Will Jakarta Road Pricing Reduce Fuel Consumption and Emission?

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Abstract: After ten years discussion on the concept of Jakarta road pricing, until now apparently there is no implementation decided yet. The concept of road pricing is not even included in the 2020 government's plan following the Kyoto Protocol to reduce CO2 emissions. This study is intended to examine whether the road pricing in Jakarta on 6 percent area will have an impact on macro travelling as has been experienced by Singapore and other countries. Questions out of the research are a singly road pricing method enough, and how far is the impact. The method is subsequently presented using 4 levels of model: selection of pricing type, modal shift model, assignment model, and combined area-indicators evaluation. The study also recommends that the road pricing should be combined with an integrated parking management for middle technology implementation. As predicted, impacts as a result of using the combined strategy will provide fuel consumption reduction of 2.14% in Jakarta city-wide, emission loading will also be reduced by 97 tonnes of NOx and 67,855 tonnes of CO.

Key Words *: TDM, road pricing, parking, public transport.*

1. INTRODUCTION

Jakarta currently has a traffic restraint scheme that has been in place since April 1992. From 6.30 am until 10 am, the city's most heavily trafficked corridor is out of bounds to cars with fewer than three occupants. It is known as the 'three in one' policy. Early results of 3 months after the policy was imposed showed a decrease of 24 percent in the number of private cars entering the zone, and dramatic increases (over 150 percent) in the average travel speed by private cars.

However, in the popular mind at least, the scheme has not been considered a success. Traffic growth between 1992 and 1997 was very high so much of the benefit was probably overwhelmed by the increasing traffic. In addition, a practice emerged of youths offering to ride as passengers for a small fee ("jockeys") to allow drivers to meet the occupancy requirement. This also undermined the image of the scheme (although it demonstrated some willingness to pay on parts of the drivers).

1.1 Comparison to Other Countries

Some cities have implemented Road Pricing as a supporting instrument for controlling the rate of growth of private vehicles. The city of Singapore implemented it since 1975, the city of Seoul's Road Pricing starts since 1996, London (2003), Stockhlom (2006), Trondheim

(1990), New York (1993) and Toronto (1997). The implementation of Road Pricing varies, such as ALS (Singapore), ERP (Singapore), Toll Ring (Seoul and Stockholm), HOT (New York) and the Congestion Charging (London).

The London congestion charging scheme (CCS) was successfully implemented in February 2003 and has measurably reduced traffic flows in central London. A comprehensive analysis of the impact using detailed traffic data combined with vehicle speed is as important as changes in vehicle numbers in reducing emissions. There is also evidence that the speed changes in kmh1 are uniform across the whole range of average speed and therefore changes at the slower speeds have a disproportionate effect on vehicle emissions, newer technology of bus engines. Finally, there is a reduction in emissions of CO2 (-19.5%) but that unlike NO and PM, a little additional benefit is apparent through a new vehicle technology (Beevers, 2004). The evidence presented shows that the congestion charging schemes could assist in attaining both the UK government's targets on air pollution as well as those relating to climate change and other international obligations.

Singapore's Electronic Road Pricing system (ERP) in 1998, which presently charges vehicles according to vehicle type, time of day and location, having regard to the level of congestion reported can reduce road traffic flows by -20% and speed has increased by +33% (Chin, 1996; Tuan Seik, 2000 in Beevers, 2004).

Stockholm's Central Area Charge was reported could reduce road traffic flow by 25% and queue times by 30-50%, and emission by 14% (Reploge, 2008).

1.2 The Jakarta BRT

In Jakarta, the first 12.9 km initial closed system BRT (BRT) corridor began operating on January 15, 2004, which starts from Blok M bus terminal and ends at Kota Station (from north to south on the main road corridors) operated by Trans Jakarta company. The Jakarta city government provided all the initial construction costs for the infrastructure and the buses. In the first year of operation (2004), 15.9 million passengers travelled by this system (approximately 44,000 passengers per day or 3,600 persons/hour/two directions).

The average BRT load factor during the week is 91% and during the weekend is 75%, with the highest load factor during the evening peak on weekdays, up to 143% (BP Trans Jakarta BRT, 2005). The completion of 15 corridors are expected to be finished by the year of 2015, while by the end of 2010 only 10 corridors are already in place.

1.3 The Next Jakarta Road Pricing

Road Pricing as one of the Travel Demand Management strategies has been reformulated due to the high traffic growth rebound after the national economic crisis during 1998-2000. A study by Bappenas-JICA (2004) recommended this issue. The City Administration proposed to replace the 3-in-1 policy with an area pricing scheme (or a "sticker" scheme) to take place in a similar area. The scheme sounds much like the Singapore Area Licensing Scheme. Cars will need to buy and display stickers to enter the area in peak hours (7.30 - 9.30 am and 5.00 – 7.00 pm).

Opposition politicians and a major consumer's organization have come out against the scheme. They said, among other things, that the system would discriminate against the poor. On the other hand, Jakarta's Governor argued that the scheme would hurt only the rich who are the ones who drive cars. But the opposition leader also argued that public transport was insufficient, said that more buses should be put onto the road before the scheme is implemented.

1.4 Jakarta Parking Management

A large amount of criticisms have been voiced against the policy of Jakarta government in the parking management aspect. Currently car pays IDR 2,000/first hour and motor cycle IDR 1,000 makes Jakarta the second cheapest city in terms of parking fares (Jakarta Post, 2010). A transportation observer proposed a zoning system for parking to discourage on-street parking by proposing that the CBD to have a parking fee five times higher than the outskirt zones.

The policy of traffic restraint in Jakarta was enacted in the Structure Plan since 1985 and then be revised in the Art. 6/99. The area of restraint divided Jakarta into 4 categories, as shown in Figure 1. In 2004, the National Planning Bureau (Bappenas) supported by JICA recommended the development restraint area to accommodate the pressure of activity in the southern part of the city (Fig.1, left).

1.5 Study Objectives

This study is intended to examine whether the road pricing in Jakarta on 6 percent area will have an impact on macro travelling as has been experienced by Singapore and other countries. Questions out of the research are: can Jakarta Road Pricing substantially reduce fuel consumption and emission, and is a singly road pricing method enough.

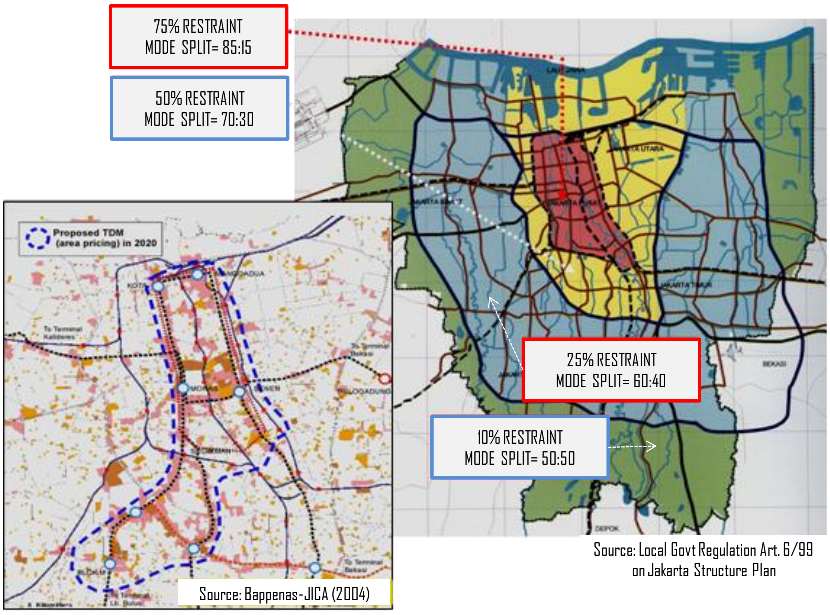

Figure 1. Government policy for traffic restraint in Jakarta

2. METHODOLOGY

The model of research is firstly understanding the travel pattern model, followed by the estimation of O-D estimation data, and finally with the assignment model.

2.1 Jakarta Activity Based Travel Pattern

The model comprising Daily Activity Pattern, Time of Day, Mode-Distribution and Sub-Work based Tour (Yagi, 2006). Nested Logit and Multinomial Logit Model are used to analyze the O-D on mode, time and level of income.

2.1.1 Upper-tier alternatives

Marginal choice probabilities for Out of Home (upper tier) DAP is presented by the equation of:

$$P_r(Out) = \frac{e^{(V_{out}+\theta_{out}\cdot\tau_{out})}}{e^{(V_H)}+e^{(V_{out}+\theta_{out}\cdot\tau_{out})}} \quad (1)$$

$$P_r(H) = \frac{e^{(V_H)}}{e^{(V_H)}+e^{(V_{out}+\theta_{out}\cdot\tau_{out})}} \quad (2)$$

$P_r(H)$ is the probability of having a home DAP; $P_r(Out)$ is the probability of having an out-of-home DAP; V_H is the individual's utility for the home DAP; V_{out} is the individual's utility for the out-of-home DAP; τ_{out} is the logsum variable for the out-of-home DAP nest; θ_{out} is the logsum parameter for τ_{out}.

$$\tau_{out} = ln\left\{\sum_{(p,s)\in A_i}\left[e^{\left(\frac{V_{p,s}+\theta_p\tau_p+\theta_s\tau_s}{\theta_{out}}\right)}\right]\right\} \quad (3)$$

$V_{p,s}$ is the individual's utility for the DAP consisting of primary tour pattern p and secondary tour pattern s; τ_p is the logsum variable calculated from the lower TOD choice utilities for primary tour pattern p.

2.1.2 Lower-tier alternatives:

$$P_r(p,s|Out) = \frac{e^{\left(\frac{V_{p,s}+\theta_p\tau_p+\theta_s\tau_s}{\theta_{out}}\right)}}{\sum_{(p,s)\in A_i}\left[e^{\left(\frac{V_{p,s}+\theta_p\tau_p+\theta_s\tau_s}{\theta_{out}}\right)}\right]} \quad (4)$$

$P_r(p,s|Out)$ is the probability of having a DAP consisting of primary tour pattern p and secondary tour pattern s, conditional on the choice of the out-of-home DAPs.

2.1.3 Time of day model

TOD choice is a multinomial logit model with 15 alternatives, and it is estimated separately for each purpose (i.e., work, school, maintenance, and discretionary). The marginal choice probabilities in the TOD choice are given by:

$$P_r(t|a) = \frac{e^{\left(\frac{V_t+\theta_t\tau_t}{\theta_t}\right)}}{\sum_{t\in\tau_i}\left[e^{\left(\frac{V_t+\theta_t\tau_t}{\theta_t}\right)}\right]} \quad (5)$$

$P_r(t|a)$ is the probability of having TOD combination (i.e., start of the tour and start of the returning segment of the tour) t, conditional on activity pattern a (i.e., primary tour pattern p or secondary tour pattern s).

2.2 Matrix Estimation from Traffic Counts Model

Tamin (1988) has developed an estimation method Maximum-Likelihood Estimation Method (ML) using equation below to maximize:

$$L = c \prod_i p_i^{e_i^k} \tag{6}$$

subject to

$$\sum_i V_i^k - \hat{V}_t^k \tag{7}$$

Tamin (1998) provides a research for public transport O-D estimation by calibrating a trip distribution – mode choice (TDMC) model from passenger counts with a case in Bandung. The research combined a family of aggregate model and a family of mode choice logit model from traffic (passenger) counts and other low cost data. Tamin (2001) also provides an estimation of best number of sample for accurate estimation for O-D matrix, using approaches of (i) proportion factor of trip interchanges for each link, (ii) independence and inconsistencies conditions, and (iii) physical link condition. The research recommended the proportion of count sample of about 3.6% from the total traffic count data.

2.3 Model for Pricing Assignment

Small and Ibanez (1998) determined the seven basic forms of congestion pricing. The need for methods which consider congestion effects to be used in urban and other heavily loaded networks is well recognized (Tamin, 1998). Some approaches that have been developed to include congestion effects in route choice models and equilibrium assignment seem to be the preferred technique on practical and theoretical grounds. This type of assignment technique is consistent with Wardrop's equilibrium principle which can be expressed in terms of the mathematical program.

2.4 Model for Traffic Assignment

- Objective Function:

$$Z(x) = \sum_{x_a} \int_0^{x_a} t_a(x)dx \tag{8}$$

- Subject to

$$x_a \geq 0, t_a \geq 0 \qquad \forall a \tag{9}$$

$$x_a = \sum_{r,a,k} f_r^k \delta_{r,s}^{a,k} \qquad \forall a,k,r,s \tag{10}$$

$$f_{r,s}^k, q_{rs} \geq 0 \qquad \forall k,r,s \tag{11}$$

Where:

$Z(x)$	:	objective function to be optimized, as total travel time in the entire road network as function of vehicle flow, *x* on each link (hour)
$t_a(x_a)$	:	travel time on link *a* as function of vehicle flow on link *a* (hour)

x_a : vehicle flow on link *a* (vehicle/hour)
$f^k_{r,s}$: vehicle flow on path *k* connecting origin *r* and destination *s* (vehicle/hour)
q_{rs} : total vehicle flow connecting origin *r* and destination *s* (vehicle/hour)
$\delta^{a,k}_{r,s}$: coincidence matrix denoting vehicle flow on link *a* of path *k* connecting origin *r* and destination *s* (not unit)

2.5 Model for Estimation of Fuel Consumption and Emission Loading

Although the model for fuel consumption and emission loading have been developed in Indonesia, Netcen formulas (2003) based on the research in the TRL (UK), is selected due to the availability for different car cylinder capacity and type of fuel. For this analysis, we select the model for car capacity of more than or equal to 1,500 cc gasoline fuelled cars.

CO Emission:

$$EF_{CO}\left[\frac{g}{km}\right] = \left[9.53 - 0.118v + 6.2\ 10^{-6}v^3 + \frac{179}{v}\right]1.87 \quad (12)$$

NO_x Emission:

$$EF_{NO}\left[\frac{g}{km}\right] = \left[1.36 - 0.0217v - 0.00004v^2\right] \quad (13)$$

HC Emission:

$$EF_{HC}\left[\frac{g}{km}\right] = \left[2.13 - 0.0317v - 0.000169v^2 + \frac{16.7}{v}\right]1.23 \quad (14)$$

PM 10 Emission:

$$EF_{PM_{10}}\left[\frac{g}{km}\right] = \left[0.0227 - 0.00028v + 1.48\ 10^{-8}v^3 + \frac{0.427}{v}\right] \quad (15)$$

Where $\boldsymbol{v}$ = speed of vehicle on link (km/h)

2.6 TDM Strategy Evaluation

Fergusson (2000) divided the effects of TDM strategies in the surrounding region (site), the corridor and the wider area (regional). Each is shown with the target to be achieved and changes in parameters that would occur (Table 1).

Table 1 TDM evaluation objectives

PERFORMANCE MEASURES	CHANGES	TARGET	DATA	METHOD	MODEL
CORRIDOR					
Vehicle Trips	Reduce	Δ # vehicle trips	DO,RP	Vehicle Count	Trip Generation
Person Trips	Constant	Δ # person trips	DO,RP	Vehicle Count	Trip Generation
Vehicle Miles of Travel	Reduce	Δ # VMT	RP	Survey	Trip Distribution
Vehicle Hours of Travel	Reduce	Δ # VHT	DO,RP	Survey	Route Assignment
Level of Service	Increase	Δ level of service	DO	Model	Network
Traffic Delay	Reduce	Δ # hours of	DO	Model	Network

		delay			
REGIONAL					
Fuel Consumption	Reduce	Δ gallons of gasoline	Model	Model	Projection
Car Emission	Reduce	Δ pounds of pollutions	Model	Model	Emission

Source: Ferguson (2000)

Remarks:
SOV= single occupant vehicle
VMT=vehicle miles of travel
PMT=person miles of travel
VHT= vehicle hours of travel
P/V= persons per vehicle
DO= direct observation
RP= revealed preference
SP= stated preference

2.7 Alternative Strategies

TDM strategy model is to provide a numerical output of each selected alternative in detail which can be defined for purposes of transportation and environmental modelling. The strategy includes (i) providing "push" effect by road pricing, (ii) parking control, (iii) public transport as a network development basis.

a. Congestion Pricing (CP) Quantities Pricing Strategy; three alternatives are assumed to be IDR 5,500, IDR 16,500 and IDR 27,500. Time entry, is in the morning (07:00 to 10:00) and in the afternoon (16:30 to 19:00). CP collection Model is using a Fully Electronic system with Smart Card, so as not to disrupt the traffic due to queue blocking.
b. Control Strategies; parking is fully regulated by law so that the location within the parking area, until the second tariff is imposed in a KP, are three times higher, or IDR 4,000 and IDR 6,000 for the first hour, and with the addition of IDR 2,000 for the next hour. Parking outside the KP is reduced, i.e., the current fixed rate of IDR 2000 per hour to IDR 1000 per hour with the addition of IDR 1000 for the next hour.
c. Public Transport Development Strategy.
   The development of public transportation system is carried out in the BRT package policy (8 corridors).

2.8 Alternative Scenarios

In conducting analysis of the alternative selection process:

- The analysis was conducted in a range of planning in 2010 and 2020.
- 44 alternatives including single, dual and triple combinations alternative strategies are made for the so called "long-list".
- The selected alternative scenarios are chosen from the list to become the so called "short list", using BRT as the basic scenario and parking and road pricing as the other mainstream strategies. This then called as 'dual strategies".
- The analysis was carried out on the single and dual strategy. The single strategy, with each set of a stand-alone alternative on the basis of the same road network and public transport network. The alternative was taken from T3 (three times the unit pricing road pricing, IDR 16,500), and P2 (additional parking fee of IDR 2,000).
- Dual strategy, by setting a combination of strategies, by selecting a combination a combined strategy. The strategy chosen was a combination of:

1. T1P2 (the unit price is a one-time road pricing (IDR 5,500) and additional parking fee of IDR 2,000).
2. T3P2 (three times the unit price of road pricing (IDR 16,500) and additional parking fee of IDR 2,000).
3. T5P2 (five times the unit price of road pricing (IDR 27,500) and additional parking fee of IDR 2,000).
4. T3P4 (three times the unit price of road pricing (IDR 16,500) and additional parking fee of IDR 4,000).

3. DATA COLLECTION AND FINDING

Jakarta has 7,650 km length of road, 40.1 km2 road areas, but this is only 6.2% of occupied land. The road length is growing by 0.01% annually, but car grows by 9.5% p.a. Of all the person trips made by motorized modes, buses make 56% percent (Bappenas-JICA, 2004). Even though the number of buses has decreased due to the economic crisis, the bus is still the most significant mode of transport used by the majority of citizens in the region. However, total private cars dominated the flow of traffic by 98 percent. In contrast, the share of private cars has increased from 22.8 percent to 30.8 percent. Of all modes, the motorcycle has been growing very fast during the last 5 years.

3.1 Model Calibration

Surveys conducted by Bappenas-JICA (2004) indicate that private cars are mostly used by higher income groups (see Figure 2). Interestingly, for the lowest income group the share of non-motorized transport is as high as 60 percent. This might also imply that the existing public transport services are economically difficult for the lowest income group. Therefore, provision of transport means for the poor is one of the important issues to tackle.

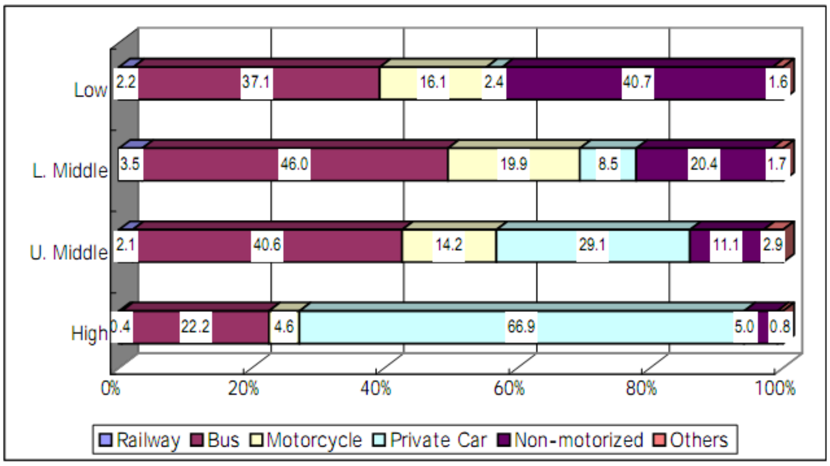

Figure 2. Modal shares by households' income

Stratified JABODETABEK trip purposes forecasted for 2020 as shown in Table 1, which shows the high trip growth by 2.41% (Bappenas-JICA, 2004). Most of higher proportion of trips are originated from the hinterland, i.e., commuter trips. The destination of most trips is not very much changed since 1985, i.e. in the city nucleus of trip attraction, around Sudirman-Thamrin. This causes the traffic congestion during morning peak hours (inbound traffic) and evening peaks (outbound). The important area is then considered as the pricing area for TDM assessment.

Table 2. Annual trip growth estimation

				Growth Rate	*Growth Rate*
Trip Purpose	**2002**	**2010**	**2020**	**2002-2010**	**2010-2020**
HBW	10,548	13,255	14,341	2.90%	0.79%
HBS	10,188	10,443	10,985	0.31%	0.51%
HBO	12,742	16,620	18,444	3.38%	1.05%
NHBB	865	1,143	1,450	3.54%	2.41%
NHBO	2,368	3,767	5,174	5.97%	3.22%
Average Growth Rate					2.41%

The profile of hourly traffic fluctuation as shown in Figure 3 is also convincing the traffic stress (high V/C) during morning and evening period.

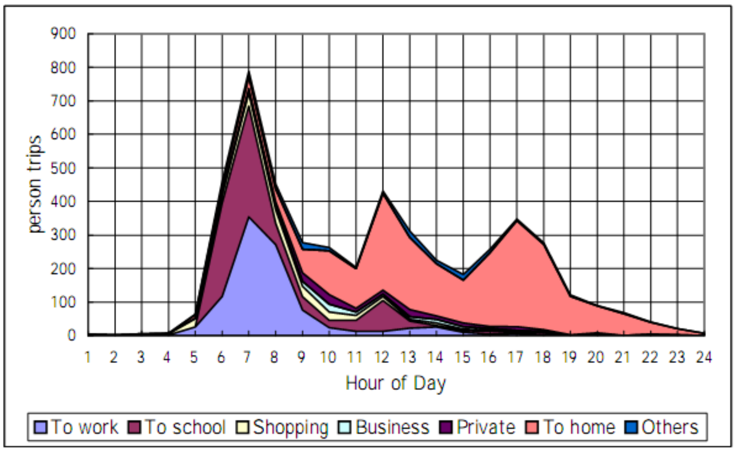

Figure 3. Hourly fluctuation by purpose

The area of pricing located in the Jakarta CBD occupying the area of about 16 km2, is modelled using Emme/2 computer package. The area is defined by a penalty time value as the Willingness To Pay (WTP scenario) for the traffic entering the road boundaries.

City dwellers, and the trip matrix are obtained based on Bodetabek household interviews (Home Interview Survey, HIS) in 2002. The survey data processing is developed by Yagi (2006). Figure 4 describes the activity-based model structure for the Greater Jakarta area.

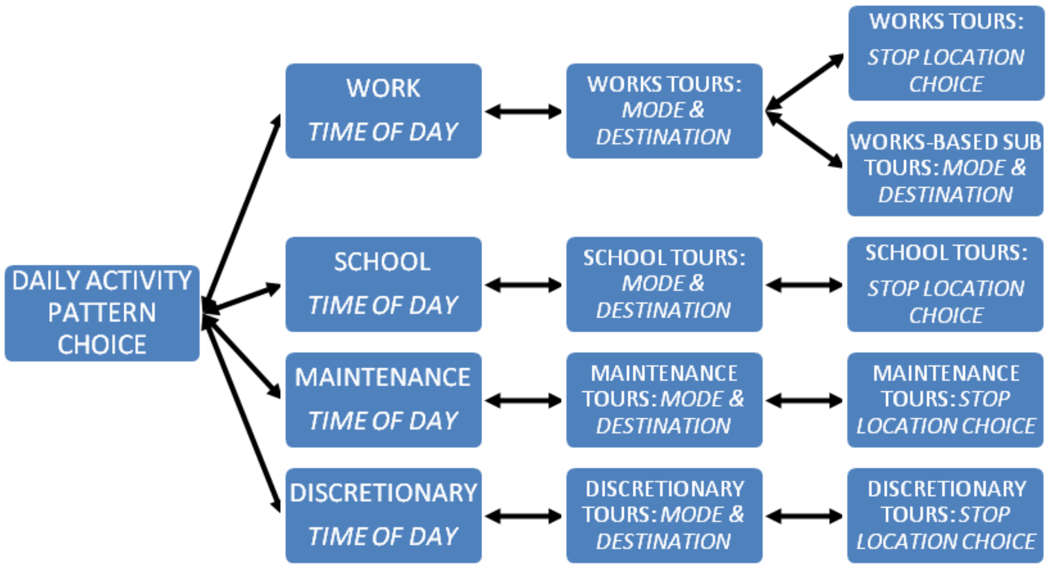

Figure 4. Structure of activity-based model for Greater Jakarta
(Source: Yagi 2006)

Mode split for low, medium, and high income levels is forecasted as in Table 3. The significant private cars reduction is estimated when the BRT and road pricing are implemented.

Table 3. Utility function by income level

Income	Beta	C	Gen Time	Utility	Prob. Car
Low	0.031367	2.28757	13.47	2.71	6%
Med	0.031367	1.24977	13.47	1.67	16%
High	0.031367	-0.03471	13.47	0.39	40%

Assignment also indicates the improvement of travel speed using the BRT and non-BRT corridors after the scheme is implemented. BRT traffic performance is depicted in Table 4.

Table 4. Evaluation at the BRT network

BRT Corridor	Speed (km/h)	Distance (1-way)	Time (hrs)	Bus Fare (IDR)
Blok M- Kota	15.6	13.76	0.88	3,500
Pulo Gadung- Harmoni	14.0	12.40	0.89	3,500
Kalideres- Harmoni	15.2	13.79	0.91	3,500
Pulogadung- Dukuh Atas	20.3	25.45	1.25	3,500

The model estimates that the time saving due to BRT operation is 10.94 minutes for average O-D pairs. Road pricing is assessed with the minimum level of income as Willingness to Pay (WTP) of IDR 5,500. In order to optimize mode shift from private car users, additional parking charging is added on top of the current price, i.e., IDR 2, 000. This is shown in table 5.

Table 5. Probability of choice

Income	Utility	Prob Car

Low	2.72	6%
Med	1.68	16%
High	0.83	30%

The average level of private car users for all parts of social stratification is about 17%, which shows a reduction from the previous (BRT) of 5%. In total, it can reduce 29% from the previous mode shift, as shown in table 6.

Table 6. Reduction of private cars

Income	Prob Car	Delta Prob cars	Prob Cars
Low	9%	3%	33%
Med	22%	7%	29%
High	40%	10%	24%

3.2 Model Validation

Model validation process is to compare the model to the results of the traffic enumeration survey estimates, so that there are small differences that can be tolerated. Traffic count locations and travel speed throughout the Greater Jakarta area were randomly selected (Figure 5). Surveys were conducted in 2007 and 2008. The validated models were for the planning condition in 2008. In this model validation processing stage, it was using the "macros" that exist in the software used (EMME).

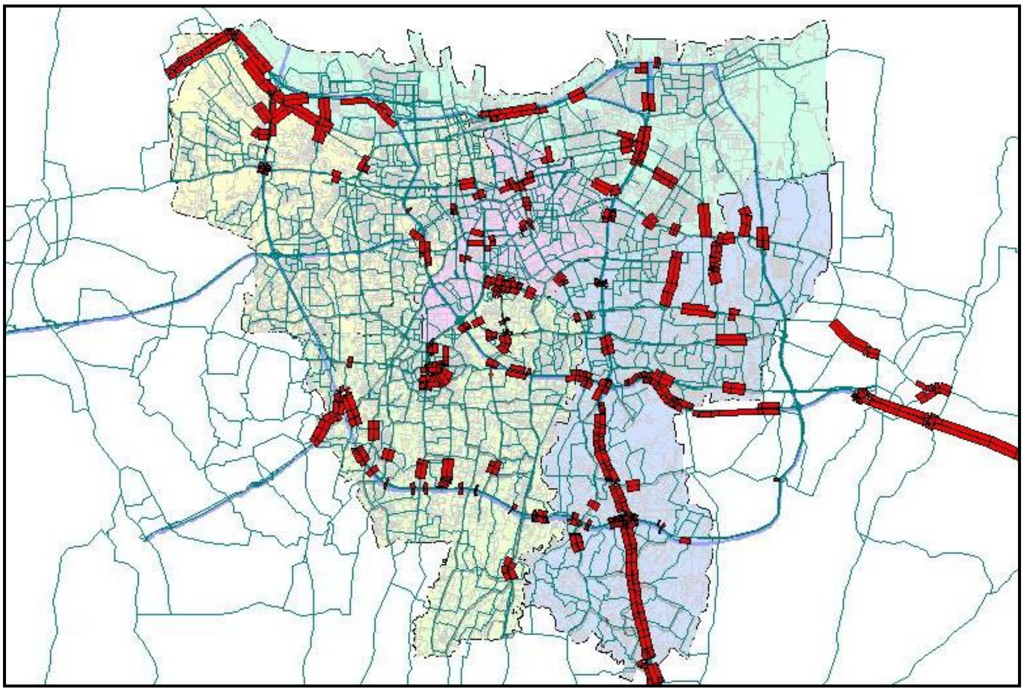

Figure 5. Traffic Counting for Model Validation

Having observed the travel characteristics data in 2008, the model is validated by comparing the assigned flows to traffic volumes, as shown in Figure 6, where the deviation is limited to 10% (as shown by green line) and 20% (red line).

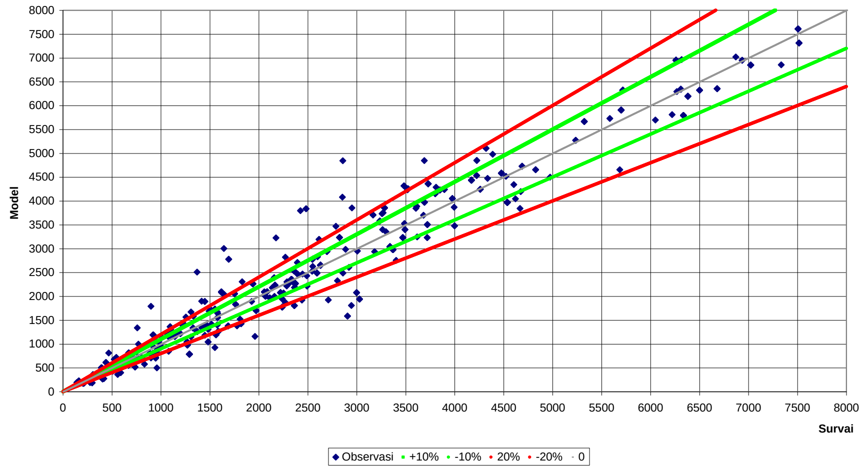

Figure 6 Comparison between the survey and the model

Using these parameters, an assessment has been made to estimate the probability of level of trips, the percentage of public transport users, with various TDM strategies. With the current assumption of pessimistic level of public transport trips of 30%, then the full BRT is assigned that will produce level of demand level increases to 57.6%. Following this, road pricing on top of the full BRT will significantly produce demand increases to 65.4%, and the parking management will finally produce public transport demand to 71.5% cumulatively as shown in Fig.7.

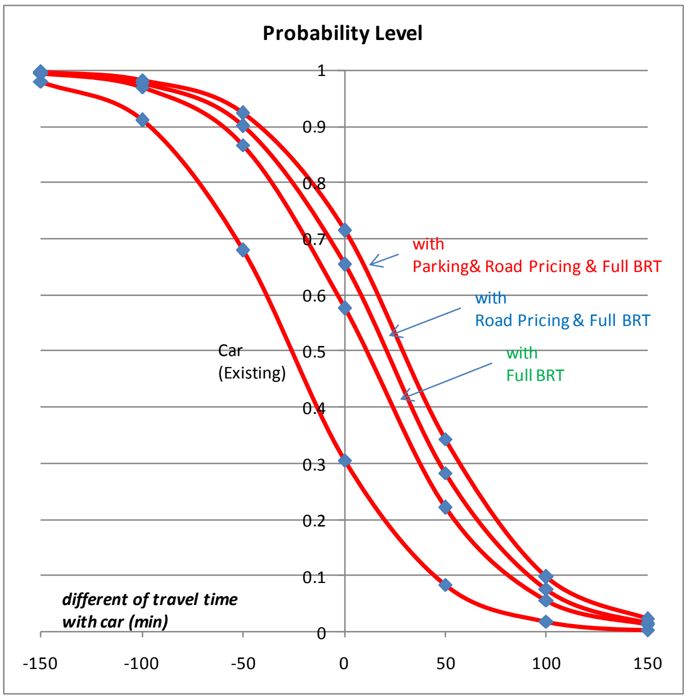

Figure 7. Modal Split Estimation for Various TDM Strategies

The network performance shows the significant improvement using TDM and BRT scenario. The benefit rises both in the TDM area and outside TDM area as well, as shown in Table 7.

Table 7. Performance with and without TDM

Scenario	Area	Veh-Km	Veh-Hr	Speed (km/h)

Do Nothing 2020	Greater Jakarta	11,494,152	8,590,830	27.70
	TDM Area	258,368	17,771	44.06
TDM + BRT2020	Greater Jakarta	10,525,409	6,789,561	29.07
	TDM Area	165,010	5,576	47.12
Impact	Greater Jakarta	968,743	1,801,269	1
	TDM Area	93,358	12,195	3
	Greater Jakarta	8.43%	20.97%	4.95%
	TDM Area	36.13%	68.62%	6.95%

Table 7 shows that the benefit at Greater Jakarta can be measured from the reduction of vehicle-kms at 8.43%, and subsequently 20.97% vehicle-hours reduction and 4.95% of speed increment. In the TDM area the benefit of reduction in vehicles-km is 36.13%, and 68.62% for vehicles-hours reduction and 6.95% for speed increment respectively.

For the purposes of model development, Jabodetabek is zoned by zoning analysis that divides the area into 4 sections, as can be seen in Figure 8.

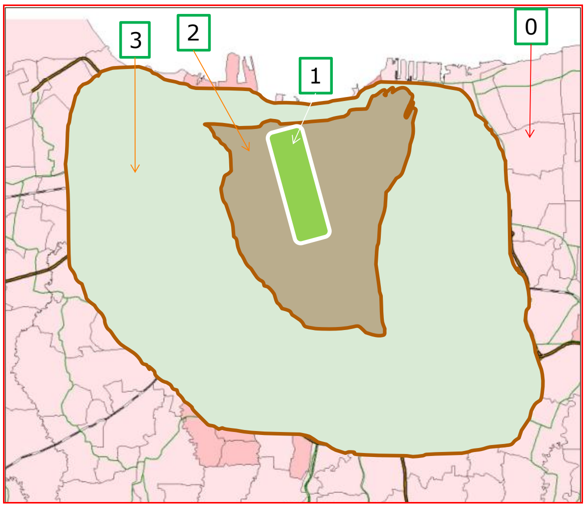

Figure 8. Zoning area : TDM area (1), Inner Tollroad (2), Outer Tollroad (3)

Having observed the travel characteristics data in 2008, the model is validated by comparing the assigned flows to traffic volumes where the deviation is limited to 10% - 20%.

4. ESTIMATION RESULTS

4.1 Improvement of Speed

Having implemented the TDM scenario, the impact of traffic volume and speed in the TDM area and its surroundings were explored. The benefit of the TDM scenario is obvious as reflected by reducing the amount of traffic volume in the TDM area and increasing its travel speed, as shown in Figure 9.

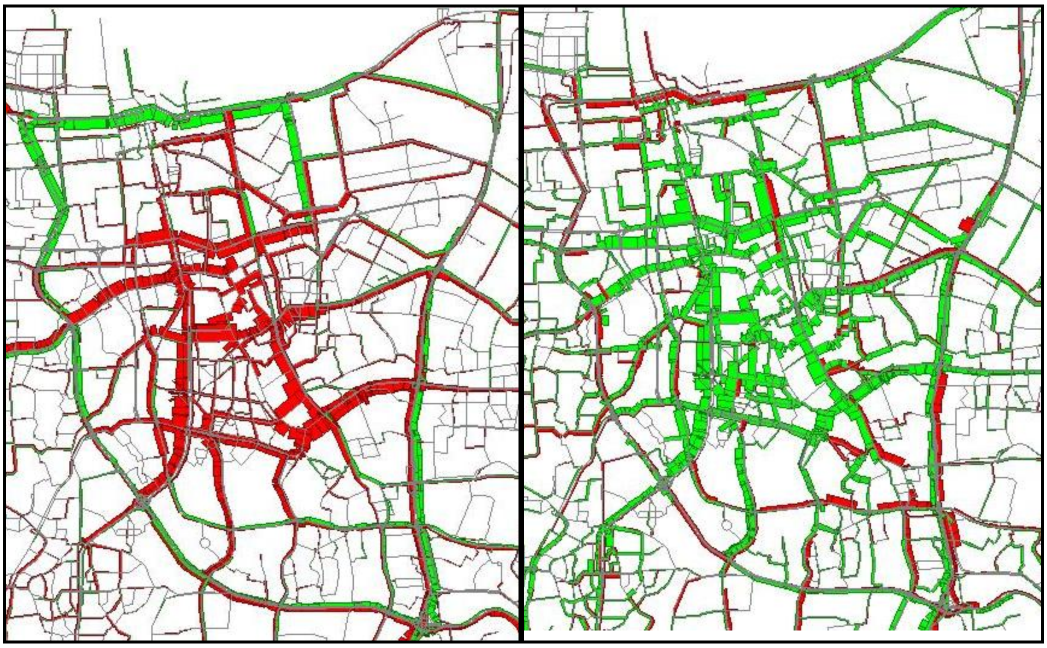

Figure 9. Impacts on volume (left) and speed (right)
Note: Red (left picture) means volume reduces, Green (right picture) means speed increases

4.2 Scenario 1

The scenario 1 assumes the condition whereby all private vehicles entering the TDM area is charged by IDR 5,500, whereas, within the area, the parking rates are subject to additional fee of IDR 4,000. In order to differentiate the impact, the study area is divided into region 0 (Greater Jakarta), 1 (TDM Area), 2 (TDM Area- Inner Tollway) and 3 (Inner Tollway- Outer Tollway). Results of analysis are presented in Table 8**.**

Table 8. TDM performances in the year 2020 scenario

Region	Vehicle-km	Vehicle-hours	Average Speed (km / h)
Greater Jakarta	5,889,691	4,892,691	5.27
TDM Area	165.010	5.576	47.10
TDM Area-Inner Tollway	1,477,600	273.340	37.10
Inner Limit-JORR	2,993,108	1,617,954	4.25

4.3 Scenario 2

The scenario 2 assumes the condition whereby all private vehicles entering the TDM area is charged by IDR 16 500, whereas, within the area, the parking rates are subject to additional fee of IDR 4,000.The analysis is done in the region 0 (Greater Jakarta), 1 (TDM region), 2 (Inner Limit-TDM) and 3 (Inner Limit-JORR). Results of analysis are presented in Table 9.

Table 9. TDM performances in scenario 2 year 2020

Region	Vehicle-km	Vehicle-hours	Average Speed (Km/h)
Greater Jakarta	5,889,708	4,811,684	4.27

TDM	114.732	3.482	47.8
Inner Limit-TDM	1,546,768	279.467	36.6
Inner Limit-JORR	3,001,692	1,608,017	3.25

By zoning the area of analysis, figure 10 shows the comparison of demand of traffic in the area, where in the TDM area, the most congested area, it caters 2% of the total movement. In the TDM and IRR (inner ring road) the traffic is 17% even though the area is only 6%.

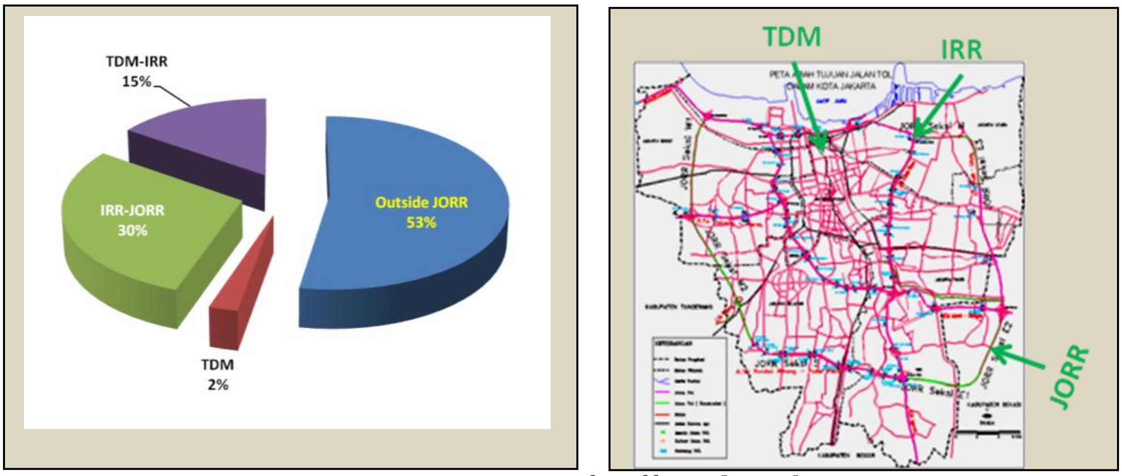

Figure 10. Percentage of traffic volume by zone

4.4 Scenario 3

The scenario 3 assumes the condition whereby all private vehicles entering the TDM area is charged by IDR 27 500, whereas, within the area, the parking rates are subject to additional cost of IDR 4,000. The analysis is done in the region 0 (Greater Jakarta), 1 (TDM region), 2 (TDM Area- Inner Tollway) and 3 (Inner Limit-JORR). Results of analysis are presented in Table 10.

Table 10. TDM performances of scenario 3

Region	**Vehicle-km**	**Vehicle-hours**	**Average Speed (Km/h)**
Greater Jakarta	5,820,981	4,821,359	7.22
TDM	114.282	3.463	38.5
TDM Area- Inner Tollway	1,536,339	280.384	34.1
Inner Limit-JORR	2,971,318	1,599,458	1.25

4.5 Scenario 4

The scenario 4 assumes the condition whereby all private vehicles entering the TDM area is charged by IDR 16 500, whereas, within the area, the parking rates are subject to additional cost of IDR 8,000. The analysis is done in the region 0 (Greater Jakarta), 1 (TDM Area), 2 (TDM Area- Inner Tollway) and 3 (Inner Limit-JORR). Results of analysis are presented in Table 11.

Table 11. TDM performances in scenario 4

Region	**Vehicle-km**	**Vehicle-hours**	**Average Speed**

			(Km/h)
Greater Jakarta	5,812,936	4,790,922	7.22
TDM Area	111.201	3.410	38.7
TDM Area- Inner Tollway	1,531,096	279.058	34.1
Inner Limit-JORR	2,963,805	1,593,442	1.25

4.5 Impact on Air Emissions

The estimated quantities of air emissions are taken into account in the analysis of gases that include CO, NOx, HC and PM-10. Comparison between scenario 1 and 2 for area classification and pollutant types during 2020 is shown in Table 12.

Table 12. Impact of emissions impact

Region	Scenario	CO emissions (Tonnes)	NOx emissions (Tonnes)	HC emissions (Tonnes)	PM-10 emissions (Tonnes)
Greater Jakarta	1	69.322	94	4.330	88
	2	67.855	94	4.241	87
TDM Area	1	399	7	22	1
	2	250	3	11	0
Inner Limit-JORR	1	12.914	76	851	16
	2	12.851	75	846	16
TDM Area- Inner Toll	1	4.279	40	275	5
	2	4.224	40	273	5

4.6 Impact on Fuel Consumption

Fuel consumption (kilo liter) due to the implementation of combination of strategies for scenarios 1 and 2 are presented in Table 13.

Table 13. Impact on fuel consumptions of scenarios 1 and 2

Region	Scenario 2020	Scenario 2020	Impact (%)
Greater Jakarta	290.330	284.214	2.11
TDM	2.055	1.346	34.50
Inner Limit-JORR	55.334	55.076	0.47
Toll Inner Limit-TDM	19.307	19.027	1.45

4.7 Performance Evaluation in the TDM Area

A review on the performance of transportation - based on the traffic performance, environment impact and financing viability, which are combined using weighing factor for Jakarta (Bappenas-JICA, 2004) - is calculated and finally presented as scenario 3 (T3P2) resulting in the highest rank as in Figure 11.

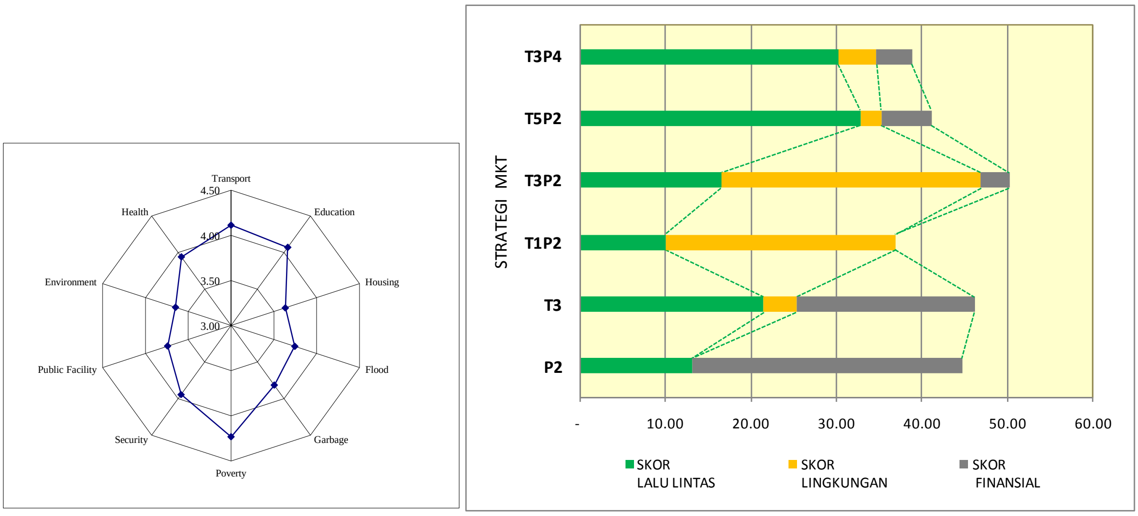

Figure 11. Weighing Factor and Combined Evaluation

5. CONCLUSION

Road pricing cannot be assumed as a single strategy for Jakarta, as a typical modern city in developing countries. However, BRT as a basic strategy should be placed on the first bottom, than pricing and parking management. The test parameters are from technical effects of vehicle-km, vehicle-hours, and average travel speed, pollutant effects by looking at the impact of HC, PM10, CO and NO_x, and the effects of vehicle fuel consumption, as well as the effect of investment costs. Starting from the very few area, which is only 6%, the impact will produce significant improvement, such as vehicle-km, vehicle-hrs, fuel consumption and emission levels. The validation process has revealed the 10% difference between the model and the counts. The analysis points out that Jakarta road pricing should be combined with the integrated parking management for middle technology implementation. As predicted, the impact using the combined strategy will provide fuel consumption reduction of 2.14% in Jakarta city-wide, emission loading is also reduced by 97 tonnes of NOx and 67,855 tonnes of CO. However this is not a guarantee that this policy could be implemented if the social impact is not considered.

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