How should Bangkok Government Promote Old Motorcycle Retirement to Reduce Air Pollution:

A Fee System or a Trade-in Program?

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Abstract

This paper examines the relationship between the government's financial incentive and market responses among motorcycle owners using Bangkok's motorcycle retirement program. While the literature studies only a "Cash for Clunkers" scheme, this quasi-natural experiment allows us to compare owners' preferences for alternative schemes. The owners prefer a fee system to a trade-in program since they worry that the trade-in program may confiscate their means of living and/or transportation. Factors such as household income are shown to be the determinants of compensation amount for losing motorcycles. Owners of old motorcycles are members of low-income households. We conclude that old motorcycle retirement will be promoted by providing financial safeguard and substitutive transportation methods.

Keywords: Air Pollution; Contingent Valuation Methods (CVM); Vehicle Retirement; Willingness to Pay (WTP); Willingness to Accept (WTA)

JEL classification: C8; Q2

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1. Introduction

Growing concern about environmental degradation has been challenging the traditional concept of economic growth in many countries. Air pollution from rapidly increasing energy consumption and motor vehicle usage is an example of how concern for the environment leads to reevaluation of economic growth goals and achievements. Specifically, severe air pollution and associated health problems are serious policy issues faced by several cities in developing countries. Air pollution deteriorates the quality of life through respiratory illness and premature mortality risk. Poor health lowers labor productivity and impairs economic growth of afflicted countries.

Bangkok is one city suffering from air pollution caused by old motorcycles. In the past few years, research has been warning of air pollution's negative health effects. Research has also studied the costs of illness in Bangkok (e.g., Chestnut *et al*., 1997). Since Bangkok contributes nearly half of Thailand's GDP, reduction of air pollution is a pressing problem faced by the government of Bangkok. Air pollution control improves health conditions of Bangkok residents. Improving citizens' health can help to achieve the goals of economic growth.

This paper examines the incentive mechanism of an old motorcycle retirement program that aims to reduce air pollution in Bangkok. Vehicle emission control policies have been explored thoroughly in the literature (Gruenspecht, 1982; Kwoka, 1983; Blair et al., 1984; Bresnahan and Yao, 1985; Greene, 1991; Kling and Rubin, 1991; Kling, 1994). However, few academic works have explored a "Cash for Clunkers" approach (Alberini et al., 1995; Hahn, 1995; Alberini et al., 1996; Innes, 1996). As market-based approaches have spurred in environmental regulation, policy makers' interests have shifted from command and control approaches such as emission standards and inspection and maintenance programs to pollution

taxes or subsidies. A specific example is a voluntary old vehicle retirement program becoming a focus of air pollution policy (Innes, 1996; Fontana, 1999).[1]

Our analysis is distinct from previous works. We compare the incentive mechanisms of two different schemes: a fee system and a trade-in program. In order to improve health and foster growth, the government plans to introduce either a fee on the usage of old motorcycles or to establish a trade-in program for these motorcycles. Under the fee system, the government will prohibit the use of old motorcycles unless owners pay the fee. Under the trade-in program, the government will ban the use of old motorcycles and confiscate such motorcycles. Owners will be compensated for the loss of their motorcycles. While the literature studies only trade-in programs, this quasi-natural experiment allows us to study owners' participation decisions in both schemes.

This study is motivated by the following policy concerns. One question is whether owners prefer one scheme to the other. The determinants of owners' preferences are clarified by examining participation decisions. The costs for each scheme as well as disposal rates of old motorcycles are important questions for the purpose of cost-benefit analysis. We estimate the maximum level of owners' willingness to pay (WTP) in order to keep using their motorcycles and the minimum level of willingness to accept (WTA) as compensation for losing their motorcycles. We introduce preference uncertainty in the procedure (Carson et al., 1992; Li and Mattsson, 1995; Champ et al., 1997). Owners are assumed to be unsure of the objective value of a motorcycle. Finally, we ask what determines the levels of WTP and WTA. From the analysis, policy implications of the proposed schemes can be inferred.

[1] Programs in California, Chicago, and Delaware are examples in the U.S. Fontana (1999) has a comprehensive survey about accelerated vehicle retirement programs in Canada, Europe, and the U.S.

We use survey data collected by the Bangkok Metropolitan Authority and the World Bank in Bangkok in July 2000. Interviews were the source of all data. The owners of the heavily polluting old motorcycles answered survey questions. The questions addressed topics such as environmental attitudes and perceptions as well as willingness to pay and willingness to accept. The survey questions are similar to the ones in Alberini et al. (1995). However, our survey extends beyond theirs as it includes owners' environmental perceptions and does not have blue book values.

The analysis provides governments with potentially useful information for implementing market-based approaches in dealing with old vehicles and associated air pollution. Owners prefer to pay fees and are reluctant to cooperate with trade-in programs. Many owners are members of low-income households. They are unable to afford new motorcycles unless compensation from the trade-in program fully funds a new motorcycle. Such owners worry that the trade-in program will essentially confiscate their means of living and/or transportation. The results of our analysis are in agreement with the Hungarian experience, where a trade-in program was not successful. Fontana (1999) explains the reason for the Hungarian failure. New vehicles are too expensive for owners of old polluting vehicles to purchase. The owners of the old motorcycles are members of low-income households. However, our results imply that the fee system can cause equity issues (Walls, 1999). At least, the trade-in program requires the government to arrange complementary policy instruments, including low interest loans, as safeguards.

This is not a general conclusion when governments expropriate property in the interest of environmental protection. Vehicle owners in developing and developed countries may have different attitudes towards compensation. The analysis shows that the level of WTA is

determined by owners' financial conditions and benefits from motorcycle usage. The results differ from those in Alberini et al. (1995) that study a 1992 trade-in program in Delaware. Alberini et al. show that the level of WTA is determined by the value of the car, but not by household income and the availability of alternative transportation. There is a distinct difference between the present case and the case in the Alberini et al. study. In the Delaware study, used vehicles are traded frequently in the market. Owners have a relatively good idea what their vehicles are worth. This may not be the case for owners in Bangkok. Well-developed markets for used motorcycles do not exist. Thus, the level of WTA in Alberini et al. is determined by objective factors. In our study, subjective factors play an important role in determining the level of WTA.

Our estimates of WTP and WTA are related to the literature on the disparity between WTP and WTA. We observe that WTA is 2.54 times larger than WTP. This value is similar to the one reported in a survey of 45 previous WTA versus WTP studies by Horowitz and McConnell (2002). Previous work provides a few possible explanations for the disparity. The lack of substitutive vehicles could create a disparity between WTP and WTA (Hanemann, 1991; Shogren et al., 1994). Property rights may also explain the disparity (Kahneman and Tversky, 1979; Kahneman et al., 1990; Knetsch, 1989; Mitchell and Carson, 1989; Tversky and Kahneman, 1991). Another possible explanation is imprecision of motorcycle values (Brookshrine and Coursey, 1987; Coursey et al., 1987; Shogren et al., 1994). We conclude by asserting that the governments' providing substitutive transportation methods promotes old vehicle retirement.

This paper will proceed as follows. Section 2 summarizes the data and the experimental design. Empirical methods used for the analysis are described in Section 3. Section 4 discusses the results of the analysis. Section 5 concludes the paper.

2. The Data

We use survey data collected in Bangkok in July 2000 by the Bangkok Metropolitan Authority (BMA) with the cooperation of the World Bank. The two institutions organized a motorcycle clinic targeting owners of heavily polluting old motorcycles. The clinic aimed to examine the possibility of accelerated motorcycle retirement based on feedback from motorcycle owners. The institutions advertised the clinic via media and in fliers. Potential participants were informed that they would enjoy free maintenance of their old motorcycles at the site. The fliers also informed potential participants that they may be issued a rebate coupon towards the purchase of a new motorcycle that would meet current/anticipated future emission standards, if the new project were legislated.

About 1500 owners participated in the clinic. They registered for the clinic and enjoyed free maintenance by manufacturers' mechanics. After the maintenance, they went through emissions tests. Among the participants, 331 motorcycles failed the tests. The BMA and the World Bank define these motorcycles as heavily polluting old motorcycles. The owners of the heavily polluting old motorcycles were asked to answer survey questions.

All data were collected by interviews. The city police officers for the BMA, who were trained for this survey, collected the information about socio-economic profiles of motorcycle owners and the use of their motorcycles at the registration. Experienced interviewers from a graduate school in Thailand collected the information on environmental attitudes and perceptions

as well as willingness to pay and willingness to accept. Both interviews were about 10 to 15 minutes in length.

The interviewers from the graduate school began the survey by explaining why air pollution in Bangkok is problematic and possible future regulations. Air pollution in Bangkok has caused thousands of premature deaths and several million cases of respiratory sickness. The problem, attributed to old motorcycle emissions, has been acute for a decade. Thus, reduction of air pollution is an urgent policy issue. The government was planning to implement new legislation geared toward upgrading motorcycle vehicles and reducing air pollution. There are two possible regulations that the government believed would achieve their goal. One is the fee system. Motorcycle owners need to pay money if they still want to use their old motorcycles. If owners do not pay the fee, they are not allowed to use their old motorcycles. Collected taxes will be used in helping air quality improvements. The other is the trade-in program. Under the trade-in program, the government will ban the use of polluting motorcycles and will confiscate such motorcycles. The government will provide compensation to motorcycle owners for their loss of property. Although these programs increase the tax burden on some motorcycle drivers, owners (and their families) will benefit from the new regulation. All citizens will benefit from the improvements in health resulting from lower levels of air pollution.

After explaining the program options, the interviewers asked whether owners are willing to pay in order to keep using their motorcycles and whether owners are willing to accept compensation for losing their motorcycles. We received 293 replies for the WTP question and 288 replies for the WTA question. The proposed regulations are not necessary welcomed. Sixty-two owners are not willing to pay a fee and 97 owners are not willing to accept compensation for trade-in. We eliminate the protest responses and missing data among the 331

respondents.[2] After identifying the workable data, 231 owners are used for the WTP analysis, and 191 owners are used for the WTA analysis. The two analyses share the same data on 155 owners.

Table 1 shows the summary statistics of the data used for each analysis. The two samples are similar for the most part. However, gross household income in the WTA sample has a larger mean value than in the WTP sample. As was mentioned before, this survey is similar to the Alberini et al. (1995) survey with the exception being that the current survey includes owners' environmental perceptions. The aim is to examine whether the victims of air pollution have different attitudes toward the regulations when compared to non-victims. Additionally, the survey asks questions relating to occupation, education, and public transportation usage that are not asked in Alberini et al. Social status may matter if people in specific social class are willing to cooperate with government objectives. Public transportation usage addresses the possibility of substituting motorcycle usage and public transportation. Although our survey includes some elements that were absent from the Alberini et al. survey, our survey does not have blue book values (i.e., the market price of used motorcycles). In the Delaware study by Alberini et al., used vehicles are traded frequently in the market. Owners and the state government have a relatively good idea of the value of used vehicles. In our case, there is not a well-developed market for used motorcycles.

3. Model

3.1 Participation

[2] About 40 owners' data are missing among the 331 respondents. The BMA reports that several owners left before the interviews took place.

The survey shows that among those who are willing to pay and/or to accept, several owners support either one proposal or the other, but not both. We examine which factors affect owners' decisions on participating in the programs. This clarifies the determinants of owners' preferences for regulations. The analysis uses a probit model: $Par_i^j = Z_i\beta^j + e_i^j$, where Par_i^j is an observed reply, with $Par_i^j = 1$ if an owner i agrees to join a program $j = \{WTP, WTA\}$ and 0 otherwise; Z is the set of variables in Table 1 and e is an error term.

Whereas several papers study the relationship between WTP and WTA, little work has been done investigating about the participation decisions in WTP and WTA programs. The literature often uses laboratory experiments, where respondents are randomly assigned to be a part of either program. Previous work is concerned with the disparity between WTP and WTA. The quasi-natural experiment of this project allows us to study how to promote participation in incentive-based regulations. The analysis also provides us potentially useful information regarding the necessity of complementary policies, such as financial safeguards, when governments expropriate private property.

3.2 Estimation of WTP and WTA

The government needs to estimate a budget in order to evaluate the proposals. This requires estimating the levels of WTP and WTA. We introduce preference uncertainty when making these estimations (Carson et al., 1992; Li and Mattsson, 1995; Champ et al., 1997; Wang and Whittington, 2000). Owners are assumed not to be confident with the objective value of a motorcycle. One possible interpretation is that owners have incomplete knowledge regarding the market value of their motorcycle since markets are not well-developed. Li and Mattsson (1995) show that ignoring this type of uncertainty may lead to biased estimates. Introducing preference

uncertainty provides more information about respondents and helps to specify their true evaluations, subsequently correcting for the bias.

The interviewers used a payment card to collect the data of WTP and WTA (Table 2). The card had six different levels of payments, 300, 600, 1,000, 1,500, 2,000 and 3,000 bahts for WTP and six levels of compensation, 2,000, 4,000, 6,000, 8,000 and 12,000 bahts for WTA. These levels were chosen based on the results of a pretest interview. The interviewers asked an owner whether s/he would be willing to pay 300 Thai bahts per year to continue to use their motorcycle. S/he selected the likelihood that s/he would agree to pay among five categories in the table. If s/he agreed, then the interviewers asked the same question with an increased price offer. The interviewers continued this procedure until the owner denied the payment. Similarly, for WTA, the interviewers offered a price and asked whether the owner would be willing to accept the stated price as compensation for giving up their motorcycles. S/he selected the likelihood from five categories in the table. If s/he agreed, then the interviewers iterated the procedure until the offer was denied.

The numeric likelihood values allow for the owner's subjective valuation of a motorcycle to be a random variable associated with a valuation distribution. The owner's WTP or WTA is defined as the mean value of the distribution. More formally, denote X as the set of the payments $\{300,600,1000,1500,2000,3000\}$ and X_j as the j-th price, where $j = \{1,2,3,4,5,6\}$. An owner, i, would agree to pay the price as long as it is lower than his/her true valuation of a motorcycle, WTP_i (e.g., Cameron, 1988). However, the owner's value assessment is expressed as $\overline{WTP_i} = WTP_i + \varepsilon_i$ due to preference uncertainty, ε_i. Denote P_{ij} as the subjective probability that the owner i agrees to pay the price j, and P_i as his/her likelihood vector (i.e., the set of the

six subjective probabilities).[3] We can write that $P_{ij}(Yes) = \Pr(\overline{WTP_i} > X_j) = 1 - F_i(X_j)$, where F is a cumulative distribution function. Suppose the error term is normally distributed, i.e., $\varepsilon_i \sim N(0, \sigma_i^2)$. The probability is rewritten as

$$P_{ij} = 1 - \Phi\left(\frac{X_j - WTP_i}{\sigma_i}\right) \qquad \text{or} \qquad X_j = WTP_i + \sigma_i \Phi^{-1}(1 - P_{ij}),$$

where Φ is the cumulative distribution function of a standard normal variable. The owner i's WTP_i is the mean value of the distribution. The standard error, σ_i, represents the consistency of responses. A smaller standard error implies that the owner is more confident in his/her valuation. We estimate the two variables, WTP_i and σ_i, by regressing X on $\Phi^{-1}(1 - P_i)$.

We estimate the level of WTA using a similar method. Denote Y as the set proposed compensation levels $\{2000,4000,6000,8000,10000,12000\}$ and Y_j as the j-th compensation, where $j = \{1,2,3,4,5,6\}$. An owner, i, would not agree to accept a price lower than his/her true valuation of a motorcycle, WTA_i. Let the owner's value assessment be $\overline{WTA_i} = WTA_i + \upsilon_i$, where υ_i is his/her preference uncertainty. The subjective probability that the owner, i, does agree to accept payment of price, j, is written as $P_{ij}(No) = \Pr(\overline{WTA_i} > Y_j) = 1 - F_i(Y_j)$. Assuming the error term is normality distributed, $\upsilon_i \sim N(0, \sigma_{\upsilon i}^2)$, the probability is rewritten as

$$P_{ij} = 1 - \Phi\left(\frac{Y_j - WTA_i}{\sigma_{\upsilon i}}\right) \qquad \text{or} \qquad Y_j = WTA_i + \sigma_{\upsilon i} \Phi^{-1}(1 - P_{ij}).$$

We estimate WTA_i and $\sigma_{\upsilon i}$ by regressing Y on $\Phi^{-1}(1 - P_i)$.

[3] Refer to Appendix for technical issues about likelihood vectors.

3.3 Determinants of WTP and WTA

We are interested in the determinants of the levels of WTP and WTA. The examination of the determinants identifies policy implications of the proposed regulations. We use two empirical models, $\log WTP_i = Z_i\alpha + \eta_i$ and $\log WTA_i = Z_i\gamma + \mu_i$, where the vector Z includes the factors in Table 1 and η and μ are error terms. The standard regression analysis reveals that only few factors are statistically significant in explaining the level of WTA. We did not expect these results, and suspect the survey suffered from inaccurate responses and/or measurement error. Some owners may hesitate to declare the exact amount of their income in interviews. Owners may give inconsistent answers when answering questions regarding subjective evaluation of motorcycle condition. We could omit independent variables of weak explanatory power from the regression. However, we would then risk losing potentially useful information.

We test the robustness of the analysis by using a statistical method in clinical trials. We introduce a composite of independent variables proposed by Tukey (1991, 1993). He suggests compounding related independent variables as a method for extracting as much information as possible from a limited number of observations. Compound variables are constructed as a weighted sum of independent variables. Greater weight is put on variables with stronger explanatory power. This method utilizes variables not included in regular regression, and adds some valuable information.

We employ the compound variables method in conducting our present analysis. First, we classify independent variables of similar nature into three groups. Group 1 is socio-economic profile, group 2 environmental perceptions, and group 3 the condition and use of motorcycles. The three categories are defined as in the original survey prepared by the World Bank. We then standardize each variable. This makes each independent variable comparable in unit and allows

compounding variables from within the same group. We determine the contribution of each variable after regressing log WTP (or log WTA) on each standardized variable. As in Tukey, we assign weights according to the p-values: ± 4 if $p < .001$, ± 3 if $.001 \le p < .01$, ± 2 if $.01 \le p < .05$, ± 1 if $.05 \le p < .25$, and 0, otherwise. The sign of weight follows one of the coefficients. A compound variable of an owner i for group j, C_j^i, is defined as a linear combination of standardized variables, z, with their weights, w: $C_j^i = \sum_{s \in G_j} w_s z_s$, $\forall j = 1,2,3$.

Compound variables do not contain redundant information. They make several independent variables complement each other.[4] This enriches the economic interpretation of the results. Instead, one may want to use a lower standard when selecting independent variables in standard regression analysis. Lower standards lead to the inclusion of more variables. The compound variable method is preferable in terms of the degree of freedom.[5] One drawback of compound variables is that their coefficients do not lend themselves easily to interpretation. We may want to use Tukey's weight to examine the effect of any individual variables.

[4] Let us illustrate the idea with an example. Economic theory suggests that socio-economic status would determine the levels of WTP and WTA. Suppose, however, a regression analysis indicates that variables such as income, occupation, and education do not have explanatory power for WTP and WTA. We can composite the three variables. The compound variable will operate as a good proxy of socio-economic background, specifically financial condition. A compound variable can be a better predictor, when each independent variable does not have a strong explanatory power.

[5] This method has other technical advantages. Suppose we are regressing y on x_1, x_2, x_3, where x_i is a categorical variable, either 0 or 1. We have eight possible clusters $(e.g., x_1 = 0, x_2 = 1, x_3 = 1)$. As is often the case in surveys, the number of the observations of each cluster could be very small. Coefficient estimates do not make much sense statistically in this case. The use of compound variables will resolve the problem.

4. Results of the Analysis

4.1 Participation

Table 3 shows the results of owners' participation decisions under each regulation. At first glance, one may wonder why gross household income has a negative coefficient in the WTP analysis. However, it is reasonable to believe that owners in the lower income class are willing to pay a fee. The WTA analysis yields a positive sign of gross household income coefficient. This sign difference has an important implication. Owners' preferences for each regulation depend on government expropriation and compensation schemes. The trade-in program expropriates old motorcycles, but does not compensate owners enough to allow for the purchase of a new motorcycle. Since it is not easy for low-income owners to afford a new motorcycle, they are likely to lose their means of transportation and/or way of living.[6] Thus, owners with a lower income prefer to pay a fee to keep using their motorcycle rather than give the motorcycle up when compensation will not be enough to afford them a new motorcycle.

We obtain expected results on other coefficients. If owners plan to replace their worn-out motorcycles in the near future (due to high mileage or old age), they are willing to join the trade-in program, but prefer not to pay a fee. Other owners may want to keep their motorcycles due to emotional attachment. This is a case where owners spend more for motorcycle purchase and/or maintenance costs. Government officials cooperate with trade-in programs but do not want to pay from their own pockets. In sum, owners with motorcycles in better condition are for the fee system and against the trade-in program.

[6] Taxi drivers receive less gross household income and spend more for their motorcycles. The availability of alternative transportation method decides owners' preferences for each regulation.

4.2 Disposal Rates

The interviews use a contingent valuation method (CVM) to collect the data. Thus, the analysis may be subject to the same criticism made of CVM: strategic bias (e.g., Knetz et al., 1985). The owners may overstate their true WTA value and understate their true WTP value. To alleviate the problem, we eliminate protest bids in the samples. Mitchell and Carson (1989) suggest eliminating protest bids helps minimize strategic bias. After protest bid elimination, the data gathered from 205 owners are valid to use for the WTP analysis, and the data gathered from 132 owners are valid to use for the WTA analysis.

The level of WTA is substantially higher than the level of WTP. The result agrees with a well-known fact in the literature. Our mean (median) value of estimated WTA is 6,651 (6,664) bahts with a standard deviation of 2,781 bahts. Our mean (median) value of estimated WTP is 584 (507) bahts with a standard deviation of 321 bahts. The WTP is an annual payment. The average owner expects their motorcycles to last 4.47 more years. Adjusting the unit (i.e., 584 multiply by 4.47) reveals that the WTA is 2.54 times larger than the WTP. Horowitz and McConnell (2002) examine 45 previous studies of WTA and WTP and find a similar difference. Horowitz and McConnell find that for private goods WTA is 2.92 times larger than WTP.

Not only are there difference in the levels of WTA and WTP. Estimated costs of the two regulations differ considerably. Figure 1 depicts the relationship between the level of WTP (or WTA) and the disposal rate of heavily polluting old motorcycles. Suppose the government plans to eliminate 90 percent of the polluting motorcycles in the market. The figure predicts that this goal can be achieved by either charging an annual fee of 1,000 bahts or by compensating each owner 10,701 bahts for their trade-in. The BMA and the World Bank report there to be about

700,000 polluting old motorcycles are in Bangkok. The fee system is estimated to raise 70 million bahts each year as tax revenue. To fund a trade-in program, the government would need to prepare 6.74 billion bahts.

4.3 Determinants of WTP and WTA

Table 4 shows the determinants of WTP and WTA. Coefficients (and the standard errors) are the results of the standard regression analysis. These are listed on the top half of the table. The results of compound variables are summarized in the bottom half of the table. We use the values in the column of "Weight" (i.e., Tukey's weights or marginal effects for each variable) to obtain the compound variables.

The analysis reveals that the determinants of WTP are owners' future financial conditions, availability of alternative transportation, and motorcycle conditions. Expected future financial condition matters more than current income level since fee payment occurs in the future. Government officials expect stable income and, thus, are willing to pay more. Families with more children are reluctant to pay. Also, the existence of substitutes is important. Motorcycles are necessities when public transportation is inaccessible. When substitutes are not available, owners are willing to pay more. Owners who plan to replace their motorcycles prefer not to pay a fee.

The level of WTA is determined by owners' current financial conditions and evaluation about transportation services from their motorcycles. Owners with lower income ask for more compensation. Current financial conditions matter since most owners need to purchase a new motorcycle once their old one is expropriated. Those who use motorcycles frequently also request a higher level of compensation. Their benefit from motorcycle usage is greater.

Financial condition could be an interpretation of the positive coefficient of mileages. The mean mileage value for taxi drivers is higher than the mean mileage for users with other occupations. Motorcycle taxi drivers are paid less than those in other occupations.

The results from the compound variables analysis are similar. However, they are different from those of standard analysis in environmental perceptions. Examining Tukey's weights tells us that those who have suffered from air pollution ask for more compensation. This could be interpreted that the variables of environmental perceptions operate as a proxy for the current income level. In fact, it turns out that victims of air pollution are members of lower income households. This observation leads one to question: who are the victims? The World Bank (2000) reports that those who use motorcycles longer have higher risk of suffering from severe respiratory symptoms. They "are literally using their lungs to clean the air." The salary of heavy motorcycle users (e.g., taxi drivers) is below average.[7]

The results differ from the ones in Alberini et al. (1995) that study "a vehicle-retirement program in Delaware in 1992." They show that the level of WTA is determined by the value of the car, but not by household income and the availability of alternative transportation. There is a distinct difference between the present case and the case in the Alberini et al. study. Owners in the Delaware study have a relatively good idea of the market value of used cars. Used cars are traded frequently in the market and, thus, published prices are available. This may not be the case for owners in this study due to the lack of well-developed used motorcycle market. Thus, the level of WTA in Alberini et al. is determined by objective factors, while subjective factors play an important role in determining the level of WTA in our study.

[7] We classify fuel expenses into two groups, below and above average, and compare the income levels for each group. The Wilcoxon rank-sum test shows a significant difference of incomes between the two groups.

4.4. Discussion

Complementary policy instruments are necessary in order to promote the retirement of old polluting motorcycles. The mean WTP is equivalent to seven percent of the mean gross income of the sample and the mean WTA is 80 percent of the mean gross income of the sample. The ratio of the WTA to the mean income is much higher than the one in the Alberini et al. study, where it is about three percent. Owners in Bangkok may have overstated the WTA. They may not have information about the precise value of motorcycles.[8] However, another plausible interpretation is that their income is relatively low compared to motorcycle prices. Many owners will lose their way of life if the government expropriates old motorcycles without providing enough compensation to fund the purchase of a new motorcycle. They are unable to afford a new motorcycle that is compatible with emission standards. The interpretation is consistent with the literature on the disparity between WTP and WTA. The lack of substitutes creates a larger difference between WTP and WTA (Hanemann, 1991; Shogren et al., 1994). Our results imply that the government needs to complement a trade-in program with other policy instruments. Possible examples include providing loans with low interest rates for new motorcycle purchases and better public transportation services.

5. Conclusions

Air pollution caused by old motorcycles and the associated health problems are serious policy issues in Bangkok. Bangkok citizens are suffering from respiratory symptoms and increased

premature mortality risk. To reduce air pollution, the government was planning to enact an old motorcycle retirement program. There are two alternative schemes available which are expected to achieve the goals of the policy. One is to introduce a fee system on the usage of heavily polluting motorcycles. The other is to establish a trade-in program for these motorcycles.

We examine the relationship between the government's financial incentive and market responses among motorcycle owners by using the motorcycle retirement program. The literature has studied only the effects of trade-in programs. This paper is distinct, since the quasi-natural experiment of Bangkok's program allows us to compare owners' preferences for two alternative schemes: a fee system or a trade-in program. The analysis reveals that owners prefer a fee system to a trade-in program, although a "Cash for Clunkers" scheme is dominant in reality. At first glance, a trade-in program is preferable to a fee system in terms of equity. However, many owners worry that the trade-in program may confiscate their means of living and/or transportation. The owners of old motorcycles are members of low-income households. New motorcycles are too expensive for these owners to purchase. Such owners prefer to pay a fee rather than lose their motorcycles in exchange for a low level of compensation.

Similar implications will be of relevance when governments expropriate private property in the interest of environmental protection, specifically in developing countries. We should be careful not to interpret a fee system as desirable. A fee system can cause equity issues if property owners are low-income households. A reasonable interpretation is that a trade-in program will deteriorates the owners' life without full compensation (or arranging alternative transportation methods in this paper). The results imply that the enactment of market-based

[8] The literature shows that imprecision (or uncertainty) causes the disparity between WTP and WTA; the disparity decreases as people learn more about the goods in repeated experiments (Brookshrine and Coursey, 1987; Coursey

regulations requires further improvement of the social infrastructure, including financial institutions and public transportation systems, in developing countries.

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et al., 1987; Shogren et al., 1994).

Appendix

A technical note: how to construct likelihood vectors

In practice, we face the problem that both $P_{ij} = 1$ and 0 do not provide useful information for estimating WTP. This is because $P_{ij} = 1$ implies $X_j = -\infty$ from $F_i(X_j) = 0$ and $P_{ij} = 0$ implies $X_j = +\infty$ from $F_i(X_j) = 1$. The analysis employs a methodology similar to the one used in the literature (Li and Mattsson, 1995; Wang and Whittington, 2000). We use the value of 0.99 instead of the last 1 and use the value of 0.005 instead of the first 0. For example, if the likelihood vector P_i is $\{1,1,0.5,0,0,0\}$, then we transform the vector to $\{1,0.99,0.5,0.005,0,0\}$. This treatment enables us to utilize more samples; otherwise we need to eliminate some samples from the analysis since we are not able to estimate WTP (e.g., the above example). The transformation makes regression possible.

Despite the merit, we do not transform all 1 to 0.99 (or all 0 to 0.005). This makes estimators very sensitive to tail prices. Suppose we transform the previous likelihood vector to $P_i = \{0.99,0.99,0.5,0.005,0.005,0.005\}$. The WTP will be overestimated. This is because the influence of larger prices (i.e., three 0.005s) is stronger than that of smaller prices (i.e., two 0.99s). The problem is more serious if payment schedules are poorly designed such as $X = \{300,600,1000,1500,2000,3000,4000,5000,6000\}$ and a likelihood vector has longer tails such as $P_i = \{1,1,0.5,0,0,0,0,0,0\}$. Transforming only the last 1 and the first 0 avoids such a problem.

One may wonder whether the results will change if we transform likelihood vectors with different values (e.g., 0.95 instead of 0.99). The authors' estimation reveals that the results are

not sensitive to the difference. Rather, we realized that it is important to adjust the different interval lengths of prices (e.g., 300=600-300 and 1,000=3,000-2000) by using asymmetric probabilities (0.99 and 0.005 instead of 0.99 and 0.01). Otherwise, we will get biased estimates. The reason is the same as in the previous paragraph. Symmetric probabilities put more weights on the tail of larger prices and, thus, overestimate the level of WTP. The price vector used for WTA has the same interval length. We used symmetric probabilities (the value of 0.99 instead of the last 1 and use the value of 0.01 instead of the first 0) in transforming likelihood vectors.

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Table 1 Summary Statistics

	WTP		WTA	
	mean	**std.dev.**	**mean**	**std.dev.**
Socio-Economic Profile				
Age	33.57	9.29	34.03	8.78
Number of Children	1.84	0.98	1.77	0.96
Number of Household Members	4.52	2.03	4.56	2.02
Number of Workers in Household	2.46	1.37	2.5	1.36
Gross.Income	8363	4636	8505	4224
Gross.Household.Income	17960	13458	20190	16207
Condition & Use of Motorcycles				
Yrs.Own	5.23	2.91	5.28	2.99
Yrs.Own.Previously	4.03	3.06	4.01	4.08
Mileage (km/day)	68.43	45.41	71.63	49.17
Purchase.Payment	48830	25089	48140	25366
Max.IM.WTP	2471	2324	2410	2284
Maintenance.Costs (per month)	624.1	630.21	549.7	487.94
Fuel.Expenses (per week)	348.8	305.15	332.2	181.69
MCLife.Expectancy	4.5	2.84	4.38	2.84
	ratio	**ratio**	**ratio**	**ratio**
Socio-Economic Profile				
Male : Female	0.99	0.01	0.99	0.01
Married : Single	0.68	0.32	0.67	0.33
HighSchool or less : Bachelor or higher	0.78	0.22	0.73	0.27
Employment-Full time : Part time	0.84	0.16	0.84	0.16
Government employee	0.07	0.93	0.09	0.91
Taxi driver & Messenger	0.43	0.57	0.37	0.63
Household head : Not HH.head	0.67	0.33	0.66	0.34
Savings : No.savings	0.37	0.63	0.39	0.61
Environmental Perceptions				
HH.RespProbs	0.16		0.19	
HH.HealthProbs	0.21		0.21	
Pay.for.Treatment	0.30		0.36	
Income.Lost	0.41		0.44	
McPollution	0.94		0.95	
Condition & Use of Motorcycles				
Business.Use	0.95		0.94	
Condition-Good : Bad	0.64	0.36	0.65	0.35
Repaired	0.25		0.30	
Emission.Checked	0.22		0.22	
Own.Other.Vehicles	0.42		0.46	
Pub.Transit.Use- Often : not Often	0.09	0.91	0.09	0.91
Sample size	231		191	

Note: The median values of each variable are also similar to the mean values in the table.

Table 2 Payment Cards

WTP

Baht/year	Definitely willing to pay (100%)	Probably willing to pay (75%)	Not Sure (50%)	Probably not willing to pay (25%)	Definitely not willing to pay (0%)
300	1	2	3	4	5
600	1	2	3	4	5
1000	1	2	3	4	5
1500	1	2	3	4	5
2000	1	2	3	4	5
3000	1	2	3	4	5

WTA

Baht	Definitely not willing to accept (100%)	Probably not willing to accept (75%)	Not Sure (50%)	Probably willing to accept (25%)	Definitely willing to accept (0%)
2000	1	2	3	4	5
4000	1	2	3	4	5
6000	1	2	3	4	5
8000	1	2	3	4	5
10000	1	2	3	4	5
12000	1	2	3	4	5

Table 3 Participation

	WTP		WTA	
Socio-Economic Profile	Coeff.	Std.Err.	Coeff.	Std.Err.
Occup.Gov't			0.542***	0.312
Gross.HH.Income	-0.011**	0.006	0.009''	0.006
Environmental Perceptions				
HH.RespProbs			-0.405***	0.213
Condition & Use of MCs				
Yrs.Own	-0.050**	0.027		
Mileage (km/day)			0.004**	0.002
Purchase.Price	0.006***	0.004		
Maint.Costs (per month)			-0.266**	0.133
Intercept	1.029*	0.255	0.436***	0.264
Sample size	293		288	

* Statistically significant at 1%; ** at 5%; *** at 10%:" at 12%
Currency Unit: 1,000 bahts

Variable description

Marital.Status…0 for Single, including Divorced/Separated, and 1 for Married
Education…0 for up to High School and 1 for Bachelor or higher, including Technical diploma
Employment.Status…0 for Full time and 1 for Part time
HouseHold.Head…0 for Yes and 1 for No
Savings…0 for any savings and 1 for no savings
HH.RespProbs…0 for family members had respiratory symptoms and 1 for otherwise
HH.HealthProbs…0 for family members had health problems by air pollution and 1 for otherwise
Pay.for.Treatment…0 for Yes and 1 for No
Income.Lost…0 for lost income due to sickness and 1 for otherwise
McPollution…0 for agree with the opinion that pollution from motorcycles causes health problems and 1 for disagree with the opinion
Total.Yrs.Own…Yrs.Own+ (years owned by previous owners, if second-hand)
Purchase.Payment…owners' gross payment to obtain their motorcycles
Business.Use;Repaired; Emission.Checked;Own.Other.Vehicles…0 for Yes and 1 for No
Condition…0 for Excellent/Good and 1 for Bad/Very Bad (Owners' subjective judgments)
Max.IM.WTP…maximum WTP/ year for regularly inspection and maintenance of motorcycles, if required by regulations
MClife.Expectancy…how many more years owners intend to keep their motorcycles.
Pub.Transit.Use…0 for Very often/Often and 1 for Sometimes/Not at all

Table 4 Determinants of WTP and WTA

	WTP			WTA		
Socio-Economic Profile	Weight	Coeff.	Std.Err.	Weight	Coeff.	Std.Err.
Age	0			0		
Marital.Status	1			1		
Number of Children	-1	-0.05***	0.03	0		
Education	0			0		
Occup.Gov't	2	0.28**	0.12	0		
Occup.TaxiDriver	1			1		
Employment.Status	0			0		
HouseHold.Head	-1			-1		
Number of HH.Members	-1			0		
Number of HH.Working	-1			-2		
Income	0			0		
HH.Income	0			-1		
PerCap.HH.Income	0			-1	-0.11"	0.07
Savings	-1			-1		
Environmental Perceptions						
HH.RespProbs	0			-3		
HH.HealthProbs	0			-1		
Pay.for.Treatment	0			-2		
Income.Lost	-1			-2		
McPollution	1			0		
Condition & Use of MCs						
Yrs.Own	0			0		
Total.Yrs.Own	0			-1		
Mileage (km/day)	0			2	.002**	.001
Business.Use	0			0		
Purchase.Price	2			1		
Condition	0			0		
Repaired	0			1		
Max.IM.WTP	0			0		
Emission.Checked	0			0		
Maint.Costs (per month)	0			0		
Fuel.Expenses (per week)	-1			0		
MClife.Expectancy	-1	-0.02***	0.01	0		
Own.Other.Vehicles	0			1		
Pub.Transit.Use	2	0.25**	0.10	-1		
Intercept		6.16*	0.12		9.49*	0.57
R-Squared		0.07			0.05	
Compound Variables						
Intercept		6.26*	0.03		8.70*	0.04
Socio-Economic Profile		0.03*	0.01		0.01"	0.01
Environmental Perceptions		0.02	0.02		0.02**	0.01
Condition & Use of MCs		0.03*	0.01		0.03**	0.01
R-Squared		0.11			0.13	

*Statistically significant at 1% level; ** at 5% level; *** at 10% level;
" p-value is 0.11.

Figure 1. The disposal rate of polluting motorcycles