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Residents' preferred measures and willingness-to-pay for improving urban air quality: A case study of Hanoi city, Vietnam

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Abstract

Purpose – This purpose of this paper is to understand residents' choice of preferred measures and their willingness-to-pay (WTP) for the measures to improve the air quality of Hanoi city.

Design/methodology/approach – Questionnaire surveys were conducted to collect the opinions of 212 household representatives living in Hanoi City. The survey tools were tested and adjusted through an online survey with 191 responses. Multivariate probit and linear regression models were used to identify determinants of respondents' choices of measures and their WTP.

Findings – Respondents expressed their strong preferences for three measures for air quality improvements, including: (1) increase of green spaces; (2) use of less polluting fuels; (3) expansion of public transportation. The mean WTP for the implementation of those measures was estimated at about 148,000–282,000 Vietnamese dong, equivalent to 0.09–0.16% of household income. The respondents' choices appear to be consistent with their characteristics and needs, such as financial affordability, time on roads and their perceived impacts of air pollution. The WTP estimates increase with perception of air pollution impacts, time on roads, education and income; but are lower for older people.

Practical implication – Increase of green spaces can be the measure to which policy makers should pay more attention. The match-up of residents needs and well-informed plans will be an important key to success.

Originality/value – This appears to be the first attempt to test the validity of public opinions on choices of measures for improving urban air quality in Vietnam. Our WTP estimates also contribute to the database on the values of improved air quality in the developing world.

Keywords Air pollution, Contingent valuation method, Willingness-to-pay

Paper type Research paper

1. Introduction

Air pollution has been a major concern for people living in Hanoi, the capital city of Vietnam. The air quality data (monitored by the US Embassy in Hanoi) showed that the average annual concentration of PM2.5 [1], in the period of 2015–2019, was 54 μg/m^3, much higher than both the Vietnamese standard (25 μg/m^3) and the WHO guideline limit (10 μg/m^3) (AirNow, 2019). During many consecutive months in late 2019, Hanoi was among the most polluted capital cities globally (Van Khuc *et al.*, 2020).

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Significant impact on human health has been caused by air pollution in Hanoi. Hieu *et al.* (2013) estimated the number of deaths due to PM10 pollution from traffic in 2009 was 3,200 people, greater than the number of deaths from traffic accidents. Luong *et al.* (2017) showed that in the period of 2010–2011, when the PM10, PM2.5 concentration increased to 10μg/m^3, the number of children hospitalizations related to the respiratory diseases in Hanoi increased by 1.4 and 2.2%, respectively. Concerning health effects on adults, Nhung *et al.* (2020) suggested that an increment in the 2-day-average level of PM2.5 by 34.4 μg/m^3 was associated with an increase of 6.3% in the daily hospital admissions for ischemic heart disease in Hanoi.

In 2016, the Government of Vietnam issued the National Action Plan on Air Quality Management with a vision toward 2025, which aimed to strengthen air quality management. In recent years, the authorities of Hanoi have made efforts to implement measures for improving air quality such as installing more air monitoring stations and planting one million trees in the period of 2016–2020. However, air pollution is still a serious problem, and more effective solutions to improve air quality are demanded by residents of Hanoi City (Vuong *et al.*, 2021). It is therefore important to understand the residents' desire for air quality improvements.

The aim of this study is to examine Hanoi residents' choices of preferred measures that are expected to improve air quality of Hanoi city. This study not only collects public opinions but also carefully investigates the determinants of residents' choices of measures based on the application of multivariate probit models. This examination plays the role of a validity test checking whether respondents' choices are consistent with their characteristics and perceptions. To the best of the authors" knowledge, our study appears to be the first attempt to undertake this type of validity test for public opinions on choices of measures for improving urban air quality in Vietnam. Hence, our study enriches knowledge about public opinions on air quality measures in developing countries where the participation of citizens in the formulation of environmental policy is limited.

In addition, policy makers should consider all costs and benefits of policy scenarios to inform planning procedures. Estimating the willingness-to-pay (WTP) is a common approach to value individual benefits from improvements in environmental quality. The Contingent Valuation Method (CVM) is used widely to evaluate the amount that people are willing to pay for environmental amenities. CVM asks individuals directly their WTP in a hypothetical market to measure the monetary value of changes in individual welfare associated with the change in environmental quality. The application of CVM for improvements in air quality has been considered in many previous studies (Carlsson and Johansson-Stenman, 2000; Wang and Mullahy, 2006; Wang and Zhang, 2009; Donfouet *et al.*, 2014; Hadian *et al.*, 2017). Using the CVM approach, this paper estimates individual WTP for improvements in the air quality in Hanoi city. Our estimates enlarge the database on the values of improved air quality in the developing world.

2. Literature review

2.1 Residents' opinions on measures to improve urban air quality

Understanding residents' perspectives, especially those in the most adversely impacted areas, are important for the effective formulation and implementation of air quality policies (Eden, 1996; Zhang and Chen, 2018). The necessity of public participation for successful environmental policy has been recognized for many years. The 1992 Earth Summit emphasized the need for public involvement in the environment policy process to ensure the effective design and implementation of formulated policies (Eden, 1996). More recently, the 2030 Agenda for Sustainable Development, which was created using unprecedented public outreach, is a global example demonstrating for the importance of public participation in decision-making process (Berry *et al.*, 2019). The protection motivation theory (Maddux and Rogers, 1983) suggests that one of the key factors determining the intention to protect one-self is the belief in the efficacy of the recommended coping measures. Policy-making process disconnected with residents' opinions may lead to failure, since residents would lack motivation for adhering to the formulated policies. For example, Alford *et al.* (2002) found that residents in Anhui province, China largely ignored existing environmental protection policies and were not adhering to expected actions. To design effective policies, it is therefore important to learn about residents' opinions on air quality improvements.

Effective public participation in policy-making design requires professional supports on the topics under concerns (i.e. measures for improving air quality) (Eden, 1996). In our survey of residents' opinions, a list of measures for air quality improvements was designed to provide respondents with legitimate information supporting their decision-making process. In urban areas, emissions from fossil-fueled vehicles are usually reported as the main source of ambient air pollution (Tung *et al.*, 2011). Moreover, the collected opinions should be related to residents' responsibilities for air quality improvement (Zhang and Chen, 2018). For these reasons, policies regarding manufacturing sectors were not included in our list of measures.

A number of different measures for urban air quality management have been proposed in the literature. Concerning the control of emissions from road transport in urban areas, the body of existing studies suggest that shifting to lower-carbon fuels and advanced vehicles (e.g. biofuels, natural gas and electric vehicles) significantly reduces vehicular emissions (Wang *et al.*, 2011; Dyr *et al.*, 2019). Application of stringent emission standards (e.g. Euro emission standards) for vehicles also lowers emissions from road transport (Wang *et al.*, 2011). Development of public transportation systems (e.g. bus systems and urban rail networks) is commonly recommended as an effective measure to improve urban air quality (Zheng *et al.*, 2019). Traffic management strategies (e.g. low emission zones, speed control and congestion charges) are applied to restrict the use of private vehicles, and to promote the transition to less polluting modes of transport in urban areas. Review of traffic management strategies indicates that some measures (i.e. low emission zones, road pricing) can have a positive effect on air quality (Bigazzi and Rouleau, 2017). Other key measures recommended for urban air quality improvement include tree plantation and air quality monitoring (Quarmby *et al.*, 2019). Existing evidence has showed that "urban greening" initiatives can have a positive effect on air quality (Gómez-Moreno *et al.*, 2019). Designing effective air quality initiatives requires knowledge of the overall air quality levels. The need to develop monitoring networks, especially in low-income countries, is consistently suggested in the literature as a fundamental prerequisite for improving air quality (Quarmby *et al.*, 2019).

Based on the review of existing studies and air-quality-related plans of Hanoi authorities, the list of measures presented to respondents includes six options: (1) use of less polluting fuels, (2) expansion of public transportation, (3) application of strict emission standard for traffic vehicles, (4) application of traffic management strategies, (5) increase of green spaces and (6) development of advanced monitoring system. It is suggested that policies for air quality improvement are most effective when they are a part of a suite of relevant measures (Quarmby *et al.*, 2019; UNEP, 2019).

2.2 Selection of CVM question format

The importance of well-informed respondents is often emphasized in a CVM exercise. However, the effects of air pollution on human and environment are very diversified and difficult to predict. Given different datasets and applied methodologies, scientific information often provides widely varying views. Hence, there is a question that whether practitioners should try to provide respondents with some "facts" formulated based on some kind of average of these views, or whether the whole issue should be presented given some levels of genuine uncertainty, where respondents would judge the air pollution using information from various sources (Carlsson and Johansson-Stenman, 2000). The latter strategy was chosen to design this CVM study. Instead of quantifying a specific scenario, this CVM survey was considered as an exercise where respondents had their own subjective views about the harmfulness of air pollution. From their own perception, respondents could judge air quality improvements related to the implementation of their chosen measures.

Among several CVM question formats (including open-ended, dichotomous choice, bidding game and payment card format), dichotomous-choice questions are usually recommended, since this type is considered to be more similar to everyday consumption decisions, i.e. where you either buy or do not buy the good at a certain level of price (Carlsson and Johansson-Stenman, 2000). However, an open-ended question format was applied in this CVM exercise. The open-ended format also has obvious advantages. According to Langford *et al.* (1998), the open-ended question format can be useful in obtaining WTP information from smaller scale studies. Carlsson and Johansson-Stenman (2000) also suggest that the open-ended format has some advantages, such as a much more efficient use and processing of the data, and absence of starting-point and yea-saying bias. Since open-ended format could reduce yea-saying, this type of questions can provide a conservative design that generally tends to give lower mean WTP compared to questions of referendum type.

Every format type has both advantages and disadvantages, and the choice of format depends on the context and the research objectives. Since air pollution may impact many aspects of society, the benefits of improved air quality would be difficult to predict, and scientists have widely varying views. To avoid anchoring and range bias effects, several CVM studies on air quality improvements have applied the open-ended format to simultaneously assess the WTP for a diversity of benefits that differ in ranges of magnitude to the individual, family, and whole population (Carlsson and Johansson-Stenman, 2000; Wang and Mullahy, 2006; Wang and Zhang, 2009; Donfouet *et al.*, 2014; Istamto *et al.*, 2014; Wang *et al.*, 2015; Hadian *et al.*, 2017). Our survey was also undertaken in small scale to inform the design of our choice experiment on improvements in air quality of Hanoi City. Therefore, the open-ended approach was the method of choice in this study, given its favorable features.

3. Methodology

3.1 Questionnaire design

In our survey, the questionnaire started with questions about respondents' perception of air pollution in Hanoi. A list of relevant measures to improve air quality was presented to respondents, who then were requested to make choices of the three most preferred measures. Respondents could also propose additional measures they preferred to the list of measures. Benefits of implementing those measures were discussed with respondents, and they were requested to choose three types of benefits which are most relevant to their situations. Being aware of benefits of improvements in air quality, respondents were asked for their maximum WTP to contribute to the implementation of the measures for improving air quality. Follow-up questions were included to identify anomalies in the responses, such as reasons for zero bids and hypothetical bias (respondents may agree to pay because the payment is hypothetical). The final part of the questionnaire collects respondents' socio-economic and attitudinal information to analyze the factors affecting their WTP.

In the open-ended WTP questions, the respondents in our CVM exercise were asked about the maximum amount of money they would be willing, and be able, to pay for the implementation of the measures they chose in the previous question. The electricity bill was used as the payment vehicle, because the electricity bill is mandatory and has good coverage (Do and Bennett, 2008). A one-off coercive payment via household electricity bill, therefore, was selected as the payment vehicle in this study. Respondents were reminded to consider their annual household disposable income into account prior to answering the WTP question.

The questionnaire was tested through a pilot online survey with 191 responses to ensure that its approach was reasonable and that participants could understand the information provided.

3.2 Reduction of hypothetical bias

Concern exists that in a hypothetical setting of CVM surveys, hypothetical WTP may overestimate real WTP (Murphy *et al.*, 2005). To minimize the hypothetical bias, certainty scales have been proposed in the literature on stated-preference methods (i.e. CVM). A body of literature show that the use of follow-up certainty scales to change uncertain "Yes" to "No" can be effective at minimizing the difference between real and hypothetical WTP (Ready *et al.*, 2010).

To adjust for the presence of hypothetical bias, this study applied certainty scales allowing respondents to indicate how sure they are that they would actually pay the amount they had indicated. Respondents' certainty was collected using five-point Likert scale with 1 labele "very uncertain" and 5 labeled "very certain". All positive WTP with the certainty answers of "very uncertain" and "uncertain" were changed to zero WTP.

3.3 Survey implementation

With the finalized survey instruments, face-to-face survey was conducted with households living near traffic roads in May and June 2018. Criteria for selecting traffic roads are near the monitoring stations showing high concentrations of air pollutants (such as the monitoring station at US Embassy Hanoi) and roads with dense traffic. As suggested in the literature on public participation, opinions from the most affected residents should be taken into the policy-making process to ensure the effective implementation of formulated policies. Moreover, it is expected that residents who are suffering from the current situation of air pollution would pay more attention to the air pollution issues and give more reliable responses to questions related to air quality in our survey. The survey was completed by 212 household representatives, so the total sample for analysis was 212 [2].

3.4 Research models for data analysis

3.4.1 Examining determinants of respondents' choices of measures. To have a better understanding of the respondents' choices of measures, our analysis includes an examination of determinants of their choices. Dependent variables in this examination have two possible outcomes (1 if a respondent chose a given measure, 0 if otherwise). The three most preferred measures are included in the analysis, and a respondent could choose one or more measures from this set of three measures. This implies that there are correlations between the three dependent variables representing the three measures. Following Carlsson *et al.* (2010) and Nguyen *et al.* (2015), multivariate probit models were applied to take into account the correlations between the dependent variables. The specification for our multivariate probit models is as follows:

$$C_i = \alpha_i + \beta_i Z + \varepsilon_i \quad i = 1, 2, 3$$

where C_i indicates the probability that Measure i was chosen, and there are correlations between the C_i variables; β_i is a vector of parameter estimates; Z is a vector of respondents' characteristics; and ε_i is the stochastic unobserved component. A constant (α_i) is included in a multivariate probit model to represent unobserved factors (i.e. the part is not represented by the covariates) affecting the likelihood that a respondent belongs to each group of measures.

The surveyed data are used to construct independent variables of the Z vector. The Z vector includes continuous variables of *perception* [3], *time on road, age, years of education* *and household income*, while *households with children and gender* were treated as dummy variables. Statistically significant covariates show factors determining the respondents' choices of measures to improve air quality. The multivariate probit models were estimated with 500 draws using the Geweke-Hajivassiliou-Keane simulator provided in the *NLOGIT 5.0* package.

3.4.2 Exploring determinants of WTP estimates. Determinants of WTP estimates were also examined in this study. The exploration of determinants can play a role as a test of the internal validity of responses and facilitate benefits transfer. In responding to the WTP question, the decision process of respondents could include two decisions: (1) whether or not to state a positive WTP and (2) how much to state (Carlsson and Johansson-Stenman, 2000). It is a common practice that a two-equation model, where the decision process is modelled separately, is applied to analyze the WTP responses. In a two-equation model, one model for binary data (dependent variable is 1 if positive WTP and 0 if others) is applied to examine probability of a 0 WTP observation, and another regression model is for exploration of the positive observations. However, most of the 0 bids in this CVM exercise could be identified as protest 0 bids [4]. If excluding the protest votes, the number of zero observations in our analysis would not be sufficient to run efficiently the binary model for probability of zero WTP. Therefore, our examination focused on the model for positive WTP values with a sample of 111 respondents who were certain about their WTP [5].

To analyze the determinants of the WTP estimates, we constructed multivariate linear regression. The dependent variable in our regression model is the logarithmic function of WTP (i.e. lnWTP). It is expected that the logarithmic transformation would help to bring the WTP data, that is skewed with a long tail toward positive values, closer to a normal distribution form and to restrict the WTP to positive values (Carlsson and Martinsson, 2001; Wang and Zhang, 2009). The specification for our multivariate linear regression is as follows:

$$\text{InWTP} = \alpha' + \beta' Z + \varepsilon'$$

where α' is constant representing unobserved factors (i.e. the part is not represented by the included covariates); β' is a vector of parameter estimates; Z' is a vector of respondents' characteristics; and ε' is the stochastic unobserved component. To keep consistency across our examinations of determinants, the Z variables in the multivariate linear regression are similar to the independent variables included in the multivariate probit models.

4. Results

4.1 Residents' preferred choices of measures to improve air quality in Hanoi city

4.1.1 The result of respondents' choices. The frequency of respondents' choice of measures is reported from high to low as follows:

(1) increase of green spaces: 76.9%;

(2) use of less polluting fuels: 43.9%;

(3) expansion of public transportation: 42.5%;

(4) development of advanced monitoring system: 36.3%;

(5) application of strict emission standard for traffic vehicles: 25.9%; and

(6) application of traffic management strategies (e.g. speed control, congestion charges): 12.7%.

The results indicate that the three most preferred measures are: (1) increase of green spaces; (2) use of less polluting fuels; (3) expansion of public transportation. In the following paragraphs, existing international experiences about implementation of the measures most preferred by residents of Hanoi city are reviewed. This would enhance the reliability of the collected public opinions which should be taken into policy-making process.

Urban green space, such as parks, forests, green roofs, gardens, greenways and trails, street trees, and green walls provides a wide range of ecosystem services for the cities (Wolch *et al.*, 2014). Big cities around the world are increasing their green spaces. Seoul, the capital of South Korea recently has planted more than 2,000 groves and gardens; the city of Melbourne in Australia planned to nearly double its green cover to 40% by 2040; and Italy's Milan planned to expand their green spaces with three million trees to be planted (Whiting, 2018). Recent studies showed that pollutants like PM10, PM2.5, NOx and O_3 can be reduced at locations near green spaces (Klingberg *et al.*, 2017; Gómez-Moreno *et al.*, 2019). In Strasbourg, France, public trees removed 1 ton of CO, 14 tons of NO_2, 56 tons of O_3, 12 tons of PM10, 5 tons of PM2.5 and 1 ton of SO_2 in one year (Selmi *et al.*, 2016). However, the development of green spaces should take into account the shape of vegetation barriers, direction and speed of wind, and the density, size and species of trees (Janhäll, 2015).

Shifting to low-carbon fuels and electric vehicles (EVs) has been a popular choice in coping with air pollution. Brazil made a significant shift to lower-carbon fuels of ethanol produced from sugar cane in 1975 (Cortez and Baldassin, 2016). China has a target of electrifying 20% of its new cars by 2025 (Reuters, 2017). A recent review article suggests that the transition to electric vehicles could have great potential to reduce emissions of gaseous pollutants (i.e. CO, NOx, VOC, SO_2) (Requia *et al.*, 2018).

Public transport system, which enables more people to travel daily together, is another environmentally friendly transport options. Among forms of public transportation, Bus Rapid Transit (BRT) system has been increasingly implemented throughout Latin and North America, South-East Asia, China, Australia (Deng and Nelson, 2011), and is more increasingly popular in Europe (Ingvardson and Nielsen, 2018). Studies showed that BRT could reduce emissions of CO, NOx, PM2.5 and PM10 (Zheng *et al.*, 2019). Increase in service frequency can also have positive impacts on reduction of CO_2 and NOx emissions (Lalive *et al.*, 2013). However, it should be noted that without changes in urban travel regulations (e.g. restrictions on the use of private vehicles), public transit may not improve the air quality (Rivers *et al.*, 2017).

4.1.2 The determinants of residents' choices. Inspection of the multivariate probit model results in Table 1 reveals that the variable of *household income* is significant in all three models. Respondents having higher household income are more likely to choose the measures of increasing green spaces and using cleaner fuels, while they are less likely to support the measure of expanding public transportation system. This is reasonable because respondents with higher income might have higher demand for green and clean environment, and they also have better financial ability to accept higher price of cleaner fuels. Respondents having higher income might also prefer more comfortable private vehicles to the public transports.

The *perception of impact* variable is significant in the models of cleaner fuels and public transportation. The signs are opposite in those models, so that the perception of air pollution impacts has positive effects on the likelihood of choosing the measure of cleaner fuels, but has negative effects on the propensity to choose the measure of public transportation. A reason here may be related to the respondents' financial ability (income). Respondents with perception of more serious impacts would be willing to pay more for cleaner fuels at higher prices; and given their financial ability, they would not prefer the public transports.

The variable of *time on roads* is significant in the group of respondents choosing the measure of increase of green spaces. This is immediately intuitive, as people who have to spend more time on roads would prefer the shadow created by trees nearby the roads. Hence, they are more likely to choose the measure of increasing green spaces.

Variables	Green spaces	Cleaner fuels	Public transportation
Constant	−3.829** (1.607)	−2.988*** (1.069)	3.722*** (1.158)
Perception[a] of air pollution levels (Mean = 4.29, Std = 0.97)	0.039 (0.139)	0.148 (0.111)	−0.079 (0.102)
Perception[a] of air pollution impacts (Mean = 4.16, Std = 0.71)	−0.236 (0.176)	0.438*** (0.139)	−0.497*** (0.148)
Households with children under 5 years old (%) (Mean = 37.74, Std = 0.48)	−0.138 (0.273)	−0.249 (0.205)	−0.040 (0.209)
Time on roads per day (hours) (Mean = 2.15, Std = 0.96)	0.426** (0.196)	−0.119 (0.103)	0.070 (0.103)
Male (% male) (Mean = 57.54, Std = 0.49)	0.272 (0.257)	−0.087 (0.194)	−0.167 (0.192)
Age (years) (Mean = 38.4, Std = 13.46)	0.005 (0.014)	−0.010 (0.007)	0.010 (0.008)
Years of education (Mean = 15.43, Std = 2.21)	0.085 (0.081)	0.003 (0.045)	−0.019 (0.047)
Household income -In(Income) (Mean = 2.56, Std = 0.50)	1.195*** (0.319)	0.432* (0.248)	−0.638*** (0.225)
Number of observations	212		
Correlation matrix			
Green spaces		−0.615***	−0.200
Cleaner fuels			−0.263**

Note(s): Standard errors are in parentheses; ***, **, * = Significance at 1, 5, and 10% level; [a]Perception was measured using five-point Likert scales ranging from very high (5) to very low (1)

Table 1. Multivariate probit models by groups of respondents choosing each measure

Examination of the model results indicates that the respondents' choices seem to be reasonable, and to be consistent with their characteristics and needs, such as financial affordability, time on roads and their perceived severity of consequences of air pollution.

4.2 Willingness-to-pay for improving air quality in Hanoi city

4.2.1 The estimation of willingness-to-pay. The design of this CVM exercise would give respondents an opportunity to "purchase" the improvements in air quality by paying for the measures that they preferred to be implemented to improve air quality. Figure 1 presents frequencies of WTP amount. Of 212 respondents, 118 respondents (~56%) were willing to pay for improving air quality of Hanoi city. Among the positive WTP respondents, 64 respondents (~30%) were willing to pay an amount of less than 250,000 Vietnamese dong; 48 respondents (~23%) had an WTP amount in the range of 250,000–650,000 Vietnamese dong; only 6 respondents (~3%) were willing to pay from 650,000 to 1 million Vietnamese dong. This is consistent with the economic theory of decreasing demand curve.

In our CVM survey of 212 respondents, 94 respondents, accounting for 44% of the full sample, had a zero WTP. A follow-up question was included in the questionnaire to

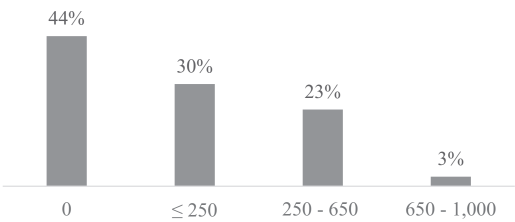

Figure 1. Frequencies of the WTP amounts in thousands Vietnamese dong (VND) (1 USD = 23.250 VND)

understand reasons for the zero WTP. The frequency of respondents' reasons is reported from high to low as follows:

(1) I support the improvements; I do not really believe that the collected money would be spent correctly on improving air quality: 77%.

(2) I support the improvements, but the Government is responsible to pay all costs of the improvements: 48%.

(3) I support the improvements, but I do not agree with paying the fee through electricity bill: 14%.

(4) I support the improvements, but cannot afford a payment of any amount: 4%.

(5) The improvements do not have any benefits to me: 4%.

Of the zero WTP respondents, the top reason was that they did not really believe that the collected money would be spent correctly, the second most frequently chosen reason was that the Government had to pay the costs of the improvements, and the third was that respondents did not agree with paying the fee through electricity bill. These three reasons, combined with the zero WTP, were used to identify a protest vote. This indicates that respondents with the protesting perception did not accept the concept of WTP. In our CVM exercise, 89 respondents (~42% of the total respondents) were identified as protesting voters. Our result of a large proportion of protest votes is similar to findings in CVM exercises in China (Wang and Zhang, 2009; Wang *et al.*, 2015) and Iran (Hadian *et al.*, 2017). It seems that when compared with developed countries, a large proportion of respondents having no incentive to bear the costs of improved air quality in developing countries indicate a relatively low environmental consciousness (Wang and Zhang, 2009). The lack of transparency and accountability of governments in developing countries may also be reasons for high proportion of protest votes.

To reduce the effect of hypothetical bias, responses to the certainty scale were used to switch the uncertain positive WTP to zero WTP. The changes in WTP values could result in the generation of more conservative measures of WTP. With the revision in WTP values, the mean value of the WTP (including zero bids) is 148,000 Vietnamese dong with the 95% confidence interval of 119,600–175,600 Vietnamese dong. This mean WTP accounts for 0.09% of annual household income. In the case of excluding zero bids, the mean value of the WTP is estimated at 282,000 Vietnamese dong with the 95% confidence interval of 242,500–321,300 Vietnamese dong. The mean WTP excluding zero bids is equivalent to 0.16% of annual household income.

Our WTP estimate including zero bids is very conservative since the certainty scale was used to switch the uncertain positive WTP to zero WTP. If excluding zero bids, the WTP value in our open-ended CVM exercise is similar to the WTP estimates of 0.15% of household income for improving air quality in Ho Chi Minh city (the biggest city of Vietnam) (Ngoc *et al.*, 2015). Our WTP estimate is also closed to the WTP estimates of 0.2% of household income in an open-ended CVM survey conducted in an African city (Donfouet *et al.*, 2014). However, the estimate in our study is relatively lower than the WTP values of 0.4–0.7% of household income, which were estimated from open-ended in some Chinese cities (Wang and Mullahy, 2006; Wang *et al.*, 2006; Wang and Zhang, 2009). A possible reason for the higher WTP estimates in China is that the issue of air pollution in big cities of China has been well known as more severe than in the other regions of the developing world.

4.2.2 The determinants of the WTP amount. The linear regression results in Table 2 indicate that *perception of air pollution impacts*, *time on roads, education levels* and *household income* have positive effects on respondents' WTP. It is intuitive that higher levels of impact,

Variables	Coefficient	Standard error	*p*-value
Constant	−2.157***	0.715	0.003
Perception of air pollution levels	−0.010	0.081	0.901
Perception of air pollution impacts	0.224**	0.102	0.030
Households with children under 5 years old	0.131	0.161	0.416
Time on roads per day	0.189**	0.080	0.020
Male	0.104	0.149	0.486
Age	−0.011**	0.005	0.039
Years of education	0.065*	0.032	0.050
Household income–Ln(Income)	0.378**	0.166	0.025
Number of observations	111		
R^2	0.214		
p-value for the model test	0.001		

Note(s): ***, **, * = Significance at 1, 5, and 10% level

Table 2. Multivariate linear regression model for determinants of WTP values

which could be related to respondents' time on roads and be reflected in respondents' perception, could motivate higher levels of WTP. Higher levels of education and income could indicate better financial ability, which ensure ability of respondents to offer higher levels of payment. People with higher levels of education are more likely informed about the environment and negative effects of pollutants, hence are more willing to sacrifice financially to protect the environment (Moon *et al.*, 2002; Marquart-Pyatt, 2012). The *age* variable has negative effects on respondents' WTP, such that older respondents had lower levels of WTP. Our findings about the positive relationship with education and income, and the negative relationship with age are consistent with the results of previous CVM studies (Carlsson and Johansson-Stenman, 2000; Wang and Mullahy, 2006; Wang and Zhang, 2009).

The significant relationship between WTP and income can be used to test the validity (Johannesson *et al.*, 1991; Wang and Zhang, 2009; Wang *et al.*, 2015). Our result was in line with what has been noted in the economic theory, that WTP is inevitably associated with ability to pay. The positive relationship with income indicates that respondents in our survey could behave in an expected way; thus, confirming the internal validity of this CVM study. However, it is noteworthy that the constant is significant and R^2 is about 0.2; this might suggest that there are significant effects of other unobserved variables. Our survey had a relatively small sample, and this could be one of the important reasons for the small R^2.

5. Conclusions

In this paper, residents' choices of preferred measures and their WTP for the measures to improve air quality of Hanoi was investigated. Respondents in our survey expressed their strong preferences for three measures for air quality improvements: (1) increase of green spaces; (2) use of less polluting fuels; (3) expansion of public transportation. The mean WTP for the implementation of those measures with the aim of improving air quality is 148,000 Vietnamese dong (if including zero bids) and 282,000 Vietnamese dong (if excluding zero bids). These WTP amounts account for about 0.09–0.16% of annual household income, which is of the same order of magnitude as the previous CVM study in Ho Chi Minh city (Ngoc *et al.*, 2015).

The determinants of respondents' choices of measures and their WTP were explored using multivariate probit and linear regression models. In the econometric models, most parameters have the expected sign. The respondents' choices appear to be consistent with their characteristics and needs, such as financial affordability, time on roads and their perceived impacts of air pollution. WTP was found to increase with *perception of air pollution impacts*, *time on roads, education* and *income*. But it was lower for older people. There still appears to be considerable uncertainty causing the zero bids, since most of zero-bid respondents did not believe that the collected money would not be used correctly for reducing air pollution in Hanoi city. However, the internal validity tests based on the examination of determinants of respondents' choices and WTP confirm that respondents' answers seem to be consistent with their characteristics and needs. Hence, the information on residents' preferred measures and WTP for improving air quality would be useful for policy makers in identifying prioritized measures and investing effectively in controlling air pollution given the budget limitation. The match-up of residents needs and well-informed plans will be an important key to success.

Although this study demonstrated reasonable results, the findings with respect to WTP should be interpreted with caution. It is recognized that our results are based on a relatively small sample. Besides, we applied an open-ended WTP format, and alternative CVM format types may yield somewhat different results. The debate on the best format to measure WTP for the environmental goods and services is ongoing; hence, more CVM exercises using different format types should be implemented in the context of developing countries. The WTP values estimated from our open-ended survey are still useful to inform the design of more complex stated-preference formats such as dichotomous-choice CVM and choice experiments.

Notes

1. PM2.5 and PM10 refers to particles that have diameter less than 2.5 and 10 micrometers, respectively.
2. When compared with the number of about two million households living in Hanoi city, our sample focusing on households nearby traffic roads is relatively small. Hence, any extrapolations to the whole population of Hanoi city should be careful to consider the sample characteristics presented in Table 1.
3. Perception was measured using five-point Likert scales ranging from very high (5) to very low (1).
4. As the reasons for 0 bids reported in Section 4.2.1, among 94 zero bids, 89 respondents revealed their motivations for zero WTP as the protesting views on the WTP for air quality improvements.
5. Responses to the open-ended WTP question contain a large fraction of zeros, hence Tobit model can be an option for analyzing the WTP responses. However, the use of Tobit model is only meaningful where the zero WTP are (or may be) true zeros, given that the respondents have answered truthfully. In our CVM exercise, if excluding the protest votes, very few zero bids may be meaningful to be explored using Tobit model.

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