Analysis of Inspection and Maintenance Program in JABODETABEK Indonesia

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Abstract
This paper describes an initial analysis of vehicle inspections and maintenance program for private cars in Jakarta and surrounding cities namely JABODETABEK, as regulated in the 2005 bylaw. The bivariate probit model used to estimate the likelihood of CO and HC emission violations given a set of vehicle characteristics. In order to analyze household's vehicle-type ownership and its usage in Jakarta city, we use person trip data in collected in 2000 and household interview survey in 2009. Data of passenger car emission measured randomly during on-road emission measurements at Jakarta city and surrounding cities Bogor, Depok, Tangerang and Bekasi in 2004, 2005 and 2009. The engine size, fuel system, vehicle maintenance quality and passenger car travelled kilometer per year play a significant role in determining the probability of emission test failure. Vehicle kilometer travelled per year has causal relationship with vehicle-type and its usage. Vehicle type Jeep and SUV were less to use by the households and also have lower probability to pass CO emission test compare to Sedan or passenger car.

Keywords: Inspection and Maintenance, Bivariate Probit, Jabodetabek

1. INTRODUCTION

There have been ongoing debates on the effectiveness of the implementation of this program to reduce the mobile emissions. In several studies by Hubbard, T. (1997), Wasburn, et. al. (2001), and O, Bin (2003), the I/M programs have been heavily criticized in their three main points since their inceptions. First, it has been argued that I/M programs are an inefficient use of resources to achieve air quality objectives. It is also inconvenient to the vast majority of the driving population. Second, the I/M programs are not the most effective way to identify gross polluting vehicles. The I/M test procedure for Jakarta city has been based on the idle-mode test, so it does not account for the real world driving conditions such as acceleration and deceleration cycles, and thus vehicles passing the emissions test may still be gross polluters in the real world driving conditions. Third, the programs have failed to provide drivers with incentives to minimize their vehicle emissions (2001). Additionally, many drivers tamper with their engine and emission control in order to past the emission test and the repair of high emitting vehicles is waived because of arbitrary cost. It is not difficult to 'cheat on' in the idle-mode emission test.

A study by Japan International Cooperation Agency (JICA) and Environmental Impact Management Agency (JICA,1997) revealed that more than 50% of Carbon Monoxide (CO) was emitted from private motor vehicles and approximately 20 percent from motorcycles. Private motor vehicles and motorcycles are responsible for approximately 40 percent of Hydrocarbon (HC) emissions (SEI,2002). In 2005, the Local Government of Jakarta issued The 2005 Jakarta's bylaw on air pollution control, which took effect on February 2006, mentioning about air pollution control from mobile sources. It was stipulated that all private car owners must get their vehicles' emission tested biennially (A.P Simamora, 2006). This testing process is commonly referred to as an inspection and maintenance (I/M) program. In order to pass the test, the vehicles emission should be lower than the in-use vehicle standard. The vehicle emission test is performed by the authorized automobile workshops and technicians. If a vehicle passes the emission test, the owners will be given a certificate and a sticker to be attached on the upper left side of the windshield. In contrast, if a vehicle fails in the emission test, it should be repaired or perform an appropriate maintenance to achieve the allowable emission standard. The bylaw No 2 Year 2005 states that the emissions certificate will be required for extending the vehicle's registration (BPLHD, 2005). Implementation of in-use passenger car emission standards and also passenger car emission testing does not usually result in additional direct costs for governments. Usually, implementation costs transferred to passenger car owners. In case of Jakarta city, the local government endorse the private passenger car mechanic workshops to perform the I/M program. The private passenger car owner can do the emission test and passenger car maintenance in order to meet the allowable standard.

This study will focus on the relationship between vehicle-type usage and its impact on the emission performance which will evaluate based on probability to pass the emission test under I/M program in Jakarta city. We explore the vehicle-type (car/passenger car, SUV/Jeep, pickup/light truck) holding by households and its usage in Jabodetabek. To evaluate vehicle usage, we use mileage driven of each vehicle-type based on actual odometer reading simultaneously with idle emission test. The Bivariate Probit analysis is conducted for the likelihood of carbon monoxide and hydrocarbon emission violations given a set of passenger car characteristics. This methodology finds the effects of characteristics such as carburetor/injection system, engine size, passenger car travelled kilometer per year and dummy variable of passenger car maintenance which determine by air-fuel ratio on the likelihood of emissions test failure. Finally, vehicle-type was included as dummy variable in our probit model to evaluate the influence on the probability to emission test results. To do so, we use several data sets which are JICA person trip data (2002), household energy consumption survey by Global Environmental Leadership Program Hiroshima University (2009) and emission measurements (2004, 2005, and 2009) and also econometric software LIMDEP Version 8.0 (Greene, W, 2002).

2. METHODOLOGY

2.1 Idle Emission Measurement of in-use vehicles

As well, emissions level is also influenced by the driving cycles. Many factors may influence on-road driving cycle and levels of passenger car exhaust pollutants. Driving cycles of urban areas differed significantly from rural areas (Chen, 2003). Urban cycles has shorter travel distance, lower travel speed, more idle time, and lower acceleration/deceleration time than rural ones. Urban areas generally have more congested traffic, intersections and traffic signal than do rural areas. Accordingly, urban driving cycles generally consumes more fuel (approx. 30% more per km) than does rural driving but the emission levels in urban driving differ insignificantly from those in rural driving (Chen, 2003).

Road traffic in big cities in Indonesia is characterized with high congestion levels during day times. Thus, there is great number of vehicles operating at idle or stop-and-go driving conditions. It is known that vehicle exhaust emissions of NOx, CO, HC and particles are different at driving conditions, being the highest during acceleration (Pujadas, et al, 2004). Nevertheless, we can assume that emission test results can be used to represent the real world conditions at sites over-congested traffic that result in long idling times. A vehicle may have over 25% of its time spent in the idle mode (Tong, 1999).

To perform idle-emissions tests, we refer to Indonesian Standard SNI 09-3678-1995 which was already revised to be SNI 19-7118.3.2005. These Indonesian standards developed based on International Organization for Standardization (ISO) 3930/OIML R99-instrument for measuring vehicle exhaust emission 2000- and United Nation for Economic Commission for Europe (UN-ECE). To prepare idle-emission test, passenger car exhaust pipe shouldn't have any leakage, under normal temperature of engine and the ambient temperature in between $20^{o}C$-$35^{o}C$. Idle conditions means the passenger car engine working without any acceleration of fuel system, neutral transmission position for manual type of passenger car, neutral transmission or parking position for automatic passenger car. At the same time, other passenger car accessories which influence to engine rotation were shut down. Vehicles exhaust gas measured by a gas analyzer to obtain the concentration or emissions levels of CO (%) and HC (ppm).

2.2 Bivariate Probit model for in-use vehicles exhausts emissions

The bivariate probit regression analysis used to examine the likelihood of CO and HC emission violations. In this study we refer to our national standard in state Ministry of Environment Decree No 13 Year 1993 which was already revised in 2006, the maximum allowable idle emissions limit value of CO is 4.5% volume and maximum HC value is 2400 ppm. Other secondary data contain information on the various passenger car characteristics of tested passenger car, manufacturer, make and model as well as model year, engine fuel system, odometer reading, lambda, and passenger car types. In the bivariate probit model, emission test violation is defined as the effect of passenger car characteristics such as engine size, engine fuel system and running kilometer of passenger car. Running kilometer per year represent the behavior use of vehicle which affected by vehicle-types. So, vehicle-type was included in our model to evaluate the effects on emission test results. Other dummy variable of maintenance quality was determined by air-fuel mixture ratio (AFR) and its deviation to the normal standard value of AFR which assume represent the car maintenance quality. Using all independent variables, we propose a Bivariate binary Probit regression model of the emission test failure. Bivariate binary Probit regression model depends on simultaneous observation of two discrete binary observed-dependent variables, i.e., y_{i1} *and* y_{i2}, that indicates the emissions test failures of CO and HC. Based on the observed dependent variables that take binary discrete values, underlying continuous dependent variables, z_{i1} and z_{i2}, can be expressed as:

$$\begin{aligned} z_{i1} &= \boldsymbol{\beta}_1'\mathbf{x}_{i1} + \varepsilon_{i1} \\ z_{i2} &= \boldsymbol{\beta}_2'\mathbf{x}_{i2} + \varepsilon_{i2} \end{aligned} \quad , y_{ij} = 1 \text{ if } z_{ij} > 0,\ y_{ij} = 0 \text{ otherwise, } j = \{1, 2\} \tag{1}$$

where i denotes an observation; $\boldsymbol{\beta}$ and $\mathbf{x}$ stand for the vectors of parameters and the independent variables respectively; ε_{i1} and ε_{i2} are random variates distributed jointly as standard Bivariate Normal and a free correlation parameter, ρ, i.e., BNV [0,0,1,1, ρ]. Based on the equation given above, the log- likelihood function of the sample can be given as:

$$\log L = \sum_i \log \Phi_2 \left[q_{i1}\boldsymbol{\beta}_1'\mathbf{x}_{i1}, q_{i2}\boldsymbol{\beta}_2'\mathbf{x}_{i2}, q_{i1}q_{i2}\rho \right] \tag{2}$$

where Φ_2 stands for the standard Bivariate Normal distribution; q is an indicator variable such that $q_{im} = 2y_{im}-1$, $m = \{1, 2\}$. Based on data collected by the on-road measurement at Jakarta, in 1999, 2000, 2004, and 2005 the model is estimated by using LIMDEP Version 8.0 econometric software (Greene, 2002).

Passenger car running kilometer per year calculated from the actual odometer reading divide by vehicle age. Based on the distributions, we classify passenger car running kilometer per year data into six groups (Table 1). We also categorized engine fuel system of cars into two groups which are carburetor and injection. Finally, we develop five categories of dummy variable maintenance quality which are very good, good, moderate, bad and very bad based on the deviation of air-to-fuel ratio measured from cars compare to the ideal reference value (one).

2.3 Vehicle-Type Ownership and vehicle usage

Vehicle ownership by household is a critical demographic characteristic influencing many aspects of travel demand and its impacts. It is well recognized that different vehicle types impose different emissions intensity. Vehicle-type ownership is a critical variable in policy analysis regarding on the Inspection and Maintenance Program in Jakarta city to reduce emissions from mobile sources. A recent study expects sharp increase in passenger car ownership level when per capita income level reaches a level between US$ 3000 and US$ 5000 (Dargay, 1999). Due to rapid development and economic growth of developing Indonesian country, household income level increase gradually. GDP per capita of Jakarta city, the capital of Indonesia, reaches US$ 4992 in 2006 (Siadari, 2007) followed by Surabaya city, second largest city in Indonesia, which

GDP per capita around US$ 3481 in the same period. Other study, Ingram and Liu (1999) estimate that passenger car ownership in developing countries is expected determinism-a sociological explanation-which associates car ownership in developing countries exclusively with the middle class life styles, and stresses the social forces on the middle class to sustain a mobility level tied to car ownership (vanconcellos, 1997). A private car is regarded as a symbol of power, status, control and freedom (Goodwin 1997). Indonesian automaker association reported that the annual vehicles sales in 2008 reached 600 thousand unit which almost 30-40% sold in Jabodetabek area (Gaikindo, 2008).

TABLE 1 Variables Definition in the Study

No	Indicator	Driver
A	Emission Indicator	
	1. Carbon Monoxide (CO)	Carbon monoxide measured by the percent of total volume of emission gas. Compare to National Standard (1 if passed the emission test, other=0)
	2. Hydrocarbon (HC)	Hydrocarbon measured by parts per million. Compare to National Standard (1 if passed the emission test, other=0).
B	Private Vehicle Characteristic	
	1. CARB	Carburetor Cars=1, Other=0
	2. RKTYRCLS	Private Passenger Car Running Kilometer per year. Calculate by observed odometer reading and vehicle age. Divided into six class: 1<10000 km/yr; 10001<2<20000 km/yr; 20001<3<30000 km/yr; 30001<4<40000 km/yr; 40001<5<50000 km/yr; 6>50000 km/yr
	3. ENGSZCLS	Engine Size Class (cc). 1 < 1000 cc; 1001<2<1500 cc; 1501<3<2000 cc; 4>2001 cc
	4. IMCODE	Dummy Variable Maintenance Quality. Calculate by using measured Air to Fuel Ratio. Very good ($0.95\leq \lambda <1.05$); Good ($0.9\leq \lambda <0.95$ or $1.05\leq \lambda <1.1$); Moderate ($0.85\leq \lambda <0.9$ or $1.1\leq \lambda <1.15$); Bad ($0.8\leq \lambda <0.85$ or $1.15\leq \lambda <1.2$); and Very bad ($\lambda <0.8$ or $1.2\leq \lambda$)
C	Attributes of Car owner	
	1. Vehicle-type	(1) Sedan/Passenger Car; (2) Sport Utility Van (SUV),Van and Jeep; (3) Pickup and Light truck

The majority of car ownership models are developed in a discrete choice framework. Automobile ownership studies have typically been modeled by using well established Multinomial Model (MNL) (Mohammadian, 2003). These models identify two major components of automobile ownership: the number of vehicles owned and vehicle type. Multiple vehicle ownership including private car, motorcycle and bicycle was also popular in developing Southeast Asian country like Indonesia. Sanko (2005) found a substitutability relationship between car and motorcycle ownership in Bangkok and Kualalumpur. Senbil (2007) use bivariate ordered probit model to analyzed household car and motorcycle ownership which are independent of each other in JABODETABEK. Refer to the comparative study between Osaka metropolitan area and Kualalumpur (Yamamoto, 2009), some portion of second cars in Osaka is replaced by

Motorcycles in Kualalumpur. Several studies examined vehicle-type holdings and vehicle usage simultaneously. Study by Bhat (2006), a multiple-discrete continuous extreme value (MDCEV) model applied to examines the important effects of household demographics, residence location and vehicle attributes on household multiple vehicle-type holding and use. Bhat (2009) also developed jointly MDCEV and MNL model to predict the impact of land-use and fuel cost changes on vehicle holdings and usage of the households. Fang (2008) developed a Bayesian Multivariate Ordered Probit and Tobit model to estimate a joint system of vehicle fuel efficiency choice and vehicle utilization in response to varying residential density. In this study, we explore the vehicle-type holding by households in Jabodetabek based on household interview survey in 2000 (Person Trip Data, JICA) and household energy consumption survey in 2009 (GELs Program, Hiroshima University). We use accumulated mileage driven based on actual odometer reading of vehicles in 2004, 2005 and 2009.

3. DATA

3.1 Vehicle-type ownership and vehicle usage in JABODETABEK.

According to The Jakarta Metropolitan Area (Metrojaya) State Police, data reveals that most of motor vehicle fleet in Jabodetabek was motorcycles around 58,9 % followed by Passenger Car around 28.7% respectively. In 2002, total motor vehicle population in Jakarta area was approximately 5 million unit or 20.3% of total motor vehicle population in Indonesia (Nugroho, 2004). Based on annual motor vehicle sales data reported by Gaikindo (Indonesian Association of Automobile) from 1976 to 2003, the highest vehicle sales accounted in 1997 around 397 thousand units per year. Due to the economic crisis, vehicle sales from 1998 drop significantly. However, the vehicles sales recently have rebound with the total annual sales were up to 354 thousand units in 2003. During the period from 2000 to 2003, the percentage of vehicle sales in Jabotabek was around 34.3 – 37.4% of total vehicle sales in Indonesia. Most of vehicles sold during period of year 2000 to 2003 were gasoline vehicles and around 92% of total sales were accounted for passenger cars and the remaining were for both trucks or and buses. Based on person trip survey by JICA in 2002, 47.5% samples (1,08 Millions samples) households in JABODETABEK have vehicles in their house. It is consists of motorcycle holders 33,2%, car holders 7,8 % and multiple ownership of car and motorcycle 6.4% (table 2). Comparing the ownership type between two different data sets, we found similar pattern for single motorcycle owner and single car owner. The proportion of non-owner, multi motorcycle, multi car and multiple car-motorcycle owners are differ significantly from these two data sets. Based on the vehicle-type distribution data in 2000 consists of Sedan/Passenger car type around 74.9 % followed by Pickup/Light Truck 15.7 % and Jeep/SUV around 9.4 % respectively. Based on person trip survey data about single-car owner households in JABODETABEK in 2000, 86.3% samples have sedan/passenger car, 7.9% own sport utility vehicle (SUV)/Jeep and 5.8 % has Pickup/Light truck.

Most of respondent used their own vehicle for commuting trips (2009) and the highest observed for MC owners which around 76% (Figure 1). Looking at multiple car and motorcycle holders, the use of car for commuting trip is higher than motorcycle (Figure 2). Furthermore, share of transit mode also higher compare to multi car or multi motorcycle holders. Looking at figure 2, the share of transit mode for commuting trip is increases from MC owner to Car owner.

TABLE 2 Vehicle Ownership in JABODETABEK

No	Type of vehicle ownership	2000*	2009**
1	Non-Owner	52.53	27.5
2	Single Motorcycle	30.1	30.4
3	Multi Motorcycle	3.15	9.9
4	Single Car	6.31	5.6
5	Multi Cars	1.55	3.3
6	Multiple Car & Motorcycle	6.36	23.3

Note: * Person trip survey-JICA, 2000
** Household energy consumption survey-GELs Program (N=1009)

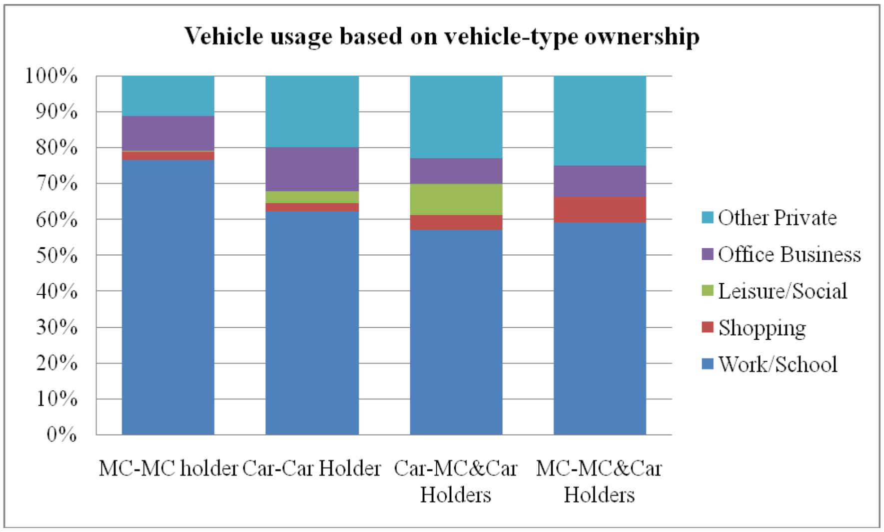

FIGURE 1 Purpose of vehicle use

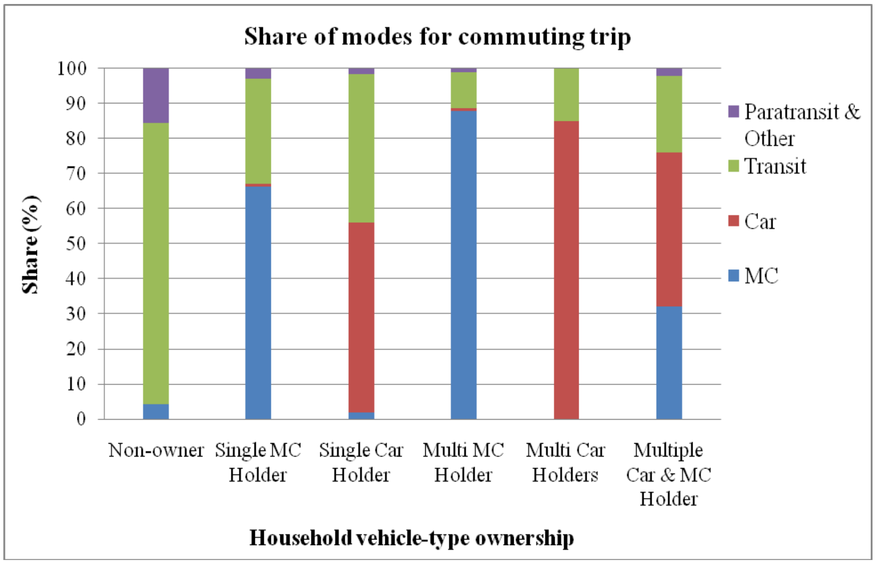

FIGURE 2 Commuting trip modes based on vehicle-type ownership

Focusing on the single car owner in 2000, tend to use as daily primary transport mode decrease from 53.7% for SUV/Jeep owner and 39.8% for Pickup or light truck owner (Figure 3). In contrast, tend to use bus a daily primary transport mode increase from 30.3% for Sedan/Passenger car owner to 39% for SUV/Jeep and 40 % for pickup/light truck owner. About daily travel time, average travel time of sedan owner's around 42.2 minutes followed by SUV/Jeep owner around 35.8 minutes and 33.3 minutes for Pickup/light truck owners. Frequency use of car is slightly decreases from 20 (sedan owner) to around 16 times/month for SUV/Jeep owner (2009).

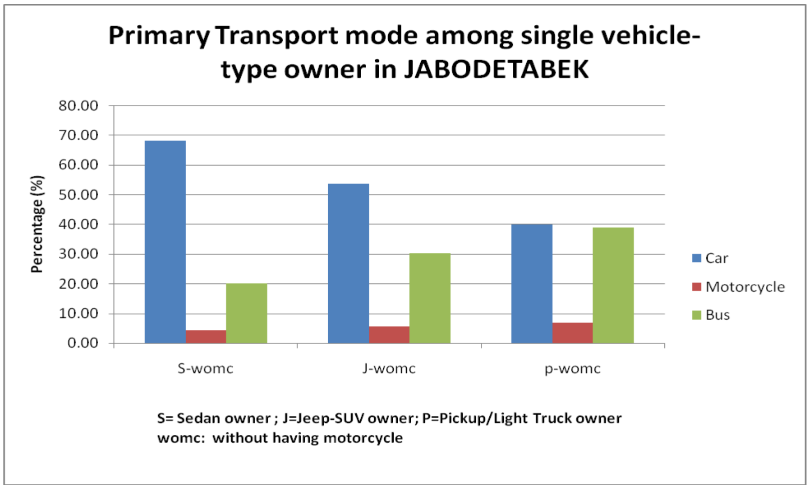

FIGURE 3 Primary transports modes among vehicle-type owner

3.2 On-road emission measurement for in-use vehicles

Idle Emission testing was held in several major roads in Jabodetabek (Figure 4). In this study, sample sizes obtained from 4 different times periods were 2730 data sets, which distributed as 727 (27%) samples taken at 2004, 441 (16%) samples in 2005, and 1562 (57%) samples measured at 2009. Nine locations were selected in 2004 as onsite vehicle measurement spots (check points) which consist of 5 locations in Jakarta city and four sampling points which located in Bogor, Depok, Tangerang and Bekasi (BODETABEK) (figure 4). A brief face-to-face interview was performed simultaneously during onsite idle emission measurement. Five hundred seventy three of samples (20.99%) were failed emission test failure which mean their emission level of Carbon monoxide nor hydrocarbon were exceed allowable limit which stated in our national emission standard. Most of failure cars have Carbon monoxide concentration higher than allowable level, only few samples failed to pass Hydrocarbon test. Medium engine size car (1000< engine size < 1500) was most popular among car holder in JABODETABEK followed by the engine size between 1500 and 2000 cc. Looking at the parameter of annual running kilometer passenger car per year in Jakarta city, around 52.67% samples were run less than 10000 km per year followed by the mobility of passenger car in between 10000 km and 20000 km per year around 26.92%. In this study, dummy variable of maintenance quality was derived from observed air to fuel ratio compare to the ideal condition (AFR=1). The owner or passenger car user whose perform good maintenance of their car around 38.10 %. Detail descriptive statistics of samples passenger car in this paper are shown in Table 3.

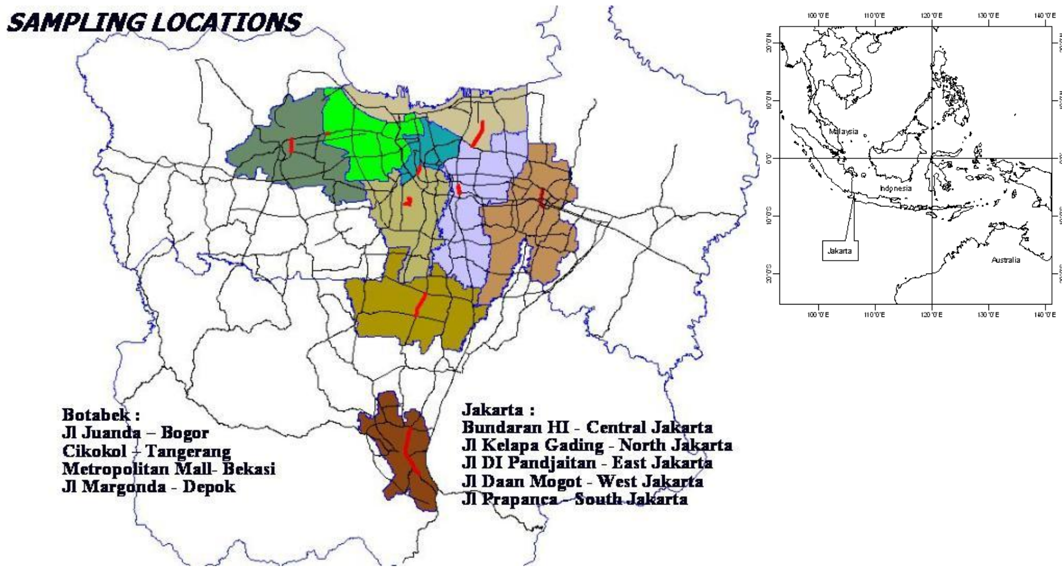

FIGURE 4 Locations of on-site emission measurement in 2004

TABLE 3 Means and standard deviations of vehicle characteristics

Variables	Definitions	Total	Fail_Test	Fail_CO	Fail_HC
	Samples (N)	2730	573	562	21
CO	Carbon monoxide measured by the percent of total volume	3.584 (13.687)	7.015 (1.788)	7.112 (1.644)	5.349 (4.028)
HC	Hydrocarbon measured by parts per million	400.563 (394.761)	766.25 (758.974)	712.620 (634.266)	3842.330 (1559.162)
ENGSCL	Engine Size classification by cubic centimeter displacement				
	(1) Engine Size ≤ 1000 cc	8.17%	34.53%	30.04%	4.04%
	(2) 1000< Engine Size ≤ 1500 cc	52.23%	22.65%	19.35%	1.82%
	(3) 1500< Engine Size ≤2000 cc	32.16%	25.51%	21.98%	1.59%
	(4) 2000 cc < Engine Size	7.44%	15.27%	12.81%	1.97%
RKTYR	Running Kilometer per year				
	(1) RKTYR ≤ 10000 km/yr	52.67%	24.83%	21.70%	2.57%
	(2) 10000< RKTYR ≤ 20000	26.92%	20.95%	17.69%	0.82%
	(3) 20000< RKTYR ≤ 30000	12.20%	25.53%	21.62%	1.80%
	(4) 30000< RKTYR ≤ 40000	2.71%	33.78%	27.03%	2.70%
	(5) 40000< RKTYR ≤ 50000	1.25%	23.53%	23.53%	2.94%
	(6) 50000< RKTYR	4.25%	25.00%	17.24%	0.86%
I/M Quality	Air to fuel ratio(Lambda)				
Very Good	0.95≤ λ <1.05	38.10%	5.19%	3.17%	0.38%
Good	0.9≤ λ <0.95 & 1.05≤ λ <1.1	21.17%	11.59%	8.48%	1.38%
Moderate	0.85≤ λ <0.9 & 1.1≤ λ <1.15	15.71%	41.03%	34.73%	1.86%
Bad	0.8≤ λ <0.85 & 1.15≤ λ <1.2	10.37%	66.08%	63.25%	3.18%
Very bad	λ <0.8 & 1.2≤ λ	14.54%	43.58%	38.04%	6.05%

Notes: in each cell, the first row indicates the mean and the second row (inside the brackets) indicates the standard deviations.

4. MODEL ESTIMATIONS AND RESULTS DISCUSSION

The Bivariate Probit regression analysis is conducted using independent variables of engine size class, running kilometer per year of passenger car, engine fuel system (Carburetor), dummy variable maintenance quality, and vehicle-type. In order to ascertain the influence of vehicles characteristics (engine size, running kilometer per year, carburetor, lambda) and the impact of households vehicle-type ownerships on passenger car emissions (i.e., CO and HC), model used to estimated the significance of inclusion of the factors. The model includes the passenger car characteristics and vehicle-types variables which determined significantly the emission test results.

Vehicle running kilometer per year tends to decrease gradually based on their vehicles age (Figure 2). Sedan and MPV cars seems have the higher mobility per years compare to other type of cars. It was also decreased slightly and smoothly compare to others. Jeep and SUV cars seems the lowest mobility per year compare to others. Looking at figure 2, samples were fit with common phenomena in Jakarta city that the most car owner willing to own and used their 6 or 7 seats car rather than other. Pickup car has a little high mobility compare to Jeep/SUV due to their bundle function for freight and passenger. Sometimes, we also found the owner modified their backside of pickup car to carry passenger and goods together. In fact, based on the empirical situations of vehicle-type and its usage, sedan/passenger car which assume less in fuel consumption compare to other type (SUV/Jeep and Pickup/Light truck) but use it more intense and longer. On the other hand, SUV/Jeep and Pickup/light truck assume consumes more fuel but it less to use and shorten. To evaluate the influence of this empirical situation on the emission test performance, we incorporate vehicle-types and sedan/passenger car's data used as the reference to compare the probability of emission test result with other vehicle-type. We also use the model to examine the probability of pickup/light truck and jeep/SUV with sedan/passenger car based on data in 2004, 2005 and 2009.

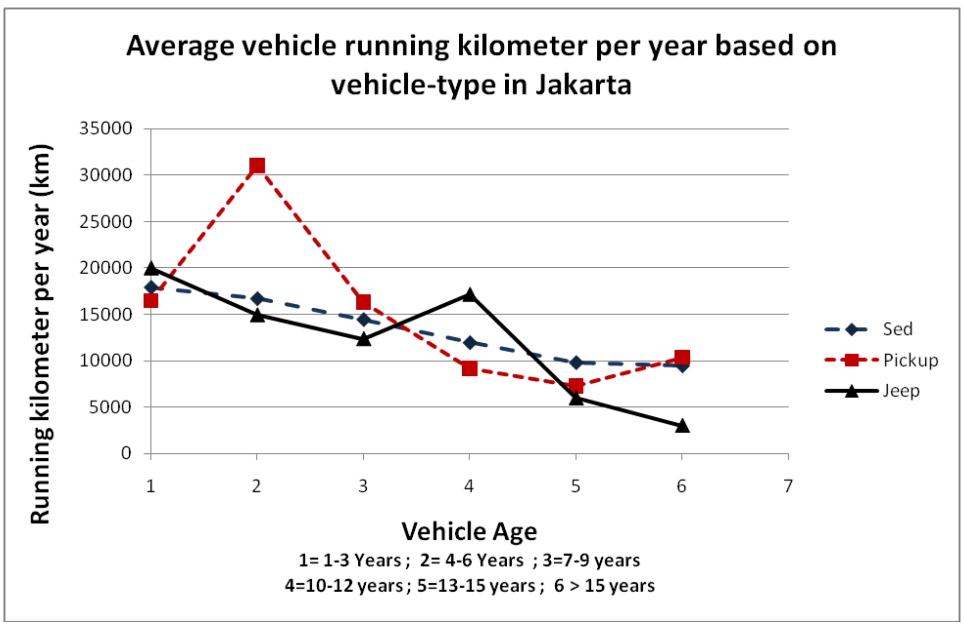

FIGURE 2 Average running kilometers per year of vehicles in JABODETABEK

Table 4 report the estimation results of the regression analyses the influence of vehicle characteristics and vehicle-type. Looking at table 4, maintenance quality plays significant role in determining emission test failure for both CO and HC at the estimation results for 2004, 2005 and 2009. Vehicle running kilometer per year negatively influences and also statistically significant for CO estimation in 2009. In contrast, it was positive and significant for HC estimation result in 2004. Basically, vehicle engine size (capacity) is directly related to emission and energy consumption. Vehicle with larger engine consume more fuel and emit more pollutions. There is often however a large difference between the most and least efficient vehicle within each engine size range (D. Stead, 1999). Also, a large difference of engine pollution control device between engine size classes. In order to comply with the regulation, small size engine cars are worse compare to medium and large engine size cars. It was empirically confirm for CO estimation in 2005 and HC estimation in 2004. We found different sign (negative value) for CO estimation in 2009. Engine fuel system (Carburetor) play significant role in determining the probability of CO in 2004 and 2009. But, it is only significant to HC emission test results in 2009. Carburetor system of car is also negatively play significant role in determining CO and HC emission test. Based on empirical situations, the probability to pass emission test of car with injection fuel system is better than carburetor car. All coefficients estimated for maintenance quality were negatively significant in determining CO and HC emission test performance. Observing all estimation results, dummy variable of maintenance quality keep remain stable as one of significant factor at 1% level which influence to CO and HC emission test failure. One key parameter very effective in the formation of CO and HC is the air-to-fuel ratio when the fuel is burned (Rubin, E.S., 2001). In this study, air–to-fuel ratio (lambda) is taken as the *stoichiometric amount*. When air–to-fuel ratio is less than 1, it is impossible to burn all fuel as there is insufficient air. In this case, CO and HC should be emitted as products of incomplete combustion. Generally, air–to-fuel ratio is subject to passenger car maintenance conditions. Routine maintenance keeps air-to-fuel ratio near the *stoichiometric amount*, which automatically sustains the passenger car emissions at the desired levels. It was justified from observed samples that reducing the maintenance quality consequently increase the probability of emission test failure (Table 4).

Empirical results confirm that Jeep/sport utility vehicle and pickup/light truck have lower probability to pass emission test in Jabodetabek. Comparing among vehicle-type, the sign were negative and statistically significant which show that the probability of Jeep/SUV and pickup or light truck to pass CO emission test is lower compare to Sedan/passenger car type in 2005 and 2009. The signs also negative but we didn’t found significant effects of vehicle-type on HC emission test all years. It is necessary to explore more detail in future about individual characteristics (fuel consumption, emission control device in car, car mobility) and its impact on vehicle emission test performance based on vehicle-type owned and usage of vehicle.

TABLE 4 Bivariate Probit Model based on Vehicle-Type

Variables	2004		2005		2009	
	Coefficient	t-score	Coefficient	t-score	Coefficient	t-score
Parameter CO						
Constant	2.382	7.036	2.369	4.881	3.147	12.697
Annual Running Kilometer	-0.007	-0.127	0.086	1.192	-0.045	-1.282
Engine Size Capacity	-0.033	-0.395	0.292	2.486	-0.137	-1.867
Carburettor	-0.806	-5,075	-0.172	-0.579	-1.261	-12.499
Maintenance Quality	-0.441	-10.76	-0.656	-8.385	-0.346	-10.132
Comparing among vehicle Type						
Passenger Car/Sedan(ref)						
- Jeep,Van,SUV	0.139	0.628	-0.485	-1.634	-0.359	-2.292
- Pickup, Light Truck	-0.003	-0.022	-0.16	-0.336	-0.2	-1.735
Parameter HC						
Constant	-	-	3.667	3.337	2.772	7.133
Annual Running Kilometer	0.3504	3.377	0.047	0.244	-0.015	-0.354
Engine Size Capacity	0.683	4.955	-0.029	-0.119	0.162	1.404
Carburettor	-0.109	-0.168	-0.315	-0.757	-0.69	-4.428
Maintenance Quality	-0.083	-1.039	-0.306	-2.304	-0.322	-7.316
Comparing among vehicle Type						
Passenger Car/Sedan(ref)						
- Jeep,Van,SUV	4.7523	0.000	-0.077	-0.126	-0.028	-0.111
- Pickup, Light Truck	0.333	1.308	5.909	0.00	-0.002	-0.016
Disturbance correlation (rho)	0.3675	2.731	0.025	0.149	0.232	2.775
Log likelihood function	-428.138		-190.44		-667.629	
Sample size	727		441		1562	

5. CONCLUSIONS AND FUTURE RESEACH ISSUES

In this study, bivariate probit regression model applied to examine the probability emission test failure of passenger car as part of the inspection and maintenance program at Jakarta city and its surrounding city as known as Bogor, Tangerang, Depok and Bekasi (BODETABEK) in 2004,2005 and 2005. We successfully identified the characteristic of passenger car which affect significantly on emission test failure of Carbon Monoxide and Hydrocarbon. As a preliminary assessment of the inspection and maintenance program for in-use vehicles in the capital city of Indonesia, this study indicates that vehicles running kilometer per year, fuel system injection, engine size capacity and air-to-fuel ratio play a significant role in determining I/M test results. In terms of citizen responsibility or their urban lifestyle toward low carbon society, passenger car owners should be fully responsible to do regular and routine maintenance and repair in order to reduce their passenger car emissions.

Related to vehicle-type own by household and its usage, empirical study confirms that the probability of CO emission test failure of Jeep/SUV and Pickup/light truck are lower than sedan/passenger car type. In order to perform cross vehicle-type evaluation for Inspection and

Maintenance Program, it is necessary to explore more detail in future about individual characteristics more specific especially on fuel consumption, emission control devices, and driving behavior.

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