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Phasing out Polluting Motorcycles in Bangkok: Policy Design by Using Contingent Valuation Surveys

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Abstract

This paper reports a contingent valuation study for the design of economic incentives to phase out polluting motorcycles in Bangkok. Like in many other cities, the government of Bangkok has been considering a series of control measures to discourage and eventually eliminate the usage of heavily polluting motorcycles. Two of the possible policy instruments under consideration are charges on those polluting vehicles which are operating in the streets and compensation to those polluting vehicles which would stay off the roads. The policy research questions then include what are the charges implied or compensation provided , given a policy target, and what are the reactions of motorcycle owners to those charges or compensation. In order to answer those policy questions, a stochastic contingent valuation survey was conducted in Bangkok to question motorcycle owners on the likelihood they would keep or give up riding their motorcycles in the streets given certain charges or compensations. Results show that among others, about 80% of those motorcycles which did not pass the emission tests would be off the streets if a charge of 1000 baht per year was levied, while under a one-time compensation of 10,000 baht, the number would be about 50%. The average values of maximum willingness to pay (WTP) for staying on the road and minimum willingness to accept (WTA) compensation for staying off the street are also estimated, and the determinants of WTP and WTA are analyzed. The econometric analysis shows that, among other factors, household income, fuel costs, use of motorcycles and/or public transit affect the value of WTP and WTA.

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I. Introduction

Motorcycle pollution emissions have caused serious environmental health problems in many urban areas in the developing world. One regulatory approach to solve the problems is to ban all vehicles which violate emission standards. This, however, can be unnecessarily costly to a developing society, because the variance of benefits in using the motorcycles by different users is not taken into consideration. Another regulatory approach is the use of economic incentives – charges or compensation can be designed and implemented to phase out, cost-effectively, the use of polluting vehicles. The major policy issues that a municipal government is facing in this area are two-fold: 1) how much the charges or compensation should be levied or provided, and 2) how the motorcycle users would react to the charges or compensations.

This paper presents a case study which uses the contingent valuation approach to help design charge and compensation polices for phasing out polluting vehicles. Bangkok, like many other big cities, has a serious air pollution problem and the use of motorcycles contributes a significant portion. To improve the air quality, the Government of Bangkok has been considering to adopt a series of counter-measures to discourage and eventually eliminate the usage of heavily polluting motorcycles. Two economic instruments under consideration are to charge or ticket owners of those polluting vehicles operating in the streets and to compensate owners of those polluting vehicles that stay off the roads. Similar to studies conducted in many other big cities, the policy research questions focus on how much the charges and/or compensations should be given a certain vehicle control target.

In order to help the Government of Bangkok improve its understanding of motorcycle owners' possible reaction towards the possible economic incentives offered and, consequently, to assist the policy makers better design economic instruments, a stochastic contingent valuation survey at a motorcycle testing clinic was conducted in Bangkok in

July 2000. Motorcycle owners were questioned on the likelihood they would keep using their vehicles under a set of possible charges per year or give up using their vehicles given a set of one-time compensation. Answers were analyzed to draw probability curves of vehicle use under different charges or compensation and to estimate the mean value of charges and compensation for implementing the policies. The determinants of mean willingness to pay (WTP) for operating the vehicles and mean willingness to accept (WTA) to stay off the road were also modeled and analyzed.

This paper consists of five sections. This first section introduced the topic. The following second section provides an overview of air quality, motor vehicle use and the control of emissions from motorcycles in Bangkok. Section 3 illustrates the contingent valuation survey. Responses to the charges and compensations are presented in section 4, and WTP and WTA estimations are provided in section 5. Finally, section 6 concludes with policy discussions and closing remarks.

II. Policy Context

Bangkok is well known for its traffic congestion and poor air quality. The air has been seriously polluted. The city's maximum roadside carbon-monoxide (CO) levels are one and a half times the Thai "8-Hour standard." The maximum roadside particulate smaller than ten microns (PM10) levels are two times the Thai "24-hour standard" and its average levels are one and a half times the Thai "annual average standards." And, the maximum ambient ozone levels are two times the Thai "1-Hour standard." Due to the increases in nitrogen oxides (NOx) and HC emissions from motor vehicles, the level of ozone is still rising. Public health in Bangkok is fairly sensitive to the effects of air pollution. It is estimated that, if the annual average concentration of PM10 could be reduced by 10μg/m3, the residents of Bangkok would receive a benefit worth 35 - 88 billion Baht (or $US1.4-3.5 billion, in 1995 prices) per year (Hagler Bailly, 1998). Specifically, there would be 700 to 2,000 premature deaths and 3,000 to 9,300 new cases of chronic respiratory disease avoided if the improvement in air quality took place.

Motor vehicles have been heavily used in Bangkok. In 1999, the total number of motor vehicles in the city was between 2.2 million in-use and 4 million registered. Like many southeast and south Asian cities, one third of the motor vehicle fleet in Bangkok is motorcycles. Nationwide, the percentage of motorcycles in the entire motor vehicle fleet was 60% in 1999. Most of the motorcycles is powered by two-stroke engines, although the sale of four-stroke engine motorcycles has been steadily rising in recent years. Many people in Bangkok rely on their motorcycles for transportation and some of them use their motorcycles for business purposes (such as taxi services). Low cost, convenience, and flexibility in driving motorcycles are major reasons why many Bangkok people rely heavily on riding motorcycles. The motorcycle fleet is aging however, partially due to the economic slowdown caused by the Asian financial crisis in 1997.

The use of motorcycles is a significant source of air pollution in Bangkok. It was estimated that motorcycles contributed up to 70% of total HC, 30% of total CO, and 18% of PM10 in the air. It is widely perceived that the old, two-stroke engine powered motorcycles contribute significantly to the emissions, especially HC and PM10, due to factors such as adulteration and excessive use of lubricating oil, poor maintenance, and low acceptance of new technologies available. In addition, the use of motorcycles has caused other external socio-economic costs to society as a whole and has increased purchasing and maintenance costs to motorcycle drivers more specifically. The serious loss of time and productivity caused by traffic jams are among those negative externalities.

The Government of Bangkok has been taking actions to reduce the emissions from both new and in-use motorcycles. The government has recognized the need to reduce white smoke emissions from two-stroke engine motorcycles as far back as 1992. The use of lubricating oil with polybutylene additive, instead of mineral oil, became mandatory for two-stroke engine motorcycles in Thailand back then. According to a technical report by the Petroleum Authority of Thailand in 1993, two-stroke engines with lower oil/fuel ratios had already been introduced into Thailand to further reduce hydrocarbon emissions. The Thai government has adopted progressively tighter standards for

motorcycle manufacture. Thai Level 5 standards, which was enacted in 2000, maintain a smoke opacity level requirement of 15% or less, CO level of 3.5 g/km or less, and HC+NOx level of 1.8 g/km or less. While motorcycle manufacturers are more likely able to continue manufacturing two-strokes engines under these standards, further tightening of the standards (as proposed) will lead to manufacturers either switching to four strokes or adopting two-strokes with catalytic converters. In order to provide an incentive for the latter, manufacturers intend to have a program whereby drivers can bring in their motorcycles for free replacement of catalytic converters.

Besides these measures, an incentive scheme has been envisioned in order to speed up the removal of highly polluting motorcycles from circulation. The scheme aims at taking off a significant number of in–use polluting motorcycles by offering two effective financial incentives. It is designed so that all motorcycle drivers are informed and invited to bring in their motorbikes for an emission test. If the vehicles pass the test, the owners can obtain a free tune-up and lube oil. But if a motorcycle fails the test, the owner is offered a financial package: he or she could obtain a rebate for trading in the old vehicle and purchasing a new one, or take a certain amount of cash for surrendering their polluting motorcycles.

The financial package proposed includes a cash incentive of 3,000 Baht from international donors, a discount of 1,000-3,000 Baht on the new purchase and a waiver of 2,500 Baht of insurance charges from motorcycle manufacturers, and an interest reduction of 0.5% from finance companies. In Bangkok, the trade-in value of an old motorcycle is estimated at 7,000 to 20,000 Baht, and the purchase price of a new motorcycle is 20,000 to 25,000 Baht at the minimum. Considering the interest charges, a motorcycle can cost as much as twice the purchase price.

This financial package, which aims to provide incentives for motorcycle owners to give up their polluting motorcycles or replace them with new ones, was tested in a pilot trade-in project in 2000. In order to better design the incentive scheme, two motorcycle emissions testing clinics were conducted by the Bangkok Metropolitan Administration

with the assistance of the World Bank and the motorcycle manufacturers in the summer of 2000. During the second clinic, a contingent valuation (CV) survey was conducted in order to better understand the values that those motorcycle owners in Bangkok may put on the vehicles and possible reactions they may take towards different possible financial packages.

III. The Survey

Two three-day clinics were conducted in Bangkok in May and July 2000, respectively, to test the motorcycle emissions. About 1,500 motorcycles were attracted to the first clinic and about 2,000 to the second one. Besides testing the emissions, a socio-economic survey on motorcycle owners was carried out. The survey questions fall in the following three categories: owners' socio-economic profile, their awareness of air pollution, and the use and condition of their motorcycles.

In the second clinic, a set of contingent valuation questions were asked of those owners of motorcycles who failed the final emission (CO, HC and opacity) tests. The stochastic payment card approach developed by Wang (1997) was used to elicit likelihood information regarding the possibility that those owners would keep or give up using their vehicles under certain charges or compensations. A list of hypothetical charges (300, 600, 1000, 1500, 2000 and 3000 baht /year) was presented to 231 owners, who were asked the likelihood they would keep using their motorcycles under these charges. The answers include "definitely willing to pay," "probably willing to pay," "not sure," "probably not willing to pay," and "definitely not willing to pay." One hundred and ninety-one of those owners whose vehicles didn't pass the emission tests received a list of likelihood questions about their willingness to give up running their vehicles under certain compensations (2000, 4000, 6000, 8000, 10000, 12000 baht/year). The answers to these questions of willingness to accept compensation include "definitely not willing to accept," "probably willing to accept," "not sure," "probably willing to accept," and "definitely willing to accept."

The basic statistics of the survey is presented in Table 1. The statistics shows that the owners of those polluting motorcycles are mostly male at an average age of 33 years old. Two thirds of them are married and, on average, they have two kids. Most of them drive motorcycles for business. One sixth of them indicated that their households suffered from respiratory symptoms and quite a number of them admitted that their households actually paid for the medical treatments of air pollution symptoms. The survey also shows that these drivers are highly aware of air pollution problems and actually consider motorcycles a contributor. Contradictorily, however, two thirds of these drivers thought their own motorcycles, which had failed the final test, were in good condition. Three quarters of drivers never serviced their motorcycles.

IV. Response to Charges and Compensations

The responses to the charges and compensations are presented in Table 2 and Table 3. Under a charge of 300 baht per year, about 48% of those polluting motors would definitely be operating in the streets. When the charge increases to 600 baht per year, the responses indicate that only about 8% would definitely remain operating in the streets, and about 46% would definitely stay off the streets. When charges increase to 1000 and 1500 baht per year, responses then indicate that 79% and 90% of polluting vehicles, respectively, would definitely be off the streets.

If a compensation policy is adopted, there would be a 72% chance of polluting motors definitely on the streets and only 7% definitely off the streets with a total compensation of 2000 Baht per vehicle. To bring about a reduction of 50% of polluting motors off the street, the necessary compensation may have to be as high as 10000 baht per vehicle. Figures 1 and 2 present percentages of polluting vehicles on or off the streets under different charges or compensation.

V. WTP and WTA

In order to have a better understanding of motorists' behaviors under different charge and compensation policies and a better design of the two potential financial instruments, an in-depth analysis is conducted on the values of the maximum willingness to pay for keeping the operations of the vehicles and of the minimum willingness to accept for compensations to give up the operations. In the following, Wang's stochastic valuation approach (Wang, 1997) is employed to estimate the mean values of WTP and WTA. Econometric analyses are also conducted to examine the determinants of the WTP and the WTA.

The Model

In the CV surveys, the probabilities of each individual's agreements to the charges or the compensations were obtained with the stochastic payment cards. Specifically, those motorcycle drivers whose vehicles failed the final emissions test were questioned on the likelihood they would be willing to pay for riding their motorcycles at a range of suggested charges/prices (300, 600, 1000, 1500, 2000, and 3000 Baht) per year. If the motorcycle owners did not want to pay the suggested minimum charge, their minimum values were asked. The likelihood answers which respondents may select for the suggested prices are: "definitely yes," "probably yes," "not sure," "probably not," and "definitely not." To enable to estimate a respondent's cumulative distribution function, a probability is assigned to each likelihood category; i.e., 99.9% to "definitely yes," 75% to "probably yes," 50% to "not sure," 25% to "probably not," and 0.05% to "definitely not." For example, if a person responded 'definitely yes' to 300 Baht, 'not sure' to paying 600 Baht and 'definitely not' to 1,000 Baht, the probabilities of 99.9%, 50%, and 0.05% would be assigned to the three prices, respectively. The reason that 99.9% and 0.05%, rather than 100% and 0% are adopted in the analyses is because 100% and 0% would introduce infinities with likelihood functions.

The procedure of estimating WTP values is modeled as follows. Let X_j be the jth price offered to a respondent i, where $j = \{1,2,3,4,5,6\}$, and X be the set of the six charges or

prices $X = \{300,600,1000,1500,2000,3000\}$. A driver would agree to pay the price as far as the price is lower than her/his willingness to pay (WTP):

$$P_{ij}(Yes) = \Pr(WTP_i > X_j) = 1 - F_i(X_j),$$

where F is a cumulative distribution function.

Under a normality assumption (Φ), it can be rewritten as

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

$$X_j = \mu_i + \sigma_i \Phi^{-1}(1 - P_{ij}).$$

The mean μ_i and standard error σ_i of respondent i's valuation distribution are estimated by regressing X on $\Phi^{-1}(1 - P_i)$, where P_i is the respondent i's likelihood vector of accepting the prices.

The value of WTA can be estimated by using a similar approach. The price (or compensation) values at which motorcycle drivers were asked for their WTA are 2000, 4000, 6000, 8000, 10000, 12000 Baht. Let Y_j be the jth compensation or price offered to a respondent i, where $j = \{1,2,3,4,5,6\}$, and Y be the set of the six prices $Y = \{2000,4000,6000,8000,10000,12000\}$. A driver would not agree to accept the price if the price is lower than her/his willingness to accept (WTA):

$$P_{ij}(No) = \Pr(WTA_i > Y_j) = 1 - F_i(Y_j),$$

where F is a cumulative distribution function.

Under a normality assumption, it can be rewritten as

$$P_{ij} = 1 - \Phi(\frac{\mu_i - Y_j}{\sigma_i}) \qquad \text{or}$$

$$Y_j = \mu_i + \sigma_i \Phi^{-1}(1 - P_{ij}).$$

The mean μ_i and standard error σ_i of respondent i's valuation distribution are estimated by regressing Y on $\Phi^{-1}(1 - P_i)$, where P_i is the respondent i's likelihood vector of not accepting the compensation.

The Values

The means and variances of WTP and WTA are estimated for all respondents by using the models presented in the last section. The mean WTP of polluting motorcycle owners for riding their motorcycles is 580 Baht per year, with the minimum value of 194 and the maximum of 2060 Baht. The sample standard deviation is 320 Baht and the mean of the estimated standard error is 180 Baht.

The frequency distribution and cumulative distribution of WTP are shown in Figures 3. Figure 3 illustrates that 80% of polluting motorcycle owners are willing to pay 320 Baht per year to keep riding their polluting motorcycles. At the price of 720 Baht per year, there is only 20% of the owners would be more likely to pay for using their motorcycles. In other words, if the government charges an annual fee of 720 Baht on those who ride polluting motorcycles, 80% of the drivers may dispose of their motorcycles. A charge of 460 Baht per year could make 50% of the drivers give up riding their motorcycles.

The estimation shows that the mean of WTA is 6,650 Baht in total, or about 1,500 Baht per year over a span of 4.5 years in which an average owner expects to keep his or her motorcycle in the future. The range of estimated individual WTA values is from 1,180 to 12,820 Baht. The standard deviation is 2,780 and the mean of the estimated standard error is 1,440.

The distribution plotted on Figure 4 indicates that 20% of motorcycle owners were willing to accept a one-time compensation of 4,000 Baht for giving up their motorcycles. The figure further shows that about 80% are willing to give up their motorcycles at the compensation of 9,000Baht. In the trade-in pilot project, there were 43 polluting motorcycle owners who actually traded in their motorcycles, given the financial incentive package of a 3,000 Baht of cash rebate and other incentives described in last section. This number composes 13% of the 331 drivers whose motorcycles failed the emission test. It is evident that the results from a real test are pretty close to the results from the WTA study.

The Determinants

Table 4 presents the determinants of the motorcycle owners' willingness to pay (WTP) for charges so that they can use their vehicles and their willingness to accept (WTA) compensation for giving up the use of their vehicles. Household income is negatively correlated with the WTP and WTA, indicating that the richer the motorcycle owner, the easier it is for them to give up the use of polluting vehicles (with smaller charges or compensation). Fuel costs are also negatively correlated with the WTP and WTA, which implies that the higher the fuel price, the easier it is for motorists to give up the use of their polluting vehicles.

For those motorists who take public transit often or very often, a lesser charge is incentive enough for them to give up the use of their motors, but a higher compensation would be needed if a compensation policy applies. A higher compensation would be necessary for a motorist who drives more frequently each day. A retired person would be willing to pay more for keeping the use of their vehicles.

VI. Policy Implications and Concluding Remarks

The CV survey results are instructive and provide a base for drafting incentive instruments, either charges or compensations, to phase out polluting motorcycles in Bangkok. The study shows that a charge of 460 Baht per year could make 50% of the drivers whose motorcycles fail emission test give up riding their motorcycles. If the charge was raised to 1,000 Baht, 80% of them would dispose of their motorcycles.

If a compensation is provided, 20% of motorcycle owners would be willing to give up their motorcycles at a one-time compensation of 4,000 Baht. The estimate is very close to the actual result of a pilot project in which 13% of polluting motorcycles drivers accepted an offer of 3,000 Baht of cash plus other incentives towards purchasing new motorcycles. The study further shows that about 80% would give up their motorcycles if the compensation increases to 9,000Baht.

The actual transaction of a driver is determined by a number of factors. Household income is a key factor driving down both the WTP and the WTA. In other words, the richer the motorcycle owners, the easier it is for them to give up the use of polluting vehicles given smaller charges or compensation. Therefore, the economic growth and the resulting increase in drivers' household income can eventually be the driving force of phasing out polluting motorcycles. Fuel costs are also negatively related to the WTP and the WTA, and therefore, an increase in fuel price can motivate the drivers to give up the use of their motorcycles. Those who also use public transit often appear to be more easily likely to give up riding their motorcycles, which indicates the importance of developing public transit systems in eliminating polluting motorcycles.

The study illustrates that CV surveys can be a useful tool for policy makers to analyze the behaviors of motorcycle drivers in designing a financial incentive scheme, either a charge or a compensation, to help phase out polluting motorcycles. The study results can also help introduce a combination of "carrot and stick", i.e., the use of charges and compensation together, as an incentive instrument to effectively eliminate polluting motorcycles.

Last but not the least, any incentive instruments, whether a charge or a compensation, will not be effective unless regulations on emissions have already been in place and been actually enforced. This requires an adequate framework of regulatory and economic policy instruments, including vehicle registration, emission standards, monitoring and supervision through pre-sales testing, and after-sales inspection and maintenance, etc.

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Table 1. Statistics of the Respondents

Variable name	Obs.	Mean	Std	Median	Min	Max
Age	228	33.57	9.29	32	19	67
# of household members	226	4.52	2.03	4	1	12
# of household members working	222	2.46	1.37	2	1	8
Personal income	223	8363	4636.41	7200	2500	50000
Household gross income	207	17960	13458.37	15000	4100	80000
Years owning MC	227	5.23	2.91	5	0.08	16
Driving distance (Km/day)	226	68.43	45.41	60	4	300
Max WTP for Inspection and maintenance	201	2471	2324.85	2000	50	20000
Spending on maintenance per month	202	624.1	630.21	500	50	5000
Spending on fuel per week	223	348.8	305.15	300	40	4000
Years to keep MC	186	4.5	2.84	4	0.42	15
MC price	214	48830	25089	49400	0	138000

Table 2: Likelihood to stay on road under different charges

Charges (Baht/year)	300	600	1000	1500	2000	3000
Definitely on	48.4%	8.4%	2.7%	1.3%	0.9%	0.9%
Probably on	19.1%	8.4%	2.2%	1.8%	0.4%	0.0%
Not-Sure	22.2%	26.7%	8.0%	4.4%	1.3%	0.4%
Probably off	1.3%	10.7%	8.4%	2.2%	3.1%	0.4%
Definitely off	8.9%	45.8%	78.7%	89.8%	94.2%	98.2%

Table 3: Likelihood to stay on road under different compensations

Compensations (Baht/year)	2000	4000	6000	8000	10000
Definitely on	72.3%	60.1%	48.9%	39.4%	25.5%
Probably on	5.9%	5.3%	2.1%	2.1%	1.1%
Not-sure	13.3%	14.9%	14.9%	9.0%	6.4%
Probably off	1.6%	8.5%	11.7%	14.9%	16.0%
Definitely off	6.9%	11.2%	22.3%	34.6%	51.1%

Table 4. Major Determinants of WTP and WTA

			WTP Model	WTA Model
Dependent Variables:			Mean WTP	Mean WTA
Independent Variables:	Explanation	Sample mean (std)	Coefficients (t-value)	Coefficients (t-value)
Hhincome	Household Income (Baht/Month)	17448.5 (11428)	-0.0023 (-1.18)	-0.039 (-1.94)**
Puboft	1=Use public transportation often or very often; 0=otherwise	0.098	-151.5** (-2.04)	1327.1 (1.72)*
Fuelcost	Fuel cost (Baht/week)	344.5 (305.6)	-0.12 (-1.59)	-2.51 (-1.55)
Kmday	Distance driving (km/day)	67.1 (45.0)		14.4 (2.28)**
Retired	1=the person is retired;0=otherwise	0.068	206.9** (2.33)	
Const	Constant term of the model		665.1*** (13.62)	7111.0*** (10.91)
R-squared			0.054	0.084
Obs.			205	132

Figure 1. Polluting Motorcycles under Charges

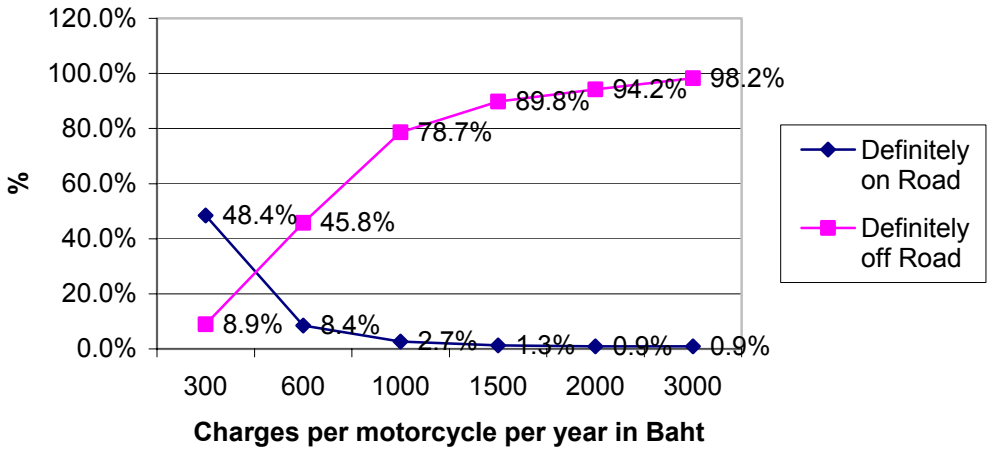
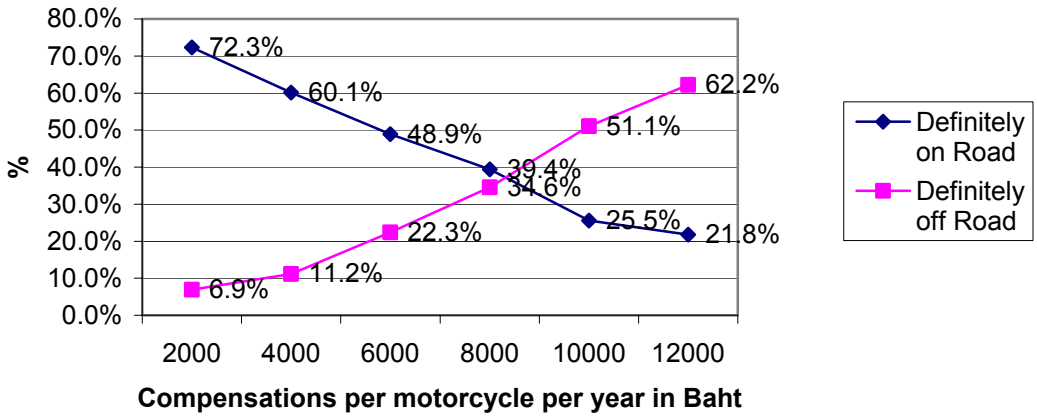


Figure 2. Polluting Motorcycles under Compensations



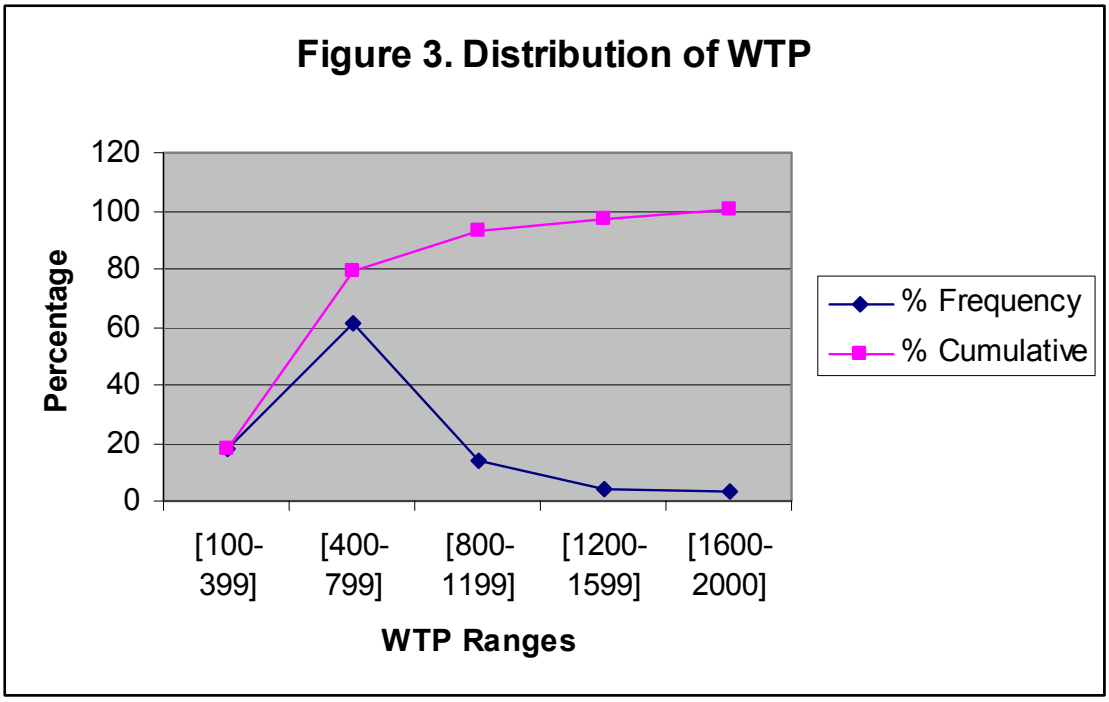


Figure 3. Distribution of WTP
120
100
80
60
40
20
0
Percentage
[100-399]
[400-799]
[800-1199]
[1200-1599]
[1600-2000]
WTP Ranges
% Frequency
% Cumulative

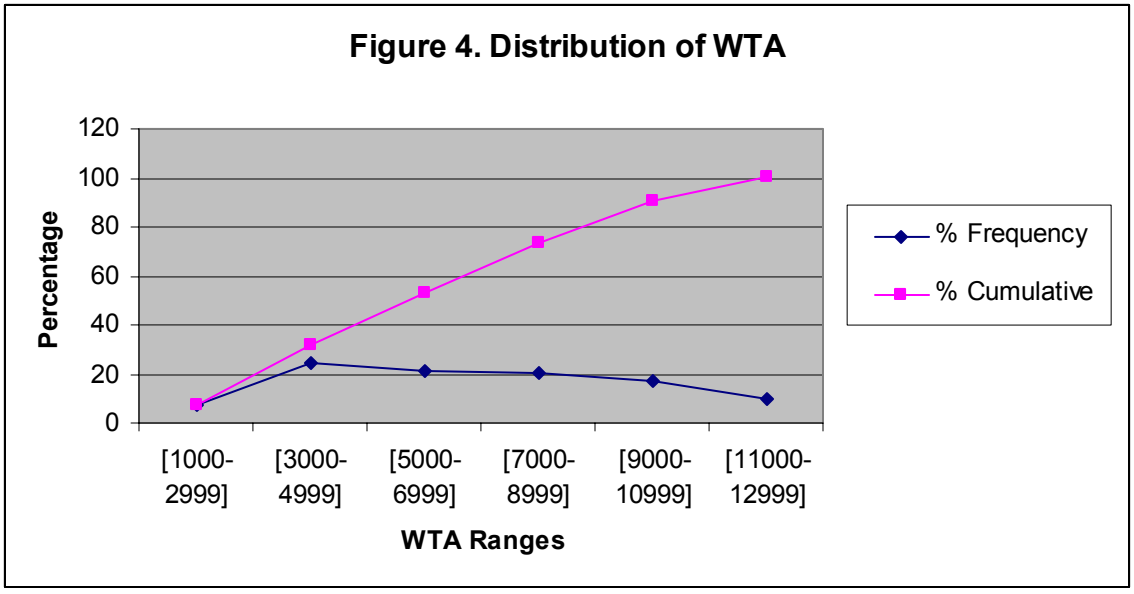


Figure 4. Distribution of WTA
120
100
80
60
40
20
0
Percentage
[1000-2999]
[3000-4999]
[5000-6999]
[7000-8999]
[9000-10999]
[11000-12999]
WTA Ranges
% Frequency
% Cumulative