Air Pollution Exposure and Willingness-to-Pay

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ABSTRACT: The increasing motorization and traffic congestion has brought about high levels of Suspended Particulate Matter (SPM) in Metro Manila. Constant exposure to high levels of SPM poses a grave health concern to the public, particularly on pedestrians and passengers. The paper estimates the willingness-to-pay of passengers and pedestrians for improved air quality using contingent valuation method.

RESUME: le développement de la motorisation et des effets de la congestion a porté à de hauts niveaux le taux de particules en suspension (SPM en anglais) dans la métropole de Manille. Une exposition constante à de hauts niveaux de SPM pose un grave problème de santé au public, particulièrement aux piétons et aux voyageurs. En s'appuyant sur une méthode de simulation par évaluation contingente, cet exposé évalue le prix que seraient disposés à payer piétons et voyageurs pour l'amélioration de la qualité de l'air.

1 INTRODUCTION

Air pollution has worsened immensely in urban areas over the last decades, primarily because of emissions from industrial establishments and motor vehicles. Air pollution, along with solid waste problems and potable water scarcity has led to the constant deterioration of the quality of life in urban areas. With approximately 10 million people, the over concentration of population in Metro Manila accompanied by increased motor vehicle use, as well as intensified human activities, has led to road traffic congestion and consequently high levels of air pollution especially along trunk roads and commercial districts. The 1992 study by the Asian Development Bank on vehicular emissions estimated that jeepney, buses and taxis contribute to two-thirds of the particulate matter pollution in Metro Manila.

Human exposure to motor vehicle emissions is greater in urban areas as compared to rural areas, primarily because cities have more roadways, parking garages, and street canyons where people may be exposed to high pollutant concentrations due to motor vehicle emissions (Schwela & Zali, 1999). The "Guidelines for Air Quality" set by the World Health Organization published in 2000 discussed different studies relating air pollution to human health. Observed effects may be an aggravation of existing respiratory diseases, disruption of physiological processes or physical inconveniences to the affected population.

Recent air quality data by the Philippine Department of Environment and Natural Resources (DENR) - Metro Manila Air Quality Monitoring Section indicated high concentrations of Total Suspended Particulates (TSP) in several areas in the metropolis. The Congressional Plaza monitoring station reached a maximum of 921μg/Ncm and averaged 358.74μg/Ncm for 24-hour sampling for year 2000. In 1999, the highest record, also for 24-hour sampling, was at 699μg/Ncm and averaged 226μg/Ncm for the Quezon Avenue monitoring station.

Considering the current air quality levels in Metro Manila and the increasing motorization, this paper aims to estimate the willingness-to-pay of passengers and pedestrians for improved air quality considering their exposure to SPM. Also, the paper seeks to investigate the viability of policies in terms of financial support from passengers and pedestrians.

2 CONTINGENT VALUATION SURVEY

The surveys conducted were random face-to-face interviews of passengers and pedestrians along key areas in Metro Manila. Survey 1 and Survey 2 were conducted in Cubao and Makati on November and December 2001. The primary respondents for Survey 1 were the passengers from the different

terminals in Cubao, while the Makati respondents were primarily pedestrians.

Survey 3 was conducted on the passengers inside Jeepneys while traveling from Philcoa to Kalaw Avenue on February 2001. Survey 4 was conducted on the pedestrians in the Philcoa Bus/Jeepney stop on June 2001.

2.1 *Questionnaire*

The study utilized three sets of contingent valuation questionnaire format. One set for Survey 1 and Survey 2, one for Survey 3, and another for Survey 4.

The discrete-response contingent valuation question introduces the relationship of motor vehicle emissions, particularly suspended particulate matter, and human health. The interviewer clearly explained to the respondent that SPM emissions by jeepneys and other diesel-fed engines could affect their health. For Survey 1 and Survey 2, the proposed policy is by adding an SPM filter on the tailpipe of buses and jeepneys, which reduces the emissions by 80%. If the law would mandate this policy, the passengers have to share in the cost by a rise in fare, because the drivers/operators would not be able to shoulder the cost. After careful explanation of this hypothetical scenario, the interviewer then asks if the respondent would be willing to pay for an increase in fare by 1 peso. If the response was 'no', the respondent would be asked to state the most probable reason for not accepting the increase in fare. If the response is yes, the interviewer follows it up with 'How about an increase of 3 pesos?'. The elicitation procedure for Survey 1 and Survey 2 is shown in Figure 1.

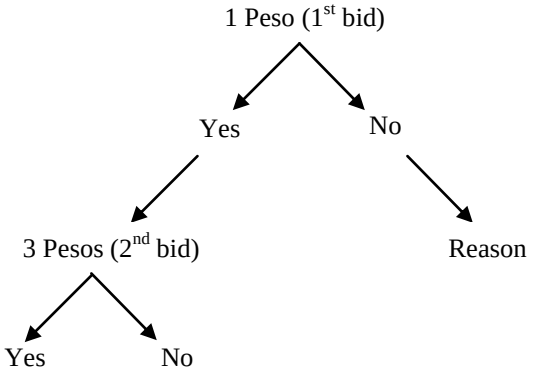

Figure 1. Bid Tree for Surveys 1 and 2

The proposed policy included in Survey 3 and Survey 4 were different from Surveys 1 and Survey 2. The proposed policy for Surveys 1 & 2 is by mandating jeepney drivers/operators to regularly comply with a monthly check-up of their vehicles with the proper authorities. Then, the interviewer also explained that the drivers/operators would not be able to comply with this policy due to financial constraints. After clearly explaining the hypothetical scenario, the interviewer then begins the elicitation with an initial bid of 1 Peso. If the reply is 'yes' then the interviewer follows up the initial bid with 2 Pesos, and otherwise, the second bid was lowered to 0.50 Pesos. The elicitation procedure is shown in Figure 2.

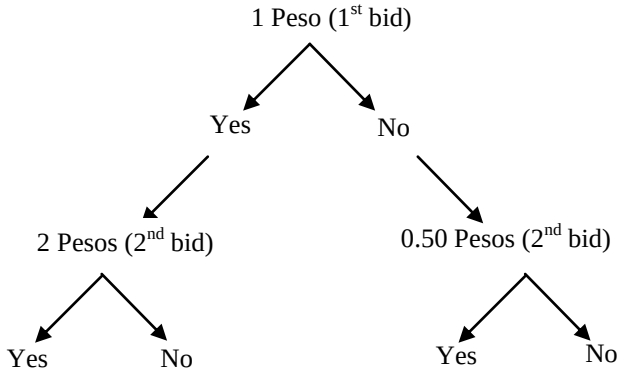

Figure 2. Bid Tree for Survey 3

For Survey 4, the elicitation procedure is shown in Figure 3. This survey utilized the draw-card method for the bids. The respondents were asked to choose one card from the prepared set. Their chosen card contained the initial bid where they are asked to answer with a 'yes' or 'no' reply. The preset bids were 0.50 Peso, 1.00 Peso, 1.50 Pesos, 2.00 Pesos, 2.50 Pesos, and 3.00 Pesos. The constant initial bid of 1 Peso was not adopted in order to know the effect of the starting bid on respondents. Depending on their reply to their randomly chosen initial bid, they would again be asked to choose from the prepared draw cards. This time they would be asked to choose from the higher bid cards if they answered 'yes' and from the lower bid cards if they answered 'no'.

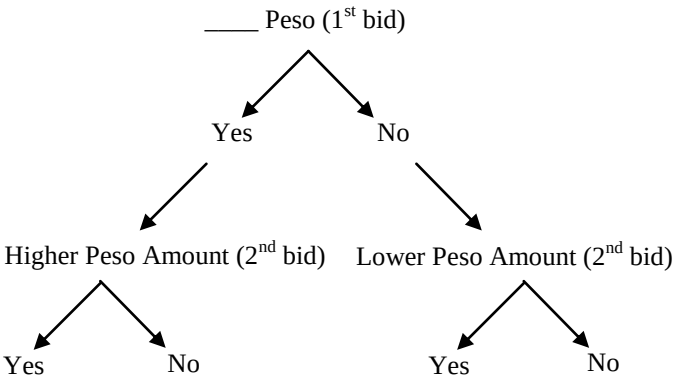

Figure 3. Bid Tree for Survey 4

3 WILLINGNESS-TO-PAY FOR IMPROVED AIR QUALITY

3.1 *Summary of responses*

3.1.1 *Survey 1 and Survey 2*

Table 1 presents the summary of replies to the proposed bids as introduced to the Cubao passengers and Makati pedestrians. Out of the 373 respondents, 78% accepted the initial bid of PhP1.00, and out of the 292 respondents, only 78 or about 27% further accepted the follow up bid of PhP3.00.

Table 1. Summary of Responses for Surveys 1 & 2

	1 Peso	3 Peso
Yes	292	78
No	81	214
Total	373	292

3.1.2 *Survey 3*

The third survey focused on the passengers of jeepneys while in-transit from the Philcoa bus/jeepney stop to and from T. M. Kalaw Avenue. The initial bid was still kept at PhP1.00, however, a follow-up bid was introduced to the respondent depending on their answer. The summary for the initial bid is presented in Table 2.

Table 2. Summary of Initial Bid Responses for Survey 3

Bid	No	Yes	Total
1 Peso	20	41	61

It can be observed that out of the 61 respondents, 67% accepted the initial bid of PhP1.00. Depending on their reply to the initial bid, a higher or lower follow-up bid was introduced to the respondent. Table 3 shows the summary of the second bid responses. The PhP0.50 second bid imply that these respondents rejected the initial bid of PhP1.00, while the PhP2.00 second bid corresponds to the number of respondents who accepted the initial bid.

Table 3. Summary of Second Bid Responses for Survey 3

Bids (PhP)	No	Yes	Total
0.50	14	6	20
2.00	25	16	41
Total	39	22	61

3.1.3 *Survey 4*

The fourth survey that focused on the Philcoa pedestrians employed a different type of bidding procedure (graphically represented in Figure 3). Tables 4 and 5 show the summaries for the initial bid and the second bid, respectively. The 'bids' column contains the possible choices that the respondents may draw from the prepared bid cards. The row totals show the number of respondents who have randomly picked the corresponding bid as their initial bid. It can be observed from Table 4 that the most number of respondents have randomly picked the PhP1.50 and the PhP2.00 bid as their initial bid. Also, the column total for 'no' show that there were more respondents who rejected their picked initial bids. This can be attributed to the fact that only a few respondents have picked the initial bids of PhP0.50 and PhP1.00. After the respondents' reply on their chosen initial bid, they were then asked to pick another card corresponding to a lower or higher value from their initial bid. The summary of answers is presented in Table 5. The totals only sum up to 137 because of the replies of two respondents who have chosen PhP0.50 and PhP3.00 as their initial bid, hence they are no longer asked for a second bid.

Table 4 Summary of Initial Bid Responses for Survey 4

Bids (PhP)	No	Yes	Total
0.50	1	8	9
1.00	3	4	7
1.50	20	22	42
2.00	31	15	46
2.50	16	5	21
3.00	13	1	14
Total	84	55	139

Table 5 Summary of Second Bid Responses for Survey 4

Bids (PhP)	No	Yes	Total
0.50	11	15	26
1.00	23	11	34
1.50	17	7	24
2.00	7	5	12
2.50	14	7	21
3.00	9	11	20
Total	81	56	137

3.2 *Quantifying the Willingness-to-Pay of the Respondents*

The contingent valuation provides an answer to whether the respondents were willing to pay for an additional increase in fare, thereby helping the drivers/operators in maintaining the good condition of their vehicles. By doing so, the vehicle-generated emissions of jeepneys would be lessened.

The double-bounded discrete response contingent valuation follows up on the initial question/bid, with a second question again involving a specific amount to which the respondent can respond with a yes or no. There are four possible combinations of answers from the respondents, yes-yes, yes-no, no-yes, no-no. The probability for the discrete response follows the general formula for logit regression.

$$\Pr(Yes) = \frac{1}{1+\exp\{-[V(1,Y-C)-V(0,Y)]\}} = 0.5 \qquad (1)$$

For this equation, *Y* is income, which may also represent other variables that may be included in the analysis and *C* is the cost introduced to the individual. The probability of getting a "yes" answer and a "no" answer is 0.5. The estimation approach used for the double-bounded model was maximum likelihood expressed in the formula below.

$$\max_{\beta_0^{SP}} : \ln L^{SP} = \sum_i \left(\delta_{yy}^i \ln P_{yy}^i + \delta_{yn}^i \ln P_{yn}^i + \delta_{ny}^i \ln P_{ny}^i + \delta_{nn}^i \ln P_{nn}^i\right) \qquad (2)$$

where δ_{xz} = indicator function that equals one when the two responses are *xz*, and zero otherwise (Hanneman, 1999).
xz = represents the different combinations *yy*, *yn*, *ny*, and *nn*,
SP = stated preference/ answer of the respondents

The median willingness-to-pay may be computed from changing *V(1, Y-C)-V(0,Y)* in the logit formula (2) to $\Delta V(C)$, in order to reflect the variations in cost. Equation 2 may be transformed to the formula below in deriving the median willingness-to-pay.

$C^* = exp\ (\alpha / \beta)$

where C^* = median cost of the responses
α and β = parameter estimates

The median was used as the measure of central tendency representing the data because the bids were already preset, meaning it is not affected by extreme values in the response distribution. The mean is the conventional measure in benefit-cost analysis and from a statistical point of view, more sensitive than the median, however, the median may be more realistic in a world where decisions are based on voting and there is a concern for the distribution of benefits and costs (Hanneman, 1999).

Computations for the maximum likelihood estimation were done using the TSP® Time Series Processor software.

3.3 *Results of the Maximum Likelihood Estimation and Median Costs for the Respondents' WTP*

The proposed policies introduced to the respondents are the installation of SPM filters to the exhaust tailpipes of buses and jeepneys, and the other one is through strict inspection and maintenance of diesel-fed engines, specifically, jeepneys. Table 1 shows a comparison of the derived median costs from Surveys 1 and 2, espousing the installation of SPM filters, and from Surveys 3 and 4, espousing the strict inspection and maintenance of jeepneys. Survey 3 and Survey 4 were analyzed jointly in order to come up with a single derivation for the median cost. The parameter estimates for both policies yielded significant results primarily due to the clustered number of samples. The number of sample size also affects the significance of the parameters. It is shown that the 'SPM Filter' policy gained a relatively higher median willingness-to-pay value. This can be partially attributed to the high secondary bid posed to the respondents for Surveys 1 and 2 (refer to Figure 1).

Table 1. Summary of Maximum Likelihood Estimation Results and Median Cost by Proposed Policy

	'SPM Filter'		'Strict Inspection and Maintenance'	
Parameter	α	β	α	β
Estimates	0.24	0.86	0.25	1.49
Standard Error	0.12	0.05	0.13	0.12
t-statistic	2.06	18.20	1.89	11.98
No. of Samples	373		200	
Log of Likelihood	-2799.77		-1320.69	
C* (PhP)	1.32		1.18	

After comparing the two proposed policies, Survey 1 and Survey 2 were clustered together and then divided into three categories by monthly household income group. The same was done to Survey 3 and Survey 4. The different categories were: households with monthly income below PhP10,000.00 (<10,000), households with monthly income between PhP10,001.00 and PhP20,000.00 (10,001-20,000), and households with monthly household income greater than PhP20,000.00 (>20,000). The complete results of the estimation results are presented in Table 2 and Table 3.

Table 2. Summary of Maximum Likelihood Estimation Results and Median Cost for the Different Income Groups of Surveys 1 and 2 (household monthly income)

	<10,000		10,001-20,000		>20,000	
Parameter	α	β	α	β	α	β
Estimates	0.12	0.79	0.48	1.04	0.74	1.33
Standard Error	0.18	0.07	0.21	0.09	0.35	0.16
t-statistic	0.67	11.17	2.24	11.64	2.13	8.56
No. of Samples	164		113		44	
Log of Likelihood	-1099.28		-707.00		-229.96	
C* (PhP)	1.16		1.58		1.75	

Table 3. Summary of Maximum Likelihood Estimation Results and Median Cost for the Different Income Groups of Surveys 3 and 4 (household monthly income)

	<10,000		10,001-20,000		>20,000	
Parameter	α	β	α	β	α	β
Estimates	-0.23	1.26	0.39	2.02	0.33	1.18
Standard Error	0.31	0.29	0.21	0.26	0.21	0.16
t-statistic	-0.73	4.41	1.85	7.70	1.58	7.16
No. of Samples	40		77		80	
Log of Likelihood	-196.14		-431.56		-456.85	
C* (PhP)	0.84		1.21		1.32	

Following economic theory and logic, the highest income groups for Tables 2 & 3 obtained the highest median cost followed by the 10,000-20,000 income group with a relatively lower median cost and then by the lowest income group with the lowest computed median cost.

However, it can be seen that the lowest income groups for both tables have an insignificant alpha parameter, hence an indication of the dependent variables non-occurrence in the sample data. This result cannot be attributed to the small number of respondents. As seen in Table 1, the lowest income group has the highest number of respondents at 164, and still the alpha parameter was found to be insignificant.

4 CONCLUSIONS AND RECOMMENDATIONS

The health effects of air pollution towards the exposed public cannot be overlooked. Several studies have already confirmed the direct causal relationship of high pollution levels to increased morbidity and mortality rates.

This paper discusses on the possibility of financial support from the public when specific policies to mitigate pollution from buses and jeepneys are put in place. The policies that were introduced to the respondents were the installation of SPM filters to the exhaust pipes of buses and jeepneys, and the other one is through strict inspection and maintenance of jeepneys.

Generally, of the 573 respondents that were surveyed, 68% answered yes to the initial question, whether they are willing to pay for improved air quality, regardless of the initial bid.

The results of the double-bounded discrete choice modeling (random utility model and maximum likelihood estimation method) showed significant results for the analysis on the proposed policies and by household income group considering that majority of the respondents came from households with monthly income of less than PhP10,000 followed closely by the PhP10,001-20,000 categories.

The results showed that households with monthly income greater than PhP10,000 were willing to pay for improved air quality for as much as PhP1.21 to PhP1.75. However, for respondents with monthly income lower than PhP10,000, it showed that there was an insignificant value on the parameter estimates. Such that, their willingness to pay for improved air quality cannot be entirely conclusive.

Considering that majority of the respondents belong to the lower income group, the results tells that the respondents may be well aware of the pollution problem and its possible effect to the people exposed so as to be willing to pay for an increase in fare.

The solicitation interviews also entailed questions regarding the perception of the respondents toward the current state of air quality. Also, the respondents were asked to answer questions regarding their health and their perceptions of the probable effect of air pollution towards their health. In a way, the flow of questioning had indirectly educated the respondent of the probable effects of air pollution exposure. This may have affected their answers in paying for improved air quality through an increase in fare.

Without the proper education of the public regarding the health hazards posed by air pollution, the proposed policies may not be as effective. The values generated are considered as the value an individual is willing to pay per trip in exchange for cleaner air, hence, better health. The concrete application of the results of this paper is that on top of the current fare in public transportation in Metro Manila, there would be an additional peso amount as high as PhP1.75 in order to help the drivers/operators of the vehicles to comply with the policies.

However, the insignificance of the parameters for the lowest income group indicates that further studies should be done in order to know the effectiveness of such policies. Also, other fee collection techniques should also be explored, such that, the imposition of an increase in fare may be hard to implement.

ACKNOWLEDGMENT

The authors would like to extend their gratitude to the Institute of Behavioral Sciences of Japan and the National Center for Transportation Studies of the University of the Philippines – Diliman, to Dr. Shoshi Mizokami, JICA Visiting Professor to NCTS

2000-2001 and Professor of Kumamoto University, Japan for teaching the contingent valuation method to NCTS graduate students and faculty. Also, sincere gratitude is given to Prof. Tetsuo Yai, Mr. Mitsuhata, and Mr. Hirata of the Tokyo Institute of Technology Planning Laboratory for the continuing study on the transportation environment in Metro Manila – JSPS Manila Project.

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