(^6\) Here the subscript indicating the point of expansion is removed. The subscript \( i \) for individuals is introduced as the disturbances, and thus observed utilities, may vary over individuals.
\[
\Delta V_i = \beta_0 + \beta_1(\Delta y_i) + \beta_2(\Delta y_i^2) + \sum \beta_{2+l}(\phi_{2+l|i}) \tag{8}
\]

where \( \beta_i = -\left(\frac{\partial V}{\partial y} + \frac{\partial^2 V}{\partial c\partial y}\right) \)

\[
\beta_2 = \frac{1}{2} \frac{\partial^2 V}{(\partial y)^2}
\]

\(\phi_{2+l|i} = l \) variables capturing \( \left(\frac{\partial V}{\partial c}\right) \) and \( \left(\frac{\partial^2 V}{(\partial c)^2}\right) \) in equation (5)

The crucial coefficient to estimate and interpret is \( \beta_2 \). However, two drawbacks of equation (8) are that income is not an explicit variable in the model and that the model cannot tell if the coefficient \( \beta_2 \) is constant or varies over incomes, i.e. if the marginal utility of income is linearly or non-linearly dependent on income. One way of solving this problem is to estimate equation (8) on different segments of income.

If the marginal utility of income is assumed to be linearly dependent on income, then the index function is:

\[
\Delta V_i = \beta_0 + \beta_{11}(\Delta y_i) + \beta_{22}[y_i(\Delta y_i) - \frac{1}{2}(\Delta y_i^2)] + \sum \beta_{2+l}(\phi_{l|i}) \tag{9}
\]

where \( \frac{\partial V}{\partial y} = f(y_i) = A + cy_i \), \( \frac{\partial^2 V}{\partial y^2} = \alpha \),

\[
\beta_{11} = -\left(A + \frac{\partial^2 V}{\partial c\partial y}\right) \quad \text{and} \quad \beta_{22} = -\alpha
\]

If the marginal utility of income decreases linearly with income then \( \alpha \) is negative and \( \beta_{22} \) positive. Both equations (8) and (9) are estimated.

3 Data

The data comes from a survey made among passengers on 12 randomly chosen outgoing trains on the MS Line in Sweden (Bångman 1994). The rate of response was 88.1%, giving 735 observations. Among other questions, the passengers were asked about their willingness to pay for further improvements in travel comfort. The closed-ended format was used for the
wtp question. This format is considered to make wtp questions less difficult to answer and gives less incentive for strategic responses, compared to open-ended questions (Hanemann 1994). The passengers were asked to state if they were willing to pay a certain lump-sum, in addition to the fare, for getting improved travel comfort on the journey they were making at the time of the survey. The question posed to the passengers was the following (see also appendix):

“Assume that SJ (the train operator) had even more modern trains (compared to the present ones) having carriages that run more silently are and more comfortable (bumping and jogging less, smoother starts and stops and more comfortable seats). Would you then be willing to pay X SEK more for the journey you are now making (either as an increase in the fare or as a fee in addition to the price of the monthly season ticket, or any similar ticket)?

     O Yes       O No       O Don’t know”

The bid price to be considered was SEK 10, 15 or 25, each presented to a third of the sample.

Other variables in the survey are socio-economic variables such as age, gender, occupation and income (monthly before-tax), the amount of time spent on the train on the journey (travel time per journey) and the passenger’s attitude to different attributes of means of transportation, for example travel comfort. These variables are briefly described in table 1, and presented more in detail in the appendix.

In this study, passengers’ preferences for travel comfort are described by the variable ”Attitude to travel comfort”. The variable is a dummy taking the value 1 when travel comfort is stated as the only important attribute or one of several important attributes, when choosing a means of transport. The variable takes the value 0 when travel comfort is not stated as an important attribute.
<table>
<thead>
<tr>
<th>Table 1</th>
<th>Descriptive statistics: Means and distributions.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age:</strong> (years)</td>
<td>10-19</td>
</tr>
<tr>
<td></td>
<td>44.6%</td>
</tr>
<tr>
<td><strong>Occupation:</strong></td>
<td>Employed</td>
</tr>
<tr>
<td></td>
<td>37.6%</td>
</tr>
<tr>
<td><strong>Income:</strong> (SEK1,000 per month)</td>
<td>0 - 9</td>
</tr>
<tr>
<td></td>
<td>50.7%</td>
</tr>
<tr>
<td><strong>Gender:</strong></td>
<td>Men</td>
</tr>
<tr>
<td></td>
<td>51.7%</td>
</tr>
<tr>
<td><strong>WTP for travel comfort:</strong></td>
<td>Sek/journey</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td><strong>Attitude to travel comfort:</strong></td>
<td>The most important attribute</td>
</tr>
<tr>
<td></td>
<td>3.9%</td>
</tr>
<tr>
<td><strong>Travel time (minutes):</strong></td>
<td>0-19</td>
</tr>
<tr>
<td></td>
<td>8.0%</td>
</tr>
</tbody>
</table>

The incomes (before-tax) of the passengers range from 0 – SEK 33,000/month. This income span covers 98% of the income distribution of the population in 1993, the year of the survey (Statistics Sweden 1996). The MS Line has a very large portion of individuals earning less than SEK 3,000/month, compared to the national population. This is because under-age individuals are over-represented in the sample. Because of this, and because the under-aged are very rarely self-supporting, data on passengers younger than 20 years are excluded in the estimations.
In table 2 the results of the estimations of the marginal utility of income, are reported. Estimations are made both without constraints on the marginal utility function (equation (8)), allowing for non-linearity, and with the marginal utility function constrained to linearity (equation (9)). The estimation of equation (8) is made on the full sample and on two sub-samples with passengers having incomes in the intervals 0 – SEK 13,000/month and > SEK 13,000/month, respectively (SEK 13,000/month is the median income of the sample). The choice of the dividing line of the incomes is somewhat arbitrary. The main reason for splitting up data at the median value SEK 13,000/month is that the sample will then be divided in two equal parts.

In the estimation of equation (8) made on the full sample, the coefficient $E_2$ (capturing changes in the marginal utility of income due to changes in income) is close to zero and not statistically significant, indicating that the utility of income is constant over income. On the other hand, the coefficient $E_1$ (embracing the level of the marginal utility of income) is not significant either, as it would be if the marginal utility of income is constant. In addition, the overall statistics are poor. If we turn to the estimations of equation (8) on the sub-samples, the coefficient $E_2$ has the expected sign (negative) but is not significant in any of the estimations, indicating that the marginal utility of income is constant. The coefficient $E_1$ is insignificant in both estimations. Apart from these two similarities, the estimations on the sub-samples produce different results. They also have better over-all statistics than the estimation based on the full sample (the Hosmer and Lemeshow-Goodness-of-Fit Test is substantially improved when estimating on the sub-sets, and almost reaches the acceptable 95% level). This, in turn, suggests that economic behaviour and marginal utility of income are not identical across the different segments of income.

---

7 Another, and perhaps more natural, line of division would be the mean income of the Swedish population, which was SEK 12,200/month in 1993 (Statistics Sweden 1996). The consequence of choosing that level would, however, have been few observations in one of the estimations (the one based on low incomes).

8 In this test the predictions of the dependent variable are compared with observed values, and the null hypothesis tested is that the difference between predictions and observations is zero i.e. owing to chance variation.
Table 2  Estimation of linear or non-linear marginal utility of income\(^1\).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coeff.</th>
<th>β</th>
<th>p</th>
<th>β</th>
<th>p</th>
<th>β</th>
<th>p</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>(\beta_0)</td>
<td>0.65</td>
<td>0.67</td>
<td>0.78</td>
<td>0.75</td>
<td>2.04</td>
<td>0.45</td>
<td>1.15</td>
<td>0.09</td>
</tr>
<tr>
<td>(\Delta y)</td>
<td>(\beta_{11})</td>
<td>-0.07</td>
<td>0.70</td>
<td>0.00</td>
<td>0.99</td>
<td>-0.32</td>
<td>0.31</td>
<td>-0.07</td>
<td>0.01</td>
</tr>
<tr>
<td>((\Delta y)^2)</td>
<td>(\beta_2)</td>
<td>0.000</td>
<td>0.99</td>
<td>-0.002</td>
<td>0.84</td>
<td>-0.01</td>
<td>0.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(y(\Delta y) - 0.5(\Delta y)^2)</td>
<td>(\beta_{22})</td>
<td></td>
<td></td>
<td></td>
<td>0.004</td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\phi_3) Gender (1=Man)</td>
<td>(\beta_3)</td>
<td>0.49</td>
<td>0.06</td>
<td>0.14</td>
<td>0.74</td>
<td>1.84</td>
<td>0.00</td>
<td>0.55</td>
<td>0.07</td>
</tr>
<tr>
<td>(\phi_4) Age</td>
<td>(\beta_4)</td>
<td>-0.02</td>
<td>0.06</td>
<td>-0.03</td>
<td>0.08</td>
<td>-0.04</td>
<td>0.17</td>
<td>-0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>(\phi_5) Attitude to travel comfort (1 = important)</td>
<td>(\beta_5)</td>
<td>0.99</td>
<td>0.00</td>
<td>1.46</td>
<td>0.00</td>
<td>0.77</td>
<td>0.08</td>
<td>1.11</td>
<td>0.00</td>
</tr>
<tr>
<td>(\phi_6) Travel time of the journey</td>
<td>(\beta_6)</td>
<td>0.000</td>
<td>0.92</td>
<td>-0.17</td>
<td>0.61</td>
<td>0.47</td>
<td>0.16</td>
<td>0.002</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Statistics:
- \(-2\ln L_0\) | 394.3 | 161.5 | 170.3 | 331.8
- \(-2\ln L\) | 359.4 | 141.6 | 137.5 | 288.1
- LR stat. sign. | 0.00 | 0.00 | 0.00 | 0.00
- LR index | 0.10 | 0.12 | 0.19 | 0.13
- Hosmer & Lemeshow Goodness-of-fit test | 0.16 | 0.65 | 0.92 | 0.08
- Correct predictions (%) | 69.0 | 68.3 | 74.8 | 68.0
- Proportion of \(\psi = 0\) (%) | 63.3 | 60.0 | 60.6 | 60.3
- N | 300 | 120 | 127 | 247
- Missing values | 93 | 51 | 26 | 146
- Not selected | 342 | 564 | 582 | 342

\(^1\)Data on adults (\(\geq 20\) years).

According to the estimation of equation (9), where the marginal utility of income is constrained to a linear function of income, the coefficient \(\beta_{22}\) is positive and significant, implying that \(\alpha\) in equation (9) is negative and marginal utility of income decreases linearly with income. The coefficient \(\beta_{11}\) is significant and negative, which is expected if the marginal utility of income is linear and the mixed partial derivative \(\partial^2 V / \partial c \partial y\) negligible.

The over-all statistics of this estimation are about as poor as those of the estimations of equation (8) on the entire sample and on the sub-sample with low incomes. Even so, considering that the crucial coefficients \(\beta_{22}\) and \(\beta_{11}\) have the expected signs and are
significant and that the differentiation of incomes when estimating equation (8) did have an effect on the results, this study gives support to the conjecture that the marginal utility of income is decreasing linearly with income (at least approximately).

Other significant variables, in the estimation of the linear marginal utility function, are the attitude to travel comfort (an increase in the probability to pay for travel comfort if it is considered important) and age (the probability to pay for travel comfort is less for older people). However, in this model we cannot determine whether the significance of age means that the preferences for travel comfort or the marginal utility of income differs with age.

5 Conclusions

The hypothesis that marginal utility of income decreases with increased income is supported by the results. The result of the estimation of the linear model indicates that the marginal utility of income is decreasing linearly with income. The estimations of the flexible model, allowing for non-linear marginal utility of income, on different segments of income (low/medium and high, respectively) indicate that the marginal utility may not be constant for all income levels. Thereby, the results of the estimations of the flexible model give some support to the result of the estimation of the linear marginal utility of income.

According to the model based on the linear marginal utility of income, there is a significant negative relation between the willingness to pay for travel comfort and age. In the model, it is not possible to determine whether the effect of age is related to preferences for travel comfort or to the marginal utility of income.

References


Jacobs, K. (2002), ‘The Rate of Risk Aversion may be Lower than you Think’, Scientific Series, CIRANO, Montreal. (http://econpapers.hhs.se/)


The Questionnaire, used on the survey on the Mid-Sweden Line and the frequencies of answers.

The introductory page, giving a presentation of the evaluation project, the members of the project team, the purpose of the survey etc, has been left out. Because of the large number of questions in the survey, only the parts of the questionnaire that contains variables of relevance for this study, are presented here.

Questionnaire to travellers along the route Sundsvall – Östersund.

1) My journey by train:

<table>
<thead>
<tr>
<th></th>
<th>Starts from</th>
<th>Ends at</th>
</tr>
</thead>
<tbody>
<tr>
<td>Östersund</td>
<td>122</td>
<td>268</td>
</tr>
<tr>
<td>Brunflo</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Pilgrimstad</td>
<td>46</td>
<td>11</td>
</tr>
<tr>
<td>Gällö</td>
<td>59</td>
<td>30</td>
</tr>
<tr>
<td>Bräcke</td>
<td>95</td>
<td>41</td>
</tr>
<tr>
<td>Ånge</td>
<td>108</td>
<td>49</td>
</tr>
<tr>
<td>Ljungaverk</td>
<td>27</td>
<td>11</td>
</tr>
<tr>
<td>Fränsta</td>
<td>34</td>
<td>18</td>
</tr>
<tr>
<td>Torpshammar</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>Stöde</td>
<td>95</td>
<td>13</td>
</tr>
<tr>
<td>Sundsvall</td>
<td>103</td>
<td>258</td>
</tr>
</tbody>
</table>

16) Assume that SJ (the Swedish State-owned Railway Company) had even more modern trains (compared to the present ones) having carriages that run more quietly and were more comfortable (bumping and jogging less, smoother starts and stops and more comfortable seats). Would you then be willing to pay SEK X more for the journey you are now making (either as an increase in the fare or as a fee in addition to the price of the monthly season ticket, or other similar tickets)?

<table>
<thead>
<tr>
<th>Bid</th>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
<th>Missing value</th>
</tr>
</thead>
<tbody>
<tr>
<td>X = 10</td>
<td>105</td>
<td>117</td>
<td>57</td>
<td>10</td>
</tr>
<tr>
<td>X = 15</td>
<td>88</td>
<td>103</td>
<td>52</td>
<td>10</td>
</tr>
<tr>
<td>X = 25</td>
<td>38</td>
<td>103</td>
<td>42</td>
<td>10</td>
</tr>
<tr>
<td>Totally</td>
<td>231</td>
<td>323</td>
<td>151</td>
<td>30</td>
</tr>
</tbody>
</table>
17) In the choice between rail travel and other means of transportation I think these attributes, of the modes of travel, are the most important ones: (mark one or several alternatives)

<table>
<thead>
<tr>
<th></th>
<th>Travel comfort</th>
<th>Travel time</th>
<th>Price</th>
<th>Other attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>The single choice</td>
<td>28</td>
<td>169</td>
<td>74</td>
<td>22</td>
</tr>
<tr>
<td>One of several choices</td>
<td>260</td>
<td>395</td>
<td>262</td>
<td>15</td>
</tr>
</tbody>
</table>

**Personal background:**

18) I am: Male 373 Female 348 Missing values 14

19) I am:

<table>
<thead>
<tr>
<th>Age</th>
<th>Frequency</th>
<th>Age</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 – 15</td>
<td>14</td>
<td>46 – 50</td>
<td>66</td>
</tr>
<tr>
<td>16 – 20</td>
<td>320</td>
<td>51 – 55</td>
<td>22</td>
</tr>
<tr>
<td>21 – 25</td>
<td>54</td>
<td>56 – 60</td>
<td>17</td>
</tr>
<tr>
<td>26 – 30</td>
<td>43</td>
<td>61 – 65</td>
<td>12</td>
</tr>
<tr>
<td>31 – 35</td>
<td>45</td>
<td>66 – 70</td>
<td>8</td>
</tr>
<tr>
<td>36 – 40</td>
<td>45</td>
<td>71 – 80</td>
<td>5</td>
</tr>
<tr>
<td>41 – 45</td>
<td>57</td>
<td>81 – 85</td>
<td>1</td>
</tr>
</tbody>
</table>

Age has been aggregated into intervals of age. Missing values: 26

20) I am:

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working outside home:</td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>271</td>
</tr>
<tr>
<td>Self-employed</td>
<td>10</td>
</tr>
<tr>
<td>Working at home:</td>
<td></td>
</tr>
<tr>
<td>Temporary</td>
<td>2</td>
</tr>
<tr>
<td>Housewife/-husband</td>
<td>4</td>
</tr>
<tr>
<td>Student:</td>
<td></td>
</tr>
<tr>
<td>At middle secondary</td>
<td>15</td>
</tr>
<tr>
<td>At upper secondary</td>
<td>303</td>
</tr>
<tr>
<td>At college/university</td>
<td>29</td>
</tr>
<tr>
<td>Retired:</td>
<td></td>
</tr>
<tr>
<td>Due to old age</td>
<td>18</td>
</tr>
<tr>
<td>Due to ill health</td>
<td>3</td>
</tr>
<tr>
<td>Others:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>65</td>
</tr>
<tr>
<td>Missing values</td>
<td>22</td>
</tr>
</tbody>
</table>
21) My income is: (monthly before-tax income, SEK 1,000/month)

<table>
<thead>
<tr>
<th>Income</th>
<th>Frequency</th>
<th>Income</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>1</td>
<td>153</td>
<td>18</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>11</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>29</td>
<td>27</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>20</td>
<td>28</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>39</td>
<td>29</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>18</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>37</td>
<td>31</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>21</td>
<td>32</td>
<td>-</td>
</tr>
<tr>
<td>16</td>
<td>20</td>
<td>33</td>
<td>2</td>
</tr>
</tbody>
</table>

Missing values: 210
RISK AVERTION AND CONCERNS ABOUT
THE PROBLEMS OF SICK BUILDINGS

Gunnel Bångman
E-mail: gunnel.bangman@home.se
tel 063- 10 74 16, 070- 343 75 74

Abstract

The object of this study is to analyse if risk aversion is of significance for the concern people show about the indoor air quality (IAQ) at home and problems of ‘sick’ buildings. The analysis is based on stated preference data on the value of an elimination of uncertainty regarding the IAQ at home. The results show that risk aversion may be a reason for the decision to pay for having the IAQ at home examined and diagnosed. The estimated mean probability to pay for having the IAQ at home examined, not because of demand for good IAQ and good health but because of risk aversion, is about 0.3 - 0.4 at sample means. The results also show that risk aversion is, in this context, dependent on age and a more prominent motive for a concern about the problems of sick buildings among young people.
1 Introduction

The existence and effects of risk aversion are important issues in welfare economics. Risk behaviour is related to the issue of the marginal utility of income,\(^1\) and thereby also related to the problem of how to attain optimal social welfare. The occurrence of risk aversion, i.e. marginal utilities of income decreasing with income, is of importance when discussing the social value of equity and need for redistribution of incomes (see e.g. Weisbrod 1968, Breit and Culbertsson 1970, Mishan 1981, Layard and Walters 1994) and also an important argument for applying weighted cost-benefit analysis (Brent 1984 or 1996). So far, most studies of risk aversion have aimed at the estimation of a constant relative risk aversion, which is also the elasticity of the marginal utility of income (Blanchard and Fischer, 1989). The results of these studies have been various. According to Dasgupta (1998), empirical studies of choices under conditions of uncertainty have revealed utility functions implying a constant elasticity of the marginal utility, and relative risk aversion, of about 2. Other studies have produced a more complex picture of risk behaviour. Gambling experiments have, for example, indicated both convex and concave segments of the utility function (Stern 1977). Recent studies have found that risk behaviour varies among individuals. Johansson-Stenman et al. (2002) and Carlsson et al. (2003 and 2005) have studied individual risk aversion by experimental studies based on choices made between hypothetical societies or lotteries, which will determine the future income of the respondent’s imagined grand-children. In these studies risk aversion was more prominent among left-wing voters or children to such voters, but less prominent among students in business administration. In one of the studies, women were proven to have more risk aversion than men (Carlsson et al. 2005). As more recent empirical studies of risk behaviour indicate that risk aversion is a heterogeneous phenomenon, and the picture is still far from complete, there are reasons to continue the exploration of individuals’ utility functions and motives for economic behaviour.

The object of this study is to analyse the significance of risk aversion as a motive for the concern people show about the problems of ‘sick’ buildings and the risks for building-related ill health. The analysis assumes that individuals have von Neumann-Morgenstern expected utility functions. Consequently, risk aversion means that the utility function is concave and that uncertainty have negative effects on total utility (see for example Mas Colell et al. 1995).

\(^1\) Risk aversion implies concave individual utility functions and so does decreasing marginal utility of income.
Data on the willingness to pay (WTP) for an examination and diagnosis of the indoor air quality (IAQ) at home is collected by contingent valuation (CVM) and the probability that the stated WTP’s are due to risk aversion analysed. In the analysis, reactions to the conditions of uncertainty have to be separated from other reasons for demanding information about the IAQ at home, e.g. preferences for good IAQ at home and good health. This is done by relating the decision to pay for full information about the IAQ at home to the decision to pay for acquiring good IAQ, good enough to eliminate any risk of building-related ill health, at home.

Sick buildings are defined as buildings where environmental factors related to the construction and maintenance of the building affect the IAQ negatively and thereby provoke illnesses or symptoms of illnesses (building-related ill-health). The most common kinds of effects on health caused by sick buildings are allergies and similar illnesses/symptoms, for example other kinds of hypersensitive reactions and the sick-building syndrome (SBS) (Godish 1995, Nilsson 1995, Sandstedt and Tielman 1999, Sundell 2002). Environmental factors that may provoke such health effects are, for example, dampness and mould, emissions of chemical compounds from building materials and inadequate ventilation systems (Fredholm 1988, Maroni et al. 1995, Bornehag et al. 2001, Sundell 2002). There is a hypothesis, at least among researchers in the Social Sciences, that also social and psychological factors may affect the probability to develop SBS. According to Sandstedt and Tielman (1999), several studies have found that the risks of developing a SBS may increase because of personal or social factors like seasonal depressions, migraine, dissatisfaction with co-workers or leaders, too much work or too much pressure to perform well at work. There is also a hypothesis that psychological factors may cause symptoms similar to SBS, although in this case the association of symptoms to a building is a way of rationalising an underlying psychological or social problem (Sandstedt and Tielman 1999). However, psychological factors may not only affect the risk of developing building-related ill health, but also the reactions to uncertainty about these issues. Because of this the problem of sick buildings provides an interesting field for empirical research on risk behaviour.

The structure of the paper is as follows: In section 2 the economic and econometric models are presented. Then follow a presentation of the CVM survey (section 3) and the results of the analysis (section 4). The study is concluded in section 5.
The economic and econometric models

Compensated Variation (CV) is defined as the maximum WTP for an increase in consumption, without becoming worse off compared to the initial level of utility\textsuperscript{2} (Johannson 1993). A problem, when estimating the value of good IAQ at home, is that we know neither what IAQ people have at home nor the complex causality between health and IAQ, which would normally be required if using the Contingent Valuation Method (CVM) to register CV data. Therefore, the evaluation is based on subjectively determined probabilities of building related ill health (non-contingent valuation) and follows the model of Johannson (1995). To simplify the model I set aside the inter-temporal aspect of the problem i.e. any time lags between the dose of environmental disturbance and the health response, and I treat the state of health as timeless (the state of health is the discounted life-time state of health).

Let individual \( i \) (\( i = 1 \ldots n \)) have a health state-dependent indirect utility function\textsuperscript{3} \( V_{is}(p, y_i, h_i(z_s)) \) where \( p \) is a vector of prices of market goods, \( y_i \) is the income and \( h_i \) the state of health, being a function of the state of the IAQ, \( z_s \). The vector \( h_i \) includes all possible states of health, dependent on all possible states of the IAQ (the vector \( z \)):

\[
h_i(z) = (h_{i1}(z_1) \ldots \ldots h_{is}(z_s)), \ s = (1 \ldots S) = \text{states of the IAQ} \quad (1)
\]

The state of health is treated as if being a certain outcome, given a specific state of the IAQ. In real life the link between IAQ and health is uncertain and determined by a probability distribution. Because the probabilities of different building-related health effects, given a specific IAQ, will be constant throughout the analysis, they need not be modelled explicitly.

Let \((\pi_{i1} \ldots \ldots \pi_{iS})\) be the probability distribution, subjectively determined by the individual, corresponding to all possible states of the IAQ, with \( \pi_{is} \geq 0 \) for all \( s \) and \( i \) and \( \sum_s \pi_{is} = 1 \).

\textsuperscript{2} It could also be the minimum willingness to accept (WTA) for a decrease in consumption, making the initial level of utility remain unchanged.

\textsuperscript{3} Besides Johannson (1995), see for example Viscusi and Evans (1990).

\textsuperscript{4} Any other effects of the IAQ, other than health effects, are ignored here.
Given the probability distribution, the expected utility of the individual is:

\[ E_i(V_i) = \sum_s \pi_i V_i(p, y_i, h_i(z_s)) \quad \forall i \]  

(2)

where \( E \) denotes expectations. A change in IAQ, or information about the IAQ, results in a change in the subjective probabilities and in expected status of health from

\[ E_i^0(h_i(z)) = \sum_s \pi_i^0 h_i(z_s) \quad \text{to} \quad E_i^1(h_i(z)) = \sum_s \pi_i^1 h_i(z_s) \]  

(initial values have top index 0 and values after the change top index 1). The change in expected utility will then be:

\[ \Delta E_i(V_i) = E_i^1(V_i(p, y_i, h_i(z_s))) - E_i^0(V_i(p, y_i, h_i(z_s))) \]

\[ = \sum_s \Delta \pi_i V_i(p, y_i, h_i(z_s)) \quad \forall i \]  

(3)

Because the state of the IAQ is uncertain, the CV value will be the WTP that makes the expected utility \( E_i^1(V) \) equal to the initial expected utility \( E_i^0(V) \). The CV is not contingent on the real outcome but the expected one. The non-contingent, or state independent, CV is:

\[ \Delta \tilde{E}_i(V_i) = E_i^1(V_i(p, y_i - CV_i, h_i(z_s))) - E_i^0(V_i(p, y_i, h_i(z_s))) = 0 \quad \forall i \]  

(4)

By substituting equation (4) into equation (3) we get:

\[ \Delta E_i(V_i) = E_i^1(V_i(p, y_i, h_i(z_s))) - E_i^0(V_i(p, y_i - CV_i, h_i(z_s))) \]

\[ = \sum_s \Delta \pi_i V_i(p, y_i, h_i(z_s)) \quad \forall i \]  

(5)

Equation (5) shows that the CV is a measurement of changes in an individual’s subjective probabilities of different states of the IAQ, and consequently in states of health.

The CV of having the IAQ at home examined and diagnosed is a measure of the utility of an elimination of the uncertainty of the nature of the IAQ at home. To make a simple illustration of the evaluation problem, let the state of the IAQ, and thereby also health, have only two levels: good and poor. Good IAQ gives good health and poor IAQ gives poor health, i.e.:
\[ \pi_s = (\pi_{sg}, \pi_{sp}) \quad \text{and} \quad h_i(z) = (h_{ig}(z_g), h_{ip}(z_p)) \] (6)

\[ g = \text{good}, \quad p = \text{poor} \]

Provided the IAQ at home is not known, the decision to pay for having a diagnosis of the IAQ is based on a comparison of the initial expected utility and the utility of the certain outcome (state 1), being a function of the expected IAQ and status of health. Thus, the WTP for having a diagnosis of the IAQ made, denoted \( CV_i^D \), is:

\[ V_i^1(p, y_i - CV_i^D, E_i^0(h_i(z))) - E_i^0(V_i^0(p, y_i, h_i(z))) = 0 \quad \forall i \] (7)

where \( CV_i^D > 0 \) if the individual has risk aversion.

In equation (7) the \( CV_i^D \) is the certainty equivalent, i.e. the amount of money making the utility of the certain outcome equal to the expected utility of a gamble, for an individual having risk aversion (Mas-Colell et al. 1995). \( CV_i^D \) measures only the disutility of the uncertainty of the IAQ, the risk of the IAQ being poor and causing ill health remaining unchanged.

However, confounding is difficult to avoid in this case. Risk aversion is just one of several possible reasons for having positive WTP for a diagnosis of the IAQ at home. Another reason is preferences for good IAQ. A person may have positive WTP for a diagnosis of the IAQ at home, regardless of whether he/she has risk aversion, because the diagnosis is a part of his/her efforts to acquire good IAQ at home. Information about the status of the IAQ at home, and what kind of detrimental factors it is affected by, is needed for the possibility to improve the IAQ by a renovation of the building. It may also be needed, as a point of reference, for the possibility to acquire a better IAQ by moving flat.

Yet another possible reason is strategic behaviour with respect to asymmetric information at the market for dwellings. Quality of the indoor air resembles a “lemons” problem, i.e. an asymmetry of information between a seller, with own experience of the IAQ, and a buyer with no such experience. In such case, an owner believing that the quality is high may be willing to pay for a certification of the status of the IAQ that can be used at some later time to
raise the price of the flat whenever it will be sold. If so, a positive WTP for making a
diagnosis of the IAQ at home provides just an upper bound of the risk aversion of the owner.

It may be possible to isolate individuals that demand information about the IAQ at home
because of risk aversion, from those who demand it because of the motives mentioned above,
by using information about the demand for acquiring good IAQ at home. Provided the initial
IAQ is not known with certainty too be good, the WTP for acquiring good IAQ at home is
determined by the initial expected utility compared to the utility of the certain outcome with
good IAQ and good health. Having the risk for building-related ill health eliminated means
that $\pi_h = (\pi_{ig}, \pi_{ip}) = (1, 0)$ and the WTP, denoted $CV_i^T$, is:

$$V_i(p, y_i - CV_i^T, h_i, (z_+)) - E_i^0(V_i(p, y_i, h_i, (z_+))) = 0 \quad \forall i \quad (8)$$

$CV_i^T$ is a measure of the total effect on utility of the elimination of the uncertainty of the
quality of the IAQ and of the elimination of the risk of having a poor IAQ at home,
i.e. $CV_i^T \geq CV_i^D$. Thus, the difference ($CV_i^T - CV_i^D$) represents the value of the elimination of
the risk of building-related ill health, denoted $CV_i^G$.

Because the demand for a diagnosis of the IAQ at home may be motivated by preferences for
good IAQ and good health ($CV_i^G > 0$), risk aversion is likely to be the motive for a positive
$CV_i^D$ only when $CV_i^G = 0$. Risk aversion may of course exist also among people who have
preference for good IAQ and good health, but may not be crucial for the decision to pay for
an examination and a diagnosis of the IAQ at home. If strategic behaviour is the motive for
having a positive $CV_i^D$, then it ought to be a motive for having also a positive $CV_i^G$. If a
certification of the current IAQ at home can be expected to increase the price of the flat at a
future sale, then so can a certified improvement of the IAQ. Thus, risk aversion is likely to be
the motive for the demand for a diagnosis of the IAQ at home when $CV_i^D > 0$ and $CV_i^G = 0$. 

6
The probability to demand an examination and a diagnosis of the IAQ at home, because of risk aversion, can be estimated by the following model:

\[ \psi_i = f(s_j), \quad \Delta cv_i = 1 \text{ if } \psi_i = 1 \quad \forall \ i, j \]  \tag{9}

\[ \Delta cv_i = 0 \text{ if } \psi_i = 0 \]

where

\[ \Delta cv_i = 1 \quad \text{if } CV^D > 0 \text{ and } CV^G = 0 \]
\[ \Delta cv_i = 0 \quad \text{if } CV^D > 0 \text{ and } CV^G > 0 \]
\[ \Delta cv_i = 0 \quad \text{if } CV^D = 0 \]

\[ \psi_i = \text{the risk aversion motive for the decision to pay for a diagnosis of the IAQ at home (} \psi_i = 1 \text{ if the motive is valid, } \psi_i = 0 \text{ if not valid),} \]

\[ s_j = \text{socio-economic variables, } j = (1, \ldots, m), \text{ capturing differences in } \psi_i \]

In the model in equation (9), the risk aversion motive for the decision to pay for a diagnosis of the IAQ at home, \( \psi_i \), is an unobserved variable. The variable is indirectly identified by \( \Delta cv_i \), which describe the decisions to pay for an elimination of the uncertainty of the IAQ at home in relation to the decision to pay for an elimination of the risks of building-related ill health.

An estimation of the model in equation (9) can give information about the probability to pay for having a diagnosis of the IAQ because of risk aversion. The model can be estimated using the binary Logit model (Greene 1997):

\[ P = \Pr(E(\Delta cv = 1)) = \frac{e^{\beta s}}{1 + e^{\beta s}} \]  \tag{10}

and

\[ L = \ln \left( \frac{P}{1 - P} \right) = \beta ' s \]  \tag{11}

where

\[ P = \text{the probability of } \Delta cv = 1 \]
\[ L = \text{the natural logarithm of the odds ratio in favour of } \Delta cv = 1 \]
\[ s = \text{the vector of independent variables in equation (9)} \]
\[ \beta = \text{the vector of coefficients to the independent variables} \]
The survey

The survey was made in 2003 by a mail questionnaire to a randomly drawn sample of owners of and dwellers in flats in housing co-operatives. The reason for taking the sample among households in housing co-operatives is that the legal and practical conditions for this kind of housing made it most suitable for this survey. Because house owners make their own decisions about renovations of their homes, the indoor environment at home is not an externality. Therefore, they are less likely to have an unsatisfied demand, and a positive WTP, for an improvement of the IAQ and/or information about the IAQ at home. Households living in a housing co-operative or a rented flats, on the other hand, cannot make their own decisions regarding environmental disturbances related to building construction factors. Accordingly, they may have a demand, for good IAQ and/or information about the IAQ at home, that has not been met. Still, tenants in housing co-operatives have more responsibility for the environment in their own dwelling, compared to tenants in rented flats. Therefore, they are less likely to refuse to state a WTP with reference to the house owner being responsible for building construction matters and the IAQ.

3.1 The questionnaire and the WTP questions

This evaluation considers only some of the existing indoor environmental problems, the ones commonly named as “sick building problems” (see the questionnaire in appendix). In the questionnaire the WTP questions are preceded by information about sick building problems, in order to give the respondents an accurate definition of the kind of problems in building construction and ill health treated in the evaluation. The first WTP question regards the value of having the IAQ at home examined and diagnosed, i.e. an elimination of the uncertainty of the IAQ at home ($CV^D$). The second WTP question regards the value of acquiring good IAQ at home; good enough to eliminate any risk of building related ill health such as allergies and similar illnesses/symptoms. Because the respondents are not asked to disregard the problem of uncertainty of the IAQ at home and deduct the WTP stated at the first WTP question, when answering the second one, the WTP of the second question is expected to embrace both the value of an elimination of the uncertainty of the IAQ at home and the value of an elimination of the risk of building-related ill health, i.e. it is expected to measure $CV^T$. 
The second WTP question is formulated as an offer to move to a new apartment, located in the same building or block as the current one and identical to the current one in all respects except for the IAQ. Thus the stated WTP is the net WTP after a reduction of any private cost for moving flat. This may result in a downward bias in the estimation of $CVT$, and consequently an overrating of the influence of risk aversion as a motive for demanding information about the IAQ at home.

The WTP questions are open-ended. Closed-ended referendums have, so far, been considered more reliable. This is, for one thing, because the lack of incentives for strategic behaviour such as free-riding (Hanemann 1984 or 1994). The closed-ended referendum does, however, have the problem of anchoring (or “psychometric bias”) which, according to Green et al. (1998), may be a more serious problem than free-riding. As the WTP questions in this survey do not concern public goods, but the private IAQ at home, there are no obvious incentives for strategic behaviour such as free-riding.

A problem when using CVM is the uncertainty of the stated WTPs, as the good offered and the decision to buy are both only hypothetical (hypothetical bias). One way to avoid hypothetical bias is to combine the WTP question with a follow-up question where the respondents have to state how sure they are of their stated WTP. According to the results of Johannesson et al. (1998), hypothetical answers in general (in a dichotomous choice the proportion of yes answers, and thereby also the mean WTP) overestimate the real values while hypothetical answers that are stated with certainty underestimates the real values. The results of Blumenschein et al. (1998), (2001) and (2005) differ from Johannesson et al. (1998) in that they found that estimations based on hypothetical answers that are absolutely certain (according to the follow-up question) may lead to an accurate estimation of the WTP. Another method suggested for removal of hypothetical bias is the “cheap talk” approach. In this case the respondent is informed about the problem of hypothetical bias before being asked to state his/her WTP, and asked to consider and adjust for this when stating his/her WTP. According to Blumenschein et al. (2005), cheap talk does not seem to remove the hypothetical bias. Yet another method is the stochastic payment card approach, used by Wang and Whittington (1999). In this approach, respondents are asked to state their likelihood to pay for a series of prices and the distribution of WTP over various prices is estimated. When applied by Wang et al. (1999), this approach turned out to produce lower estimates of WTP than the traditional referendum contingent valuation approach (without follow-up question and correction for
hypothetical bias). The stochastic payment card approach is, however, a substitute only for the closed-ended referendum.

I deal with the problem of uncertainty by using a follow-up questions. Like e.g. Fredman and Emmelin (2001), I have used a scale of 0%-100% certainty for the follow-up questions. An alternative procedure, in my opinion less flexible, would have been to let the respondents choose between the alternatives “fairly sure” and “absolutely sure” (Blumenschein et al. 2005, Johannesson et al. 1998, 2005).

Another problem to be dealt with is that the stated WTP may be zero for other reasons than lack of preferences for the good (Calia and Strazzera 1999). The respondent may for example be unwilling to pay because he/she thinks it is the duty of the government or the building association to provide people with good IAQ. I have dealt with this problem in the same way as, for example, Söderqvist (1995), by asking respondents stating zero WTPs to give their reasons for doing so. All cases where the WTP is stated as zero as a form of protest have been excluded from the analysis. Excluding them leads to an unbiased estimation, provided there is no sample selection bias (Calia and Strazzera 1999).

3.2 The sample

The questionnaire was distributed to 850 randomly chosen persons and was followed by two reminders. The number of questionnaires returned was 366 and the response rate 43%. The response rate is lower than I hoped for⁵. The low number of participants makes the results more susceptible to random variations but does not cause any systematic bias if the sample is representative for the population. Some questionnaires (36) were returned by persons who are registered as owners of an apartment in a housing co-operative but living in a private house or rented flat. These cases have been excluded from the set of data.

⁵ In, for example, the survey “Bostads- och hyresundersökningen (BHU)”, made by Statistics Sweden in 2002 (see Statistics Sweden (2005)), mail questionnaires to households living in flats in housing co-operatives or rented flats resulted in a participation rate of 55% and 56% respectively while interviews by telephone and households with owners of houses resulted in a participation rate of 65%.
Table 3.1 Descriptive statistics of the sample; socio-economic variables.

<table>
<thead>
<tr>
<th>Respondents:</th>
<th>366</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases in analysis:</td>
<td>330</td>
</tr>
<tr>
<td>Gender:</td>
<td>Male 44% Female 56%</td>
</tr>
<tr>
<td>Age:</td>
<td>20 – 29 18% 30 – 39 23% 40 – 49 19% 50 – 59 28% 60 + 12%</td>
</tr>
<tr>
<td>Mean size of the household:</td>
<td>Adults 1.7 Children at home full-time 0.3 Children at home part-time 0.1</td>
</tr>
<tr>
<td>Mean income per capita and month:</td>
<td>SEK 33,700 (SEK 22,300)</td>
</tr>
</tbody>
</table>

The distribution of the participants by gender is fairly even (see table 3.1). The distribution by age corresponds quite well to that of the national population (Statistics Sweden 2004 b), except for the age range 50 – 59 being over-represented and the age range 60+ being under-represented. The average household consists of 2 persons, the same as that of the Swedish population in 2000 (Statistics Sweden 2004 a). The average monthly income per adult is about SEK 33,000/month, which is considerably higher than the mean income of employment in Sweden in 2003 of SEK 24,000/month (Swedish Statistics, 2004 c). In some cases, however, the stated monthly income of the household is surprisingly large (between SEK 200,000 and SEK 1,200,000). In at least some of these cases there are indications that the participants may have stated their annual income instead of their monthly income. When incomes of more than SEK 200,000/month are excluded (11 observations) the average per capita income is about SEK 22,300/month.

About 18% of the households in the sample have had their indoor environment at home examined by experts (see table 3.2). Environmental disturbances were found in 40% of the apartments examined, i.e. 7% of the total number of apartments. In about 41% of the households, at least one member suffers from an allergy or similar illnesses/symptoms (AS). Among them, about 10% are sure their ill health is related to the building (BRAS). These results correspond fairly well to the results of estimations of the prevalence of problems of sick buildings.
Table 3.2  The prevalence of sick building problems.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>Perhaps</th>
<th>No</th>
<th>Don’t know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of AS$^1$</td>
<td>40.9</td>
<td>7.7</td>
<td>49.5</td>
<td>1.8</td>
<td>100</td>
</tr>
<tr>
<td>Presence of BRAS$^1$</td>
<td>4.1</td>
<td>(10.1)</td>
<td>26.3</td>
<td>4.1</td>
<td>49.9</td>
</tr>
<tr>
<td>The IAQ has been examined</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detrimental factors were found</td>
<td>17.7</td>
<td>50.7</td>
<td>31.6</td>
<td>(100)</td>
<td>(100)</td>
</tr>
</tbody>
</table>

$^1$ AS = Allergy and similar illnesses/symptoms
BRAS = AS that are building related

The WHO has estimated that sick buildings in developed countries amount to 10%-30% of the stock of newly built or renovated buildings, and the population showing symptoms to be 10%-30% of people spending their time in sick buildings (Fredholm 1988, Nilsson 1995, Sandstedt and Tielman 1999). Swedish estimations have found that 9% of apartment buildings and 10% of houses in general have indoor environmental problems (Sandstedt and Tielman 1999). Thus, the sample seems to be representative of the population both regarding socio-economic variables and the prevalence of sick-building problems.

4 Analysis

This section starts with descriptive results and a non-parametric test of the hypothesis that risk aversion plays a significant role for the decisions to pay for an examination and a diagnosis of the IAQ at home. Then follows the results of an econometric analysis of the probability to pay, for an examination and a diagnosis of the IAQ at home, due to risk aversion. The analysis is based on the full sample and on a sub-sample of respondents being 70%-100% certain of their stated WTPs.$^6$ The responses from those who stated their WTP with 100% certainty ought to produce the most accurate results. Such a sub-sample would, however, be very small and less reliable from a statistical point of view.

$^6$ The cut-value of 70% corresponds roughly to the cut-values 7.0-8.4 (on the scale 0-10) tested in Blumenschein et al. (2001).
In the analysis, the value of an elimination of the conditions of uncertainty of the IAQ at home, $CV^O$, is measured by the willingness to pay for having an examination and a diagnosis made of the IAQ at home, denoted $WTP^O$. The willingness to pay for acquiring good IAQ at home, denoted $WTP^T$, is a measure of the total value of an elimination of the conditions of uncertainty as well as the risk of building-related ill health ($CV^T$). Thus, the value of an elimination of the risk of building-related ill health, $CV^G$, is measured by the difference between the WTP for acquiring good IAQ at home and the WTP for an examination of the IAQ at home, i.e. $WTP^T - WTP^O$. This difference will be denoted $WTP^G$.

### Table 4.1 Descriptive statistics of $WTP^O$ and $WTP^T$

<table>
<thead>
<tr>
<th></th>
<th>WTP$^O$ Sample</th>
<th>WTP$^O$ Sub-sampled$^1$</th>
<th>WTP$^T$ Sample</th>
<th>WTP$^T$ Sub-sampled$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
<td>292</td>
<td>153</td>
<td>291</td>
<td>146</td>
</tr>
<tr>
<td><strong>Mean WTP (SEK)</strong></td>
<td>840</td>
<td>814</td>
<td>14,574</td>
<td>12,281</td>
</tr>
<tr>
<td><strong>St. error of mean</strong></td>
<td>86</td>
<td>141</td>
<td>2,240</td>
<td>2,914</td>
</tr>
<tr>
<td><strong>St. deviation</strong></td>
<td>1,468</td>
<td>1,748</td>
<td>38,223</td>
<td>35,207</td>
</tr>
<tr>
<td><strong>Percentile, 25%</strong></td>
<td>200</td>
<td>200</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td><strong>Percentile, 75%</strong></td>
<td>1,000</td>
<td>1,000</td>
<td>10,000</td>
<td>10,000</td>
</tr>
<tr>
<td><strong>Maximum value</strong></td>
<td>20,000</td>
<td>20,000</td>
<td>300,000</td>
<td>300,000</td>
</tr>
<tr>
<td><strong>Proportion of:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WTP &gt; 0</strong></td>
<td>80%</td>
<td>81%</td>
<td>51%</td>
<td>42%</td>
</tr>
<tr>
<td><strong>WTP$^O &gt; 0$ if WTP$^T &gt; 0$</strong></td>
<td>98%</td>
<td>98%</td>
<td>42%</td>
<td>42%</td>
</tr>
<tr>
<td><strong>WTP$^O &gt; 0$ if WTP$^T = 0$</strong></td>
<td>63%</td>
<td>48%</td>
<td>63%</td>
<td>63%</td>
</tr>
</tbody>
</table>

$^1$ Consists of respondents stating their WTP with 70% - 100% certainties.

$^2$ Two extremely large values (SEK 500,000 and SEK 1,000,000) have, for the sake of caution, been excluded. They are large enough to possibly regard the WTP for buying a new apartment, instead of the WTP for trading the old apartment for a new one, and have a substantial effect on the estimation of the mean WTP.

The descriptive results, in table 4.1, show that about 80% have a positive WTP for an elimination of the uncertainty of the IAQ at home but only about 40% - 50% have a positive WTP for acquiring good IAQ at home. Among the respondents who stated a positive WTP for acquiring good IAQ at home ($WTP^T > 0$) almost everyone is willing to pay for having the IAQ at home examined. Among the respondents who stated no WTP for acquiring good IAQ
at home ($WTP^T = 0$) about 50% - 60% are willing to pay for a diagnosis of the IAQ at home. This is a surprising result, as $WTP^T$ is expected to be at least as large as the WTP for having the IAQ at home examined and diagnosed ($WTP^D$). However, in this case there may be a downward bias in the $WTP^T$ because good IAQ is acquired by moving flat and there may be a private cost for moving flat. Because of this the $WTP^T$ can be less than $WTP^D$ (or zero even though $WTP^D$ is positive). Because WTP is defined only for non-negative values a negative value of the difference ($WTP^T - WTP^D$) implies a zero value of $WTP^G$.

In table 4.2 the results of the McNemar non-parametric tests of two related samples are reported. In this test the null hypothesis is that of no difference between the binary responses of two matched samples or one sample measured twice. The binary responses in table 4.2 correspond to the decision to pay or not to pay for having the IAQ at home examined and diagnosed ($WTP^D > 0$ or $WTP^D = 0$) and the decision to pay or not to pay for having the risk of building-related ill health eliminated ($WTP^G > 0$ making $WTP^T > WTP^D$, or $WTP^G = 0$ making $WTP^T = WTP^D$). In this case, the null hypothesis is that randomness, instead of risk aversion, may explain the fact that some individuals have stated a positive WTP for a diagnosis of the IAQ even though they have not (indirectly) stated a positive WTP for an elimination of building related health risks, i.e. $WTP^G = 0$ and $WTP^D > 0$. (The reverse difference in decisions, $WTP^G > 0$ and $WTP^D = 0$, occurs only in 3 or 0 cases, probably because the IAQ at home has already been examined, and is not likely to affect the test results.)

**Table 4.2 The McNemar non-parametric test of 2 related samples**

<table>
<thead>
<tr>
<th>Sample / sub-sample</th>
<th>$WTP^G = 0$</th>
<th>$WTP^G &gt; 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$WTP^D = 0$</td>
<td>47 / 22</td>
<td>3 / 0</td>
</tr>
<tr>
<td>$WTP^D &gt; 0$</td>
<td>92 / 37</td>
<td>128 / 47</td>
</tr>
</tbody>
</table>

Test statistics:

<table>
<thead>
<tr>
<th>N</th>
<th>Asymp. Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>270 / 106</td>
<td>0.00 / 0.00</td>
</tr>
</tbody>
</table>

According to the level of significance of the test, the null hypothesis can be rejected, both for the sample and the sub-sample. Thus, the differences in decisions to pay or not to pay for the two hypothetical offers cannot be explained by randomness. This, the hypothesis that risk
aversion may be a motive, for the demand for an examination of the IAQ at home, is still valid.

The probability to pay to have the IAQ at home examined because of risk aversion, is also estimated using a binary Logit regression, based on the models in equations (9) - (11). The independent variables are the personal and family attributes age, gender and size of the household. It is relevant to include the size of the household as it represents having a family (partner and/or children), which could possibly affect a person’s risk behaviour. The model also includes a variable controlling whether or not the IAQ at home has already been examined. The estimation based on the full sample includes also the degree of certainty of the stated WTPs among the independent variables. The sample means for the independent variables, of the full sample and on the sub-sample, are reported in table 4.3.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Values of sample / sub-sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (female = 1))</td>
<td>Max</td>
</tr>
<tr>
<td>Age1</td>
<td>6</td>
</tr>
<tr>
<td>Size of the household</td>
<td>6</td>
</tr>
<tr>
<td>IAQ already examined (yes = 1)</td>
<td>1</td>
</tr>
<tr>
<td>Certainty of stated WTP (70%-100% sure =1)</td>
<td>1</td>
</tr>
</tbody>
</table>

1 Age = age groups: 2 for age 20 – 29, 3 for 30 – 39 etc up to 6 for 60 +.

The results of the estimations are reported in table 4.4. In the estimation on the full sample, none of the independent variables is significant. On the other hand, this estimation is not reliable, according to the test statistics. The estimated model does not make better predictions than when using only a constant. The level of significance of the Hosmer & Lemeshow Goodness-of-Fit Test, testing the null hypothesis of no difference between predicted and actual values of the dependent variable, does not reach the preferred level of 95% for any of the estimations. It is, however, at an almost acceptable level in the estimation on the sub-sample.
Table 4.4 The probability to pay for a diagnosis of the IAQ at home because of risk aversion

<table>
<thead>
<tr>
<th></th>
<th>Estimation Full sample</th>
<th>Marginal effects $^1$</th>
<th>Estimation Sub-sample</th>
<th>Marginal effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>$p$</td>
<td>$\hat{c}P_j/w_{sj}$</td>
<td>$\beta$</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>-0.14</td>
<td>0.20</td>
<td>-0.03</td>
<td>-0.50</td>
</tr>
<tr>
<td><strong>Gender (female = 1)</strong></td>
<td>0.44</td>
<td>0.10</td>
<td>0.10</td>
<td>-0.03</td>
</tr>
<tr>
<td><strong>Size of the household</strong></td>
<td>0.11</td>
<td>0.40</td>
<td>0.02</td>
<td>+0.08</td>
</tr>
<tr>
<td><strong>IAQ already examined</strong></td>
<td>-0.22</td>
<td>0.56</td>
<td>-0.05</td>
<td>+0.32</td>
</tr>
<tr>
<td><strong>Certainty of stated WTP</strong></td>
<td>+0.05</td>
<td>0.86</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>-0.54</td>
<td>0.34</td>
<td>1.10</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Statistics:

- $-2 \ln L_0$ | 337.9 | 137.1 |
- $-2 \ln L$   | 331.4 | 128.8 |
- LR index     | 0.02  | 0.06  |
- Hosmer & Lemeshow Goodness-of-Fit Test, sign. | 0.57  | 0.90  |

Correct predictions, %:

- by a constant (0) | 64.6 | 65.1 |
- by the model      | 64.6 | 67.0 |
- $N$               | 260  | 106  |

Mean predicted probability | 0.35 | 0.36 |

$^1 \hat{c}P_j/w_{sj} = [e^{\beta_j(1+e^{\beta_j})}] W_j = P(1-P) \beta_j$, see e.g. Maddala (1992) and Amemiya (1981). The marginal effect is developed at sample means.

According to the estimation based on the sub-sample, the probability to pay for an examination of the IAQ at home because of risk aversion is significantly associated to age. The probability to pay because of risk aversion is, at sample mean values, 0.36. The mean age of the sample is 4 (i.e. 40 - 49 years). The marginal effects of the independent variables ($\partial P_j/\partial s_{ji}$) indicate that the probability to pay for an examination of the IAQ at home, because of risk aversion, is about 0.5 for people in their thirties but only about 0.2 for people in their fifties.
5 Conclusions

About 80% of the households have a positive WTP for having the IAQ at home examined and diagnosed, and thereby the conditions of uncertainty of the IAQ at home eliminated. However, only about 45% of the households have also a positive WTP for an improvement of the IAQ that eliminates the risks of building related ill health. According to the results of the McNemar non-parametric test, the large portion of households that do not demand good IAQ but still have a positive WTP for having the IAQ at home diagnosed cannot be explained by randomness. Thus, the test does not dismiss the hypothesis that risk aversion is the motive for the demand for having the IAQ at home examined and diagnosed.

According to the econometric analysis, the importance of risk aversion, as a motive for the demand for a diagnosis of the IAQ at home, is dependent on age. Risk aversion is a more prominent motive for young people. The estimated mean probability to pay because of risk aversion is about 0.3 – 0.4 for the sample (having the mean age 4, i.e. 40 - 49 years). The probability to pay may be about 0.5 for people in the thirties but only about 0.2 for people in the fifties. Because the estimation of the value of acquiring good IAQ at home may have a downward bias, the estimation of the probability to pay, for having the IAQ at home examined and diagnosed, only because of risk aversion should be regarded as an upper bound.

References


Statistics Sweden, (2005), 'Bostads och Hyresundersökningen (BHU)',

(Eds.), Studies in modern economic analysis, Oxford: Basil Blackwell.

Environment and Energy, Technical University of Denmark, Lyngby, DK.

Söderqvist, T. (1995), Four essays on Reductions of Health Risks Due to Residential Radon

Viscusi, W.K. and Evans, W. N. (1990), ‘Utility Functions that Depend on Health Status;
Estimates and Economic Implications’, The American Economic Review, 80(3),
353-374.

Sofia, Bulgaria’, No 2280, Policy Research Working Paper Series from the World Bank,
Washington DC.

Brookings Institution.
Questionnaire

**Question no 1.** Your gender is:  □ Man □ Woman

**Question no 2.** Your age is:  □ 20 – 29 □ 30 – 39 □ 40 – 49 □ 50 - 59 □ 60 -

**Question no 3.** In what part of Sweden do you live? Postal code: ___________

**Question no 4.** How many persons are living in your household?

Number of: _____ adults _____ children younger than 18, staying full time
_____ children younger than 18, staying part time

**Question no 5.** What kind of dwelling do you have?

□ Apartment in a housing co-operative □ My own house □ Rented flat

---

**Question no 11.** Do you, or any other member of your household, have any kind of allergy (asthmatic symptoms, hay-fever, eczema) or symptoms similar to allergies?

□ Yes □ No □ Perhaps □ Don’t know

If your answer is yes: Do you believe the illnesses/symptoms may depend on or become aggravated because of the quality of the air at your home?

□ Yes □ No □ Perhaps □ Don’t know

---

**Question no 12.** Are you worried that you, or any other member of your household, will suffer from new or aggravating problems with building-related ill-health in the future (e.g. allergies, hyper-sensitivity or asthma) because of the quality of the indoor air at your home?

Not at all worried

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

Very much worried
Question no 15. Have the indoor environment at your home been examined by experts, so that you know for certain whether or not the quality of the indoor air may affect your health?

☐ Yes ☐ No ☐ Don’t know

If your answer is yes: What was the result of the examination?

☐ No problems
☐ Problems with dampness and mould
☐ Inadequate ventilation
☐ Emissions of chemical compounds that may affect health negatively
☐ Other kind of problem (What?: ..................................................)

Question no 16. In your opinion, how important is it to have the indoor environment at home examined by experts, so as to know for certain whether or not the indoor environment may affect health negatively.

Not at all important Very important
1 ------------ 2 ------------ 3 ------------ 4 ------------ 5

Instructions to the respondents before answering the WTP questions

Read the facts about problems of sick buildings below before you continue:

The kind of health problems people may suffer from, because of poor indoor air quality, are mainly allergies, asthma, other hypersensitive reactions or the Sick-Building Syndrome (SBS). SBS produces symptoms similar to allergies and other hypersensitive reactions, such as: 1. Smarting and itching sensations and/or reddening of skin. 2. Irritated mucous membranes in eyes, nose or throat, e.g. hoarseness, running nose or eyes. 3. Headache, tiredness, dizziness, nausea, reduced capacity to concentrate etc.

The most common reasons for a building to be “sick” and provoke health problems are:

1. Dampness and mould.
2. Inadequate ventilation and ventilation systems.
3. Chemical compounds in building and decoration materials (e.g. in glue, paint, putty) that may produce negative effects when emitting from the materials.

Question no 17. Suppose you are offered to have an examination made, by experts, of the quality of the indoor air at your home. The experts would investigate your apartment regarding the presence of chemical compounds or biological substances that may provoke symptoms or ill health, the presence of dampness and mould and the function of the ventilation system.

What is the maximum amount you are willing to pay for having such an investigation made in your apartment?

Maximum amount SEK _____________________

How certain are you about the amount you have stated?

Very uncertain Definitely sure
0%---10---20---30---40---50---60---70---80---90---100%

If you have stated 0 as your maximum amount (or no amount at all), please explain why:
**Question no 18.** Suppose you were offered the opportunity to trade your present apartment for a new one. The new apartment is guaranteed to have good ventilation and be completely free from dampness and matters (mould and other biological substances or chemical compounds) that may cause health problems like allergy, other hypersensitive reactions or the sick-building syndrome. The new apartment is, in all other respects, identical to your present one (the same housing cost and located in the same building or block as the present one). To trade your present apartment for the new one you have to make a lump-sum payment, corresponding to the differences in value of the apartments. What is the maximum amount you would be willing to pay, to trade you present apartment for the one offered one with guaranteed good indoor air quality?

Maximum amount SEK ________________

How certain are you about the amount you have stated?

<table>
<thead>
<tr>
<th>Very uncertain</th>
<th>Definitely sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%---10---20---30---40---50---60---70---80---90---100%</td>
<td></td>
</tr>
</tbody>
</table>

If you have stated 0 as your maximum amount (or no amount at all), please explain why:

**Question no 19.** In order to analyse differences in the value of good indoor air quality among people at different income levels, information about the level of the total income of your household is needed.

The total monthly income (pre-tax) of the household is (rounded off to thousands of SEK):

SEK __________________ /month
MOTIVE FOR VALUING GOOD INDOOR AIR QUALITY:
ALTRUISM OR SELF-INTEREST?

Gunnel Bångman

E-mail: gunnel.bangman@home.se

tel 063-10 74 16, 070-343 75 74

Abstract

The object of this study is to examine the existence of altruistic preferences. This is made by an analysis of the willingness to pay for good indoor air quality, i.e. for an elimination of the risk of building-related ill health. The existence of altruistic preferences is analysed using a model suggested by Johansson (1994 or 1995), where questions on the willingness-to-pay are posed in different ways in order to reveal possible differences in motives for economic behaviour. The results do not support the hypothesis of altruistic preferences, either pure or paternalistic.
Traditional neo-classical economic theory is based on the concept of “the economic man”, who is characterised by being rational and selfish and maximising the utility experienced by his own consumption. However, environmental economists have for some time been aware of the presence of motives for economic behaviour other than selfishness, such as bequest motives, gift motives or sympathy for people and animals, inducing existence values of environmental amenities (Pearce and Turner 1990). The issue of motives for economic behaviour, and the possible existence of altruistic preferences, has received even more attention in recent years, particularly among experimental economists. According to Fehr and Schmidt (2001) altruism can explain some of the results of experimental economic studies, which self-interest cannot, e.g. observed behaviour such as the propensity to give in ‘Dictator games’, voluntary contributions to public goods in ‘Public Goods Games’ and kind behaviour of the respondent in ‘Trust Games’ and ‘Gift Exchange Games’. However, altruism cannot explain negative behaviour towards other people and is not the only plausible motivation for un-selfish economic behaviour. Studies of social preferences have often been studies of the existence of social inequality aversion, which is a motive based on fairness implying altruism towards poor people and envy towards rich people. Johansson-Stenman et al. (2002) and Carlsson et al. (2003) have made experimental studies where subjects have to choose the future society they prefer for their hypothetical future grandchildren and risk aversion is interpreted as social inequality aversion. According to their results, the majority of individuals have social inequality aversion, reflected by risk aversion. Also in Carlsson et al. (2005), where risk aversion and inequality aversion are estimated separately, the majority of individuals seem to be willing to sacrifice income for a more equal society. The inequality aversion parameter does, however, vary among individuals. Amiel et al. (1999) have studied the presence of inequality aversion by “leaky bucket” experiments among groups of university students, and found that the aversion to inequality seems to be relatively low.

People seem to be heterogeneous as to their motives for economic actions. Some people are altruistic, some are selfish, some have other motives and some may appear to behave selfishly in certain situations and altruistically in others (Fehr and Schmidt 2001). Sometimes, seemingly altruistic behaviour may be motivated by the pleasure of giving, i.e. the “warm-glow” effect (Andreoni 1990). One example of heterogeneous behaviour is that men and

---

1 See Mas-Colell et al. (1995) or any textbook in Microeconomics.
women seem to behave differently. Andreoni and Vesterlund (2001) found that men are more likely to be either perfectly selfish or perfectly selfless. Another example is that left-wing voters and women are more averse to inequality than others (Carlsson et al 2005). Economists, on the other hand, seem to care less about inequality than other people (Fehr and Schmidt 2004). Moreover, the economic context may be of importance for selfless behaviour and cooperation. The results of Andreoni (1995), for example, indicate that the utility of doing good exceeds the utility of not doing bad. However, the picture of the motives (social preferences such as social inequality aversion, altruism, envy or even spitefulness) that drive different parts of the population in different economic contexts is still far from clear.

The purpose of this study is to investigate the motives, altruism or selfishness, when valuing good indoor air quality (IAQ). This is done using contingent valuation (CVM) data on the value of a public project carrying out a renovation of all sick buildings (SB) and thereby ensuring good IAQ and eliminating the risk of building-related illnesses/symptoms such as allergies, asthma, other kinds of hypersensitive reactions and the Sick Building Syndrome (SBS). The method of analysis follows a model developed by Jones-Lee (1991 and 1992) and Johansson (1994 or 1995). This model suggests three different ways of posing WTP questions producing different values of compensated variation and thereby capturing different kinds of preferences. A comparison of these different values will make it possible to trace pure altruism or paternalistic preferences. In this study, a fourth value will also be used, namely the WTP for a private good consisting of the acquisition of good IAQ at home. This value is used as a proxy for the value of the individual’s consumption of good IAQ and as a point of reference when analysing the stated value of the public project. It is also used for the detection of free-riding, when stating the WTP for the public good of acquiring good IAQ for all buildings, and thereby also a means of detecting altruistic preferences. A selfish person, but not an altruistic one, has incentives to free-ride when stating the WTP for the public good, but not for the private good.

The structure of the paper is as follows: In section 2 the economic model underpinning the analysis is presented. Section 3 presents the CVM survey and the sample, and section 4 the results of the analysis. The paper is concluded in section 5.
Detection of altruism when measuring welfare changes by Compensated Variation

The model follows the one set up by Jones-Lee (1991, 1992) for the analyses of the value of a statistical life, and further developed for applications in cost-benefit analysis by Johansson (1994, 1995). The model is simplified in that it sets aside any temporal aspects, as it is formulated as a one period model. This is a simplification that will not affect the results of the analysis.

Let individuals $i$ and $j$ ($i, j = 1, ..., n$) have preferences over their own as well as other people’s good health and levels of wealth. They are assumed to have the following well-behaved indirect utility function$^2$:

$$ v_i = v_i(\pi_i(z), y_i, \ldots, \pi_i(z), y_i, \ldots, \pi_n(z), y_n) \quad \forall i $$

(1)

where $y_i =$ level of wealth, represented by the net of tax income

$\pi_i(z) =$ the probability of good health

$z =$ the level of the indoor air quality at home

The function $v_i(\cdot)$ is assumed to always strictly increase in $\pi_i$ and $y_i$. For a selfish person both $\frac{\partial v_i}{\partial \pi_j}$ and $\frac{\partial v_i}{\partial y_j}$ are zero, for all $j \neq i$, but for the purely altruistic person they are strictly positive. For a person who is a paternalistic altruist, in this case a person who cares only about the status of the health of others, $\frac{\partial v_i}{\partial \pi_j} > 0$ and $\frac{\partial v_i}{\partial y_j} = 0$, for all $j \neq i$. $^3$

A public project ensuring good IAQ in all buildings by renovating all sick buildings, and thereby eliminating the risk for building-related ill health, will change the probability of good health from $\pi_i^0$ to $\pi_i^1$ and the utility from $v_i^0$ to $v_i^1$. The project is financed by a once-and-for-all lump-sum tax $T_i$. By asking individuals for their WTP in different ways, we get different monetary measures of utility (Johansson 1994, 1995). If a person $i$ is asked to state his/her total WTP for this project, then the total non-contingent compensated variation $CV$ is:

$^{2}$ The indirect utility function is the result of the optimisation problem: max $U(q, \pi_i)$ regarding $q$ and subject to the budget constraint $pq \leq y_i$, where $q$ is a vector of market goods and $p$ a vector of market prices. For practical reasons the vector $p$ is not explicit among the arguments of the indirect utility function

$^3$ The indirect utility function decreases in market prices, even though the market prices are not explicit.
\[ v_i(\pi_i^1, y_i - T_i, \ldots, \pi_i^1, y_i - CV_i, \ldots, \pi_n^1, y_n - T_n) = v_i^0 \quad \forall i \] (2)

If, on the other hand, individual \( i \) is asked for his/her WTP, on condition that everybody else has to pay an amount corresponding to their maximum WTP, and thereby remain at their initial level of utility, then the conditional compensated variation \( CCV \) is:

\[ v_i(\pi_i^1, y_i - CCV_i, \ldots, \pi_i^1, y_i - CCV_i, \ldots, \pi_n^1, y_n - CCV_n) = v_i^0 \quad \forall i \] (3)

where \( T_j = CCV_j, \forall j \neq i \)

If he/she is asked for her/his WTP when disregarding any effects of the project for other people, i.e. when acting selfishly, then the monetary measure is:

\[ v_i(\pi_i^0, y_i, \ldots, \pi_i^1, y_i - PCV_i, \ldots, \pi_n^0, y_n) = v_i^0 \quad \forall i \] (4)

If all three measures are estimated then the following conditions holds:

\[ CV_i \geq CCV_i = PCV_i \quad \text{for pure altruism} \] (5a)

\[ CV_i = CCV_i \geq PCV_i \quad \text{for paternalistic altruism} \] (5b)

\[ CV_i = CCV_i = PCV_i \quad \text{when acting selfishly} \] (5c)

According to equations (2) - (5), the pure altruist values increases in other people’s consumption of good IAQ and probability of good health, only if such effects lead to higher levels of total utility for other people. The paternalistic altruist values such increases even if they do not lead to a net increase in other people’s total utilities. A person acting selfishly do not value any changes in other peoples consumption of good IAQ and probability of good health.

If good IAQ is provided as a private good (the individual acquires an improvement in his/her IAQ by a renovation of his/her flat or by moving to another one), then only the probability of good health for oneself is affected. However, the monetary measure for the private good of acquiring good IAQ at home, denoted \( CV_i^{PR} \), is not equal to \( PCV_i \) as people consume good
IAQ also at other places than home (e.g. at the work place, at the homes of friends and relatives). Therefore the value of the total individual consumption of good IAQ in all buildings may be larger than the value of the individual consumption of good IAQ at home, i.e. $PCV_i \geq CV_i^{PR}$.

The conditions in equations (5a) – (5c) form the basis for the empirical analysis. They are tested using data on the WTP for a public project, ensuring good IAQ in all buildings, measured in different ways for different sample groups, i.e. measured by $CV$, $CCV$ and $PCV$ for the sample groups A, B and C respectively. In the empirical analysis possible altruistic preferences will be detected by an analysis of differences in the mean WTP and in the decision to pay or not to pay for the public project between the sample groups and compared to the private good of acquiring good IAQ at home.

3. Data and data collection

The evaluation concerns some of the most frequent kinds of indoor environmental problems and ill health related to the construction and maintenance of buildings, i.e. the presence of dampness and mould, building construction material emitting chemical compounds detrimental to health and inadequate ventilation systems (Maroni et al. 1995). Such factors affect the IAQ negatively and thereby cause building-related ill health. The effects on health treated in the evaluation are the most common ones, i.e. allergies and similar illnesses/symptoms, such as asthma, other kinds of hypersensitive reactions and the Sick Building Syndrome (SBS) (Godish 1995, Sandstedt and Tielman 1999). These indoor environmental problems are commonly referred to as sick building problems.

The CVM survey, planned and administered by myself, was made in the spring of 2003 using a mail questionnaire to 850 randomly chosen persons owning and living in a dwelling in a housing co-operative in Sweden. The survey contained questions about socio-economic variables such as age, gender, income etc, questions about housing and health conditions and the WTP questions. The questionnaire also contained information defining the particular problems of building construction and building-related illnesses/symptoms treated in the study.
3.1 The WTP questions

The first WTP question (see table 3.1) considers the provision of good IAQ as a private good by means of offering a new dwelling, identical to the current one in all respects except for having a guarantee of good IAQ. The WTP asked for is the maximum willingness to pay for trading the current apartment for the new one. The second WTP question (see table 3.2) concerns the WTP for a public project aimed at renovating all sick buildings and thereby ensuring good IAQ in all buildings. In this case, the question is formulated in different ways for different sub-samples. In one third of the questionnaires, denoted group A, the WTP question concerns the total WTP for a public project ensuring generally good IAQ, i.e. CV in equation (2). In another third of the questionnaires, denoted group B, the WTP questions concern the total WTP, provided that all other individuals have to pay according to their utility of the project, i.e. CCV in equation (3). In the last third of the questionnaires, denoted group C, the WTP question concerns the WTP when any effect for other people is disregarded, i.e. PCV in equation (4).

Table 3.1 WTP question regarding good IAQ at home (private good)

<table>
<thead>
<tr>
<th>Question no 18. Suppose you were offered the opportunity to trade your present apartment for a new one. The new apartment is guaranteed to have good ventilation and be completely free from dampness and matters (mould and other biological substances or chemical compounds) that may cause health problems like allergy, other hypersensitive reactions or the sick-building syndrome. The new apartment is, in all other respects, identical to your present one (the same housing cost and located in the same building or block as the present one). To trade your present apartment for the new one you have to make a lump-sum payment, corresponding to the differences in value of the apartments. What is the maximum amount you would be willing to pay, to trade you present apartment for the one offered one with guaranteed good indoor air quality?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum SEK ____________________</td>
</tr>
<tr>
<td>How sure are you about the amount you have stated?</td>
</tr>
<tr>
<td>Very uncertain</td>
</tr>
<tr>
<td>0%---10---20---30---40---50---60---70---80---90---100%</td>
</tr>
<tr>
<td>If you have stated 0 as your maximum amount (or no amount at all), please explain why:</td>
</tr>
</tbody>
</table>
The reason for measuring $CV$, $CCV$ and $PCV$ on different sub-samples, instead of letting all individuals answer all three questions, is to make sure the observations of $CV$, $CCV$ and $PCV$ are independent of each other. Variations in WTP, over the sub-samples, due to differences in the utilities of individuals’ own consumption of good IAQ, instead of differences in motives, is taken account of by using information from the first WTP question concerning the private good of acquiring good IAQ at home.

Table 3.2 WTP question regarding good IAQ in all buildings (public good)

| Question no 21. Assume the government intends to carry out the following project: |
| The project will examine all buildings (used for housing and work places) in order to find all sick buildings, i.e. all buildings having problems with dampness, mould, inadequate ventilation or emissions of chemical compounds that may increase the risk of illnesses and symptoms. The project will also renovate all sick buildings in order to eliminate the risks of building-related ill health. The examination and renovation of the buildings will be financed out by taxation. One single lump-sum tax will be imposed at the start of the project, in order to finance the project. |
| For Group A (1/3 of the sample): What is the maximum amount you would be willing to pay, as a lump-sum tax, to finance this government project? |
| For Group B (1/3 of the sample): All other households will have to pay a tax corresponding to their utility of the project, leaving their welfare unaffected by the project. What is the maximum amount you would be willing to pay as a lump-sum tax to finance this project? |
| For Group C (1/3 of the sample): Disregard any effects of the project for other people, and consider only the benefits of the project for your own household. What, then, is the maximum amount you would be willing to pay as a lump-sum tax to finance this project? |
| Maximum SEK _________________________ |
| How sure are you about the amount you have stated? |
| Very uncertain              Definitely sure |
| 0%---10---20---30---40---50---60---70---80---90---100% |
| If your stated maximum amount is 0 (or no amount at all), please explain why: |
The WTP questions concern the value of acquiring good IAQ, at home or in all buildings, not the value of having good IAQ. The difference between these two measurements consists of the private cost for moving flat (affecting the value of the private good) or the cost for inconveniences during the renovation of the building (affecting the value of the public good). The difference between these two measurements makes it difficult to relate the levels of the two measures to each other. This problem is considered in the analysis. More importantly, the difference between the two measurements is in no way related to the differences in the WTP questions, concerning the public good, capturing altruistic preferences.

The WTP questions are open-ended questions measuring the maximum WTP. Closed-ended referendums have, so far, been considered more reliable than open-ended ones as a means of measuring utility. This is because of, among others, the lack of incentives for free-riding (Hanemann 1984 or 1994). The closed-ended referendum does, however, have the problem of anchoring (or “psychometric bias”), which according to Green et al. (1998) may be a more serious problem than free-riding. Besides, the possible presence of free-riding is not a problem in this case but an interesting part of the analysis. Free-riding is a phenomenon that is likely to occur only if the respondents to the survey are motivated by self-interest and aim at maximising the personal utility of their own income and consumption (at other people’s expense if possible). Thus, the occurrence (or absence) of free-riding is one of the factors that may indicate the absence (or presence) of altruism. In this study, the presence of free-riding can be detected as the value of good IAQ is estimated both when provided as a private good and as a public project.

As the stated WTPs are hypothetical they are more or less uncertain, due to the respondents uncertainty of his/her preferences, regardless of how the WTP question is formulated. In a dichotomous choice contingent valuation the proportion of yes answers, and thereby also the mean WTP, is overestimated if the respondents uncertainty of their preferences is not taken into account while estimations based on the sub-sample being absolutely certain about their WTP statements may be too low (Johannesson et al. 1998) or correct estimates (Blumenschein et al. 1998, 2001 or 2005). Botelho and Pinto (2002) have demonstrated the presence of hypothetical bias and overestimation of the mean and median WTP also in contingent valuation based on open-ended WTP questions. Hypothetical bias can be dealt with in several ways. It can possibly be avoided if the respondents are asked, in a follow-up question, to state how confident they are in their stated WTP and analyses are made only on the sub-sample of respondents being highly confident in their stated WTPs. I have, like
Fredman and Emmelin (2001) among others, used follow-up questions where the respondents have to state the degree of certainty (or uncertainty) on a scale of 0%-100%. An alternative would be to ask the respondents to state if they are absolutely/definitely sure or probably/fairly sure of the WTP they have stated (Blumenschein et al. 2005, Johannesson et al. 1998, 2005). The advantage of asking for the degree of certainty is that the variable can be used either to identify the sub-sample that is highly confident in their statements or as an argument in the estimation of the WTP function (the latter may be a useful alternative if the sub-sample of respondents who are highly confident in their statements is very small).

A stated WTP may be zero either because of the lack of preferences for the good or for other reasons. In this survey, the respondent could be unwilling to pay because he/she thinks it is the duty of the government or the building association to provide him/her with good IAQ. I have dealt with this problem the same way as, for example, Söderqvist (1995), i.e. by asking respondents stating a zero WTP to give their reasons for doing so.

### 3.2 The sample

The questionnaire, and two subsequent reminders, was distributed to 850 randomly chosen persons from all over the country. The total number of questionnaires returned was 366, which gives a rate of participation of 43%. The rate of participation is lower than expected\(^4\). This will not cause any severe problems if the sample is representative of the population. Some questionnaires (36) were returned by persons registered as owners of an apartment in a housing co-operative but who were now living in private houses or rented flats. These cases have been excluded from the analysis.

As can be seen in table 3.3, the distribution of the participants over gender is fairly even. The distribution of the participants over age corresponds quite well to the age distribution of the national population, except for the age range 50 – 59 being over-represented and the age range 60 + being under-represented. The average level of age of the sample is in the range

---

\(^4\) Statistics Sweden (see Statistics Sweden 2005) had a participation rate of 55% - 56% in the mail survey, to households living in housing co-operatives and rented flats, made for the “Bostads- och hyresundersökningen (BHU)” in 2002.
The average household consists of 1.7 adults having 0.3 under-age children at home on a permanent basis and 0.1 under-age children being only part-time members of the household. The size of the average household of the Swedish population was 2.0 in the year 2000 (Statistics Sweden 2004 a), which is close to the average household size of the sample.

Table 3.3 Descriptive statistics of the sample; socio-economic variables.

<table>
<thead>
<tr>
<th>Sample groups</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Full sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of respondents</td>
<td>119 (32.5%)</td>
<td>133 (36.3%)</td>
<td>114 (31.1%)</td>
<td>366 (100%)</td>
</tr>
<tr>
<td>Cases in analysis</td>
<td>102 (30.9%)</td>
<td>121 (36.7%)</td>
<td>107 (32.4%)</td>
<td>330 (100%)</td>
</tr>
<tr>
<td>Gender, males</td>
<td>45.5 %</td>
<td>41.3 %</td>
<td>44.9 %</td>
<td>43.8 %</td>
</tr>
<tr>
<td>Mean level of age</td>
<td>40-49</td>
<td>40-49</td>
<td>40–49</td>
<td>40-49</td>
</tr>
<tr>
<td>Mean size of the household</td>
<td>2.0</td>
<td>2.1</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Mean income/ adult and month (SEK):</td>
<td>28,200 (24,300)</td>
<td>41,700 (21,800)</td>
<td>29,900 (21,000)</td>
<td>33,700 (22,300)</td>
</tr>
</tbody>
</table>

The average monthly income per adult is about SEK 33,700/month in the sample. In some cases (12 observations) the stated monthly income of the household was surprisingly large, between SEK 200,000 and SEK 1,200,000. In these cases, the participants may have misinterpreted the question and stated their annual income (other responses, e.g. about housing conditions, indicated a lower standard of living). These extreme values are excluded from the analysis. When these extreme values are excluded the average per capita income (reported within brackets in table 3.3) is about SEK 22,300/month, which is lower than the Swedish average income from employment in 2003 of about SEK 24,300/month (SCB 2004 c). The sample groups A, B and C correspond well to each other and the full sample regarding the socio-economic attributes. The only notable deviation, of one sample group in relation to the others and the full sample, is the large average per capita income of

---

5 The average age of the Swedish population, in the age range 18 – 89 is about 49 (Statistics Sweden 2004 b).
sample group B. However, this deviation vanishes when the most extreme income values are excluded from the data set.

Table 3.4  Housing and health conditions of the sample

<table>
<thead>
<tr>
<th>Distribution, %</th>
<th>Yes</th>
<th>Perhaps</th>
<th>No</th>
<th>Don’t know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Presence of AS(^1)</td>
<td>40.9</td>
<td>7.7</td>
<td>49.5</td>
<td>1.8</td>
<td>100</td>
</tr>
<tr>
<td>of which is BRAS(^1)</td>
<td>4.1</td>
<td>6.4</td>
<td>26.3</td>
<td>4.1</td>
<td>40.9</td>
</tr>
<tr>
<td>2. The IAQ at home has been examined and detrimental factors were found</td>
<td>17.7</td>
<td>50.7</td>
<td>31.6</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.0</td>
<td>10.7</td>
<td>17.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Worried about getting new or aggravated BRAS in the future</td>
<td>65.1</td>
<td>20.4</td>
<td>11.1</td>
<td>2.8</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>4. Knowledge of SB problems</td>
<td>9.2</td>
<td>34.4</td>
<td>33.7</td>
<td>16.9</td>
<td>5.8</td>
<td></td>
</tr>
<tr>
<td>5. Important to get the IAQ at home diagnosed</td>
<td>8.6</td>
<td>12.9</td>
<td>25.8</td>
<td>23.4</td>
<td>29.2</td>
<td></td>
</tr>
<tr>
<td>6. Important to renovate all sick buildings and acquire good IAQ everywhere</td>
<td>0.9</td>
<td>1.5</td>
<td>8.4</td>
<td>29.4</td>
<td>59.8</td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) AS = Allergy or Similar illnesses/symptoms. BRAS = Building Related AS

According to the results in table 3.4, about 41% of the households have at least one member with an allergy or similar illness/symptom. About 10% of these cases are or may be building-related ill health. Only about 3% of the households worry much about contracting new or aggravating problems with building-related ill health in the future. Still, about 52% of the households consider it important to have their IAQ at home diagnosed and about 60% consider it important to find and renovate all sick buildings so as to acquire good IAQ everywhere. A minority of the sample seems to have actual problems and/or fear for future problems with building-related ill health while a majority of the sample consider it important to take action against all problems with sick buildings. This suggests the possibility that people consider not only their own health and welfare but also that of other people.
4 Analysis

Analyses have been made on the full sample and on the sub-sample consisting of the respondents that stated their WTP with 70% - 100%\(^6\) certainty. The focus in this study is on detecting systematic differences between the WTPs of the sample groups having answered differently posed WTP questions, capturing different kinds of preferences. If any remaining hypothetical bias is independent of differences in the formulations of the WTP questions, it will not cause any problem.

All cases where the WTP is stated as zero as a protest against having to pay for something that is considered to be the responsibility of someone else (the government or the housing co-operative) have been excluded from the analysis (56 cases). By doing so, a downward bias is avoided (Calia and Strazzia 1999).

4.1 Descriptive statistics

Table 4.1 presents the mean and median WTPs for a public project ensuring good IAQ in all buildings (\(WTP^{PU}\)) and for the private good of acquiring good IAQ at home (\(WTP^{PR}\)). Mean values of the sample groups A-C are reported both for \(WTP^{PU}\) and \(WTP^{PR}\), even though only \(WTP^{PU}\) is measured in different ways for these groups. The mean \(WTP^{PU}\) for the sample groups A, B and C corresponds to the mean values of \(CV\), \(CCV\) and \(PCV\) respectively. The mean \(WTP^{PR}\), on the other hand, corresponds to \(CV^{PR}\), for all sample groups.

According to the conditions in equations (5a) – (5c), and given individuals have equal preferences for their own consumption of a good IAQ, pure altruism demands that the mean \(WTP^{PU}\) for group A is significantly higher than the mean \(WTP^{PU}\) for group B and C. Paternalism demands that the mean \(WTP^{PU}\) for group C is significantly lower than the mean \(WTP^{PU}\) of group A and B. No significant difference among the mean \(WTP^{PU}\)s of the groups implies selfishness. All \(WTP^{PU}\)s could be expected to be larger than the \(WTP^{PR}\)s as \(PCV \geq CV^{PR}\).

\(^{6}\) The cut-value of 70% corresponds roughly to the cut-values 7.0-8.4 (on the scale 0-10) tested in Blumenschein et al. (2001).
As shown in Table 4.1, the estimated WTP for the public project of acquiring good IAQ in all buildings \((WTP_{PU})\) is considerably smaller than the estimated WTP for the private good of acquiring good IAQ at home \((WTP_{PR})\), for all sample groups and in total. The mean \(WTP_{PU}\) is only about 12-13 % of the mean \(WTP_{PR}\). This is clearly an unexpected result as a straightforward interpretation of the questions, as they are posed in the questionnaire, is that the public good is a whole of which the private good is a part. Indeed, this may also have been how the majority of the respondents perceived this relationship. As shown in the final column of the table, a larger portion of the respondents have a positive WTP for the public project ensuring good IAQ in all building, than for the private good of having good IAQ at home.

---

Table 4.1 Mean and medium value of good IAQ in all buildings \((WTP_{PU})\) and of good IAQ at home \((WTP_{PR})\), (SEK)

<table>
<thead>
<tr>
<th>Group</th>
<th>Measure</th>
<th>Mean WTP</th>
<th>Median WTP</th>
<th>WTP&gt;0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public project ((WTP_{PU}))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All respondents:</td>
<td>A</td>
<td>CV</td>
<td>1,055</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>CCV</td>
<td>1,666</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>PCV</td>
<td>1,888</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td></td>
<td>1,541</td>
<td>500</td>
</tr>
<tr>
<td>Highly confident respondents:</td>
<td>A</td>
<td>CV</td>
<td>1,269</td>
<td>875</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>CCV</td>
<td>1,684</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>PCV</td>
<td>2,272</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td></td>
<td>1,782</td>
<td>625</td>
</tr>
<tr>
<td><strong>Private good ((WTP_{PR}))</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All respondents:</td>
<td>A</td>
<td>CV(_{PR})</td>
<td>20,142</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>CV(_{PR})</td>
<td>9,283</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>CV(_{PR})</td>
<td>15,703</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td></td>
<td>14,572</td>
<td>500</td>
</tr>
<tr>
<td>Highly confident respondents:</td>
<td>A</td>
<td>CV(_{PR})</td>
<td>14,640</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>CV(_{PR})</td>
<td>7,851</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>CV(_{PR})</td>
<td>15,565</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td></td>
<td>12,281</td>
<td>0</td>
</tr>
</tbody>
</table>

1 For the sake of caution, two values of WTP\(_{PR}\) have been excluded in the analysis. The values of WTP\(_{PR}\) are distributed over the interval 0 – SEK 300,000, except for 2 values of SEK 500,000 and SEK 1,000,000, respectively. These 2 values alone have a considerable impact on the mean WTP. Because of their size, it cannot be precluded that the respondents have stated their total WTP for buying a flat instead of the WTP for trading their current flat for a new one.
Several other studies have reported similar findings of a considerably larger WTP in a private good framework than in a public good context (e.g. Johannesson et al. (2005) and Hultkrantz et al. (2005)). Such a phenomenon could be explained by envy, free-riding strategic behaviour or payment vehicle biases such as a dislike of having to pay taxes or distrust in the efficiency or fairness of public provision of goods. If the explanation is envy or free-riding, then the motives behind the economic behaviour of the respondents must be selfishness rather than altruism.

Yet another explanation may, in this case, be that the WTP for good IAQ at home is affected by expectations regarding the future value on the property market of an apartment having good IAQ. If the supply of dwellings having good IAQ is limited then an investment in good IAQ may lead to a capital gain as well as positive health effects. If, on the other hand, all buildings have good IAQ then the good IAQ is less highly valued on the property market.

The sample means of $WTP^{PU}$ suggest that $CV < CCV < PCV$, which implies envy rather than altruism. On the other hand, a larger portion of the respondents have a positive WTP for the public project ensuring good IAQ in all building, than for the private good of having good IAQ at home. This may perhaps be an indication of the existence of altruism. On the other hand, given the mean WTP results, it may be an indication of a warm-glow or signalling effect, i.e. some people want to make a small contribution to help others for the pleasure of giving, as a sign of good citizenship etc. Another explanation may be that some people already have good IAQ at home but would, for the sake of their own health, welcome an improvement the IAQ in other buildings, e.g. at work or at dwellings of friends or relatives. However, a more profound analysis has to be made before we draw any conclusions.

---

7 According to Johannesson et al. (2005), this phenomenon may, under certain circumstances be compatible with pure altruism. If the respondent assumes that financing the public project through taxation will have larger negative utility effects for other people than the positive effects of the provision of the good, then a concern for other people can lead to a reduction of, instead of an increase in, his/her WTP. This explanation is not likely to hold in this case. The reason is that the mean WTP for the public good is only 12-13% of the WTP for the private good also for sample group C, the group whose members were explicitly asked not to consider utility effects for other people when stating their WTP for the public project. Therefore, strategic behaviour or vehicle bias seems to be more likely explanations.
4.2 Independent samples tests, Chi-square tests and econometric analysis

The effect on the mean $WTP^{PU}$, of posing the WTP questions in different ways for different sample groups in order to capture possible altruistic preferences, has been tested using an independent samples test, namely the t-test for equality of means. The null hypothesis of the t-tests is that there is no difference between the sample means (in this case the means of sample groups). Tests has been made also of $WTP^{PR}$, in order to assure that differences between the mean WTP values of the sample groups are random when the WTP question is identically formulated for all sample groups.

<table>
<thead>
<tr>
<th>Sample groups G1 &amp; G2</th>
<th>Variable tested</th>
<th>Difference in mean (G1 - G2)</th>
<th>p value (2-sided)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>A &amp; B</td>
<td>$WTP^{PU}$:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full sample</td>
<td>- 611</td>
<td>0.14</td>
<td>85 &amp; 95</td>
</tr>
<tr>
<td></td>
<td>Sub-sample$^1$</td>
<td>- 415</td>
<td>0.56</td>
<td>34 &amp; 37</td>
</tr>
<tr>
<td></td>
<td>$WTP^{PR}$:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full sample</td>
<td>10,859</td>
<td>0.09</td>
<td>85 &amp; 110</td>
</tr>
<tr>
<td></td>
<td>Sub-sample$^1$</td>
<td>6,788</td>
<td>0.39</td>
<td>43 &amp; 57</td>
</tr>
<tr>
<td>A &amp; C</td>
<td>$WTP^{PU}$:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full sample</td>
<td>- 834</td>
<td>0.09</td>
<td>85 &amp; 85</td>
</tr>
<tr>
<td></td>
<td>Sub-sample$^1$</td>
<td>- 1,003</td>
<td>0.23</td>
<td>34 &amp; 43</td>
</tr>
<tr>
<td></td>
<td>$WTP^{PR}$:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full sample</td>
<td>4,438</td>
<td>0.52</td>
<td>85 &amp; 96</td>
</tr>
<tr>
<td></td>
<td>Sub-sample$^1$</td>
<td>- 926</td>
<td>0.92</td>
<td>43 &amp; 46</td>
</tr>
<tr>
<td>B &amp; C</td>
<td>$WTP^{PU}$:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full sample</td>
<td>- 222</td>
<td>0.71</td>
<td>95 &amp; 85</td>
</tr>
<tr>
<td></td>
<td>Sub-sample$^1$</td>
<td>- 588</td>
<td>0.55</td>
<td>37 &amp; 43</td>
</tr>
<tr>
<td></td>
<td>$WTP^{PR}$:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full sample</td>
<td>- 6,421</td>
<td>0.11</td>
<td>110 &amp; 96</td>
</tr>
<tr>
<td></td>
<td>Sub-sample$^1$</td>
<td>- 7,714</td>
<td>0.20</td>
<td>57 &amp; 46</td>
</tr>
</tbody>
</table>

$^1$ Respondents have stated their WTP with 70%-100% certainty.

The results of the tests, of the pairs of sample groups A-B, A-C, and B-C, are reported in table 4.2. The results of the tests made on the sub-samples, whose members have stated their WTP with a high self-reported confidence, are based on very small samples. Even so, they are
reported. The results of the tests of differences in mean values of $WTP^{PR}$, between the sample groups A, B and C, are the expected ones. The null hypothesis cannot be rejected. However, the same conclusion holds for the mean values of $WTP^{PU}$. There are differences in the mean values among the sample groups, but these differences may, according to the results of the t-tests, be due to randomness. Thus, the t-test cannot falsify the conjecture that $CV = CCV = PCV$ and that no altruism exists, either pure or paternalistic.

Chi-square tests have been made, of the association between the $WTP^{PU}$ and sample groups, controlling for the socio-economic variables gender, age and size of the household. The reason for controlling for the size of the household is that families with children may, for the sake of their children, be more concerned about having good IAQ everywhere than singles. The null hypothesis of the Chi-square test is that there is no association between sample group membership and the level of the stated $WTP^{PU}$. The results of the chi-square tests, reported in table 4.3, confirm the results of the independent samples test. The null hypothesis cannot be rejected, not for any category of gender, age or size of the household.

<table>
<thead>
<tr>
<th>Control variable</th>
<th>Value of the variable</th>
<th>N of valid cases</th>
<th>p value (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>117</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>147</td>
<td>0.64</td>
</tr>
<tr>
<td>Age</td>
<td>20 – 29 years</td>
<td>49</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>30 – 39 years</td>
<td>60</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>40 – 49 years</td>
<td>53</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>50 – 59 years</td>
<td>77</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>60 + years</td>
<td>26</td>
<td>0.29</td>
</tr>
<tr>
<td>Size of the household$^1$</td>
<td>1 person</td>
<td>78</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>2 persons</td>
<td>111</td>
<td>0.37</td>
</tr>
<tr>
<td></td>
<td>3 persons</td>
<td>33</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>4 persons</td>
<td>27</td>
<td>0.51</td>
</tr>
</tbody>
</table>

$^1$ Test values are reported only for sub-samples that have more than 10 valid cases.
To further test the hypothesis of the existence of altruistic preferences, an econometric analysis has been made of the binary decision whether to make a payment or not. If altruism exists, it will affect not only the level of the $WTP_{PU}$ but, indirectly, also the probability to have a positive $WTP_{PU}$. The probability to pay to the public project is modelled as follows:

$$D(WTP_{i}^{PU}) = f(D(WTP_{i}^{PR}), A_{Ai}, A_{Ci}; s_{i})$$  \hspace{1cm} (6)$$

$$\frac{\partial f}{\partial D(WTP_{i}^{PR})} > 0 , \quad \frac{\partial f}{\partial A_{Ai}} > 0 \quad \text{and} \quad \frac{\partial f}{\partial A_{Ci}} < 0$$

where

$$D(WTP_{i}^{PU}) = 1 \text{ if } WTP_{i}^{PU} > 0 \quad \text{and} \quad D(WTP_{i}^{PU}) = 0 \text{ if } WTP_{i}^{PU} = 0$$

$$D(WTP_{i}^{PR}) = 1 \text{ if } WTP_{i}^{PR} > 0 \quad \text{and} \quad D(WTP_{i}^{PR}) = 0 \text{ if } WTP_{i}^{PR} = 0$$

$D(WTP_{i}^{PU})$ = the decision to pay for the public project (good IAQ in all buildings)

$D(WTP_{i}^{PR})$ = the decision to pay for the private good (good IAQ at home)

$A_{Ai}$ = a dummy variable representing sample group A and pure altruism

$A_{Ci}$ = a dummy variable representing sample group C and paternalism

$s_{i}$ = socio-economic characteristics

Equation (6) describes the probability to have a positive WTP for the public project ensuring good IAQ in all buildings as a function of preferences for individual consumption of good IAQ, captured by the probability to have a positive $WTP_{i}^{PR}$ and of altruistic motives, captured by dummy variables representing sample groups and differences in $WTP_{i}^{PU}$ questions. Because $WTP_{i}^{PR}$, and thus $CV_{i}^{PR}$, is a part of $PCV_{i}$, it can be used as an indicator of the utility of the individual’s own consumption of good IAQ that is made possible by the public project ensuring good IAQ in all building. The model is estimated on $WTP_{i}^{PU}$ and $WTP_{i}^{PR}$ data transformed to dichotomous variables. The dummy variables, $A_{Ai}$ and $A_{Ci}$, represent the membership in sample groups A or C, whose members have answered WTP questions formulated so as to measure $CV_{i}$ or $PCV_{i}$. If the dummy variable $A_{Ai}$ is significantly positive, then equation 5(a) holds and individuals’ motive for economic behaviour is pure altruism, but if the dummy variable $A_{Ci}$ is significantly negative, then equation 5(c) holds and the motive is paternalism. If, on the other hand, both dummies are significant ($A_{Ai}$ positive and $A_{Ci}$ negative) then there is a mixture of motives, some people are pure altruists and some are paternalists. If the motive for economic behaviour is selfishness, then neither of the dummies is significant.
The socio-economic variables included, in order to allow for individual variations in equation (6), are age, gender, income and size of the household. In the estimation based on the full sample the degree of self-reported confidence in the stated WTP is included as an explanatory variable.

Equation (6) is estimated using the binary choice Logit (Greene 1997):

\[
P = \Pr(WTP_{PU} > 0) = \frac{e^{\beta'x}}{1 + e^{\beta'x}} \tag{7}
\]

where \( P \) = the probability of \( D(WTP_{i,PU}) = 1 \) and \( WTP_{PU} > 0 \)
\( x \) = a vector containing the independent variables in equation (6)
\( \beta \) = a vector of coefficients to the independent variables

The results of the estimations are reported in table 4.4. The degree of self-reported certainty of the stated \( WTP_{PU} \) has a significantly positive effect in the equation estimated on the full sample. However, the conclusions to be drawn are the same for both estimations. According to the results, the decision to pay to the public project is significantly associated with the decision to pay for the private good of acquiring good IAQ at home, as expected. But, the decision to pay to the public project is not significantly associated to any of the dummy variables representing sample groups A and C, and thereby altruistic preferences,\(^8\) in any of the estimations. Thus, the fact that a larger portion of the households are willing to pay for the public project ensuring good IAQ in all buildings, compared to the portion being willing to pay for the private good of acquiring good IAQ at home, does not seem to be the result of altruistic motives. Instead, it may be the result of the value of individuals’ own consumption of good IAQ at other places than home. None of the socio-economic variables are significantly associated to the probability to pay for the public project.

The overall statistical test values are rather poor. For example, the levels of significance of the Hosmer and Lemeshow Goodness-of-Fit Test, testing the null hypothesis that differences between real values and values predicted by the model are coincidental, are considerably lower than the desired level of significance (95%). Thus, the test values indicate that the

---

\(^8\) A higher probability to have a positive \( WTP_{PU} \) for group A, compared to group B and C, represents pure altruism while a lower probability for group C, compared to group A and B represents paternalism.
model, specified so as to embrace possible altruistic preferences, does not conform to the empirical data.

Table 4.4 The results of the Logit regressions

<table>
<thead>
<tr>
<th></th>
<th>Sub-sample¹</th>
<th>Full sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(WTP_{PR}) = 1</td>
<td>+ 0.00</td>
<td>+ 0.00</td>
</tr>
<tr>
<td>A_A (pure altruism)</td>
<td>+ 0.11</td>
<td>+ 0.06</td>
</tr>
<tr>
<td>A_C (paternalism)</td>
<td>+ 0.84</td>
<td>- 0.90</td>
</tr>
<tr>
<td>Age</td>
<td>- 0.76</td>
<td>- 0.21</td>
</tr>
<tr>
<td>Gender (female)</td>
<td>+ 0.34</td>
<td>+ 0.92</td>
</tr>
<tr>
<td>Size of household</td>
<td>+ 0.42</td>
<td>+ 0.36</td>
</tr>
<tr>
<td>Income</td>
<td>- 0.44</td>
<td>- 0.28</td>
</tr>
<tr>
<td>Certainty of the stated WTP_{PU}</td>
<td>+ 0.00</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>- 0.89</td>
<td>- 0.30</td>
</tr>
</tbody>
</table>

Statistics:
- 2 Ln L₀              | 95.1         | 263.0       |
- 2 Ln L                | 69.1         | 176.6       |
Log Likelihood Index    | 0.27         | 0.33        |
Hosmer % Lemeshow       | 0.39         | 0.21        |
Goodness-of-Fit Test, Sign
Correct predictions (%):
  By a constant (0 or 1) | 80.0         | 72.1        |
  By the model           | 82.1         | 82.4        |
N                       | 95           | 222         |

¹ The sub-sample consists of the respondents who have stated WTP_{PU} with 70%-100% certainty.

The conclusion is that neither of the dummies, representing sample groups and differences in motives altruism, have a significant effect and that the hypothesis of altruistic preferences fails. Thereby, the results of the binary choice estimations confirm the results of the independent samples tests and the chi-square tests.
Conclusions

No support for altruistic preferences, either pure or paternalistic, can be demonstrated in this study. Posing the WTP questions in different ways in order to find evidence of altruism did not give any significant effect. The explanation for this may be that selfishness is the most frequent and/or dominant motive for behaviour when valuing good IAQ. But, it may also be that unselfish motives do exist but are of other kinds than pure or paternalistic altruism. A third possible explanation may be that the method of detecting altruistic preferences, by posing the WTP question in different ways in order to capture different kinds of preferences, did not work as well in practice as it does in theory.

However, there is another fact suggesting that selfishness may be a dominant motive when valuing good IAQ. The sample mean of the WTP for the private good of acquiring good IAQ at home is much larger than the sample mean of the WTP for a public project ensuring good IAQ in all buildings (about eight times larger). Similar results have been reported in other studies. Vehicle bias (a dislike of paying taxes) and dislike of or distrust in public projects are factors that may make people more willing to pay for private solutions than for public ones. Another explanation may be strategic behaviour such as free-riding. Such behaviour is compatible with selfishness but not with altruism.

References


Blumenschein, K., Johannesson, M., Yokoyama, K. K. and Freeman, P. R. (2001), ‘Hypothetical Versus Real Willingness to Pay in the Health Care Sector: Results From a Field Experiment’, *Journal of Health Economics*, 20, 441-457.


