NON LINEAR MODEL CITY TRANSPORTATION SYSTEM AND CONTROL OF FUEL CONSUMPTION

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Abstract

The national economy development affects the vehicle ownership which ultimately increases fuel consumption. The rise of the vehicle ownership is dominated by the increasing number of motorcycles. This research aims to analyze and identify the characteristics of fuel consumption, the city transportation system, and to analyze the relationship and the effect of the city transportation system on the fuel consumption. A multivariable analysis is used in this study. The data analysis techniques include: a Corelational Analysis, a Multivariate Regression Analysis by using the R software. More than 70% of fuel is consumed in metropolitan cities, 14.2% in large cities and 15.67% in moderate cities. The city transportation system variables that strongly affect the fuel consumption are population, public vehicles, and private vehicles. The effect of the net population density is not too big. The higher the population density is, the larger the fuel consumption will be. This not same the Kenworthy theory (1999) that the higher the population density is, the lower the fuel/per capita consumption will be.
The model for the effect of the city transportation system on the fuel consumption = $0.1441 * MPU^{0.1590} * MPP^{0.2148} * \mathbf{JP}^{0.7659}$. This method can be developed to control the fuel consumption by improving qualified and reliable public transportation services, efficient routes, improving the city potentials, reducing the number of private vehicles and land use arrangement, transforming transportation to information technology.

Key words: consumption, fuel, city typology, transportation system, relationship.

1. Introduction

The development of the national economy affects the vehicle ownership which will increase the fuel consumption (Marcotullio, 2007). In 1983, Indonesia has a total of 5 million units of vehicles; in 2003 the number grew quickly and reached over 20 million units or 7.2% each year (Department of Mineral Energy Resources, 2004). The growth of vehicle ownership is dominated by motorcycles. The Department of Mineral Energy Resources (2004) states that fuel consumption for transportation in Indonesia has risen sharply. If in 1993 fuel consumption was around 200 million oil-equivalent barrels (sbm), in 2003 it doubled to 400 million oil-equivalent barrels. Fuel consumption of the industrial sector is relatively constant when compared to the fuel consumption by the transportation sector (Department of Mineral Energy Resources, 2004). This means that the transportation sector is the largest fuel consumer (Official Nebraska Government Website, 2003), which is around 50% of the world fuel consumption, road transportation in developed countries consumes around 80% of the entire fuel consumption in the transportation sector. In developing countries, energy consumption in the transportation sector is 70 % (Robert Q. Riley Enterprise, 2006). The transportation sector is the largest fuel consumer and in the status quo, the need for fuel is bigger than the government’s capability in providing subsidies (Observing and Evaluating Team on the National Transportation Performance/TPEKTN, 2008). Therefore, the fuel consumption for road transportation should be a concern, for example energy saving through more beneficial policies (Breheny, 1992) or by raising awareness on the issue of sustainable energy consumption (Regional Office for Europe, 2002).
Pearece dan Warford (1996) point out that the concept of sustainable transportation is the foundation as well as the challenge in developing and implementing it effectively. One of the challenges in sustainable transportation is the urban resource conserving mobility (Carrol, 1977; Cheng-Min and Cheng-Hsien , 2007) or by developing a transportation mobility strategy in developing countries (World Bank, 2006). Improving the city transportation system, specifically those triggered by growing ownership and consumption of private vehicles, has a negative effect on the city, such as traffic jams and traffic accidents, space usage, environment conservation (gas emission, air pollution, energy resource exploitation, etc.). This occurs in large cities in developed countries and large cities in developing countries, like Rio de Jenairo, Mexico City, Jakarta, New Dehli, Bangkok.
In implementing the city transportation system, vehicles are direct consumers of the fuel (except for pedestrians and engineless vehicles). To repress the fuel consumption, there needs to be an attempt to find out the effect of the city transportation system on the fuel consumption. Stopher And Meyburg (1987), state that there is a significant relationship between the city transportation system and fuel consumption with uncovered influencing factors.
The city typology and the city transportation system affect each other. The parameter of the city typology in this regard is a demand, including: population density, population, land usage and regional gross domestic product (RGDP). Whereas the parameter of the city transportation system is divided into 2 (two) parts, which are: supply: road length, road network pattern, road condition, public transportation vehicles, cargo vehicles and public transportation route length. There is also demand: private vehicles.
One thing rarely found in developing cities, especially in Indonesia is research on the fuel consumption using the city transportation system variable presented in the model. The research that creates the model of the effect of the city

transportation system on the fuel consumption in developing countries, can hopefully be made into a macro model, which is a useful basis in making decisions and national policies, based on a strongly justified research. This research aims to create a tool to help the planner and designer of the city transportation system in examining the effect of the city transportation system on the fuel consumption.

2. Literature review

The literature review in this research contains in detail varies theories and has three objectives. First, it presents theories and experience that clarify and strengthen what has been previously mentioned in the introduction (especially reaffirming the various backgrounds and reasons for choosing the research topic). Second, it presents the result of searching through various theoretical and conceptual knowledge considered relevant to the research, like the concepts of the city transportation system, city typology, fuel consumption, factors that influence the city transportation system on fuel consumption. The review is used as knowledge enrichment and background knowledge relevant with the research, explaining the theoretical and pragmatic knowledge from searching the city transportation system, city typology and fuel consumption both in the world (globally), in certain cities abroad and cities in Indonesia.

The literature review is used to gain information on: (a) the source and elements of the city transportation system; (b) city typology; (c) fuel consumption; (d) the effect of the city transportation system on the fuel consumption. The cross-reference review is to gain information on the parameter, factors, and variables, also to gain information and support (justification of researh) of research opportunities from parameters that have barely been touched and have not been done in developing countries, like the model for the effect of the city transportation system on the fuel consumption which is considered the key in the sustainable and environmental transportation system.

The Concept of City Transportation System

Transportation is the attempt of transferring, moving, carrying, or transmitting an object from one place to another so the object will be more beneficial or can be useful for certain purposes. The above definition can mean that transportation is the proses of transferring, the process of moving, the process of carrying, and transmitting that can not be separated from supporting tools to ensure the process runs smoothly according to the desired time (Miro, 2005).

The Concept of City Typology

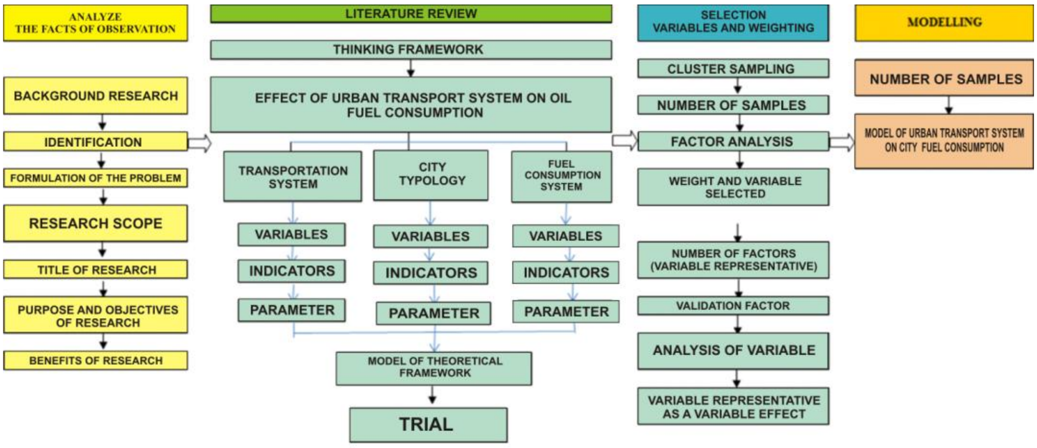
City is a very complex human-lead environment. A city seen as a container has very complex humans inside, have experienced interrelation processes between humans and the environment. The product of interrelation produces an orderly pattern in land usage which caused the city structure theory to rise (Rodrigue, 2004). City can be discussed through various perspectives. City morphology is the city public space, like downtown areas, city space, main roads. City forms basically occur due to interactions between inhabitants. Individuals in city societies are not isolated in individual activities, but interact in the form of city space.

The Concept of Fuel Consumption

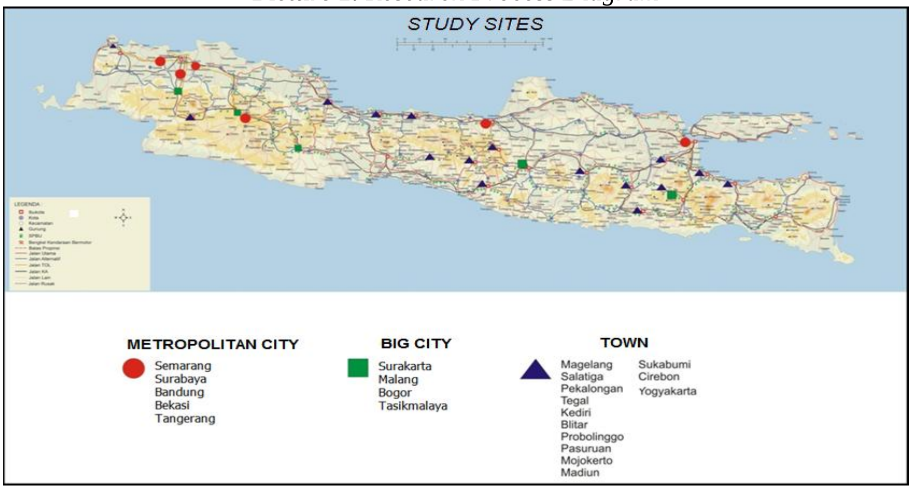
Fossil energy is a form of unrenewable energy. This energy type has long been known as fossil fuel. Meanwhile, fossil fuel supplies are limited, because it is unrenewable energy, in time it will not meet the people's needs or run out altogether (Department of Land Transportation, 2008). Therefore, there should be a national fuel consumption conservation especially in the land transportation sector. Fossil fuel is an organic substance needed in combustion to create energy or force which is the result of crude oil distillation into the desired fractions. The types of fossil fuel include: avgas, petrol, karosene, avtur, diesel oil as well as burning oil. The fuel consumption observed in this research includes petrol and diesel oil, because motor vehicles in the Java island (2007 and 2008 data) use more petrol and diesel oil.

3. RESEARCH METHODS

As stated in the theoretical study, this research includes many variables and data, so the focus is on multivariate analysis which is an application method related to the large number of variables made in each object in one or more data simultaneously, whereas the development analysis for the nonlinear model is done with the help of software R (nonlinear least square). To determine which independent variable should be put into the nonlinear least square (nls) model, the Cobb-Douglas production function is used, which is a production function involving the influence of the input used with the output desired. The diagram of the research process can be seen in Picture 1 below.



Picture 1. *Research Process Diagram*



Picture 2. *Research Location*

4. Analysis

Data on Fuel Consumption

The data on the fuel consumption was collected in 2007 and 2008 based on petrol station purchases from Pertamina (Indonesian Oil Company) in each city each year. The average fuel consumption (petrol+diesel) of cities in Java is 3.411.421 kilo litres /year, where the petrol is 2,432,872 kl/year, diesel fuel is 978,549 kl/year. The comparison between petrol and diesel fuel consumption is 71%: 29%. Petrol is used more by motor vehicles in Java island because the number of private vehicles is very high (6,384,406 units or 99.37% of the total number of passenger vehicles), the number of public transportation vehicles is low (40,726 units or 0.63% of the total number of passenger vehicles), the percentage of motorcycles is more than 82% of private vehicles.

The highest fuel consumption/year in 2008 was Surabaya (650,085 kilo litres/year), the lowest fuel consumption/year was in Mojokerto in 2007 (13,568 kilo litres/year). Meanwhile, Sukabumi had the highest fuel consumption/population/day (0.6 litres). The city of Sukabumi has a developed area width of 19.63 km2, 12 units of petrol stations. The population of the Sukabumi District partly live around the city of Sukabumi, buying fuel in petrol stations in the city of Sukabumi. Sukabumi District has a population of 2,391,736 people with an administrative area of 4,199.7 km2, the largest throughout Java and Bali, 4.48 % of developed area (18.814 ha). The population of Sukabumi District is almost the same as the city of Bandung's population (2,329,928 people). Bandung has 96 petrol station units. The number of petrol stations in Sukabumi District is 20 units. So there is a big possibility that the people of Sukabumi District buy fuel in the city of Sukabumi.

The total total fuel consumption of moderate cities in Java ranges between 13.568 kl/year- 87.898 kl/year. The total fuel consumption of large cities ranges between 99.968 kl/year- 152.155 kl/year. The fuel consumption of metropolitan cities is 292.923 kl/year – 650.260 kl/year. The average, maximum, minimum fuel consumption and number of gas stations can be seen in Table 1.

Table 1. Fuel Consumption all Cities in Java

No.	Description	Maximum	Minimum	Average
1.	Number of gas stations	96	3	22.32
2.	Total Fuel Consumption (kl)	650,260	13,568	155,064.56
	Petrol Consumption (kl)	456,962	9,776	110,585.09
	Diesel Fuel Consumption (kl)	193,123	3,792	44,479.47
3.	Petrol fuel consumption/population/day(l)	0.65	0.12	0.36
4.	Diesel Fuel consumption/population/day(l)	0.29	0.07	0.15

Source: Total Results, Mudjiastuti Hadajani, 2011.

Model Development

The Total City Fuel Consumption Model for total fuel consumption in all cities in Java is:

Lntot= A0 + A1lnpj + A2lnbu + A3lnmpu + A4lnmpp +A5lnbp + A6lnab + A7lnsm + A8lnkpdt + A9lnjp + A10lnpdrb + A11lnptr + A12lnldt

The above equation is analyzed using the R program (Fox, 2002). Table 1 shows the VIF value for independent variables in the model 1 equation. Some VIF value of independent variables are more than 10 and some are less than 10, variables with a VIF value above 10 is the Lnptr variable of 11.0181. The next process is to remove the Lnptr variable, and produce a new model that does not include that variable.

Table 2 VIF (model 1) All Cities Total Fuel Consumption

vif(model 1) –Total Fuel of All Cities					
lnpj	lnbu	lnmpu	lnmpp	lnbp	lnab
5.4793	1.9281	6.5396	25.9299	2.0185	21.4938
lnsm	lnkpdt	lnjp	lnpdrb	lnptr	lnldt
24.2485	238.7008	1,963.4482	6.7604	11.0181	1,404.2180

Once the Lnptr variable is removed, a new model is obtained like in Table 3. Although the Lnptr variable has been removed, it is evident that the VIF value of independent variables is still big though not as big as it was previously (the non multicolinierity assumption has not been fulfilled). In the second model, the VIF value above 10 is in the Lnsm variable of 18.8100. The next process is to remove the Lnsm variable, and produce a new model that does not include that variable.

Table 3 VIF (model 2) Total Fuel Consumption of All Cities

Vif (model 2) –Total Fuel of All Cities					
lnpj	Lnbu	lnmpu	lnmpp	lnbp	lnab
3.4898	1.6866	6.5382	25.7073	1.9401	19.3867
lnsm	Lnkpdt	lnjp	lnpdrb	lnldt	
18.8100	236.2672	1963.0924	6.5579	1399.1252	

Table 4 shows that the Lnsm variable has been removed. Although the Lnsm variable has been removed, the VIF value for independent variables is still big though not as big as it was previously (the non multicolinierity assumption has not been fulfilled). In the third model, the VIF value above 10 in the Lnab variable is 10,6945. The next process is to remove the Lnab variable, and produce a new model that does not include that variable.

Table 4 VIF (model 3) Total Fuel Consumption of All Cities

Vif (model 3) – Total fuel consumption of all cities					
lnpj	lnbu	lnmpu	lnmpp	lnbp	lnab
2.9457	1.6268	4.7517	21.5801	1.9112	10.6944
lnkpdt	lnjp	lnpdrb	lnldt		
196.1071	1623.0934	6.5568	1170.7635		

Table 5 shows that the Lnab variable has been removed. Although the Lnab variable has been removed, the VIF value of independent variables is still big though not as big as it was previously (the non multicolinierity assumption has not been fulfilled). In the fourth model, the VIF value above 10 is the Lnkpdt variable of 189,9373. The next process is to remove the Lnkpdt variable, and produce a new model that does not include that variable.

Table 5 VIF (model 4) Total Fuel Consumption of All Cities

Vif (model 4) – Total fuel consumption of all cities					
lnpj	lnbu	lnmpu	Lnmpp	lnbp	lnkpdt
2.8547	1.3956	4.5583	9.5120	1.9070	189.9373
lnjp	lnpdrb	lnldt			
1578.5464	6.4243	1125.1742			

Table 6 shows the Lnkpdt variable has been removed. Although the Lnkpdt variable has been removed, the VIF value for independent variables is still big though not as big as it was previously (the non multicolinierity assumption has not been fulfilled). In the fifth model, the VIF value above 10 is the Lnldt variable of 11,2038. The next process is to remove the Lnldt variable, and produce a new model that does not include that variable.

Table 6 VIF (model 5) Total Fuel Consumption of All Cities

Vif (model 5) – Total fuel consumption of all cities					
Lnpj	lnbu	lnmpu	lnmpp	lnbp	lnjp
2.8185	1.3807	4.5464	9. 0588	1. 8982	19.2361
Lnpdrb	lnldt				
6.2855	11.2038				

According to Table 7 (model 6), the VIF value of each variable is now lower than 10. This means the non multicolinierity assumption has been fulfilled, next the variable with the significant value is chosen. From Table 8 (model 7), the Public Passenger Vehicles, Private Passenger Vehicles and JP variables have significant values and will be used in the Total Fuel Consumption of All Cities model.

Table 7 VIF (model 6) Total Fuel Consumption of All Cities

vif(model 6) – Total fuel consumption of all cities					
lnpj	lnbu	lnmpu	lnmpp	lnbp	lnjp
2.3793	1.3803	4.4183	8.9208	1.8683	9.6168
lnpdrb					
6.1371					

Table 8 VIF (model 7) Total Fuel Consumption of All Cities

Vif (model 6) – Total fuel consumption of all cities					
lnpj	lnbu	lnmpu	lnmpp	lnbp	lnjp
2.3793	1.3803	4.4183	8.9208	1.8683	9.6168
lnpdrb					
6.1371					

Model on the Effect of The City Transportation System – Fuel Consumption of All Cities

By using the R program the following output is produced:

```
lm(formula = lntot ~ lnmpu + lnmpp + lnjp)
Residuals:
    Min       1Q   Median       3Q      Max
-0.47247 -0.14277  0.02748  0.14329  0.35725
Coefficients:
          Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.93692    0.55982  -3.460  0.00141 **
lnmpu        0.15898    0.05539   2.870  0.00683 **
lnmpp        0.21475    0.06668   3.221  0.00271 **
lnjp         0.76590    0.08850   8.654 2.55e-10 ***
---
Signif. Codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.2102 on 36 degrees of freedom
Multiple R-squared: 0.9723,     Adjusted R-squared:  0.97
F-statistic: 421.1 on 3 and 36 DF,  p-value: < 2.2e-16
```

Based on the above output, the total fuel consumption model is:

Lntotal = -1.9369 + 0.1590 Lnmpu + 0.2148 Lnmpp + 0.7659 Lnjp
This equation can also be written as:
Total fuel consumption = $e^{-1.9369}$. $MPU^{0.1590}$. $MPP^{0.2148}$. $JP^{0.7659}$
The total fuel consumption model of all cities in Java has a model accuracy of 0.9723, meaning 97.23% consumption. Total fuel consumption of all cities in Java is influenced by variables of public passenger cars, private passenger cars, and population. The remaining 2.77% total fuel consumption of all cities in Java is influence by other variables. The resulting model of the influence of the city transportation system, cities in Java toward fuel consumption:

Total fuel = $0,1441 * MPU^{0.1590} * MPP^{0,2148} * JP^{0,7659}$ (1)

Note:
MPU= public passenger vehicles; MPP= private passenger vehicles; JP= population

From the model (1) above, the city typology variable which is the number of city people has a strong effect on the total fuel consumption. This strong effect is shown through the power value that approaches 1. This means that the cities with a bigger population will have higher total fuel consumption. Public passenger vehicles has an effect on the total fuel consumption, though not too strongly. Public transportation is actually very helpful in controlling fuel consumption because people who use private passenger vehicles can be accommodated by public passenger vehicles. The existing condition shows that the number of public passenger vehicles in each city is generally higher than the number of buses. The bigger the number of public passenger vehicles is, the bigger the total fuel consumption will be. To manage fuel consumption there needs to be a transition from motorcyle/private vehicle usage to public transportation.

Elasticity is measuring the sensitivity of one variable to another variable. In detail, elasticity can be explained as a number which shows the percentage of change happening to one variable as a reaction to each 1 percent rise of another variable (Robert S.P. dan Daniel L.R., 2009). From the above definition, it can be interpreted that one percent change in public passenger vehicles by assuming that the values of private passenger vehicles and population remain constant will cause a change to the total fuel consumption of all cities in Java up to 0.1590 percent. One percent change of private passenger vehicles by assuming that the values of public passenger vehicles and JP remain constant, will change the total fuel consumption of all cities in Java up to 0.2148 percent. One percent of population by assuming that the values of private passenger vehicles and public passenger vehicles remain constant, will change the total fuel consumption of all cities in Java up to 0.7659 percent.

The Effect of public passenger vehicles on Total Fuel Consumption in All Cities
The effect of public passenger vehicles on fuel consumption is measured by using elasticity. An increase of public passenger vehicles of 1 percent causes an increase in the fuel consumption prediction of up to 0.1590 percent. Figure 3 shows the simulation of the effect of the number of public passenger vehicles in the prediction of the Total Fuel Consumption of All Cities in Java.

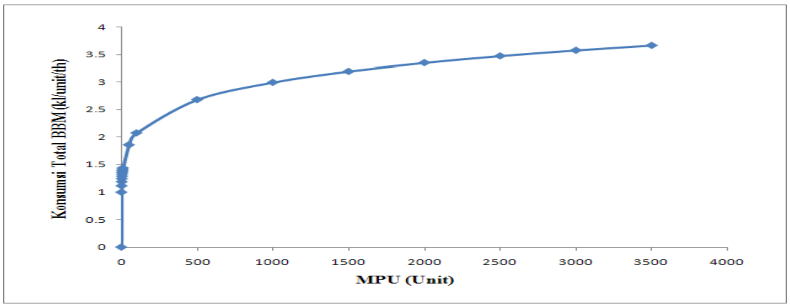


Figure 3. Simulation on the Effect of Public Passenger Vehicles in the Prediction of the Total Fuel Consumption of all Cities in Java

The Effect of Private Passenger Vehicles on Total Fuel Consumption in All Cities
The effect of private passenger vehicles on the total fuel consumption can be measured using elasticity. An increase of private passenger vehicles of 1 percent causes an increase in the fuel consumption prediction of up to 0.2148. Figure 4 shows the simulation of the inflluence of the number of private passenger vehicles in the prediction of the Total Fuel Consumption of all Cities in Java.

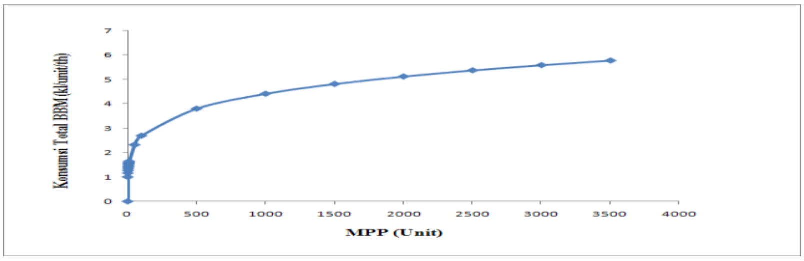


Figure 4. Simulation on the Influence of private passenger vehicles in the Prediction of the Total Fuel Consumption of All Cities in Java

The Effect of Population on the Total Fuel Consumption in All Cities

The effect of population on total fuel consumption can be measured using elasticity. An increase of population of 1 percent causes an increase in the fuel consumption prediction of up to 0.7659. Figure 5 shows the simulation of the inflluence of the number of population in the prediction of the Total Fuel Consumption of all Cities in Java.

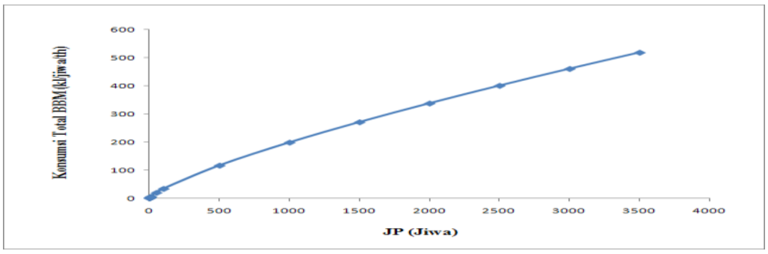


Figure 5. Simulation on the Influence of population in the Prediction of the Total Fuel Consumption of All Cities in Java

Controlling Fuel Consumption

From the results of the above model, the transportation system variables that influence fuel consumption include public passenger vehicles, private passenger vehicles, population. To control fuel consumption due to the public passenger vehicles variable is by changing public passenger vehicles with a larger capacity vehicle/buses/Bus Rapid Transit (BRT), if possible, use *Light Rapid Transit* (LRT) or *Mass Rapid Transit* (MRT). For the private passenger vehicles variable, it is by suppressing the growth of private vehicles (private passenger vehicles and motorcycles), using them as little as possible, providing reliable, qualified and cheap public transportation, setting an age limit on operating vehicles (private passenger vehicles + motorcycles), schools or work provide pick-up services, car-pooling.

The concept of moving people from one place to another from passenger vehicles is based on the people's need to move or the people's presence for certain purposes, not movement of vehicles. Nowadays the people's presence can be exchanged with voices, writing, pictures and activities can still be done. Therefore, to control the fuel consumption due to the population variable is by transforming transportation to information technology, especially passenger transportation. By transforming transportation to information technology, fuel consumers will reduce and activities can still be done in an even shorter time than the transporting process.

Some examples of transforming transportation to information technology are as below:

1) Invitation to various meetings: at the beginning paper invitations were used and sent to each place personally through transportation, later they have been shifted to inviting through short message service (SMS).
2) Booking traveling tickets: it was previously done by visiting personally to travel agents, now people can get tickets on-line without having to travel.
3) Using e-banking: to know the account or savings balance and do transactions can be done without having to go to the bank, but just by using the *e-banking* facility, so the purpose of checking the balance and doing transactions can be completed. The same goes for ATM, people do not have to go to the bank to withdraw money and do transactions, as well as pay monthly water, electricity and telephone bills.
4) Talking through SKYPE, communicating through Facebook and email, people do not need to travel or use transportation.
5) School or work registration, shopping can be done *on-line*.

5. Conclusion

The effect of the city transportation system on the fuel consumption :

1. Population has a very strong effect on the fuel consumption.
2. Personal and public vehicles affect the fuel consumption.
3. The model of the effect of the city transportation system on the total fuel consumption = $0.1441 * MPU^{0.1590} * MPP^{0.2148} * JP^{0.7659}$
5. Controlling fuel consumption: controlling the fuel consumption by improving qualified and reliable public transportation services, efficient routes, improving city potential, reducing the number of personal vehicles and *land use* arranging, transforming transportation to information technology.

References

1. Aman, Djauhari, *Pedekatan Fungsi Cobb-Douglas dengan Elastisitas Variabel dalam Studi Ekonomi Produksi, Informatika Pertanian*, 1999, Vol 8.
2. Breheny, M., *Sustainable Development and Form Europiean, Research in Regional Science*, 1992, vol 2.
3. Carrol, T.A., *Calculating Community Energy Demand. In Energt and the Community*, edited by R.J. Burby and A. Flemming Bell. Cambridge, MA: Ballinger, 1977.
4. Cheng-Min F., and Cheng-Hsien H., The Implicaion of Transort Diversity for Sustainable Urban Transportation, *Journal of The Eastern Asia Society for Transportation Studies*, 2007, Vol. 7, 1236-1249.
5. Departement ESDM, *Konsumsi Energi di Indonesia*, 2004
6. Departement Perhubungan Darat, *Perencanaan Umum Pengembangan Transportasi Massal di Pulau Jawa*, Jakarta, 2008.
7. Fox John, *Appendix to An R and S-Plus Companion to Applied Regresion, Strutural Equation Models*. 2002.
8. Marcotullio Peter J., Limited Provision of Roads as Botleneck on Vihecle, *Journal Environment and Pollutan vol.30*, no 1, Hunter college CUNY, NY, USA 2007.
9. Miro Fidel, *Perencanaan Transportasi*, Erlangga, Jakarta, 2005.
10. Mudjiastuti Handajani, Model of the Urban Transport System in Java on City Fuel Consumption, *World Academy of Science, Engineering and Technology, an International Journal of Science, Engineering and Technology*, WASET, Cemal Ardil, Paris, issue November 2011.
11. Newman, P.W.G dan Kenworthy J., Gasoline Consumption and Cities : a comparison of us cities with global survey, *Journal of The American Planning Association*, 55: 24-37, 1989.
12. Official Nebraska Goverment Website, *Energy Consumption Transportation Sector*, 2003, Nebraska.
13. Pearece dan Warford, *World Without End*, World Bank, Oxford University Press pp 43-44, 1996.
14. Regional Office for Europe, *Sustainable Consumption and Transport*, United Nations Environment Programme, 2002
15. Robert Q. Riley Enterprise, LLC, *Energy Consumption and The Environment, Impact and Option for Personal Transportation*, Phonix, 2006.
16. Robert, S.P. and Daniel L.R., *Mikroekonomi*, Edisi 6, Jilid 1, P.T. Indeks, Jakarta, 2009
17. Rodrigue Jean-Paul, Transportation and The Environment, Dept. of Economics & Geography Hofstra University, Hempstead, NY, 11549 USA, 2004.
18. Stopher Peter R. dan Meyburg Armin H., Urban Transportation Modelling and Planning, Lexington books, London, 1987.
19. Tim Pemantau dan Evaluasi Kinerja Transportasi nasional (TPEKTN), Urgensi Kebijakan dan Program Komprehensif Dalam Penghematan BBM Transportasi, 2008.
20. World Bank, A Panorama of Urban Mobility Strategies in Developing Countries, Hubert Metge, Aurelie Jehanno, Systra 2006.