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Willingness to pay for improved air quality in Sweden

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The aim of the paper is to quantify individual willingness-to-pay measures of improved air quality in Sweden by using the Contingent Valuation Method (CVM). Such measures are important for policy makers when deciding about public investments and policy instruments in order to regulate environmental impacts, e.g. from road transportation and industry. The mean willingness to pay (WTP) for a 50% reduction of harmful substances where the respondents live and work was about 2000 SEK/year, which is of the same order of magnitude as earlier stated preference studies in Nordic countries. Most parameters in the econometric analysis had the expected sign. WTP was increasing in income, wealth and education; it was larger for men, members of environmental organizations, people living in big cities (which are on average more polluted), and people who own their house or apartment. It was lower for retired people. However, the additional WTP for people in big cities, although significantly higher than for other people, was lower than expected, indicating a possible insensitivity-to-scope effect.

I. INTRODUCTION

The aim of this paper is to quantify individual willingness to pay (WTP) measures of increased air quality in Sweden by using the contingent valuation method (CVM). Such measures are important for policy makers when determining public investments and policy instruments in order to regulate environmental impacts, e.g. from road transport and industry. The Swedish Institute for Transport and Communication Analysis (SIKA) recommends the use of certain monetary 'shadow values' for pollution, which have been largely based on work by Leksell and Löfgren (1995), which in turn draws heavily from earlier survey-based studies by Saelendsminde and Hammer (1994) and Transek (1993).

It should be obvious that it is an intrinsically difficult task to measure welfare increases associated with improved air quality. Consequently, one should be sceptical when applying various kinds of quantification methods. Most things we are genuinely interested in, however, are very difficult to measure (such as freedom, welfare and happiness). Hence, avoiding measuring everything that is difficult to measure does not appear to be very sensible. As expressed by Sen (1987, p. 34): 'Why must we reject being vaguely right in favour of being precisely wrong? The conflict between relevance and simplicity of use [. . .] is indeed a hard one in economic measurement and evaluation, but it is difficult to see why simplicity of use should have such priority over relevance.' This is of course *not* to say that any measure is better than no measure at all (Diamond and Hausman, 1994). For comprehensive discussions about the reliability of CVM see Kahneman and Knetsch (1992a, b), Smith (1992), Arrow *et al.* (1993), Hausman (1993), Diamond and Hausman (1994), Hanemann (1994) and Portney (1994). We see two main alternatives to survey-based methods, i.e. CVM or other stated preference methods.[1] (1) Dose–response studies. This method has often been considered unreliable because of uncertainties in the estimated dose–response relations. However, there now exist several dose–response studies which focus on health effects due to air pollution, and according to the recent survey by Krupnick *et al.* (1997) there are indications of decreasing uncertainties over time. (2) Critical loads or safe minimum standards. Based on these standards, or on a level that is considered politically acceptable, one can calculate the implicit shadow price for achieving this goal. The latter strategy has often been applied in relation to regional environmental damage such as acidification. Nash (1997), among others, argues in favour of this strategy when placing monetary values on road transport externalities, primarily due to the very large uncertainties involved.

In Sweden, the official valuation of NO_x (40 SEK/kg NO_x) has been quantified using critical loads. Health effects, however, are in a sense more straightforward to value directly since these effects may be somewhat easier to foresee, and since the effects on future generations and other countries are more limited. For this reason it is of interest to separate the willingness to pay for reduced health impacts from the willingness to pay for a cleaner natural environment. In this CVM study, we therefore try to separate an individual's valuation of health effects due to air pollution from other effects. It would of course be difficult to directly ask the individuals to do this. Therefore, this is done by only considering reductions of air pollution where the individuals live and work, and leaving the concentration unaffected elsewhere. This implies that there might also be some local environmental effects that are valued.

II. DESIGN OF THE SURVEY

This survey is a part of the larger Household Market and Nonmarket Activities (HUS) survey, which includes 3240 individuals in 1922 households, conducted in 1996. The HUS survey is made up of two parts; a panel survey, addressed to respondents in the 1993 survey, and a supplementary survey, addressed to young people in panel households who were born between 1975 and 1977, as well as certain new household members who had not previously been interviewed. For the panel survey (95% of the respondents), a combined contact and main interview was conducted by telephone, after which a self-enumerated questionnaire was sent out to each respondent by mail. For the supplementary survey, the respondents were not interviewed by telephone until they had been interviewed personally. The HUS questionnaire from 1996 includes an Environment Section, which includes the contingent valuation question, follow-up questions, questions on their knowledge about emissions from car traffic and nature, and questions about their health status. This section was addressed to all respondents, while some of the other sections were addressed only to the head of the household.

The importance of well-informed respondents is often emphasized in the CVM-literature. However, the consequences of air pollution for health and environment are very difficult to predict and scientists have often widely varying views. It becomes then a question of whether we should try to provide some kind of average of these views to the respondents and present these as the 'facts', or whether we should see the whole issue as a problem of genuine uncertainty, where we leave it to the respondents to judge the information from various sources. We have chosen the latter strategy. If, on the other hand, we had chosen to give the respondents more extensive information about the consequences of air pollution, and if the respondents fully believed in this information (which one may doubt),[2] the whole study would have been reduced to an exercise of estimating values of statistical lives, WTP to avoid diseases, and WTP to avoid certain effects on the environment. This type of study would be extremely difficult both to quantify and to present in an easily accessible way. Furthermore, in order to estimate the value of a statistical life, more suitable ways most likely exist. Instead we see this survey as an exercise where people have their own subjective views about the harmfulness of air pollution. The result of this study can then be compared to other methods, such as dose–response studies linked with values of statistical lives and similar information.

Since the environmental questions were part of a larger survey, we were unfortunately restricted in our survey design; in particular we were forced to use an open-ended question for the maximum WTP. As is well known, these types of questions have often been criticized in the CVM-literature (Arrow *et al.*, 1993; Hanemann, 1994). Instead, referendum type questions are often recommended, since such questions are often considered to be more similar to everyday consumption decisions, i.e. where you either buy or do not buy the good at a certain price. However, the open-ended format also has obvious advantages such as a much more efficient use of the data and absence of starting-point and yea-saying bias. In this paper we also exploit the advantage of using two-equation models when analysing

[1] Using revealed preference measures of air pollution quality such as the hedonic pricing method or some kind of travel cost method could of course be an alternative. One problem with using hedonic pricing in this case is that it would only capture the value of improved air quality at home, and not at the workplace. In this study we wish to measure the value both at home and at work.
[2] See Pollak (1998) for a discussion of CBA when risk perceptions differ largely between experts and the general public.

Table 1. *Stated reasons for positive and zero WTP, respectively*

	Only reason: Health	Most important: Health	Most important: Nature	Most important: Dirtying	Most important: Other reasons
%	34.0	54.3	26.8	6.4	12.5
	A minor problem problem for me	Cannot afford it now	Someone else should pay	Other reasons	Uncertain, do not know
%	10.7	22.3	13.6	19.9	33.5

WTP, i.e. the possibility of making separate estimations of whether individuals have a positive WTP, and what their maximum WTP is. Perhaps one could also claim that open-ended provides a conservative design since open-ended questions generally tend to give lower mean WTP compared to questions of referendum type (Hausman, 1993).

III. ANALYSIS

Aggregating and interpreting mean WTP

The hypothesis in this study was that we would get an estimate of individuals' valuation of health effects from air pollution by asking people for their maximum WTP to reduce the concentration of harmful substances by 50% *where they live and where they work*, but leave the concentration unaffected elsewhere. Another reason for this strategy was that there are still ongoing discussions concerning how to interpret non-use or existence values (Johansson-Stenman, 1998). For example, Common *et al.* (1997) and Sagoff (1998) have recently argued that respondents seem to answer such questions more as citizens than as consumers. Thus, the welfare consequences from non-use values are not at all straightforward to interpret. It is also reasonable that problems associated with a 'purchase of moral satisfaction' (Kahnemann and Knetsch, 1992a, b) and 'warm-glow effects' (Andreoni, 1989, 1990) are much smaller on issues which to a large extent relate to the individuals themselves, and not to other people or to nature in general.

It is not clear, however, whether the chosen strategy was successful in this respect. As follow-up questions we asked the respondents for their motives for a stated zero or positive WTP, respectively. Of those with a positive WTP, about 80% considered health effects to be an important reason, but about 40% also considered reduced damage to the environment to be of importance for their stated WTP. One possibility is that respondents also value local effects on the environment. However, as seen in Table 1, only slightly more than half of the respondents said that reduced health impact was the most important reason for their stated WTP. Thus, our strategy to *only* consider health effects seems to have failed. A possible reason for the failure could be that some respondents had problems understanding the question.[3] An appropriate interpretation of the stated WTPs would then perhaps be to assume that they reflect more than health effects, but less than their total benefit from reduced air pollution by 50% *everywhere* in Sweden.

Of the zero responses, only a small fraction considered air pollution to be a minor problem. Unfortunately, a large portion of the zero responses is unexplained, which could indicate that we did not manage to construct valid response alternatives on the follow-up question. We have chosen not to exclude any of the responses as protest bids in the analysis.[4]

Of the total sample, 3107 individuals answered the valuation question, or about 96%. Table 2 reports the WTP for the whole sample, as well as for different sub-samples.

We see that men have a larger mean WTP than women and that people living in (by Swedish standards) big cities have a larger mean WTP than others. Using a standard t-test, we can reject the hypothesis of equal mean between men and women, and between those who live in big cities and those who live in other areas, respectively, at a 5% significance level or better. Still, although people living in big cities report a larger WTP than others, the difference is perhaps smaller than what one would suspect if health effects are the main concern, since air pollution problems on average are much worse in bigger cities. This could be an indication of scope or warm-glow effects. However, another explanation to this result is that individuals in big cities may have a lower marginal valuation of air pollution on average.

[3] Another possibility is that most respondents answered the question as it was intended, but that on the follow-up question they responded whether they thought that health effects are the most serious problem with air pollution *in general*. In addition, using a standard t-test we cannot reject the hypothesis of equal mean between the two groups, Health being the most important reason and Other reasons.

[4] The econometric analysis and conclusions are not altered by excluding those who said 'someone else should pay' as protest bids.

Table 2. *Willingness-to-pay for the sample*

		Mean	Std.	Median	No. zeros	Max	N
Whole sample		156	286	100	34%	5000	3107
Positive WTP		236	324	150		5000	
Men:	all responses	179	335	100	36%	5000	1540
	WTP > 0	279	384	200		5000	
Women:	all responses	133	224	100	32%	5000	1567
	WTP > 0	196	249	100		5000	
Big city:	all responses	179	342	100	35%	5000	672
	WTP> 0	277	392	200		5000	
Other areas:	all responses	149	268	100	34%	5000	2435
	WTP > 0	226	302	100		5000	

Table 3. *The result from other Nordic stated preference studies*

Study	Good	WTP for a 50% reduction	Method
Halvorsen (1996)	Reduction in air pollution due to reduced emissions from traffic in Norway	1250 SEK/year and person	Open-ended CVM
Saelensminde and Hammer (1994)	Local air pollution, noise, dust and CO_2 in Oslo/Akershus	4600–9300 SEK/year and household for local air pollution	Experimental choice
Transek (1993)	Reduction of emissions from car traffic in cities. Decomposition on health, nature and pollution	Health: 1750 SEK/year and person Nature: 1490 SEK/year and person Dirtying: 760 SEK/year and person	Experimental ranking
Strand and Taraldset (1991)	Air pollution	1800–3700 SEK/year and household	Open-ended CVM

The payment vehicle was a charge related to individual income, which, the respondents were told, would affect everybody in the area. Hence, the presence of pure (non-paternalistic) altruism would not imply any systematic double-counting here since a higher WTP would both imply a higher environmental quality for others, but also correspondingly higher charges. Paternalistic, environment-focused altruism would imply a larger WTP compared to the case with no altruism, but, assuming a utilitarian SWF, the socially optimal quantity of environmental quality would also change in a corresponding degree, so we would have no double counting here either; see Johansson-Stenman (1998) or Johansson (1992). As mentioned earlier, however, the presence of impure altruism, warm-glow effects or the 'purchase of moral satisfaction' would imply that the stated WTP is larger than the actual WTP.

As shown in Table 2, the mean WTP was approximately 160 SEK/month or 2000 SEK/year. This can be compared with other Nordic studies on WTP of reduced air pollution (Table 3).

Note that the WTP in both Saelensminde and Hammer (1994) and Transek (1993) are for individuals/households in cities, while the others are mean WTP for the whole country. The mean WTP from our study is higher than the mean WTP in both Halvorsen (1996) and Transek (1993).[5] In the case of Halvorsen, this is probably largely due to the difference in the number of zero responses; 58% in Halvorsen, 34% in our study. One explanation for this difference could be the payment vehicle; in Halvorsen the payment vehicle was a tax, while in our case it is a charge related to income. Still, the result from our study seems to conform in general to the result of previous studies.

On the basis of the result from Sælensminde and Hammer (1994), Leksell and Löfgren (1995) calculate the economic valuation of the *inhaled* dose as 4 SEK/mg NO_x, 4 SEK/mg VOC and 40 SEK/mg particles.[6] Johansson-Stenman and Sterner (1998) found that the order of mag-

[5] Unfortunately, we do not have information about the standard deviation of WTP, and therefore we cannot say whether the differences are significant or not.
[6] The estimations were for one city in Sweden. The contributions by CO and SO_2 were considered small, and were therefore dropped.

Table 4. *Descriptive statistics based on observations included in estimations*

Variable	Description	Mean	Std.	Min	Max
Income	Individual net income	113 022	56 327	0	593 792
Low income	Individual net income if net income is lower than 30 000 SEK	6258	6 707	0	19 859
Partner income	Partner's income	80 339	73 075	0	478 365
Wealth	Household net wealth	575 817	562 904	−745 000	3 450 000
No. children	Number of children	0.66	1.01	0	6
Age	Age in years	46.9	15.8	19	92
Sex	1 if male	0.52	0.50	0	1
Education	Education in years	11.9	3.4	5	34
Retired	1 if respondent is retired	0.16	0.37	0	1
Big city	1 if respondent lives in a big city	0.27	0.44	0	1
House owner	1 if respondent owns house	0.16	0.36	0	1
Serious disease	1 if respondent has some pollution-related disease such as asthma or bronchitis	0.083	0.28	0	1
Pollution knowledge	1 if respondent has good knowledge of emissions	0.44	0.50	0	1
Environmental organization	1 if member of an environmental organization	0.09	0.29	0	1
Nature knowledge	No. of birds the respondent can identify	15.2	14.0	2.5	75
Nature important	1 if nature was important for stated WTP	0.50	0.50	0	1

nitude of these cost estimates seems to be comparable with other studies on the external environmental cost. These studies include both the environmental valuations used by different public institutions in the US (Bell, 1994), and dose–response studies on urban external costs from road transport in Belgium (Mayeres *et al.*, 1996). The second study arrives at similar values for VOC but somewhat higher for NO_x. They also give values for PM which correspond well to the city average figures used in Sweden.

If we make the, quite strong, assumption of a linear damage WTP function in concentration levels, we get a mean WTP equal to 4000 SEK/year to reduce the level of harmful substances to zero. Assuming that the welfare of children is perfectly internalized by their parents, and there are 6 million adults in Sweden, this corresponds to about 1.5% of GDP. If, on the other hand the median value is used, we end up with slightly less than 1% of GDP. Based on dose–response functions, Maddison *et al.* (1996) estimates the external air pollution costs from road transport in UK to be approximately £20 billion, which corresponds to about 3% of GDP. Pearce and Crowards (1996) end up with similar figures for health effects from particular matters in the UK. Based on Leksell and Löfgren (1994) and officially used parameter values in Sweden, health costs in Sweden were estimated to be about 0.45% of GDP in Maddison *et al.* (1996), and the regional environmental costs to be 0.7%. These figures may also be compared to the survey of estimates presented by Quinet (1997) consisting of 10 studies (dated from 1985–92) where the aggregate health cost from air pollution varied from 0.02% to 0.6% of GDP (in different countries). Thus, the estimated WTP from our study seems to be higher than the WTP from the latter studies, but lower than the more recent UK dose–response based studies.

Descriptive statistics

Many of the questionnaires were incomplete, primarily due to incomplete responses on income and wealth. Therefore, the estimations include only 2120 of 3107 responses. However, using a standard *t*-test we cannot reject the hypothesis of equal mean WTP between the two groups. Table 4 reports descriptive statistics for variables included in the final estimations. We can divide the independent variables into three categories; socio-economic and demographic variables, health variables, and attitude and knowledge variables.

Econometric analysis

The dependent variable, WTP, is censored since it is zero for a large fraction of the observations; hence, a basic OLS regression would be biased. There are two types of limited dependent variable models that account for this type of problem; one-equation censored models and two-equation models. The standard one-equation censored model is the Tobit type 1 model:

$$WTP^* = x'\beta + \varepsilon;\ WTP = \max(0, WTP^*),\quad \varepsilon \sim N(0,\sigma^2) \tag{1}$$

$$E[WTP] = \Phi(x'\beta/\sigma)[x'\beta + \sigma\lambda(x'\beta/\sigma)];\ \lambda(z) = \frac{\phi(z)}{\Phi(z)}$$

where λ is Mill's ratio and where $\Phi(z)$ and $\phi(z)$ are the standard normal distribution function and the standard normal density function, respectively. In this model, WTP can in principle take on negative values and the zero values are assumed to result from a non-observability of these negative values. However, this is hardly a correct specification of our problem. Instead we have two different responses: zero WTP and positive WTP, where the zeros are (or may be) true zeros, given that the respondents have answered truthfully. Thus, the zeros are due to the decisions of the respondents, and not non-observability. Furthermore, the ratio between the estimated change in probability and the estimated change in WTP, given WTP > 0, due to a change in an independent variable, is in Tobit 1 the same for all independent variables. Obviously, this is very restrictive. Therefore, a two-equation model, where the decision process is modelled separately, is more appropriate, and we estimate two different two-equation models. The first is a model where the probability of a zero observation is assumed to be independent of the regression model for the positive observations; we call this the independent model. Therefore, the two decisions – whether or not to state a positive WTP, and how much to state – are separated and estimated separately as follows:

$$d^* = x'\gamma + u \text{ and} \tag{2}$$

$$WTP^* = x'\beta + \varepsilon \text{ where} \tag{3}$$

$$WTP = 0 \text{ if } d^* = 0;\ WTP = WTP^* \text{ if } d^* = 1;$$

$$E[WTP|WTP > 0] = x'\beta$$

Only the sign of d^* is observed and in our case d^* is either zero or one. The selection Equation 2 is a Probit model and the structural Equation 3 is a regression model on positive WTP.

However, the assumption of independence can be questioned. It might for example be reasonable to assume that both the probability of a positive WTP, and the WTP given a positive WTP, depend positively on income. The second (structural) effect can then be assumed to depend negatively on the first effect, since one may assume that those individuals who change from zero WTP to a positive WTP would have a lower WTP (on average) than those who had a positive already before. This would be the result if the error terms ε and μ were positively correlated. The other two-equation model estimated is therefore a Tobit type 2 model (Amemiya, 1981), where a covariance between the error terms, ρ, is estimated:

$$\text{and } d^* = x'\gamma + u \tag{4}$$

$$\text{where } WTP^* = x'\beta + \varepsilon; \operatorname{Cov}[\varepsilon, u] = \rho \tag{5}$$

$$WTP = 0 \text{ if } d^* = 0;\ WTP = WTP^* \text{ if } d^* = 1$$

$$E[WTP|WTP > 0] = [x'\beta + \rho\sigma\lambda(x'\gamma)] = [x'\beta + \beta_\lambda\lambda(x'\gamma)]$$

We estimate this model with MLE in order to make efficient use of the data. Tobit 1 is a special case of both Tobit 2 and the independent model, where $d^* = WTP^*$. The Tobit 2 model, in turn, would collapse to the independent model for $\rho = 0$, so the independent model is a restricted Tobit 2 model. Although Tobit 1 is restrictive, we report the results from this model as well since it is still commonly used, and since it illustrates the gains of using a more suitable model.

In order to test for functional form of Equations 3 and 5 we performed a standard Box–Cox transformation as follows:

$$WTP^{(\theta)} = \alpha + \sum_{i=1}^{K} \beta_i x_i^{(\lambda)} + \sum_{i=K+1}^{N} \beta_i x_i + \varepsilon \tag{6}$$

based on a Heckit estimation of the Tobit 2, and on the independent regression on positive WTP. $\theta = \lambda = 1$ and $\theta = \lambda = 0$ imply a linear and log-linear specification, respectively. The K transformed independent variables are in our case income and wealth. For the Heckit estimation of Tobit 2, the estimated λ is 0.008, with a prob-value of 0.95, and the estimated θ is 0.977, with a prob-value of less than 0.001. Similar results were obtained for the independent regression. These results clearly suggest a specification with WTP as the dependent variable and the log of income and wealth as independent variables. Table 5 reports the estimated marginal effects based on this functional form for the three models discussed. In order to obtain the total marginal effects, and hence taking the effects of both the selection equation and the structural equation into account, we use the McDonald and Moffit (1980) decomposition of the total marginal effect:

$$\frac{\partial E[WTP]}{\partial x_i} = P[WTP > 0]\frac{\partial E[WTP|WTP > 0]}{\partial x_i} + E[WTP|WTP > 0]\frac{\partial P[WTP > 0]}{\partial x_i} \tag{7}$$

where x_i is in log-form for income and wealth.

For Tobit 2, the coefficient for ρ is negative (the unexpected sign) and insignificant. The problem with this type of two-equation model is that the Probit equation usually explains the selection quite poorly. In our case, the goodness of fit for the Probit equation is very low, with a likelihood ratio index of 0.07. In addition, the significance of the coefficient for ρ could be very sensitive to the specification of the model. However, we tested several different specifications of the selection equation, and for all cases when the model converged the estimated coefficient for ρ was insignificant. It is not clear in our case which of the models to prefer, but we can make some additional comments on the performance of the two models. Leung and Yu (1996) show that a sample selection model, e.g. a Tobit 2 model, will perform worse than an independent model if

Table 5. *Marginal effects (evaluated at sample means) for Tobit type 1 and 2, and independent specifications. p-values in parentheses*[7]

		Tobit 2		Independent model				
		Homoscedastic		Homoscedastic		Heteroscedastic		Tobit 1
	Probit[8]	Structural	Total	Structural	Total	Structural	Total	Total
log (*Income*)	0.078	47.15	51.37	48.07	52.14	33.07	42.65	47.65
	(0.003)	(0.068)	(0.005)	(0.01)	(0.000)	(0.001)	(0.000)	(0.000)
Income elasticity			0.32		0.32		0.26	0.29
log (*Partner income*)	0.007	22.29	17.37	22.35	17.40	12.31	10.81	12.07
	(0.67)	(0.38)	(0.34)	(0.07)	(0.07)	(0.027)	(0.05)	(0.10)
Partner elasticity			0.11		0.11		0.07	0.07
log (*Wealth*)	0.007	−4.12	−1.22	−4.01	−1.13	−2.28	−1.60	0.54
	(0.02)	(0.16)	(0.56)	(0.10)	(0.54)	(0.22)	(0.22)	(0.70)
No children	−0.013	17.23	9.15	17.49	9.31	22.10	11.73	5.77
	(0.29)	(0.15)	(0.32)	(0.05)	(0.17)	(0.004)	(0.05)	(0.27)
Sex	−0.054	65.10	33.30	65.07	33.22	48.08	20.78	21.03
	(0.02)	(0.01)	(0.08)	(0.000)	(0.02)	(0.000)	(0.02)	(0.04)
Education	0.005	9.33	7.83	9.59	8.03	5.78	5.42	4.64
	(0.11)	(0.01)	(0.004)	(0.001)	(0.000)	(0.001)	(0.000)	(0.004)
Serious disease	−0.027	13.34	3.19	13.14	2.30	6.44	−2.51	1.06
	(0.48)	(0.78)	(0.93)	(0.67)	(0.90)	(0.64)	(0.85)	(0.95)
Pollution knowledge	−0.015	13.44	5.94	13.59	6.02	31.24	18.35	−0.51
	(0.48)	(0.56)	(0.73)	(0.42)	(0.64)	(0.002)	(0.03)	(0.96)
Retired	0.022	−61.28	−38.02	−65.53	−41.02	−53.41	−32.82	−16.38
	(0.55)	(0.32)	(0.40)	(0.02)	(0.06)	(0.000)	(0.01)	(0.37)
Env. org.	0.081	67.56	66.50	68.74	67.45	18.95	32.88	47.49
	(0.03)	(0.03)	(0.005)	(0.01)	(0.002)	(0.35)	(0.05)	(0.004)
Big city	−0.047	47.49	22.61	47.21	22.23	14.06	−0.97	11.90
	(0.05)	(0.05)	(0.21)	(0.01)	(0.13)	(0.23)	(0.93)	(0.28)
House owner	0.001	70.23	49.77	69.96	49.58	49.03	35.30	28.55
	(0.96)	(0.005)	(0.01)	(0.002)	(0.004)	(0.002)	(0.01)	(0.03)
Nature knowledge	−0.0003	1.56	1.04	1.54	1.02	0.83	0.55	0.48
	(0.73)	(0.01)	(0.03)	(0.01)	(0.03)	(0.08)	(0.15)	(0.18)
Age	−0.009		−2.08		−2.08		−1.98	−2.30
	(0.000)		(0.000)		(0.000)		(0.000)	(0.000)
Nature important		5.34	3.76	5.49	3.79	17.82	12.55	133.6
	(0.82)	(0.82)	(0.75)	(0.75)	(0.75)	(0.05)	(0.05)	(0.000)
Rho		−0.042						
		(0.30)						
No. of observations	2120	2120	2120	1467	2120	1467	2120	2120
log-L	−1216.2	−11 725.3				−10 030.21		−11 104.0
Restr. Log-L	−1309.1							

there is correlation between the regressors in the second stage and the inverse Mill's ratio, and that the degree of censoring affects the co-linearity problem. In our case there are approximately 30% with zero WTP and there does not appear to be any problem with co-linearity.[9] Because of this the significance test of ρ will be more reliable. The marginal effects, and their probability values, for the independent and Tobit 2 models have the same interpretation, and the differences between them are small. In the following discussion we will thus largely focus on the independent model.

The hypothesis of homoscedasticity can be strongly rejected for the independent model. Therefore we estimate an independent model with multiplicative heteroscedasti-

[7] All equations also include a constant, a dummy variable for positive partner income, a dummy variable for low income and an income variable for low income. In Tobit 2, age is included only in the Probit equation in order to avoid over-specification.

[8] A similar Probit model was estimated for the independent model with slightly lower *p*-values.

[9] The condition number for the regressors in the second stage is 110, while the condition number for the regressors and inverse Mill's ratio is 115.

city in the structural equation by MLE. The estimated marginal effects are somewhat different from the estimated model under homoscedasticity, but the signs appear quite robust. Further, even though these types of models are known to be sensitive to heteroscedasticity, it is difficult to know the most appropriate way of correcting for this.

The estimated marginal effects for own income and education are positive and significant in both the selection (Probit) and the structural equation. Thus, an increase in one of these variables increases both the probability of having a positive WTP, and the WTP given a positive WTP. The 'marginal effects' for sex are significant in both equations, but have opposite signs. A reported Probit marginal effect of -0.054 will then imply that men have about 5 percentage units lower probability of a positive WTP than women do. A reported structural marginal effect of 65 will then imply that males have a maximum WTP, which is about 65 SEK/month larger than females, given a positive WTP. The estimated marginal effects for wealth and environmental organization are positive and significant only in the selection equation. The marginal effects for partner income, number of children, knowledge about pollution, retired, house owner and knowledge about nature are only significant in the structural equation. The estimates for serious disease and big city were expected to be positive and significant, but the first is insignificant in both equations, and the second is negative and significant in the selection equation.

We can also compare the total marginal effects of the three models, i.e. the effect on WTP of a change in one of the dependent variables. Here we clearly see the virtues of using the more suitable two-equation models compared with the simple Tobit 1 model, since the latter model cannot reveal the separate effects on WTP. This is also an explanation of why the marginal effect for nature important is so much higher in the Tobit 1 model, since this variable only explains the WTP given a positive WTP. Furthermore, the difference between the estimated total marginal effects for the independent model and the Tobit 2 model are very small. The total own-income elasticity[10] in both homoscedastic models is 0.32, and the elasticity for partner's income is 0.11, while the corresponding elasticities for the heteroscedastic specification are 0.26 and 0.07. Thus, WTP depends positively on both individual and household income.[11] Hence, a percentage income increase for both adults would then imply an increased WTP by slightly more than 0.4% (0.3%) in the homoscedastic (heteroscedastic) case, implying that the WTP income share decreases in income. Still, an income elasticity far below unity is typically found in most CVM studies for environmental goods according to Kriström and Riera (1996).

We also see, for example, that members of an environmental organization are expected to have an additional WTP of almost 70 SEK/month according to the homoscedastic models, but only slightly more than 30 SEK/month according to the heteroscedastic model.

IV. CONCLUSIONS

In this paper we have tried to measure individual WTP for air quality improvement where the respondents live and work. The mean WTP for a 50% reduction of harmful substances was about 2000 SEK/year, which is of the same order of magnitude as earlier stated preference studies in Nordic countries.

We have also demonstrated the large potential gains by using the more suitable Tobit 2 or independent specifications, instead of the standard Tobit 1 model. In the econometric analysis, most parameters had the expected sign. WTP was found to increase in income, wealth and education. Furthermore, it was larger for men, members of environmental organizations, people living in big cities, and people who own their house or apartment, and it was lower for retired people. However, the additional WTP for people in big cities was lower than expected (although significant), indicating a possible insensitivity-to-scope effect. Hence, we cannot reject the hypothesis that people's responses to CV surveys to some extent reflect a 'purchase of moral satisfaction'. There still appears to be considerable uncertainty regarding the appropriate benefits of reduced air pollution; an uncertainty that we to a large extent probably will have to live with.

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[10] It is likely that very low reported incomes are positively correlated with positive transfers, which we have not been able to measure. Therefore, we included both a dummy variable for individuals with an income lower than 20 000 SEK, and a variable equal to the product of the dummy variable and income. Thus, all reported income elasticities are for individuals with an income higher than 20 000 SEK.

[11] Often a model with constant elasticity is estimated, i.e. with ln (WTP) and ln ($Income$). The problem with this specification is that the marginal effect is not the income elasticity of expected WTP, instead it is the expected value of the individual income elasticity.

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