POLICY RESEARCH WORKING PAPER 2280

Willingness to Pay for Air Quality Improvements in Sofia, Bulgaria

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People in Sofia are willing to pay 4.2 percent of their income or more for a program to improve air quality.

The World Bank
Development Research Group
Infrastructure and Environment
January 2000

Summary findings

Through a survey, Wang and Whittington study willingness to pay for improvements in air quality in Sofia, Bulgaria.

Using a stochastic payment card approach — asking respondents the likelihood that they would agree to pay a series of prices — they estimate the distribution of willingness to pay various prices.

They find that people in Sofia are willing to pay up to about 4 2 percent of their income for a program to improve air quality. The income elasticity of willingness to pay for air quality improvements is about 27 percent.

For comparison, they also used the referendum contingent valuation approach. Results from that approach yielded a higher estimate of willingness to pay.

This paper — a product of Infrastructure and Environment, Development Research Group — is part of a larger effort in the group to understand the economics of pollution control in developing countries. Copies of the paper are available free from the World Bank, 1818 H Street, NW, Washington, DC 20433. Please contact Roula Yazigi, room MC2-533, telephone 202-473-7176, fax 202-522-3230, email address ryazigi@worldbank.org. Policy Research Working Papers are also posted on the Web at www.worldbank.org/research/workingpapers. Hua Wang may be contacted at hwang1@worldbank.org. January 2000. (27 pages)

Willingness to Pay for Air Quality Improvement in Sofia, Bulgaria

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I. Introduction

A number of empirical studies have suggested that, rather than having a single point economic value, respondents in Contingent Valuation (CV) studies may instead have a range of economic values in their mind or a valuation distribution (e.g., Cameron and Quiggin, 1994; DuBourg et al., 1994). This notion has been directly incorporated into several CV surveys that explicitly acknowledge that respondents may face uncertainties in answering valuation questions. For example, Li and Mattsson (1995) assumed that respondents had incomplete knowledge about their true valuation of a commodity and might give wrong answers in dichotomous CV surveys. After they answered the valuation question, respondents were asked a follow-up question to measure their confidence in their CV answer. This was used to characterize the degree of preference uncertainty. Ready et al. (1995) acknowledged that respondents might have difficulty in resolving ambivalent information presented in CV studies, so they offered respondents the opportunity to express the intensity of their preferences. This enabled the authors to estimate "regions of ambivalence" for their respondents. Welsh and Bishop (1993) and Welsh and Poe (1998) presented a multiple bounded discrete choice (MBDC) approach that asked respondents certainty intensity questions over a range of price thresholds. Their question format is also consistent with the assumption that CV respondents may have a distribution or range of possible values.

Wang (1997a & 1997b) has argued that uncertainty is an inherent characteristic of people's economic valuation process for both market and non-market commodities, and can never be fully resolved. He explicitly discussed the concept of an individual's valuation distribution, and proposed a random valuation model for treating "don't know" responses in dichotomous CV surveys, and a stochastic payment card approach to estimate individuals' valuation distributions. In this stochastic payment card approach, the enumerator presents the respondent with a payment card and asks her the likelihood that she would agree to pay a series of prices. By assuming (1) that the likelihood of a "yes"

answer to the valuation question is the probability of an increase in the individual's utility, and (2) a specific functional form for the individual's valuation distribution, each individual's valuation distribution can be estimated.

This paper presents an empirical study of people's willingness to pay (WTP) for an air pollution control program conducted in Sofia, Bulgaria. Two surveys were conducted in Sofia: one using the stochastic payment card and the other a referendum CV question. The CV scenario presented to the two groups of respondents was the same. The study thus provides a comparison of estimated WTP using the stochastic payment card and the traditional referendum contingent valuation approaches. The results show that the traditional referendum approach gave much higher estimates of individuals' WTP than the stochastic payment card approach.

The paper is organized as follows. The next, second section briefly reviews the stochastic approach of an individual's valuation. Section III presents the empirical study conducted in Sofia. Further discussion of the stochastic valuation and referendum approaches is provided in Section IV.

II. The Stochastic Valuation Approach

It has been argued that uncertainty is an inherent characteristic of people's economic valuation process for both market and non-market commodities and can never be fully resolved, and that an individual's valuation should be characterized as a random variable with an associated distribution (Wang, 1997a &b). Wang notes that there are several sources of uncertainty associated with an individual's valuation process for nonmarket goods and services. First, uncertainty may exist with respect to the commodity in question. The quality of a good or service such as air quality improvement has numerous attributes. Air quality improvements can be approximately described in terms of changes in the concentrations of a specified number of pollutants, but strictly speaking, it is not practically possible to give a complete description of an air quality change. Quantitative measures are typically presented for mean or peak values of concentrations of selected pollutants.

Second, even if the quality change could be completely known, an individual may be still uncertain about how to *use* the good or service in question. For example, an individual may wonder what the quality change means to him, e.g., what is the health effect of the air quality change? What are the savings in terms of reduced medical care costs associated with this air quality change?

Third, uncertainty exists in markets. The value to an individual of a commodity is influenced by *prices* of both substitute and complementary goods or services. In the air quality valuation example, future medical care costs and the prices of air pollution control technologies are directly related to an individual's value of an air quality change and are somewhat unknown to the individual.

Fourth, uncertainty may also exist with respect to an individual's own characteristics and preferences. Individuals are sometimes uncertain about their future income. Furthermore, people's tastes may change over time due to learning or other experiences. In the context of contingent valuation surveys, because of the hypothetical nature of the valuation task, individuals may face other uncertain factors, such as the terms of provision of a public good.

The notion that an individual's value of a good or service is stochastic, and is best characterized as a random variable with an associated a valuation distribution, is consistent with daily observations on the ways people talk about their willingness to pay for a commodity. Many people use two ways to express their willingness to pay for a good. One is to say that they are willing to pay *about* X dollars, which may be interpreted as the mean value of a valuation distribution; the other is by giving a range from Y to Z dollars, which can also be interpreted as information about a valuation distribution.

A general valuation framework under uncertainty can be described as follows. Let the value of an individual's utility function at a status quo level of environmental quality, E_0, be:

$$V_0 = V(Y, P, E_0, Z, \varepsilon_1) \qquad (1)$$

where Y is income; P is a price vector; Z is a vector of socioeconomic variables; and ε_1 represents uncertain factors which are not reflected in Y, P, E_0, and Z. When the level of environmental quality improves from E_0 to E_1, and the individual's utility changes to $V_1 = V(Y, P, E_1, Z, \varepsilon_1)$. Assume that an individual is willing to pay up to an amount of WTP for the change in environmental quality, such that :

$$V_0\,(Y\text{-}WTP, P, E_1, Z, \varepsilon_1) = V_0\,(Y, P, E_0, Z, \varepsilon_1) \qquad (2)$$

Solving for WTP yields ...

$$WTP = WTP(Y, P, E_0, E_1, Z, \varepsilon_1) = E[WTP] + \varepsilon_2 \qquad (3)$$

where E[.] is an expectation transformation, and ε_2 is the random term of the individual's economic value WTP. One would expect that this random variable ε_2 should be different for different individuals.

To measure individuals' valuation distributions, Wang (1997b) proposes a new value elicitation format termed the stochastic payment card approach. An example is presented in Figure 1, which is similar to the multiple bounded dichotomous choice model employed by Welsh and Bishop (1993), except that in Figure 1, numeric likelihood values are presented with verbal likelihood references. Respondents are directly asked how likely they would be to agree to pay certain amounts of money for the commodity. A card showing different prices is presented to respondents and they are asked how likely they would be to agree to pay each of the amounts shown. Respondents are asked to select a number as the likelihood or probability that they would agree to pay a specific price. If the respondent answers a series of such questions, a likelihood matrix can then be observed. Results from the fields of experimental psychology and decision analysis (Wallsten et al., 1983 & 1995; Clemen, 1990) have shown that people use subjective probabilities in their daily lives and that a person can express a likelihood value either verbally or numerically. However, some individuals will interpret language differently

than the numerical values; many people find numbers too abstract to use in expressing likelihood values.[1] Therefore, in the design of the stochastic payment card, respondents are provided with both numbers and words so that they more easily express themselves.

The likelihood matrix obtained with the stochastic payment card approach provides probabilities of an individual saying "yes" to referendum questions with different payments. This likelihood matrix can be interpreted as a record of the individual's cumulative valuation distribution function (CDF). As in dichotomous-choice contingent valuation studies where different prices are presented to different split-samples of respondents, the probability that a utility maximizer, with a cumulative valuation distribution function F(.), would accept the offer presented in this dichotomous choice question (or vote for the proposal) would be,

$$
\begin{aligned}
Pr(yes) &= Pr\,\{V(Y\text{-}t, P, E_1, Z, \varepsilon) > V(Y, P, E_0, Z, \varepsilon)\} \qquad (4)\\
&= Pr\,\{V(Y\text{-}t, P, E_1, Z, \varepsilon) > V(Y\text{-}WTP, P, E_1, Z, \varepsilon)\}\\
&= Pr\,\{WTP > t\}\\
&= 1 - F(t)
\end{aligned}
$$

where again V is an indirect utility function; Y is income; P is a price vector; Z is a vector of individual's socioeconomic characteristics; E_0 is the initial environmental quality, which would be improved to E_1 if the air quality management plan is implemented; t is the price offered to obtain the environmental quality change; and WTP is the individual's value for the certain change. The likelihood matrix obtained with the stochastic payment card is a record of an individual's probabilities of accepting different proffered payments.

The cumulative valuation distribution function F(.), the valuation probability density function, the mean and the variance of the probability function can be estimated with the likelihood matrix data. The estimation of the valuation distribution is straight

[1] It is possible that introducing uncertainty explicitly in the CV questions could create confusion for the respondent rather than enabling a respondent to give a more complete valuation response. This concern is especially pertinent in countries where people do not have a long experience with democratic voting procedures, such as Bulgaria. However, the results of our case study and the findings of Welsh and Poe (1998) would appear to indicate that this threat is perhaps not as serious as one might fear.

forward. From (4), we have $P_{ij} = 1\text{-}F_i(t_j)$, where P_{ij} is individual i's probability (the number circled by respondent i on the stochastic payment card) of voting for the referendum at the *j*th payment point t_j; $F_i(.)$ is the person *i*'s CDF. By assuming a specific functional form for $F_i(.)$, standard statistical software can be used to estimate the parameters in $F_i(.)$, and the mean μ_i and standard variance σ_i of individual i's valuation distribution. For example, if a normal distribution is assumed for F(.), we have,

$$
\begin{aligned}
Pi &= 1 - \Phi(\frac{\mu - ti}{\sigma}) \\
ti &= \mu + \sigma\Phi^{-1}(1 - Pi)
\end{aligned}
\qquad (5)
$$

With a set of t_i's and P_i's, a simple regression can be used to estimate μ and σ.

For cases where numeric likelihood values cannot be obtained for estimating a valuation distribution, it might be possible to estimate an upper bound, a lower bound, and a mean value with some reasonable assumptions about the meaning of the verbal likelihood data. An estimate of the upper bound of an individual's valuation range is the lowest price where a respondent gives a "definitely no (0%)" answer. Likewise, the lower bound of an individual's valuation range can be found at the highest price where a respondent gives a "definitely yes (100%)" answer. The mean of a valuation distribution can be obtained from prices where a respondent says "not sure (50%)."

III. Sofia Air Valuation Study

Study Design

In October 1995, we conducted a CV survey in Sofia, Bulgaria, to estimate households' willingness to pay for air quality improvement. The purpose of the CV survey included: 1) to estimate people's willingness to pay for air quality improvement in Sofia, Bulgaria; 2) implement the stochastic payment card value elicitation procedure; and 2) to compare the stochastic payment card approach with the conventional referendum CV approach. The CV scenario section of the household questionnaire had

five parts: (1) Background: Current Air Quality Conditions in Sofia; (2) A Description of an Air Pollution Clean-up Plan; (3) Consequences of the Air Pollution Clean-up Plan; (4) Costs of the Air Pollution Clean-up Plan; and (5) Valuation Question(s). Respondents were also asked questions about their socioeconomic characteristics, environmental attitudes and perceptions, and reactions to the air quality improvement program.

The study design is summarized in Figure 2. A stratified random sample of households was drawn from neighborhoods throughout the city. The response rate was about 60%, and reflects some suspicion that people in Sofia feel when a stranger comes to their home and requests an interview. Five hundred and fourteen in-person interviews were completed with household heads or their spouses. The sample was first split into two approximately equal parts. Two hundred and forty three interviews were completed with respondents who received a survey instrument with a standard referendum CV question (Version A). Five different referendum prices were used (100, 300, 500, 1000, 2000 levas[2] per month); there were thus five split-samples of approximately 48 respondents each. These prices represent from 1% to 18% of the mean household income of the respondents.

The remaining 271 respondents received a stochastic payment card (Version B). These respondents were subdivided into two groups: B1 (n = 135) and B2 (n = 136). Respondents in Group B1 received a standard stochastic payment card with the full set of eight prices (25, 50, 100, 300, 500, 1000, 2000, 3000 levas per month); respondents in group B2 received a truncated stochastic payment card with five prices (100, 300, 500, 1000, 2000 levas per month). Respondents who received versions B1 and B2 were given numeric likelihood values of 0% ("Definitely no"); 25% ("Probably no"); 50% ("Not sure"); 75% ("Probably yes"), and 100% ("Definitely yes") to indicate the probability that they would pay the specified prices.

Specifically, respondents were asked the following willingness-to-pay question in conjunction with the stochastic payment card:

> I (the enumerator) want you (the respondent) to suppose that the people of Sofia had an opportunity to vote for this (air quality improvement) plan. If the majority of people voted for the plan, the

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[2] In October, 1995, US$1 = 68 levas.

plan would go into effect and every household would have to pay. If the majority of people voted against the plan, no one would have to pay and air pollution would stay as it is now.

Now, I want you to tell me how likely you would be to vote for the air quality improvement plan in Sofia, if your monthly expenses for transport, electricity, etc. would increase in different amounts. In other words, I want to know how likely it would be that you would vote for the air quality clean-up plan if it would cost your household different monthly amounts.

There are no right or wrong answers; we really want to know how you would vote on this proposal.

If the number indicated in the left column (monthly price in leva) were the increase in your monthly expenses for the implementation of the air pollution clean-up plan, how likely is it you would vote for the plan?

Results of Analysis

Overview

Table 1 presents the socioeconomic and demographic information on respondents who received both Version A and Version B questionnaires. As hoped, there are no statistically significant differences in these two subsets of sample respondents for any of the socioeconomic or demographic variables.

Table 2 presents eight possible types of response patterns that respondents could give to the questions on the stochastic payment card, and the percentage of sample respondents in each. For the standard version of the payment card, 71% of respondents gave answers that suggest the individuals' WTP ranges were covered by the payment card,[3] while 11% of respondents had WTP ranges that were partially covered by the card. Thirteen percent of respondents' WTP ranges were not covered by the card (or these respondents were unwilling to reveal their WTP ranges). Valuation distributions could not be estimated for these respondents.

Table 3 summarizes the answers of respondents who received the referendum valuation question (Version A). Of the 243 referendum interviews, 216 yes/no/not-sure answers were recorded and could be used for further analyses (27 respondents did not

[3] There were six observations for which respondents gave answers with a higher probability of voting for the proposal at a higher price. We considered these to be enumerator mistakes and deleted them from the sample for purposes of analysis.

answer the valuation question). As expected, as the price of the air quality improvement plan increased, the percentage of respondents in each split-sample that rejected the plan (i.e., that refused to pay) increased.

Estimation of Individuals' Valuation Distributions

Valuation functions were calculated for 219 respondents in the group B subsample (Cases 1, 2, and 3 in Table 2); the mean and the variance of these valuation functions were estimated using the approach described in Section II. Valuation distribution functions could not be estimated for the 46 respondents with Case 4-8 response patterns (17 percent of the total number of 271 respondents that received either the B1 or B2 version of the questionnaire). The inability of the stochastic payment card elicitation approach to handle these cases could pose a serious threat to the validity and usefulness of the method if the excluded respondents are systematically different from respondents who give Case 1-3 response patterns. However, no systematic difference between these two groups was found in this study.[4]

In calculations of mean values and variances of individuals' valuation distributions, values of 0.005 and 0.995 were used in the regressions instead of 0 and 1 for probability P_i. Assuming the individuals' valuation functions are all normally distributed,[5] the mean values of μ and σ are 508 and 159 levas respectively (Table 4)[6]. The average of the standard variance of the mean WTP estimation is 73 levas, and the average standard error of the standard variance estimation is 51 levas.

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[4] However, the average value of the mean WTPs of the sample does change somewhat if responses for cases 4 and 5 are included with reasonable assumptions on the WTP values. For example, if one assumes a WTP of 3000 levas for those respondents who gave all "definitely yes" answers and a WTP of 25 levas for those giving all "definitely no" answers, then the sample mean WTP would be 602 levas rather than 508 levas. We do not feel that there are strong reasons for treating cases 4 and 5 as protest bids. In future studies, we intend to expand the price range of the payment card.

[5] In fact, there is no reason to suppose that each individual in the sample has the same functional form for his valuation function; we make this assumption for simplicity.

[6] The average value of those prices corresponding to the indifferent (50%) responses is about 473 levas which is very close to the value estimated by modeling the individuals' valuation distributions.

Econometric Analysis of Individuals' Valuation Distributions

Assuming individuals' valuation distributions have the same functional form,[7] the calculated mean WTP and standard variances vary across respondents in systematic ways. Figure 3 shows how the mean WTP values and the standard variances of the valuation distributions for Group B1 respondents vary with household income. As expected, respondents with higher household incomes have higher mean WTP's and larger variances.

Table 5 presents the results of three econometric models that attempt to explain differences across respondents in their mean WTP and the standard variance associated with their valuation distributions. Both the household income and the education of respondents had significant effects on respondents' willingness to pay for the air pollution clean-up plan, with expected, positive signs. The elasticity of mean WTP with respect to income is about 0.27. Older respondents and women had lower WTP. However, the models show that people with higher uncertainty about their future income would be willing to pay more for the air pollution clean-up plan.

There are also several significant variables in the second model in Table 5 that explain differences in the estimated variances of individuals' valuation functions, i.e., the variance of an individual's valuation distribution is correlated with individuals' socioeconomic and demographic status. Men have larger variances of their valuation distributions than women; respondents with higher uncertainties about their future income had larger variances in their valuation distribution. Truncation also had a significant effect, indicating that respondents' answers are sensitive to the payment card design.

The same variables were generally statistically significant in both the mean value and variance models. A regression of $\log(\sigma/\mu)$ against other exogenous variables showed that the variable MALE was positive and statistically significant. Men thus have a wider variance of WTP than women, even when the mean WTP's are the same. The variable UNCERT has the expected positive sign but is not statistically significant.

Comparison with the Referendum Approach

After deleting observations with missing values, 194 interviews were available to estimate probit models explaining the determinants of respondents' answers to the referendum CV question (Version A). The modeling results are provided in Table 6. These results are used to estimate mean WTP values for the Group A sample. There were 49 "not sure" ("Don't know" or DK) answers to the referendum questions given by Group A respondents. Two methods were used for analyzing these data: 1) treating DK as "no"; 2) the threshold approach developed by Wang (1997a). The two methods gave consistent results.

The results of these probit models indicated that the price offered to respondents had a strong negative effect on the likelihood that a respondent would accept the air quality improvement plan. Income and education have significant, positive effects on the likelihood of voting for the air quality improvement plan; age has a significant, negative effect. Contrary to expectations, respondents who have a respiratory disease or who live in a household in which a family member has a respiratory disease were less likely to vote for the air quality improvement plan. Female respondents were more likely to give a "not sure" answer.

Using these estimated probit model results, the mean WTP for the sample was calculated. When the DK responses were treated as "no's," the mean WTP for the Group A respondents was 1430.[8] Other ways of handling the DK responses resulted in higher mean WTP estimates. The lowest mean WTP estimated with the referendum CV data is almost three times the highest mean WTP calculated using the data from the stochastic payment card (508 levas per month; Table 4)

This difference in the estimated mean WTP between the Group A and Group B respondents could be a result of several factors because the analyses with the data from the stochastic valuation approach and the referendum question are based on different theoretical assumptions and different procedures for handling "problematic" responses.

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[7] The results with the normal distribution assumption were used in the econometric analyses.

To isolate the effect of the two elicitation procedures on the estimated mean WTP, we conducted additional analyses in which we treated the data obtained from the stochastic payment card at a specific price as if it were the individual's answer to a single referendum question. A new data set was thus constructed for Group B respondents by randomly assigning a price to each respondent. In this way, we were able to use the answers from all of Group B respondents (except the six with inconsistent responses). This new data set for the Group B respondents was then analyzed in exactly the same way as the data set for the Group A respondents.

Six different ways were used to encode the likelihood answers from the stochastic payment card as yes/no/not-sure answers in order to generate a referendum CV sample for the WTP estimation for respondents in Group B:

(1) "definitely yes" answers in the stochastic payment card treated as "yes" in the referendum model; "probably yes", "not sure" and "probably no" treated as "don't know's"; "definitely no" treated as "no";

(2) "definitely yes" and "probably yes" answers in the stochastic payment card treated as "yes" in the referendum model; "not sure" treated as "don't know's"; "probably no" and "definitely no" treated as "no";

(3) answers in the stochastic payment card simply treated as an ordered ranking;

(4) "definitely yes" answers in the stochastic payment card treated as "yes" in the referendum model; all others treated as "no";

(5) "definitely yes" and "probably yes" answers in the stochastic payment card treated as "yes" in the referendum model; all others treated as "no";

(6) "definitely yes" and "probably yes", "not sure" answers in the stochastic payment card treated as "yes" in the referendum model; all others treated as "no."

Because the results for the Group B respondents depend upon the price a particular respondent is assigned, we conducted a Monte Carlo analysis with different trial price

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[8] The estimated model was used to calculate the WTP for each respondent in the sample; 1430 levas is the mean of these values.

assignments, and calculated the sample mean WTP for each trial. For each of these six ways of converting likelihood answers to a referendum format, 1000 trial price assignments to Group B respondents were made. The sample mean WTP result presented for Group B respondents for each way of converting likelihood answers from the stochastic payment card to a referendum format is the mean of the 1000 trial price assignments.

Table 7 shows that the highest mean WTP obtained from the stochastic payment card data is 523 levas, when "definitely yes," "probably yes," and "not sure" are all treated as "yes" responses in a referendum model. This estimated mean WTP number is still much lower than the lowest estimate obtained using the referendum value elicitation approach (1430 levas).[9] This Monte Carlo analysis confirms that the difference in the mean WTP estimates obtained from the stochastic payment card data and the referendum data is largely due to the elicitation procedure itself, and not to the assumptions underlying the calculation procedures.

V. Discussion

The stochastic payment card approach presented in this paper is a preliminary, exploratory attempt to collect data that can be used to estimate individuals' valuation distributions. It requires respondents to give subjective probabilities about whether a hypothetical action would be taken. The approach assumes that the probability that a respondent is going to take an action is the probability that respondent's utility value increases. This in turn is based on a rational choice assumption that individuals take actions when and only when their utility values increase. The procedure proposed for estimating an individual's valuation distribution is simple and does not require the use of sophisticated econometric models. However, the analyst must assume a functional form for individuals' valuation distribution functions. The evidence from our Sofia case study

[9] The ordered probit modeling approach for the stochastic payment card data gives a sample mean WTP estimate of about 516 levas (Wang, 1997b).

suggests that the mean value and the variance of the valuation distributions are not very sensitive to specific functional form assumed.

The stochastic payment card approach seems to have worked reasonably well in the case study. At the lowest price all respondents would ideally choose "definitely yes," and at the highest price, all responses would be "definitely no" (assuming the survey designers succeed in selecting low and high prices that bound all respondents' valuation distribution functions). Eighty two percent of respondents who received the full stochastic payment card (B1) gave "definitely yes" answers to the lowest price offered (25 levas) and 88% gave "definitely no" answers to the highest payment point (3000 levas). The results of the Sofia case study do indicate, however, that respondents' likelihood answers to questions on the stochastic payment card can be affected by the way payment cards are designed.[10] At a price of 100 levas (the lower end of the truncated payment card), respondents were more likely to give positive answers if they received the truncated payment card,[11] suggesting that they interpreted that lowest price as an indication that it was acceptable. One approach for dealing with this possible bias may be to extend the range of prices presented on the stochastic payment card, possibly including zero as the minimum price. Before we conducted the case study, we were concerned that respondents' unfamiliarity with democratic voting processes in Bulgaria would affect people's ability to answer CV questions in general, and the stochastic payment card questions in particular. However, based on our experience in Sofia during the fieldwork, we do not believe that this is a serious threat to the validity of our results.

In the economic valuation literature, analysts have generally used the option price approach to deal with the issue of uncertainty in future outcomes. This option price approach assumes a single point value in an individual's mind even when there exist obvious uncertainties. An option price can be estimated with data collected by a traditional contingent valuation survey with dichotomous choice valuation questions. The stochastic valuation approach, on the other hand, does not assume that a respondent

[10] An exponential increase of prices on the payment card could also have an effect on the valuation distribution estimation. One consequence could be an overestimate of the correlation of variance and the mean value of a valuation distribution.

[11] This is consistent with Rowe et al. (1996)'s findings (they did not find range and centering biases).

has a single point value for his maximum willingness to pay, even for a market good. The Sofia air valuation study suggests that the single point value assumption may be incorrect, because estimated variances of individuals' valuation distributions are correlated with uncertainty levels. The single value assumption would suggest that the variances estimated are white noise.

The valuation information obtained with the referendum elicitation procedure is necessarily incomplete, a fact well recognized by CV practitioners. A yes/no answer only gives information about one point on a valuation distribution function (with 0 or 1 representing a probability that should often be a number between 0 and 1). Because a yes/no answer is quite easy for respondents to offer (a positive side of the approach), such a yes/no answer might be offered without respondents seriously considering the question. The stochastic payment card approach attempts to obtain a more complete description of each individual's preferences. It focuses on measuring each individual's valuation intensity information; this information is relatively complete compared to that obtained from a single dichotomous choice question. The sample size required for a study using a stochastic payment card approach should thus be smaller than for a conventional referendum CV study.

The stochastic payment card approach, however, requires respondents to give numeric likelihood values; some respondents may have difficulty doing this. Significant confusion may be induced in some respondents if a study is not well designed. Providing corresponding verbal or visual aids may help respondents report likelihood values, but this may not solve the problem, especially for illiterate respondents. More research is needed to assess the nature of subjective probabilities that respondents give in CV interviews. However, as discussed in Section II of this paper, even when the numerical likelihood information obtained is not sufficient to construct a model to estimate an individual's underlying valuation distribution, reasonable assumptions can be made based on the verbal likelihood data to estimate an upper bound, a lower bound and a mean value.

The traditional procedures used to implement the referendum CV approach are problematic if one does not assume that an individual's valuation is a single point

estimate. The error terms in the value estimation models proposed by Hanemann (1984) and Cameron (1989) are assumed to be homogeneous over the population; according to the stochastic theory of economic valuation they should be heterogeneous. The empirical study presented in this paper shows that the traditional dichotomous choice CV gave an estimate of people's WTP that was 2-3 times higher than the stochastic approach, despite the fact that the two approaches found the same determinants of WTP. More research is warranted to better understand the reasons for this difference.

Acknowledgements:

We would like to thank Dr. Dafina Gercheva for her guidance and advice on survey design and implementation issues in Sofia, and Dr. David Guilkey for his many helpful suggestions on the econometric analyses.

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Figure 1. An Example of the Stochastic Payment Card Design

(Please circle one number for each payment)

How would you vote if the passage of this envir. plan meant your utility bill would increase by $x per month for one year?

Price	Definitely Yes		Probably Yes			Not Sure	Probably No		Definitely No		
0	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
2	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
4	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
6	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
8	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
10	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
12	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
....	....										
100	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0

Figure 2. Sofia Air Valuation Study Design

(Total Sample Size N=514)

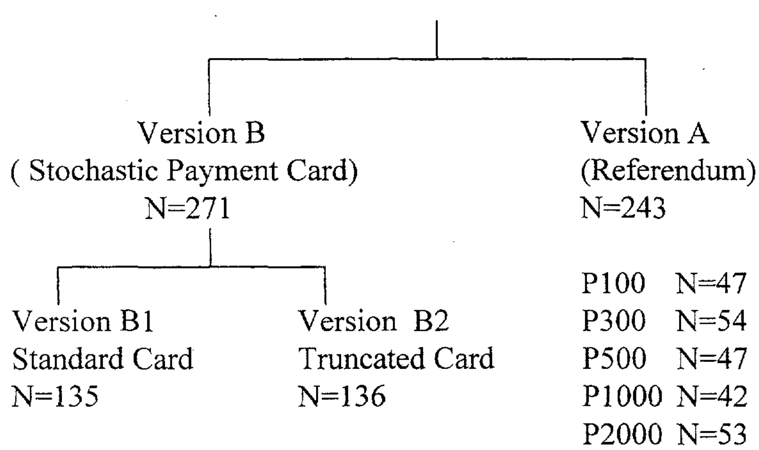

Figure 3. Income vs Mean Value and Standard Variance of an Individual's WTP Distribution

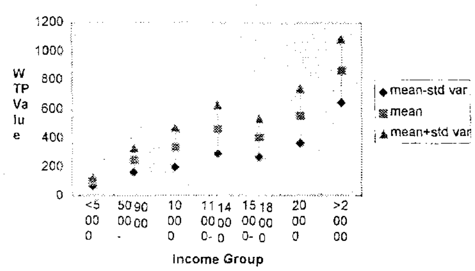

Table 1: Description of Major Socioeconomic and Demographic Variables

Variable Name	Description of Variables	Mean Value (Std Dev) of Sample A	Mean Value (Std Dev) of Sample B
Price	Hypothetical monthly cost in levas		
INC	Household monthly income in levas.	11,925 (8,424)	12,925 (10,908)
SCHOOL	Number of years a respondent attended a school.	13 (2.3)	12 (2.6)
MALE	1=the respondent is male; 0=otherwise.	0.37	0.47
AGE	Age of a respondent.	46 (14)	47 (15)
MARRY	1=the respondent was married; 0=otherwise.	0.77	0.83
RESP	1=there were respiratory diseases found in a household; 0=otherwise.	0.43	0.34
UNCERT	1=the respondent did not know how the household income would change over the next five years; 0=otherwise.	0.18	0.18
No. of Obs.		243	245

Table 2. Eight Possible Types of Response Patterns to Valuation Questions in the Stochastic Payment Card

Cases	Type of Response Pattern	Standard Version (B1)	Truncated Version (B2)
1	Set of responses includes both "definitely yes" and "definitely no" answers	96 (71%)	71 (52%)
2	Set of responses includes "definitely yes" but not "definitely no" answers	6 (4%)	23 (17%)
3	Set of responses includes "definitely no" but not "definitely yes" answers	9 (7%)	14 (10%)
4	"Definitely yes" response at the highest prices	7 (5%)	4 (3%)
5	"Definitely no" response at the lowest prices	11 (8%)	20 (15%)
6	All responses "probably-yes"	0	2 (1%)
7	All responses "not-sure"	0	2 (1%)
8	All responses "probably-no"	0	0
9	Inconsistent answers	6 (4%)	0
Total		135	136

Table 3: Percent of Respondents Giving Different Answers to Referendum CV Questions by Price

	Referendum Prices (Levas/Month)				
WTP Answers	100	300	500	1000	2000
No	4	14	24	29	42
Not Sure	2	6	11	24	6
Yes	94	80	65	46	52

Table 4: Sample Means of Individuals' Estimated Mean WTP and Standard Variance of WTP

Distribution Parameters	Normal Distribution
Mean WTP's	
Mean	508
Std. Dev.	458
Std Var of WTP	
Mean	159
Std. Dev.	135
Average R^2	0.86

Table 5: Econometric Analyses of Individuals' Valuation Distributions

	Dependent Variable: log(μ)	Dependent Variable: log(σ)	Dependent Variable: log(σ/μ)
Constant	3.4	2.7	-1.3
	(3.5)***	(2.4)**	(-19.9)***
log(INC)	0.27	0.21	
	(2.64)***	(1.84)*	
SCHOOL	0.07	0.06	
	(3.16)***	(2.31)**	
MALE	0.36	0.53	0.16
	(3.08)***	(3.96)***	(1.93)*
AGE	-0.02	-0.02	
	(-4.02)***	(-3.81)***	
RESP		0.24	0.14
		(1.76)*	(1.59)
UNCERT	0.30	0.44	0.14
	(2.02)**	(2.55)**	(1.24)
Shorter Card	0.44	0.39	
	(3.96)***	(2.99)***	
Adj-R^2	0.27	0.23	0.02
N	198	198	198

***-Statistically significant at the 1% level

**-Statistically significant at the 5% level

*-Statistically significant at the 10% level

Table 6: Model Results for Referendum Data (Group A Respondents)

Data Treatment	Treating "not sure" as "no"		Threshold Approach	
	Full Model	Reduced Form	Full Model	Reduced Form
PRICE	-0.8e-3 (-4.8)***	-0.8e-3 (-4.8)***	0.8e-3 (5.0)***	0.8e-3 (5.3)***
Constant	2.6 (3.1)***	1.6 (3.2)***	2.8 (3.5)***	1.9 (3.9)***
INC	0.3e-4 (1.9)**	0.2e-4 (1.6)*	0.3e-4 (2.0)**	0.2e-4 (1.7)*
SCHOOL	-0.1 (-1.4)		-0.05 (-1.1)	
MALE	0.2 (1.1)		0.1 (0.5)	
AGE	-0.02 (-2.0)**	-0.02 (-1.9)*	-0.02 (-2.4)**	-0.02 (-2.3)**
MARRY	-0.3 (-1.0)		-0.3 (-1.1)	
RESP	-0.4 (-1.8)*	-0.4 (-1.8)*	-0.4 (-1.8)*	-0.4 (-1.9)*
UNCERT	0.02 (0.08)		0.02 (0.06)	
threshold:				
Constant			0.2 (4.1)***	0.2 (4.2)***
Male			-0.1 (-1.6)	-0.1 (-1.7)*
Mean WTP		1429		1618
Std Error of Mean WTP		212		200
Std Dev of WTP		525		533
Sample Size		194		194

***-Statistically significant at the 1% level
**-Statistically significant at the 5% level
*-Statistically significant at the 10% level

Table 7: Estimation of WTP with Data from the Stochastic Payment Card, Using Traditional Referendum Modeling Methods and Monte Carlo Simulation

Models	I	II	III	IV	V	VI
Likelihood Answer Treatment	DY as yes; PY, NS & PN as DK; DN as no	DY/PY as yes; NS as DK; DN/PN as no	5 Ordered Answers	DY as yes; others as no	DY/PY as yes; others as no	DY/PY/ NS as yes; others as no
Modeling Method	Ordered Probit	Ordered Probit	Ordered Probit	Probit	Probit	Probit
Mean WTP	354	392	360	14	267	523
Std. Dev. of WTP	63	61	64	138	74	62
N	265	265	265	265	265	265

DY = Definitely yes; PY = Probably yes; NS = Not sure; DK = Don't Know; PN = Probably no; DN = Definitely no

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