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Willingness to pay to reduce health risks related to air quality: Evidence from a choice experiment survey in Beijing

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Abstract

This study reports the results from a discrete choice experiment (DCE) conducted in Beijing China. The aim and the objectives of the study are to elicit monetary values for the value of a statistical life (VSL) and the value of a statistical illness (VSI) that can be considered for policy purposes in China, and to examine how different payment regimes influence WTP and whether WTP is age-dependent. We find that our estimates of VSL and VSI are robust between different econometric models specifications and that they are reliable when compared to previous Chinese findings. We find no evidence of any VSL-age relationship but we find that the payment scheme had an effect on the levels of the estimates of the VSL and VSI, and that taking it into account the payment regimes when estimating the models improved their performance. However, levels were relatively close and not statistically significantly different for VSL which may suggest that respondents considered both schemes as similar.

Keywords: age, choice experiment, mortality risk, tax reallocation, willingness to pay

1. Introduction

The negative effects from air pollution, especially from fine particulate matters ($PM_{2.5}$), have over the last couple of decades been a growing concern in China (Parrish and Zhu, 2009; Wang and Hao, 2012). The

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increase in pollution levels causes significant adverse health impacts with substantial social costs (Zhang et al., 2010; Huang et al, 2012; Shang et al., 2013). To improve the air quality in China its public authorities are undertaking several measures, e.g. the *Air Pollution Prevention and Control Action Plan* issued by the State Council in 2013 (MEP, 2013). Measures taken, such as funding for research or large scale policies, need to be evaluated, though, to make sure that resources are allocated efficiently. Cost-benefit analysis (CBA) is drawing increasingly attention for research and policy making in China, and hence the valuation of costs and benefits, including health risk reductions.

Monetizing mortality risk reductions has been shown to be critical in many applications of CBA of environmental policy and regulation assessment (U.S. EPA, 2011) and the concept of the value of a statistical life (VSL) is widely applied and studied throughout the world. The VSL is a measure of the marginal rate of substitution between mortality risk and wealth and to date most of the empirical studies eliciting individual willingness to pay (WTP) to reduce health risks have been based on either the hedonic regression method (Rosen, 1974) applied on compensating-wage-differentials (Viscusi and Aldy, 2003), or the contingent valuation (CV) method applied in a vast range of different settings (Lindhjelm et al., 2011). The former is a revealed preference (RP) method in which actual decisions are used to derive monetary values, whereas the latter, i.e. the CV method, is a stated preference (SP) method in which individuals are asked to state their preferences in a hypothetical market setting. Recently another SP method, discrete choice experiments (DCE), has gained ground in the area of health risk evaluation (e.g. Cameron and DeShazo, 2013). The DCE elicit individual preferences by observing hypothetical choices employing multi-attribute goods (see, e.g., Bateman et al., 2002), Whereas the CV employs a more direct approach to elicit preferences for one-attribute goods. In this study we will employ the DCE to elicit individual preferences to reduce health risks from improving air quality. The reason for using an SP approach is a combination of the public good nature of air pollution and the special market conditions and developments in the Chinese property market which means that we prefer a controlled hypothetical market to actual market data. We prefer the DCE to the CV for our study since we aim to elicit preferences for several attributes, something the CV is not capable of.

Nonmarket valuation techniques usually consider respondent's additional WTP through, e.g., a tax increase as the payment vehicle for environmental improvement. However, an additional payment through, e.g. taxes or fees, is not the only alternative to finance public programs. A reallocation of existing government resources from the provision of other public services is another feasible alternative (Bergstrom et al., 2004). Whereas an additional payment may seem more intuitive, the tax reallocation format may be more in line with how policy decisions are taken in many situations when the government is not in a position to raise taxes. To extend the standard "additional WTP" format and examine how sensitive the respondents' WTP is to different payment vehicles that resembles actual policy situations is of high relevance and the question has been examined in a few recent studies (e.g., Swallow and McGonagle, 2006; Ivehammar, 2008; Nunes and Travis, 2009; Carneiro and Carvalho, 2014).

Another debated issue in the VSL literature is the VSL-age relationship, i.e. whether people's WTP for mortality risk reduction depends on their age. For instance, should policy makers use different values for young individuals compared to older ones? The issue of considering age heterogeneity in VSL has aroused great public controversy (Viscusi, 2010) but is important when estimated VSL is considered for evaluating different risk reducing policies where benefits and cost may not be evenly distributed in the affected population. Plenty of theoretical (e.g. Johansson, 2002) and empirical work (e.g. Aldy and Viscusi, 2007; Krupnick, 2007) have examined the VSL-age relationship. As described in the following section the evidence of a VSL-age relationship is still ambiguous and uncertain. Both the theoretical and empirical literature do not provide strong support for any specific relationship; predictions instead depend on assumptions about the models and contexts examined.

The aim of our study is to better understand and estimate how much people in China would be willing to pay for a reduction in their risk of dying or being sick from air pollution. Most of the studies to date on VSL have been conducted in developed countries with only a few studies being conducted in China. This study will therefore contribute knowledge about preferences for clean air in China. One objective of the study is to elicit monetary values that can be used for policy purposes. Two other objectives that are of both policy and research reliance are to (1) examine the effect from presenting respondents with either a new tax contribution or a tax reallocation and (2) examine the WTP-age relationship for reducing mortality and morbidity risks. For our empirical analysis we conduct a DCE study in Beijing, China, where we ask respondents about their WTP to reduce health risks in a context of air pollution. To the best of our knowledge, this is the first study in China that uses DCE to elicit VSL. To examine the different payment vehicles we use a split sample design where we let one subsample face an additional cost to obtain the health improvement, whereas the other subsample is asked about a reallocation of the government budget from other spending to more spending on health improvements.

In the following section we briefly present the theoretical and empirical evidence on the tax reallocation regime and the VSL-age relationship, and a summary of previous Chinese studies on VSL. We thereafter describe our survey, including the sampling and data collection, and questionnaire design. The empirical models and the results are shown in Sections 4 and 5. In the final section we discuss our findings and provide some conclusions.

2. Background and methods

2.1 Willingness to pay and payment vehicles

In the pioneer work of Bergstrom et al. (2004), a tax reallocation and a special tax are theoretically analyzed and examined empirically. In their work the new tax contribution is simply the compensation surplus (CS) defined by the expenditure functions by

$$CS = e(P, Q^0, Z^0, u^0) - e(P, Q^1, Z^0, u^0), \tag{1}$$

where P is the price of goods, Q the environmental quality, with superscripts denoting with (1) or without (0) an increase in the environmental quality, Z denoting the composite commodity of all other public goods (omitting Q), and u the utility index.[1] The "payment" with the tax reallocation is defined as the compensating tax reallocation (CTR) and is given by

$$CTR = e(P, Q^0, Z^0, u^0) - e(P, Q^1, Z^1, u^0) = Z^0 - Z^{1*}(P, Q^0, Q^1, Z^0, u^0). \tag{2}$$

[1] For the full description of the models see Bergstrom et al. (2004).

Hence, the CTR is given by how much an individual is willing to give up of his/her current provision of other public goods (Z^0), which means a new level of the provision of these other public goods (Z^1), in order to have the increase in the environmental quality. Whether CS will be larger or smaller than, or equal to CTR is not possible to predict. Bergstrom et al. (2004) state that "[W]e cannot predict a priori the relative magnitudes of CTR and CS unless we have some prior information on the relative marginal values of the existing bundles of public and private goods." (537). This can be seen in equation (2) where Z^1* depends on Z^0. Hence, theoretically the model does not provide any prediction of the relationship between CS and CTR, which therefore has to be examined empirically instead.

In Bergstrom et al. (2004), two tax regimes are used in a CV study to assess the individual WTP for groundwater protection in the United States. The results show that the mean WTP under the tax reallocation regime is about 18 times higher than that under a standard tax. Swallow and McGonagle (2006) use these two payment regimes in a DCE study to assess the conservation of coastal land. Their results also show that respondents are more likely to support land conservation program without direct and new withdrawals from the respondents' disposable income, particularly among those with low income. Their estimated WTP based on tax reallocation was about 3.5 times larger than that based on a new tax. Another study also using DCE formally tested the robustness of the WTP for rail noise reduction in Italy under three payment regimes, i.e. a regional tax, a transport tax reallocation scheme and an administration tax reallocation scheme (Nunes and Travisi, 2009). They found that the WTP estimates were statistically different for the tax reallocation and the new tax regimes, values were 37% lower with a new tax, a relationship which is consistent with the previous results by Bergstrom et al. (2004) and Swallow and McGonagle (2006).

However, whereas Bergstrom et al. (2004) and Swallow and McGonagle (2006) did not specify from which areas resources would be reallocated Nunes and Travisi (2009) did specify that the reallocation would either come from a public transport budget or an administrative/entertainment budget.[2] They found that there was no difference in the marginal values across the two tax reallocation treatments, indicating

[2] For instance, Swallow and McGonagle (2006) assumed that each respondent "interprets the use of [reallocations] as being drawn from all publicly provided goods in proportion to their existing share of the public budget" (59).

that the marginal value of the public money did not depend upon the budget source. The findings in Nunes and Travis (2009) were confirmed by Morrison and MacDonald (2011) who provided the respondents with information about the extent of expenditures in each of public areas, and described the exact opportunity costs of a reallocation from specific areas of the budget.[3] They found that the aggregated WTP estimated from new taxes or tax reallocations were of a similar magnitude. However, Remoundou et al. (2014) in a DCE on the valuation of a marine restoration program in the Black Sea did find that source of the tax reallocation had an effect on the respondents' WTP.

Hence, results are mixed but overall they suggest that tax reallocation schemes produce higher WTP estimates than schemes demanding new tax contributions. In this paper, we test and compare different payment schemes in a less developed country context, exploring the difference of marginal value via new tax and tax reallocation payments for health risk reductions from air quality improvement programs. The comparison of the two schemes is not to resolve whether CTR should replace CS as the primary measure of WTP. We have more confidence in CS as a measure of WTP but since policies/programs are often financed by governments reallocating existing revenues, which individuals are aware of, we believe that it is of importance to examine whether the different approaches produce similar WTP estimates.

2.2 Willingness to pay to reduce mortality risk and age

There is today a vast theoretical and empirical literature on the relationship between VSL and age. Theoretically the relationship has been examined using a life-cycle model in which it is assumed that individuals maximize their expected discounted value of the utility of consumption. Let τ, $u[c(t)]$, θ, and $\mu(t)$, denote the point of reference, the utility of consumption at time t, the subjective discount rate, and the probability of becoming at least t years old conditional of surviving until τ. The value function ($V(\tau)$) that defines the solution to the dynamic optimization problem for the optimal life-cycle consumption can then be written as

[3] Here, the opportunity cost indicates which part(s) of the existing tax resources that will be reallocated, e.g. reducing funding for health, education, transport, etc., in order to increase the quantity provided of the good defined in the survey.

$$V(\tau) = \int_{\tau}^{\infty} u[c^*(t)]e^{-\theta(t-\tau)}\mu(t)dt, \quad (3)$$

where the asterisk denotes consumption values along the optimal path. The value function in equation (3) can then be used to derive the individual WTP for a change in the survival probability, both for immediate and latent risk changes (Hammitt and Liu, 2004). For instance, assume an immediate drop in the hazard rate at age τ that lasts ε and the individual's marginal WTP (VSL) is given by

$$VSL(\tau) = \frac{V(\tau)}{\lambda^*(\tau)} \approx \frac{WTP(\tau)}{\varepsilon dp}. \quad (4)$$

The denominators $\lambda^*(\tau)$ and εdp denotes the marginal utility of wealth and the risk reduction for the time period ε, respectively.[4] The predicted relationship has been shown to depend on assumptions about saving and borrowing opportunities, discount rates, and hazard rates. For instance, Shepard and Zeckhauser (1984) predicted a monotonically declining relationship between VSL and age when individuals could borrow against future earnings, but an inverted U-shape in a model with only saving but no borrowing opportunities. However, more recent studies (Johansson, 2002; Ehrlich and Yin, 2005) have indicated that the age-VSL relationship is ambiguous and could be positive, negative, or zero. In particular, Johansson (2002) indicates that VSL could be increasing, decreasing, or have no systematic dependency on age in spite of the existence of actuarially fair insurance markets, depending on the optimal age pattern of consumption.

The empirical VSL literature is vast but it was nicely summarized in two articles by Aldy and Viscusi (2007) on evidence from RP studies and Krupnick (2007) on evidence from SP studies. In the two studies they covered the literature in which the specifications for the age variable vary, including age dummies, age entered into the models linearly, log-linearly, and quadratically; and age interacted with other variables such as health status and background risks. Another approach has been to divide the sample into sub-samples by different age groups and to estimate VSL separately in these age groups and compare them. The evidence from the RP literature surveyed in Aldy and Viscusi (2007) suggested an inverted U-

[4] For a more detailed description, see, e.g., Johansson (2002).

shaped relationship, whereas the SP review by Krupnick (2007) suggested that the evidence was mixed, i.e. there was no strong evidence of any specific VSL-age relationship.

More recent evidence has confirmed the findings found in Aldy and Viscusi (2007) and Krupnick (2007). For instance, whereas Carlsson et al. (2010) found evidence indicating a negative relationship between VSL and age, Blomquist et al. (2011) found a non-monotonic relationship between VSL and age. In their study VSL first dropped before rising, and then finally dropped again. Leiter (2011) focused on the relevance of age-specific hazard rates in explaining the VSL age variation related to avalanche risk by comparing the WTPs of two subsamples (skiers and non-skiers, where for the former group the hazard rate varied across age). The results showed an age dependency of the WTP for respondents whose hazard rate varied with age (skiers), while no age-related variation was observable for the non-skiers (whose avalanche-related fatality rate was independent of age). Moreover, to further explore the various sources of heterogeneity of VSL, Cameron and DeShaozo (2013) conducted a representative national survey wherein 2,407 US adults made choices over alternative risk-mitigation programs in a SP survey. They specifically analyzed the VSL-age relationship, and found a similar relationship as Aldy and Viscusi (2007) did for RP studies, i.e. an inverted U-shaped relationship. In Viscusi's (2010) review of the heterogeneity of VSL based on both RP and SP studies the influence of age on VSL was found to be non-monotonic. The VSL appeared to be high for young children and showed an inverted-U shape for adults, though the decline in VSL at very old age groups did not appear to be stark.

2.3 Willingness to pay to reduce mortality risk in China

Only a few studies on VSL have been conducted in mainland China. All of the studies have been conducted using either the CV or based on hedonic wage differentials. Thus, to the best of our knowledge, to date no DCE on VSL have been conducted in China. In Table 1 we list the available Chinese VSL studies, six based on the CV and two using the hedonic wage method.

[Table 1 about here]

All CV studies use the standard approach and asked respondents about a new payment, i.e. none of them examined the effect on either a new tax or a tax reallocation. Regarding the VSL-age relationship, Wang and Mullahy (2006) found a positive relationship, whereas Hammitt and Zhou (2006), Wang and He (2014), and Zhang (2002) found a negative relationship. In Hoffmann et al. (2010) results also showed a negative effect for all three age groups (age 50-59, age 60-69, and age 70 and older, separately) but only significantly for age 60-69, taking age 40-49 as the baseline group.

In addition, some of the studies also estimated the value of a statistical illness (VSI) based on the WTP for morbidity risk reductions, such as asthma (Guo et al., 2006), or episodes of minor illness similar to cold and chronic bronchitis (Hammitt and Zhou, 2006). Since their morbidity scenarios are not comparable to our scenario, due to different specifications of the diseases, we do not list the elicited VSI from their studies in Table 1.

Two studies using the hedonic regression approach were conducted to estimate the VSL in China based on wage risk differentials (Guo and Hammitt, 2009; Qin, Liu, and Li., 2013). However, neither of them explored the VSL-age relationship.

3. Survey

3.1 Sampling and data collection

The survey was conducted during about three weeks from 17 September to 11October in 2010 and was administered in 18 different locations in different urban districts of Beijing. Interviews were conducted face-to-face by 14 graduate or undergraduate students from Peking University and other universities in Beijing who were trained as enumerators. They were randomly sent to the different locations every day, where they randomly chose respondents to answer the survey. Other modes for the survey were considered, such as a postal questionnaire, face-to-face in respondents' homes, or a web-based survey, but at the time of the survey the interviews in the street was the mode considered as the best available one for this survey.[5]

3.2 Survey design

The survey was designed following state-of-the-art and it was revised and improved after three focus groups, a pre-test and a pilot survey. The questionnaire was divided into four parts. Part 1 elicited personal basic attitudes to air quality in Beijing, and Part 2 elicited individual information about the respondent and his/her immediate family, including age, education, income, family size, health status, etc. Part 3 was the core of the questionnaire. In this part, the respondents were first introduced to background information about the status quo of air pollution and corresponding health impacts in Beijing, and then presented with a scenario where the local Beijing municipal government over a 10 year period would implement new programs with stricter measure for air quality management, and finally shown the choice sets with a color card visually illustrating the small risk changes. The respondents faced choice sets with three alternatives including the status quo alternative. The last part of the questionnaire was a debriefing of the interview recorded by enumerators, which was used to identify respondent who had trouble comprehending the survey or did not take the survey seriously.

[Figure 1 about here]

One example of a choice set as presented to the respondents is shown in Figure 1. As illustrated, respondents had the choice between two different policies, and to choose none of these, i.e. the status quo alternative. The choice set consisted of four attributes and each respondent was asked to answer 4 choice sets. The attributes and their levels are given in Table 2.

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[5] Either face-to-face in individuals' homes or a web-based survey based on stratified sampling would have been preferred modes in most contexts. However, we were concerned about the representativeness of the sample using these modes (e.g. a very low internet penetration at the time of the survey in China and also the low response rate of mail surveys). Moreover, it would have been hard to get authorization to conduct in home interviews based on a random or a stratified sample from the Beijing authorities, and most of the Chinese people do not like being interviewed at home by strangers due to cultural reasons and also for security reasons.

[Table 2 about here]

The first attribute, *ΔCold*, was included as a minor health effect from air pollution. To increase acceptance and realism of the scenario, respondents were asked to state their own number of times per year suffering the described symptoms similar to a cold, here simply referred to as "cold". The reduced number of times sick was then calculated based on the respondents' own reported times sick and a randomly assigned proportional reduction according to the designed levels. When answering the survey respondents saw both the proportional reduction and the absolute number of less times being sick, i.e. *ΔCold,* which were written in the brackets by the enumerator before respondents saw the choice sets. The absolute levels presented for the two programs were a combination of the respondents' self-reported number of days sick, and the exogenously and randomly assigned proportional risk reductions. When analyzing the data, the change of numbers of times with a symptom similar to cold was used (i.e. *ΔCold*) to address the endogeneity issue from respondents providing the status quo level for this alternative. As explained above, this attribute was only included to increase acceptance of the survey scenario and despite us addressing the endogeneity issue we are still concerned about the accuracy of the attribute (heterogeneity in the interpretation of the question). The findings for this attribute in our empirical analysis are therefore of limited interest. The second and the third attributes are our health attributes of main interest, i.e. the morbidity and mortality risks. The baseline levels were chosen based on epidemiological studies on health effects based on Beijing data (Aunan and Pan, 2004; Zou and Zhang, 2010). Respondents were informed that the levels were based on scientific studies. The risk levels were presented as the numbers of event per 100,000, in line with the statistical format Chinese people usually are usually presented with. This together with Beijing residents' regular experience of bad air quality, and a visual aid to illustrate the risk levels to increase comprehension[6], increase the likelihood that our respondents would accept and understand the health risk scenarios.[7] The final attribute is the cost of the

[6] There is evidence that individuals have difficulties understanding small probabilities but that visual aids can help them understand (Corso et al. 2001).

[7] To clarify, this morbidity risk was not based on self-reported baseline levels and in the survey design *Morbidity* and the risk changes in *ΔCold* are orthogonal.

program, a cost that would be paid during the length of the program. The bid levels were based on levels used in previous SP studies conducted in China and then adjusted based on discussions and findings in the focus groups and in the pilot. Health risks reductions and costs were presented as individual, i.e. respondents were asked to state their preferences for themselves, not for their household or the public.

The last "attribute" listed in Table 2 is the payment vehicle. The payment vehicle defines that the cost of the program is either a new tax or a tax reallocation. It was decided after feedback from the focus groups and the pilot not to include the payment vehicle as an attribute in the choice sets since it made the scenarios less realistic and harder for the respondents to understand. Instead a split sample design was used to test the effect from the payment vehicle, where one subsample was presented a scenario that required a new tax payment and the other a scenario where the cost for the project would be financed by reallocating taxes from other public spending. To simplify the task for the respondents it was not specified in the tax reallocation scenario where resources would be drawn from. Based on the findings in Nunes and Travis (2009) and Morrison and MacDonald (2011) who found no evidence that the marginal WTP depended on the budget source, we believe this simplification to be non-problematic for the purpose of our study, and our design also follows the setup in Bergstrom et al. (2004) and Swallow and McGonagle (2006).

We used a fractional-factorial and cycling designing based on D-efficiency to construct 20 choice sets with two alternatives (Carlson and Martinsson, 2003).[8] The choice sets were then randomly blocked into five groups, and thus each respondent faced four choice sets.

4. Empirical Methods

4.1 Baseline model

As described, the respondents were asked to choose their preferred option out of a total of $J=3$ alternatives (two hypothetical scenarios and the status-quo) in $T=4$ choice sets. Assuming a linear utility specification the utility that respondent n derives from choosing alternative j in choice set t is given by

[8] To construct the choice sets the SAS program was used.

$$U_{njt} = \beta_0 sq_{njt} + \beta_1 \Delta Cold_{njt} + \beta_2 Morb_{njt} + \beta_3 Mort + \beta_4 Cost_{njt} + \varepsilon_{njt} \quad (5)$$

where $\beta_0, \ldots, \beta_4$ are coefficients to be estimated, sq_{njt} is an alternative-specific constant for the status quo alternative and ε_{njt} is a random error term which is assumed to be IID type I extreme value. The remaining attributes in the utility function are described in Table 2 and we expect all of them except $\Delta Cold$ to have a negative coefficient sign. Since the β show the effect on the utility from changes in the attribute, dividing the β of one of the attributes with the β of the cost attribute will provide a monetary estimate of the WTP for that attribute. For instance, the marginal WTP for reducing the mortality risk (VSL) is given by

$$\frac{\partial U_{njt}/\partial Mort_{njt}}{\partial U_{njt}/\partial Cost_{njt}} = \frac{\beta_3}{\beta_4} \quad (6)$$

By replacing the variable mortality with morbidity, we obtain the VSI, which can be interpreted as the WTP for a reduction in risk equivalent to preventing one case of illness. Equation (5) is also estimated by including interactions between the attributes and the payment scheme or the age groups.

4.2 Generalized multinomial logit

The baseline specification assumes that the respondents have identical preferences for the attributes of the policies and that the choices made by the respondents are independent. Empirical findings have shown that this is unlikely to be the case in reality. We therefore extend our basic model with specifications that allow for heterogeneity and take the panel structure of the data into account and estimate models which can be defined as different versions of the generalized multinomial logit (GMNL, Fiebig, et al., 2010). The GMNL nest models that take into account scale and preference heterogeneity.

Again, let us assume *J* choice alternative, and *T* choice situations, and that we have *N* individuals. The probability of respondent *n* choosing alternative *j* in choice situation *t* is

$$Pr(choice_{nt} = j|\beta_n) = \frac{exp(\beta_n' x_{njt})}{\sum_{k=1}^{J} exp(\beta_n' x_{nkt})} \quad (7)$$

where x_{njt} is a vector of observed attributes of alternative j and β_i is a vector individual specific coefficients defined as[9]

$$\beta_n = \sigma_n \beta + [\gamma + \sigma_n(1-\gamma)]\theta_n \quad (8)$$

We set γ=1, a parameter that "governs how the variance of residual taste heterogeneity varies with scale" (Fiebig et al., 2010, p. 398), and we will focus on four special cases of Eq. (5):

1. Conditional logit: $\beta_n = \beta$
2. Conditional logit with scale: $\beta_n = \sigma_n \beta$
3. Mixed logit: $\beta_n = \beta + \theta_n$
4. Mixed logit with scale: $\beta_n = \sigma_n \beta + \theta_n$

The conditional logit model assumes that respondents have identical preferences and that answers to the choice sets are independent, the latter being in line with the instructions to the respondents when answering the choice sets. The conditional logit model with scale allows for scale heterogeneity between different subsets of the sample, which could be a result of combining different data sets (Hensher et al., 1999). In our case scale heterogeneity could arise from combining the two data sets with different payment vehicles and we will, therefore, test whether scale heterogeneity depends on the payment vehicle. The mixed logit relaxes the assumption about identical preferences and allows for taste heterogeneity. In case 4, we estimate a model that allows for both taste and scale heterogeneity.[10] In cases 3 and 4 we assume in our estimations a normal distribution, except for *Cost* which we assume is constant. The latter to avoid the issue of non-existence of the mean and variance as a result of taking the ratio of two normal distributions to estimate the VSL and VSI (Meijer and Rouwendal, 2006).

4.3 Latent class models

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[9] See Fiebig et al. (2010) and Hole (2008) for descriptions of these models.

[10] Stata was used to run the regressions. For cases 2, 3, and 4, we used the commands clogithet (http://econpapers.repec.org/software/bocbocode/s456737.htm), mixlogit (Hole, 2007), and GMNL (Gu, et al., 2013).

We further explore preference heterogeneity by estimating latent-class models, in which the utility function is given by

$$U_{njt} = \beta_{c0} sq_{njt} + \beta_{c1} \Delta Cold_{njt} + \beta_{c2} Morb_{njt} + \beta_{c3} Mort + \beta_{c4} Cost_{njt} + \varepsilon_{njt} \quad (9)$$

The subscript *c*, where *c = 1,…,C*, indicates the class membership of the individual respondent. In addition to taking the panel structure of the data-set into account, the latent class model allows the preferences of respondents in different classes to vary, while maintaining the assumption of preference homogeneity within classes.[11] Extending equation (7) to be conditional on membership in class c the probability of respondent *n* choosing alternative *j* in choice set *t* in the latent class model can also be expressed by equation (7). We follow Hensher and Greene (2003) and specify the probability that respondent *n* belongs to class *c* as

$$H_{nc} = \frac{exp(\gamma_c' z_n)}{\sum_{c=1}^{C} exp(\gamma_c' z_n)}, \quad (10)$$

where z_n is a vector of characteristics relating to individual *n* and γ_c is normalized to zero for identification purposes. In the application, we either set z_n=1, which implies that the class membership probabilities are constant across respondents, or we let the class membership depend on *payment vehicle*. In the baseline case where there is only one class this model reduces to the standard conditional logit model. The parameters in the model are estimated by maximum log-likelihood.

It should be noted that the number of classes, *C*, must be specified prior to estimating the model. In practice *C* is unknown, and so a common strategy is to estimate the model with different numbers of classes and choose the preferred specification based on goodness-of-fit measures such as the Akaike and Schwarz criteria. We return to this issue in the Results section.

5. Results

5.1 Descriptive statistics

[11] Latent class models have for instance been used in DCE to examine non-attendance to attributes (e.g., Campbell et al. 2011).

In total 540 respondents were interviewed. However, based on feedback from the numerators of the respondents' performance, 59 respondents were dropped according to one of two criteria: (1) refusal to make any choice or (2) an evaluation of the respondent's overall performance in the survey. The evaluation was conducted immediately after the interview and was based on a scoring system where a value below 7 (out of 10) indicated that answers were not reliable, either because the respondent had not understood the survey, or had behaved in a way that suggested he/she did not take it seriously.[12] Moreover, six respondents did not provide information about the number of days in a year with a symptom similar to cold, information necessary to calculate the first attribute of the choice set (see Table 2). Thus, the final sample consists of answers from 475 respondents.

Table 3 provides descriptive statistics for our sample. A concern with the survey mode chosen, i.e. face-to-face interviews in public places, is sample-selection bias. As given in Table 3 the sample is well representative of the general population in Beijing. Comparing the statistics of our sample with that of Beijing general population (data from the statistical yearbook marked in parentheses), we find that the average age of all respondents is 40.6 (40.2), the average family size is 2.9 (2.8), the average proportion of male is 53% (52%), and the average personal income is about RMB 37,421 (33,360). According to the data availability and comparability, we conducted Chi tests for age and gender. The results show no significant differences in the 95% confidence interval (Pearson chi^2=1.05) for the three age groups between the survey sample and Beijing general population, and no significant difference in the 98% confidence interval (Pearson chi^2=5.12) for gender. Hence, the sample is representative of the Beijing population to a certain extent, but we may still have sample selection in the sense that only respondents interested in air pollution and health effects were prepared to take their time to answer the survey. We cannot test for this type of selection effect and it is not unique to our survey, though, but to all surveys whether using stratified or random sampling, or are conducted online or face-to-face in individuals' homes.

[12] The scoring system was created prior to the interviews were conducted. After the data had been collected a random control was conducted by one of the involved researchers and for all checked observations no evidence was found suggesting that the scoring system did not serve its purpose.

[Table 3 about here]

5.2 Regressions results, and VSL and VSI

We start by presenting our results for the baseline model, i.e. the conditional logit model. In Table 4 we show four versions of the conditional logit model, i.e. the standard conditional logit (Model C1), conditional logit with scale (Model C2), and the standard conditional logit extended with interactions variables between the attributes and the payment vehicle (Model C3), and a model also including age and income interactions (Model C4).

Focusing first on Model C1, we see that all the attributes have the expected sign and are highly statistically significant. For instance, when the cost of a program increases then respondents are less likely to choose that alternative. Model C2 allow for scale heterogeneity from the two different payment schemes, and we find that the coefficient for scale heterogeneity is highly statistically significant. In Model C2, we find that the qualitative results are the same except for Δ*Cold* which no longer is statistically significant, and that overall coefficient estimates are smaller compared with Model C1. Model C3 allows for heterogeneity on how the payment vehicle may influence the effect from the different attributes on the respondents' choices. In this model, we again find the same qualitative results for the attributes, but interestingly we also find that the effect from the cost is lower when it is a tax reallocation, i.e. the coefficient for the interaction is positive. This suggests that those who were presented with the tax reallocation scenario are less sensitive to the cost of the programs than those who were presented with the new tax contribution scenario. Model C3 also shows that respondents presented with the tax reallocation were less likely to have preferences for the status quo alternative. Among the three specifications Model C3 performs best according to the log-likelihood ratio test (p-value < 1%).

[Table 4 about here]

Since Model C3 performs best we use that model when examining how age influences respondent's WTP. Both theory and empirical evidence suggest that WTP increases with wealth (Hammitt and Robinson,

2011) and we, therefore, also include income interactions in Model 4. Focusing on age, as can be seen, the respondents were divided into three different age groups which were then interacted with the different attributes. We find no strong pattern suggesting that WTP to reduce health risk depends on age.[13] The only age interaction variables that show any statistical significance are SQ×age>54 and Morbidity× age>54. Regarding income, we find that the probability of choosing a costlier program increases with the income level, i.e. the interaction between cost and income is positive, which is in line with the expectations. The main focus regarding individual characteristics in this study is age and we will get back to how the results from Model C4 on age translates into VSL and VSI estimates when discussing the marginal WTP estimates.

In Table 5 we show the results from our different mixed logit models. The structure of the table follows that of Table 4, i.e. we first present the standard mixed logit (Model Mix1), we then show it when we allow for scale heterogeneity (Model Mix2), and finally the model with interactions between the attributes and the payment schemes (Model Mix3).[14] The results show evidence of heterogeneity in all models. Qualitatively the results are again similar between regressions, with again only ΔCold being sensitive to the chosen model specification. Moreover, qualitatively the results in the mixed logit models are overall the same as in the conditional logit models. One exception is *SQ* which when accounting for preference heterogeneity is negative and statistically significant in Model Mix1 and Model Mix2. As for the conditional logit models, the specification with interactions, i.e. Model Mix3, performs best according to the log-likelihood ratio test (p-value < 1%).

[Table 5 about here]

As explained above, to further examine the effect on preference heterogeneity on our results we also run latent class models. The cost variable was prior to estimation converted to *mCost* by multiplying *Cost*

[13] These findings were robust to different specifications to how age was treated in the regressions, such as different age group definitions, continuous age variables, etc.

[14] A mixed logit model based on Model Mix3 with age and income interactions did not converge, and hence we are not able to provide a mixed logit model that corresponds to Model C4.

with -1, and thus we expect a positive coefficient sign for *mCost*. The results are given in Table 6. The models are run with two classes since Model L2, i.e. the model with interactions, did not converge for more classes. Both model specifications reveal preference heterogeneity. For instance, in Model L1 we find that the cost variable has an effect on the respondents' choices, but only for class 2 do the risk attributes influence the respondents' decisions. We also find opposite sign for *SQ*. The results considering class 1 can be interpreted as a group having strong preferences for the status quo alternative and among the attributes they only consider the cost attribute when making their decisions. Moreover, the results from Model L1 also suggest that those who were presented with a tax reallocation are less likely to belong to class 1.

[Table 6 about here]

In Model L2, we find that the class that takes into account the cost and risk attributes, i.e. class 2, provide the same qualitative results are the conditional logit and mixed logit models with interactions. For instance, the interactions terms suggest that those being presented with the tax reallocation scenario are less likely to choose the status quo scenario and that the cost attribute has a smaller effect on the choices of this group. Moreover, taking into account the class membership probabilities the mean *SQ* coefficient will be negative. This is in line with the findings for the models in Table 5. Hence, the results suggest that when allowing for preference heterogeneity the *SQ* coefficient change from positive to negative. Overall, given the results from the latent class models, which suggest that there is not a smooth distribution of preferences, as assumed in the models of Table 5, our preferred models are the latent class models.

In Table 7, the estimates of VSL and VSI based on the results from Tables 4-6 are shown. Comparing the different model specification we find that the levels of VSL and VSI are robust. The only exception is the mixed logit with scale (Model Mix2) which produces lower values than the other specifications. Examining the effect from the different payment regimes show that the tax reallocation regimes produces VSL and VSI that are between 45%-63% and 83%-136% higher than with a new tax, with the largest differences found in the mixed logit specification. However, we only find statistically significant difference for VSI. Our preferred model is, as explained, the latent class model. The VSL and VSI from this model are RMB 5.24 million and RMB 1.13 million, which correspond to US$ 774,000 and US$ 167,000. Comparing the VSL with the values from Table 1, we see that the value is generally higher than the estimates from the previous studies. One plausible explanation is the wealth increase in China during recent years. Another may be the increased public awareness of air pollution and health effects in China.

[Table 7 about here]

Table 8 provides VSL and VSI estimates for the different age groups based on Model C4 in Table 4. Both VSL and VSI are increasing with age. However, differences in estimates are small and they are not statistically significantly different. Hence, based on the estimates we do not find any support for any age relationship.

[Table 8 about here]

6. Discussion and conclusions

This study reports the results from a DCE conducted in Beijing, China. The aim and the objectives of the study were to elicit monetary values for VSL and VSI that can be considered for policy purposes in China, and to examine how different payment regimes influence WTP and whether WTP is age-dependent.

Our preferred VSL from our analyses, i.e. RMB 5.24 million (US$ 774,000), is significantly higher than the estimates from the previous Chinese air-pollution studies reported in Table 1. As explained, the plausible reasons may be the wealth increase that has taken place in China during recent years which we expect would increase individuals' WTP to reduce health risks, as well as the increased public awareness of air pollution and its health effects in China. Concerning our preferred VSI, i.e. RMB 1.13 million (US$ 167,000), since our health effects differ from the effects in the other Chinese studies that also elicited WTP to reduce morbidity risk no comparison is informative. Differences in values may be a result of the different effects examined.

Adjusting benefit values for environmental policies or programs to take into account age differences is controversial, but from an efficiency point of view the values should be differentiated if the theoretical and empirical evidence suggest that they differ. Based on both theoretical and empirical evidence, including the empirical evidence from China, the relationship between VSL and age can still be considered ambiguous, which motivated one of the research questions of this study. Based on our analysis we found no evidence of any age relationship for VSL or VSI. Hence, the results from this study together with the mixed evidence from previous Chinese findings suggest that there is no need to differentiate VSL and VSI according to age in China.

Bergstrom et al. (2004) explained that there is no theoretical prediction whether one should be larger than the other, but when examining how the different payment vehicles influence respondents' WTP in our study we found that the VSL with the tax reallocation was 45%-63% higher than with the new tax, a relationship almost identical to the findings in Nunes and Travis (2009) for rail noise abatement, and that it for VSI was 83%-136% higher. Nunes and Travis used, as we did, DCE, which was also used in Swallow and McGonagle (2006) who found a 3.5 ratio between the two payment vehicles. All these findings are very different from the empirical analysis in Bergstrom et al. (2004) where they found the WTP to be 18 times higher for the tax reallocation scenario. A difference between Bergstrom and co-workers and the other three studies is that Bergstrom and co-workers conducted a CV study. CV and DCE studies both have their strengths and weaknesses, but one strength of the CV method is that the scenario description is relatively simplistic. The CV asks the respondents a direct question about how much he/she is willing to pay, or alternatively whether he/she is willing to buy (or vote yes to a program) the good for a given price (or cost of a program), whereas the DCE require the respondents to choose between different bundles of goods. This more simplistic approach may not be optimal if a tax reallocation is going to be used, since it may trigger a perception of a non-zero opportunity cost of the reallocation. The DCE scenario may be preferred since respondents are choosing between different programs, which resemble many policy situations, and it mitigates the risk that respondents' perceive the tax reallocation as a "zero cost" regime. However, as shown in our study, and in Swallow and McGonagle (2006) and Nunes and Travis (2009), it is not eliminated since results between the payment vehicles differ.

Our regression analyses showed that the type of payment influenced respondents' choices which resulted in different VSL and VSI for the different payment groups. However, only for VSI did we find statistically significantly difference. This could suggest that respondents perceive that also the tax reallocation scheme will cost them something, i.e. they have to give up some other good provided by the government. However, some caveats should be raised. Concerning the monetary values elicited, since it is a public good it is not sure whether respondents only considered their own health or also stated altruistic motives, for instance towards other family members. This aspect was not possible to examine within the design of the survey in this study. Concerning the relatively small difference in estimated values between the two tax designs, it is possible that respondents in DCE studies focus on the level of the cost of the program, ignoring the payment vehicle format. This could explain the smaller difference found in DCE compared with CV studies. However, we do find that the type of payment vehicle had an effect on respondents' choices in our regression analyses, which would support that respondents do take into account which type of payment vehicle they were presented with when making their decisions.

We have in this study found estimates of VSL and VSI that are robust between elicitation models and seem reliable when comparing them with previous Chinese findings. We believe that we have contributed important findings to the areas of health risk valuation in China, the payment vehicle format's effect on WTP, and the VSL-age relationship, but there is still room for further research on these topics.

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Notes

1. For the full description of the models, see Bergstrom, Boyle, and Yabe (2004).

2. For instance, Swallow and McGonagle (2006) assumed that each respondent “interprets the use of [reallocations] as being drawn from all publicly provided goods in proportion to their existing share of the public budget” (59).

3. Here, the opportunity cost indicates which part(s) of the existing tax resources that will be reallocated, e.g. reducing funding for health, education, transport, etc., in order to increase the quantity provided of the good defined in the survey.

4. For a more detailed description see, e.g., Johansson (2002).

5. Either face-to-face in individuals’ homes or a web-based survey based on stratified sampling would have been preferred modes in most contexts. However, we were concerned about the representativeness of the sample using these modes (e.g. a very low internet penetration at the time of the survey in China and also the low response rate of mail surveys). Moreover, it would have been hard to obtain authorization to conduct in home interviews based on a random or a stratified sample from the Beijing authorities, and most of the Chinese people do not like being interviewed at home by strangers due to cultural reasons and also for security reasons.

6. There is evidence that individuals have difficulties understanding small probabilities, but that visual aids can help them understand (Corso, Hammitt, and Graham 2001).

7. To clarify, this morbidity risk was not based on self-reported baseline levels and in the survey design Morbidity and the risk changes in $\Delta Cold$ are orthogonal.

8. To construct the choice sets, the SAS program was used.

9. See Fiebig et al. (2010) and Hole (2008) for descriptions of these models.

10. Stata was used to run the regressions. For cases 2, 3, and 4, we used the commands clogithet

(http://econpapers.repec.org/software/bocbocode/s456737.htm), mixlogit (Hole, 2007), and

GMNL (Gu, Hole, and Knox 2013).

11. Latent class models have, for instance, been used in DCE to examine non-attendance to attributes (e.g. Campbell, Hensher, and Scarpa 2011).

12. The scoring system was created prior to the interviews being conducted. After the data had been collected, a random control was conducted by one of the involved researchers and for all checked observations no evidence was found suggesting that the scoring system did not serve its purpose.

13. These findings were robust to different specifications to how age was treated in the regressions, such as different age group definitions, continuous age variables, etc.

14. A mixed logit model based on Model Mix3 with age and income interactions did not converge, and hence we are not able to provide a mixed logit model that corresponds to Model C4.

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Tables and figures

Table 1: Review Chinese VSL studies

Risk source	Authors	Data year	Survey location	Method	Payment format	VSL[a]	Age interval (mean)	VSL–age relationship
Air pollution	Wang and Mullahy (2006)	1998	Chongqing	CV	Open-ended and bidding	1.58	15-80 (48)	Positive
	Hammitt and Zhou (2006)	1999	Beijing. Anqing and rural areas near Anqing	CV	Double-bounded	1.24–2.72[b]	18-65 (37,43,43)[c]	Negative (Beijing not stat. sign.)
	Guo et al. (2006)	2003	Chengdu	CV	Double-bounded	0.62	(39)	NA
	Zhang (2002)	1999	Beijing	CV	Combined open-ended and payment card	1.23–1.69	95.5% less than 45	Negative
Occupational	Guo and Hammitt (2009)	1999	Cities in 11 provinces	Hedonic wage	-	1.71–4.19	(39)	NA
	Qin, Liu, and Li (2013)	2005	One percent sampling of national survey in 31 provinces	Hedonic wage	-	7.14	(38)	NA
Other Cancer	Wang and He (2014)	2000	Tianjin. Jiangsu and Guizhou	CV	Multiple-Bounded Dichotomous Choice	2.21-3.74	16-77 (36)	Negative
General	Hoffmann et al. (2010)	2006	Shanghai. Nanning and Jiujiang	CV	Payment card	2.93	40-90 (55)	Negative

[a](1) Mean estimation in million RMB, 2010 price level. CPI adjusted, base year=2010, according to the data of China Statistics Yearbook 2013 (2) Income elasticity of VSL is assumed to be 1.4 (Hammitt and Robinson, 2011).
[b]Estimated by median WTP for each region.
[c]Mean of age for three subsamples of Beijing, Anqing and rural area near Anqing, respectively.
Note: US$ 1 = RMB 6.77 (stats.oecd.org, 10 September 2012)

Table 2: Attributes and levels

Attribute	Variable name	Attribute levels of programs	Status quo levels
Change in number of times per year with symptom similar to a cold[a]	Δ*Cold*	Continuous variable in [0,12.5]. Calculated based on respondents' own estimate of times sick during a year multiplied by a proportional reduction (1/6; 1/3; or 2/3). Both proportional reduction and absolute value presented to respondents in choice sets	Self-reported
Morbidity reduction[b]	*Morbidity*	500; 1,000; 1,500; and 2,500	2500
Mortality reduction[b]	*Mortality*	50; 100; 150; and 250	250
Cost of program	*Cost*	Cost in RMB per month[c] Bids used: 5; 10; 20; 50; and 100	0
Payment vehicle	*Payment*	Dummy equal to one if tax reallocation and zero if new tax	

a: Variable converted to change in number of days sick to avoid problem of endogeneity.
b: Unit of all levels for morbidity and mortality reduction: 1/100,000
c: US$ 1 = RMB 6.77 (stats.oecd.org, 10 September 2012)

Table 3: Descriptive statistics of respondents according to age groups

Age group	Living years	Age[a] (%)	Family size	Olds (>64)	Kids (<15)	Education[b]	Personal income[c]	Household income[c]	Male[d] (%)
<35 (n=201)	12.46 (10.43)	41.88 [44.11]	2.60 (1.21)	0.24 (0.58)	0.29 (0.49)	4.52 (1.04)	36,850 (41,837)	74,925 (55,011)	47.26 (49.94)
35-54 (n=177)	31.54 (14.93)	36.88 [35.44]	3.18 (0.88)	0.37 (0.67)	0.42 (0.52)	4.23 (1.16)	47,159 (46,574)	100,114 (94,185)	58.19 (49.34)
>54 (n=103)	47.43 (19.96)	21.25 [20.45]	3.17 (1.16)	1.17 (0.92)	0.24 (0.43)	3.04 (1.28)	21,584 (20,820)	74,286 (109,143)	55.89 (49.67)
Total (n=481)	26.97 (19.94)	40.59 (14.29)	2.94 (1.12)	0.51 (0.80)	0.33 (0.49)	4.10 (1.27)	37,421 (41,397)	84,059 (84,643)	53.01 (49.91)
Beijing	NA	40.16	2.8	0.48	NA	NA[e]	33,360	93,408[f]	51.53

Note: Mean values with standard deviations in parentheses

a: Proportions of sample size of each age group in the total sample. Numbers in squared brackets indicate the proportion of each age group for Beijing population (Beijing statistical yearbook 2011). (Since the age is more than 15 for the whole sample, to be comparable, the proportion of age less than 35 and mean age for Beijing population excludes population aged less than 15.)

b: 0-7 indicates illiterate, primary school, junior high school, senior high school/technical secondary school, junior college, college, master, and PhD, respectively.

c: Mean estimates calculated from intervals presented to respondents in the survey.

d: Proportions of the male.

e: 54.96% above senior high school, calculated by author from Beijing statistical yearbook 2011.

f: Calculated by authors based on mean personal income and household size from the data of Beijing statistical yearbook 2011.

Table 4: Regression results – conditional logit

	Model C1	Model C2	Model C3	Model C4
SQ	1.355***	0.286***	1.829***	1.800***
	(0.176)	(0.108)	(0.266)	(0.404)
ΔCold	0.096***	0.019	0.129***	0.105
	(0.030)	(0.012)	(0.049)	(0.072)
Morbidity	-0.001***	-0.000***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Mortality	-0.004***	-0.001***	-0.005***	-0.004**
	(0.001)	(0.000)	(0.001)	(0.002)
Cost	-0.012***	-0.003***	-0.016***	-0.020***
	(0.001)	(0.001)	(0.002)	(0.003)
SQ × payment			-1.262***	-1.301***
			(0.364)	(0.370)
ΔCold × payment			-0.085	-0.101
			(0.064)	(0.066)
Morbidity × payment			-0.000	-0.000
			(0.000)	(0.000)
Mortality × payment			0.000	0.000
			(0.002)	(0.002)
Cost × payment			0.006**	0.007***
			(0.002)	(0.002)
SQ × age<35				-0.480
				(0.406)
SQ × age>54				1.321**
				(0.534)
ΔCold × age<35				0.050
				(0.074)
ΔCold × age>54				0.093
				(0.088)
Morbidity × age<35				0.000
				(0.000)
Morbidity × age>54				-0.000*
				(0.000)
Mortality × age<35				-0.000
				(0.002)
Mortality × age>54				-0.003
				(0.002)
Cost × age<35				-0.001
				(0.003)
Cost × age>54				-0.004
				(0.003)
SQ × income				-0.000
				(0.000)
ΔCold × income				-0.000

				(0.000)
Morbidity×income				0.000
				(0.000)
Mortality×income				0.000
				(0.000)
Cost×income				0.000***
				(0.000)
/het (payment)		1.333***		
		(0.217)		
N	5,700	5,700	5,700	5,652
Log likelihood	-1,893.17	-1,853.25	-1,801.51	-1,764.33

***p<0.01, **p<0.05, and *p<0.1

Note: Standard errors in parentheses.

Table 5: Regression results – mixed logit

	Model Mix1		Model Mix2		Model Mix3	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
SQ	-7.285***	13.083***	-3.392***	-7.007***	-1.658	11.006***
	(2.285)	(2.491)	(0.771)	(1.401)	(1.505)	(2.250)
ΔCold	0.082	0.295***	0.268***	0.446**	0.102	0.354***
	(0.062)	(0.113)	(0.102)	(0.200)	(0.108)	(0.118)
Morbidity	-0.002***	0.002***	-0.002***	-0.003***	-0.001***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Mortality	-0.007***	0.009***	-0.013***	0.017***	-0.008***	-0.010***
	(0.001)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Cost	-0.018***		-0.040***		-0.027***	
	(0.002)		(0.010)		(0.003)	
SQ $\times$ payment					-9.607***	
					(2.370)	
ΔCold $\times$ payment					-0.029	
					(0.135)	
Morbidity $\times$ payment					-0.000	
					(0.000)	
Mortality $\times$ payment					0.001	
					(0.002)	
Cost $\times$ payment					0.013***	
					(0.004)	
/het			0.361			
			(0.247)			
N	5,700		5,700		5,700	
Log likelihood	-1,314.42		-1,295.58		-1,282.31	

*** p<0.01. **p<0.05. *p<0.1

Note: Standard errors in parentheses.

Table 6: Regression results – latent class models

		Model L1		Model L2	
		Class 1	**Class 2**	**Class 1**	**Class 2**
SQ		1.572***	-1.820***	1.657	-0.735
		(0.597)	(0.440)	(1.903)	(0.471)
ΔCold		-0.231	0.059	0.575**	0.106
		(0.178)	(0.047)	(0.256)	(0.065)
Morbidity		0.000	-0.001***	-0.001	-0.001***
		(0.000)	(0.000)	(0.001)	(0.000)
Mortality		0.004	-0.005***	-0.006	-0.006***
		(0.004)	(0.001)	(0.009)	(0.001)
mCost		0.023**	0.012***	0.519***	0.018***
		(0.009)	(0.002)	(0.161)	(0.003)
SQ×payment				-0.419	-1.790**
				(2.048)	(0.754)
ΔCold×payment				-1.022***	-0.053
				(0.388)	(0.091)
Morbidity×payment				0.000	0.000
				(0.001)	(0.000)
Mortality×payment				0.008	0.001
				(0.010)	(0.002)
mCost×payment				-0.504***	-0.008**
				(0.161)	(0.004)
Prob(1)	Payment	-1.533***			
		(0.252)			
	Constant	-0.578***		-1.257***	
		(0.141)		(0.111)	
N		5,700		5,700	
Log likelihood		-1,326.05		-1,323.36	

***p<0.01. **p<0.05. *p<0.1

Note: Standard errors in parentheses.

Table 7: VSL and VSI estimates (million RMB)

		Conditional logit		Mixed logit		
		Standard	**Scale**	**Standard**	**Scale**	**Latent class**
Pooled	VSL	4.53	5.04	4.72	3.80	5.24
		(2.91-6.14)	(3.03-7.05)	(3.19-6.24)	(2.56-5.03)	(3.51-6.98)
	VSI	1.04	1.21	1.01	0.49	1.13
		(0.84-1.25)	(0.94-1.48)	(0.79-1.23)	(0.25-0.73)	(0.85-1.41)
New tax	VSL	3.54		3.63		4.18
		(1.70-5.38)		(2.00-5.28)		(2.24-6.13)
	VSI	0.71		0.61		0.79
		(0.50-0.92)		(0.38-0.83)		(0.55-1.04)
Tax reallocation	VSL	5.51		5.90		6.06
		(2.89-8.33)		(3.22-8.59)		(3.22-8.90)
	VSI	1.34		1.44		1.44
		(0.96-1.72)		(1.00-1.89)		(0.90-1.99)

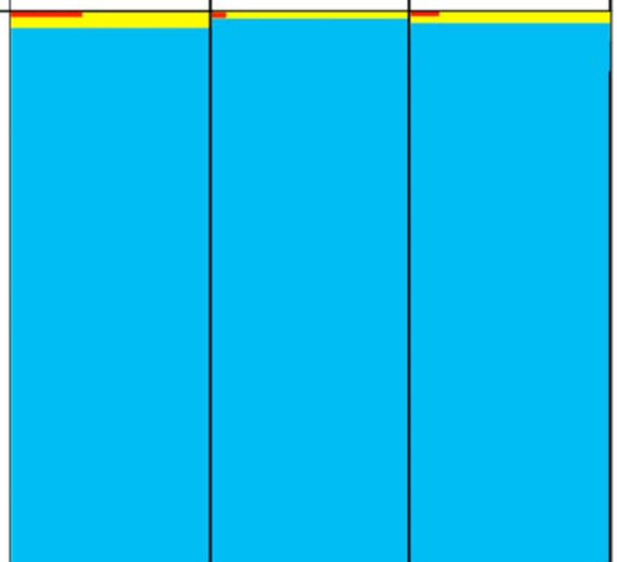
Notes: Confidence intervals calculated with delta method
Scale refers to model controlling for scale heterogeneity (Models C2 and Mix2)
Latent class estimated for class when risk and cost attributes statistically significant
US$ 1 = RMB 6.77 (stats.oecd.org, 10 September 2012)

Table 8: VSL and VSI estimates based on age groups (million RMB)

		Model C4	
		VSL	**VSI**
New tax	Age <35	2.65	0.51
		(0.67-4.64)	(0.30-0.72)
	Age 35-54	2.74	0.62
		(0.53-4.94)	(0.38-0.87)
	Age >54	3.87	0.74
		(1.57-6.16)	(0.48-1.01)

Notes: Confidence intervals calculated with delta method
Evaluated at the population mean of personal income in Table 3.
US$ 1 = RMB 6.77 (stats.oecd.org, 10 September 2012)

Figure 1: Example of a choice set (freely translated from Chinese)

	Current situation	Program A	Program B
Annual average symptom similar to cold for yourself	( )	1/3 ( )	1/6 ( )
In 10 years, the probability of getting sick from respiratory or cardiovascular diseases caused by air pollution for yourself (1/100,000)	2500	1000	1500
In 10 years, the probability of dying from respiratory or cardiovascular diseases caused by air pollution for yourself (1/100,000)	250	50	100
Yellow: probability of getting respiratory or cardiovascular diseases by air pollution **Red**: probability of dying from respiratory or cardiovascular diseases by air pollution **Blue**: probability of no health effects from air pollution			
Bids (RMB/month)	0	50	20
Your vote	☐	☐	☐