FORMULATION OF A CAR TAXATION ANALYSIS MODEL IN JAPAN AND AN ASSESSMENT OF ITS VIABILITY IN DEVELOPING COUNTRIES

Yoshitsugu HAYASHI
Professor
Dept. of Geotech. & Env'l. Eng'g.,
Nagoya University
Furo-cho, Chikusa-ku Nagoya,
4640814 Japan
Fax: (81-52)-789-1454
E-mail: yhayashi@genv.nagoya-u.ac.jp

Hirokazu KATO
Assistant Professor
Dept. of Geotech. & Env'l. Eng'g.,
Nagoya University
Furo-cho, Chikusa-ku Nagoya,
4640814 Japan
Fax: (81-52)-789-1454
E-mail: kato@genv.nagoya-u.ac.jp

Rene Val R. TEODORO
Graduate Student
Dep't. of Civil Engineering
Nagoya University
Furo-cho, Chikusa-ku Nagoya,
4640814 Japan
Fax: (81-52)-789-5175
E-mail: val@genv.nagoya-u.ac.jp

Abstract: This study presents the formulation of a model system that analyzes the effects of car related taxes for Japan and the examination its viability for developing countries. The initiatory model is designed to examine the changes in car fleet; CO_2 emissions; and total tax revenues, attributed to car-related taxation. Results for the case of Japan highlights the forecasting estimates, sensitivity tests and policy analysis for different taxation scenarios. The model framework was then modified to suit the concerns of developing countries. Assessment of the viability of the model includes the review of car-related tax systems, its pertinent issues and trends; the formulation of a preliminary work procedure for the development and application of the model system; and the analysis of the implication of modeling results for the case of Japan in the context of the Southeast Asian region. Initial results hinted the viability of model development and its potentials as a tax reform tool.

Key Words: car tax, car ownership, emissions forecasting, CO_2 life cycle assessment

1. INTRODUCTION

Increasing motorization trend, aging vehicle fleet, and worsening traffic congestion are among the most significant factors contributing to the severe degradation of air quality in urban centers of developing countries in the Southeast Asia (Villoria et al, 1998). Recent studies indicate that suspended particulate materials, nitrogen oxides, lead, and sulfur are currently among the most predominant air pollutants. Future projections also reveal an increasing level of carbon monoxide emissions (ADB, 1992). These pollutants pose dangers to human health, the urban physical environment, and the economy in general. Meanwhile, as developing countries are dealing with local air quality hazards attributed to high levels of criteria pollutants, global concerns over an increasing rate of CO_2 emissions has been alarming developed countries. This growing concern on green house gas emissions is expected to lead to the inclusion of carbon dioxide among the criteria pollutants in the near future. An effective approach in addressing the air pollution problem is the development of an institutional tool to directly deal with the contributing factors. This study aims to explore the potentials of taxation policies in managing motorization trend and disposal of old vehicles, thus reducing pollution emissions by developing a car taxation analysis model.

Tax, being a component of cost, can significantly influence the economic choices of individuals pertaining to a certain commodity or service. High importation taxes for instance have been used in developing countries to protect domestic industries by making imported products more expensive for the consumers, relative to its domestic counterparts. Likewise, various tax schemes are affecting the stakeholders of the car industry. These include: purchase tax, ownership tax, fuel tax, and road user's tax, among others. In addition to these basic taxes are fees like vehicle registration and annual vehicle inspection fees. As there may be legal differences between the nature of taxes and fees, these charges being components of car ownership cost, are viewed by the general public as all vehicle taxes and hence will be referred herein as tax (Rainbow, 1997).

An initiatory model system, which comprises aggregate choice models, was developed in Japan using car ownership and related data from 1980 to 1994 (see Hayashi et al, 2001). Performance tests conducted against the sub-models generally yielded encouraging results. The model system was utilized to determine the impact of the 1989 tax reform in Japan and to forecast future scenarios using different taxation schemes. Findings on the general effects of the different tax schemes were validated and found to be consistent for the case of Germany. Currently, various research directions are being undertaken to further improve the initial model and expand its potential applications. This study seeks to evaluate the viability of the formulating a functionally similar model system for developing countries in the Southeast Asian region. Among the main proposed improvements for the new model include: (a) the inclusion of other vehicle types, say trucks; (b) the inclusion of criteria pollutants; and (c) the inclusion of diesel fuel type in addition to gasoline.

2. CAR AND FUEL TAXATION SYSTEM

2.1 Mechanics and Trends

Car related taxation is based on the on a sustainable environmental policy known as the user pays principle. All around the world is the quest to recover the costs incurred for transport facilities giving rise to the axiom: "Transport finances transport" (Metschies, 1999). For instance, industrialized countries have come to rely increasingly on fuel taxation as a means of financing roads and highways. The international trend most noted among the EU countries, is that fuel taxation is a suitable means of covering not only the total cost of roads and highways construction and administration, but also for offsetting railroad deficits. For instance, statutory taxation of 0.15 DM/liter (US cents 9/liter) is earmarked for the German states' absorption of their regional rail traffic. Developing countries are likewise expected to pursue this setup. Tax likewise, being a component of cost can be used to influence the economic choices of individuals pertaining to a certain commodity or service. Hence the influence of car related taxes could be a potential tool in dictating the car market mechanism.

2.2 Taxation by Vehicle Classification

Tax rates vary depending on vehicle characteristics. Typical vehicle cross-classification are based on vehicle type, fuel type, engine size and vehicle age. Further sub-classification of cars by engine size for the case of Japan and Germany are presented in Table 3. Vehicle tax classifications in developing countries being studied are generally complicated due to the use of varied vehicle categories. Other further classification and sub categorization are based on parameters such as weight of vehicle, sitting capacity, type of ownership and purpose of usage. Vehicle classification is further complicated by the evolution of new vehicle types in the market. Classification by vehicle type basically includes automobile, utility vehicle, bus and truck. In addition are semi-categories due to existence of locally built vehicles using second hand engines and parts. In the Philippines for instance, semi categories include jeep, jeepney, jitney, and Asian Utility Vehicles.

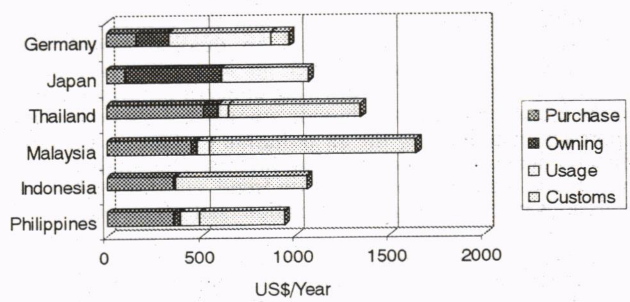

Figure 1. Annual Car Related Taxes (Assuming that car is gasoline-engined, 1500 cc, 1020 kg, at purchase cost of 1.5 million yen.(USD 13,500), fuel consumption rate:12 km/l, and 10-years life span)

2.3 Tax Schemes by Car Ownership Stages

At present, tax schemes affecting the stakeholders of the car industry are collected in the car ownership stages of purchasing, owning and using. Taxes in purchasing stage basically include the payment of sales tax or value added tax (VAT), while tax collection in owning stage includes the payment of annual taxes and fees. Usage tax is primarily comprised of fuel taxes, among which includes VAT, carbon tax, and other environmental taxes. The degree of taxation on these stages however varies among countries. A comparative summary of the cost component of annual car related taxes for the case of Japan, Germany and four Southeast Asian countries are presented in Figure 1. Based in the figure, developed countries have consistent low purchase and customs tax as compared to taxes in developing countries. Owning tax on the other hand, is generally higher in developed countries as compared to the developing. A detailed tax comparison for ASEAN countries is presented in the next section.

2.4 Car-Related Taxation in Southeast Asia

Purchase Tax

Sales tax ranges from 10% to as high as 60% of the vehicle price in Southeast Asia. A general convention on sales tax is that tax rate increases with respect to engine size, at times different set of tax rates are applied to different vehicle and fuel types. The Philippines, for instance, uses different set of tax rates for gasoline and diesel cars and still another for utility vehicles while Indonesia uses the same set of tax rates regardless of vehicle type. Custom duties apply to imported vehicles or vehicle parts. Existing rate under this category may reach as high as 140%-200% such as that in Malaysia but is expected to decrease with the firming of the World Trade Organization agreement on tariff and trade. The rate of custom duties is generally higher for completely built up (CBU) vehicles than the complete knock down (CKD) component. The difference in the tax rate of CBU and CBK is noted to dictate the competitiveness of vehicles locally manufactured or assembled against that of imported ones.

Table 1. Comparative car related taxes in developing countries.

	THAILAND (1997) 1Baht=JPY 2.7	**INDONESIA** (1993) 1Rupiah=JPY0.014	**PHILIPPINES** (1996) 1Peso= JPY 2.5	**MALAYSIA** (1978) 1Ringgit=JPY27
Purchase Tax	**Sales Tax** (Gasoline) 3000cc~: 55% 2400cc~: 47.3% ~2400cc: 41.25%	**Luxuries Sales Tax** Car: 20% Motorcycle: 10%	**Excise Tax** (Gasoline) -1600cc: 15% -2000cc: 35%	----
	VAT (Value Added Tax): 10%	**VAT**: 10%	**VAT**: 10%	**Consumption Tax**: 25-60% **Sales Tax**: 10%
Owning Tax	**Vehicle Tax**	**Road Tax** **Vehicle Tax**	**Registration Fee** **Private Motor Vehicle Tax** (by weight)	**Registration Tax** **Road User Tax** (by engine displacement)
Fuel Tax	**Oil Product Tax (OPT)**: 12%(1997) 18%(1998-?)	----	**Excise Tax** -LG: 5.35peso/l -UG: 4.35peso/l -D: 1.63peso/l	----
	VAT: 10% (Price including OPT)	**VAT**: 10%(Price including OPT)	**VAT**: 10%	**Consumption Tax**: 0.31 ringgit /l
Customs Duties	**Passenger Car** -CBU: 80% -KD: 22%	**Passenger Car** -CBU: 65-80% -CKD: 35-50% -IKD: 15%	**Passenger Car** -CBU: 40% -KD: 7%	**Passenger Car** -CBU: 140-300% -KD: 22-80%

CBU-Complete built up; **CKD**-Complete knock down; **IKD**-Incomplete knock down; **KD**-Knock down

Owning Tax

Registration tax or fee is an annual ownership tax commonly charged as a fixed amount for each vehicle categories. A notable convention adopted in the charging of vehicle fee is that rates are considered as a function of the motor vehicle's market value. This leads to high tax rates for new vehicles and a lower rate for old vehicle. This, however, may indirectly promote the use of older cars. Road user's tax likewise is similarly applied in all countries. Malaysia bases its road user's tax on engine displacement while the Philippines adopts a classification by vehicle weight. It is observed however that the road user's tax does not necessarily apply the user pay concept pertaining to amount of emissions as there have been cases wherein car is paying higher fees than bigger vehicles such as trucks.

Fuel Tax

Fuel taxes directly influence the vehicle usage pattern and can be used as a good pollution control stimulant. For instance, higher tax rates for leaded, as compared to unleaded gas is being used to promote the use of cleaner fuel. Current tax rates tend to promote diesel due to a generally higher gasoline tax rate. Two sets of fuel taxes are being charged in all four countries: the 10% value added tax, which is uniform across most goods and services, and an excise tax especially applicable for petroleum products. In Thailand, the excise tax for oil products rated as a certain percentage of the cost while it is charged as a fix amount per unit volume of fuel in the other countries. Among the studied developing countries, an average car in Indonesia yields the lowest fuel tax per year while the highest is that of the Philippines. It should be noted however that these tax rates are way below than that charged in most industrialized countries wherein taxation are means of financing not only the total cost of road and highway construction administration, but also utilized to offset railroad deficits.

3. THE CAR TAXATION ANALYSIS MODEL

Car-related taxes can be classified based on the various stages of car ownership, namely: purchasing, owning, using and decommissioning. On each of these stages are a number of choices for the car users to decide on. This includes matters such as what car to buy; how long to own; how often to use; and whether when to decommission and repurchase a new car. Individual responses to these choices are dictated by one's socio-economic background through its perception of the cost of each choice against the perceived benefit. An aggregate of these responses, in combination with supplementary data, will determine the composition of the vehicle fleet in terms of type and age, and the average car usage pattern of each individual. Both are among the significant parameters in determining the total air pollution load attributed to motor vehicles. The formulation of the model system, as used in the study is based on this concept.

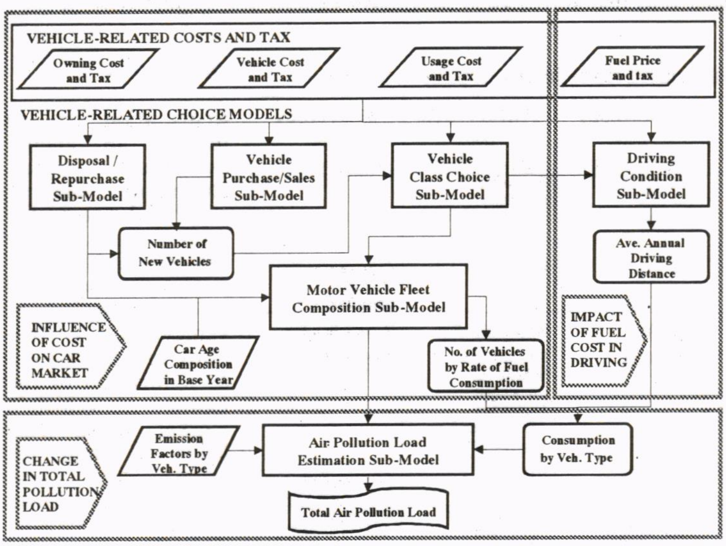

Figure 2. General structure of the Model System

Air pollution load estimation sub-model adopts the concept of Life Cycle Assessment (LCA). The concept considers the process of vehicle production, car maintenance and disposal series of emission sources that is contributing to the total emissions. The LCA is an environmental impact assessment tool and a component of International Standard Organization 14000 Series. Related researches in the field of transport engineering (e.g. Sterner, et al., 1992; Bunch et al., 1993; Gronau, 1994; Sperling et al., 1995; Koopman, 1995; Kurani et al., 1996) mainly evaluate the reduction of CO_2 in car usage stage through simulations with respect to driving distance and economy. However, assessment on CO2 generation during production, maintenance, and disposal were never conducted. In the initial model, the sum of life cycle embodied CO_2, which is called the "Extended Life Cycle CO_2 (ELC-CO_2)" of car, is estimated. De Luchi et al. (1989) introduced this concept in measuring electric vehicle performance in 1989.

Based on the initiatory model for the case of Japan, an improved and more general model structure is being developed for other countries. The modified model system is composed of six sub-models comprised in three main processes. The process include: (1) the examination of the influence of related costs on the vehicle market; (2) the assessment of the impact of fuel cost in the driving pattern; and (3) the estimation of the total air pollution load, in consideration of the different stages of vehicle ownership. The vehicle market is examined by tracing the change in motor vehicle composition over time considering the process of vehicle purchase, disposal and car class choice in new purchase, while driving pattern refer to parameters like the average driving distance as a function of fuel cost. Cost components include the basic cost and the additional taxes. The general structure of the model system is presented in Figure 2.

4. THE SUB-MODELS IN DETAIL

4.1 Motor Vehicle Composition Sub-model

The motor vehicle composition sub-model is the core part of the model system. It is basically designed to generate the total number of vehicles, cross-classified by type and age, using a mathematical formulation developed by Morisugi and Ohno (1996) as illustrated in Table 2. The total number of new vehicles for each year will be calculated based on the number of disposed vehicles, implying a repurchase, and the number of new vehicles purchased by new car owners, representing an increase in vehicle ownership. The annual survival rate equation is shown in a text box at the bottom of Table 2, where $C^k_{a,t}$ is the number of existing cars of age *a* and class *k* in year *t*. The vehicle mix will be based on the Vehicle Choice sub-model and the class mix of the new vehicle will be assumed to be that of the repurchased vehicles.

Table 2. Vehicle fleet by age and vehicle type.

	0 (NEW)	1	2	3	...		Total
1997	$C^K_{0,97}$	$C^K_{1,97}$	$C^K_{2,97}$	$C^K_{3,97}$			$\sum_a C^K_{a,97}$
1998	$C^K_{0,98}$	$C^K_{1,98}$	$C^K_{2,98}$	$C^K_{3,98}$			$\sum_a C^K_{a,98}$
1999	$C^K_{0,99}$	$C^K_{1,99}$	$C^K_{2,99}$	$C^K_{3,99}$			$\sum_a C^K_{a,99}$
2000	$C^K_{0,00}$	$C^K_{1,00}$	$C^K_{2,00}$	$C^K_{3,00}$			$\sum_a C^K_{a,00}$
2001	$C^K_{0,01}$	$C^K_{1,01}$	$C^K_{2,01}$	$C^K_{3,01}$			$\sum_a C^K_{a,01}$
⋮	⋮	⋮	⋮	⋮	⋮		⋮

Annual Survival Rate: $L^k_{a,t} = C^k_{a,t} / C^K_{(a+1),(t+1)}$

Motor vehicle classification to be used in the study will be based on any or a combination of the following parameters, namely: type of vehicle, engine displacement, vehicle weight and type of fuel. Sub-categories for each parameter will be based on the prevailing vehicle classification system used in each study area. For instance, vehicle categories may include car, utility vehicle, bus and truck. Sub-categories for car can be by engine displacement, where as by fuel type for the case of utility vehicles. As to the case of Japan and the validation run for Germany, the model only considered cars which are assumed to be all gas-engined and classified by engine size as shown in Table 3.

Table 3. Car classification used for the case of Japan and Germany.

Japan Car Classification		Germany Car Classification	
Classification	Engine Displacement	Classification	Engine Displacement
Class A	2,001 cc or bigger	Car 1	1,400 cc or smaller
Class B	1,501 cc- 2,000 cc	Car 2	1,400 cc to 2,000 cc
Class C	1,001 cc- 1,500 cc	Car 3	2,001 cc or bigger
Class D	1,000 cc or smaller		

4.2 Vehicle Purchase / Sales sub-model

Vehicle Purchase sub-model, in relation with the Disposal/Repurchase sub-model, will generate the total number of new vehicles added in the vehicle fleet of the study area. The total number of new vehicles will be classified into types through the Vehicle Class Choice sub-model and will comprise the new car ownership input for the Motor Vehicle Fleet Composition sub-model. Depending on the availability of data, the Vehicle Purchase sub-model can be formulated using the aggregate approach based on market trends and macro-economic parameters. Existing forecasting tools on car sales will also be reviewed for possible adoption into the sub-model.

4.3 Disposal / Repurchase Choice Sub-model

The choice process whether to continue the use of the current car or to repurchase can be formulated as an aggregate binary logit model by vehicle type as follows:

$$L = exp(U_{cur})/\{exp(U_{cur}) + exp(U_{new})\} = 1/(1+exp(U_{new}-U_{cur})) \quad (1)$$

where

$U_{new}-U_{cur}= a_0 + a_1x_1 + a_2x_2 + a_3x_3 + \ldots + a_nx_n$

U_{cur}: Utility gained by continuing to use the current vehicle

U_{new}:Utility gained by disposing the current vehicle and purchasing a new one

Input variables x_1 to x_n consists of cost and utility parameters in comparison between the two alternatives. The following are for the case of Japan:

x_1: Difference in the purchase costs between the current and the new vehicle

x_2: Difference between owning cost of current vehicle and its remaining value

x_3: Difference in using the cost between the current and the new vehicle

x_4: Additional utility by purchasing a new vehicle; and

a_0 to a_n: Parameter estimates

Cost parameters will include tax and will be normalized by per capita GDP in each year. Similar cost variables will be used in the vehicle-type choice model. The average vehicle purchasing price and fuel consumption rates will be calculated from the purchasing price, engine size, and fuel consumption rate by vehicle type data derived from car registration records. Likewise, the rate of annual depreciation of the vehicle will be calculated based on the average life span for each vehicle type.

4.4 Vehicle-Class Choice Sub-model

As it is observed that people choose a vehicle-class which gives the highest utility, the aggregate multi-nominal logit modeling technique will be utilized for the Vehicle-Class Choice model. The choice mode is formulated as follows:

$$P_i=exp(U_i)/ \Sigma_{j=1,4}exp(U_j) \quad (2)$$

where, the choice set will be categorized into a desired number of classes

P_i: Choice probability of class i

U_i: Utility of class i

An expected complexity in the actual modeling is the consideration of cross choices between cars and utility vehicles. The two may tend to compete as they are interchangeably used for the same purpose in developing countries.

4.5 Driving Condition Sub-model

If the fuel price increases, car users may tend change its driving pattern by reducing its driving distance in order to lower fuel consumption. The initial model describes this phenomenon on change in driving distance by assuming that driving distance fluctuation is as equal to the price elasticity of gasoline, which is estimated to be –0.23 using data in Japan from 1981 to 1989. With this value, the relationship between gasoline price P_i and driving distance D_i at any year was formulated. However, change in driving pattern may be affected by several other factors other than the fuel price. Preliminary results of a land use transport interaction study for instance identifies the total length of road network as a significant factor affecting travel distance. Related formulation generated from recent household interview surveys or other travel demand pattern studies can also be also referred from in order to improve the initial model formulation. Expected output for this sub-model will be an average travel distance for each vehicle cross category, for instance, as a function of fuel cost.

4.6. Air Pollution Load Estimation Sub-model

Given the average travel distance and the average fuel consumption per vehicle type, the proposed air pollution estimation sub-model for developing countries will be utilizing available emission factors to estimate the total mass of each pollutant. Criteria pollutants such as CO, NOx, SO_2, lead and suspended particulate matter will be among the pollutants to be considered. In cases wherein emission factors may not be available, existing air pollution models used by each country in conducting pollution load inventories will be adopted in the model system. The model for Japan calculates the total CO_2 using the Extended Life Cycle CO_2 (ELC-CO_2) estimation method, which combines the CO_2 emissions from car as derived using the Life Cycle Assessment method and the emissions generated from usage. Depending on data availability, it will be ideal to consider the extended life cycle approach as this considers the total emissions in from a vehicle in its entirety.

5. FORMULATION AND APPLICATION

5.1 Model Formulation

Generation of the model system for the case of Japan involves two major sets of choice models, namely: the Disposal/Repurchase choice models as formulated in Equation 1, and the Vehicle Class choice models as presented in Equation 2. Utilizing aggregate binary and multinomial logit modeling respectively, the parameter estimates for the disposal/repurchase choice model is presented in Table 4 while that of car class choice are summarized in Table 5.

Table 4. Disposal/Repurchase Choice Sub-Model[a] for the case of Japan (Hayashi et al, 2001)

	Class A	Class B	Class C	Class D
Constant	2.97 (9.3)	1.12 (3.0)	0.677(2.2)	0.940(3.6)
Difference in Purchase Cost (x_1)[b]	-0.647(-1.9)	-1.16 (-1.2)	-2.76(-2.0)	-5.54(-3.5)
Owning cost- Car's current value(x_2)	-2.93(-17.2)	-6.6 (-17.5)	-10.9(-20.0)	12.8(-21.1)
Difference in Driving Cost (x_3)	10.6(0.8)	-	-	14.2 (0.4)
Log Sum Utility of New Car (x_4)	-0.453(-3.9)	-0.101(-0.7)	-0.047(-0.5)	-0.151(-1.6)
Adj. R^2-Value	0.78	0.70	0.74	0.79
No. of Samples	124	142	144	144

[a] The t-values are given in parenthesis.
[b] Difference in Purchase cost = ((new car price)-(price when purchased current car))/per capita income.

Result of the Disposal/Repurchase choice modeling as presented in Table 4 shows that most significant tax scheme influencing decommissioning of cars is the owning tax. The t-value for the parameter for x_2 (the difference in owning cost and value of current car) is further observed to be increasing as the car-class gets smaller. This indicates that the owners of smaller cars are more sensitive to the owning cost. The high value of the constant for Class A can be attributed to its having a high relative attractiveness and that their owners' sensitivity to cost is low. The difference in driving cost is not significant. This further means that fuel tax does not influence so much on disposal/repurchase choice.

Results of the car class choice modeling, as presented in Table 5, was generated using the same set of data used in the disposal/repurchase sub-model excluding that of the transition period strongly influenced by the tax reform (from 1989 to 1992). Generally, the most significant parameter is still the owning cost followed by the purchase cost. Difference in usage cost is observed to be not significant between car classes A and B due to a very slight difference in the consumption rate. The constant parameters have high significance, thus indicating other factors that is contributing to the attractiveness of bigger cars over that of the smaller alternatives. Sensitivity to cost change of the low class cars is higher than that of the high class.

Table 5. Car Class Choice Sub-Model for the Case of Japan[a] (Hayashi et al, 2001)

	Class A/B	Class A/C	Class A/D
Constant	1.38 (8.2)	2.42 (4.2)	27.9 (12.6)
Diff. In Purchase Cost (P_A-P_i)	-0.495 (-1.1)	-1.22 (-1.2)	-9.87 (-4.3)
Diff. In Owning Cost (O_A-O_i)	-24.5 (-12.7)	-17.9 (-2.9)	-59.2 (-3.7)
Diff. In Usage Cost (U_A-U_i)	-	-11.5 (-0.5)	-73.2(0.2)
Adj. R^2	0.99	0.96	0.96
No. of Samples	12	12	12

[a] The t-values are given in parenthesis.

[b] The subscript A in the independent variable refers to Car Class A while *i* refer to the other choice.

5.2 Application of the Model

The application of the model system for the case of Japan was aimed to quantitatively estimate the effects of tax policy on CO_2 emission in the stages of car ownership. As the model system can forecast the number of existing cars by engine class and age, it makes it possible to examine the balance in taxation rates for reducing life cycle CO_2 emissions. Preliminary results of a parallel study formulating a similar model for the case of Germany was referred from in order to verify the results for the case of Japan.

5.2.1 Tax Reform Post Analysis and Sensitivity Tests

Prior to the 1989 Tax Reform, passenger cars were classified into big and small cars at engine displacement of over and below 2000 cc respectively. Tax rates for purchasing and owning for big cars were then about twice as high as that of small cars. But, after the tax reform, the tax rates for purchasing and owning for both classes became almost equal. As a result, the number of big passenger cars increased drastically. The initiatory model was applied in analyzing the effects of the tax reform on (a) the changes in car class share; (b) the amount of CO_2 emission; and (c) the amount of car-related tax revenue. The result shows that, if the tax reform had not been executed, the shift from Class B to Class A (small to big passenger cars) cars had not occurred, and that the ELC-CO_2 emissions from all passenger cars in 2010 could have been lower by 8 %. Accordingly, the tax revenue would have been higher by 10%. The calculated results are presented in Figure 4.

A sensitivity test was conducted to compare the elasticity of an incremental increase in each tax category (purchase, ownership, and usage) to the changes in car-class share and CO_2 emission using an annual increment of 10,000 yen (approx. US$100)/car equivalent extra charge beginning in 1995. The amounts of increase in purchase and ownership taxes are set to be linearly proportional to the engine displacement. Using the model, the corresponding changes in car-class share and ELC-CO_2 emission per car by engine class due to the incremental increase in each tax category are forecasted for the year 2010 as compared to the no-change forecasting scenario for the same year.

The additional charge of 10,000 yen/year in every class corresponds to an equivalent of 40% increase in purchase tax. Applying this incremental equivalent increase to all car types results to a slight shift resulting to an insignificant increase in the share of car Class A. The change in total CO_2 emissions likewise is a low 0.3% decrease due to a 0.2% decrease in production CO_2 in class A and by a 1% decrease in the other classes. As to ownership tax, an additional charge by 10,000 yen/year in every class is equivalent to 15.0% increase per car class in the tax category. The result shows that such increase yields a more significant decrease in the share of car Class A due to shifts favoring car classes B and C. This indicates that the incremental increase in ownership tax is more influential than that of the purchase tax in effecting car class shift. As to CO_2 emissions, the increases in ownership tax result to an overall reduction of 1.3% by the year 2010. The reduction is attributed to a slight increase in production CO_2 due to a heightened decommissioning and a significant decrease in driving CO_2 due to the shift to smaller cars.

The additional charge of 10,000 yen/year in every class is equivalent to an average increase of 20.6% in usage tax. The study shows that the share of each car class changes a little as usage tax is not so significant to the purchasing behavior as seen in the purchase sub-model parameter estimates. On the other hand, the reduction rate in CO_2 emission is at the highest among other tax increases as the increase in fuel tax resulted to shorter trips and more efficient driving practices. Comparing the results of the sensitivity analysis among the three tax categories, it can be concluded that an increase in usage tax can effectively reduce CO_2 while an increase in ownership tax can fairly yield a significant shift to a smaller car.

5.2.2 Preferential Taxation Policy

The minimal effect of an increase in ownership tax on the reduction of CO_2 emission is due to the fact that each car class is allocated a tax increase that is linearly proportional to the engine displacement. However, if tax rate is set in proportion to fuel efficiency or CO_2 emission rate, a bigger effect is expected since the taxation scheme will be indirectly promoting the shift to lower emission cars. In this section, forecasting was conducted using different tax weight combinations for each engine type. This is referred to as preferential taxation scheme where in tax is selectively applied so that a particular alternative will be more attractive than others. The different scenarios are as presented below:

Policy 0: Keep the current tax rates
Policy 1: Doubling ownership tax rate for only class A from 1995
Policy 2: Doubling ownership tax rate for classes A and B from 1995
Policy 3:Doubling ownership tax rate for all classes from 1995

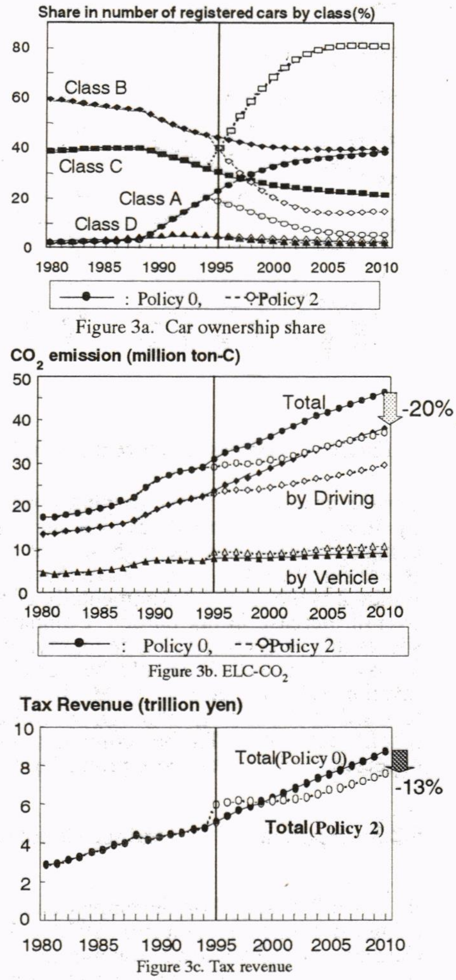

Figure 3. Summary of effects of Policy 2.

For Policy 1, the share of class A will decrease reaching the level of that in1980 by the year 2003 when almost all cars will finish one cycle of disposal and will be repurchased. The decrease in Class A is mainly due to a shift to Class B and slightly to a shift to Class C. This will result to a 6% decrease of CO_2 emission from driving as compared to that in Policy 0. As to revenue from taxes, revenue is expected to initially increase due to the rise of tax rate but it will later decrease due to the shift to smaller cars of which ownership tax rate is lower. The overall change in revenue by 2010 is an 8% decrease as compared to Policy 0.

In the case of Policy 2, the share of classes A and B for new cars will decrease while the combined classes C and D will increase to an 80 % share of the class mix by the year 2010. Total car emission, on the other hand, is forecasted to be 20% lower than Policy 0. The decrease can be attributed to a 25% decrease in driving CO_2 due to the car class shift, and a 5% decrease due to a lower propensity to decommission. This policy scenario comparatively yields the most significant reduction in total CO_2 emissions. However, the total revenue is forecasted to decreases by 13% by the studied year. Results for the Policy 2 are summarized in Figure 3.

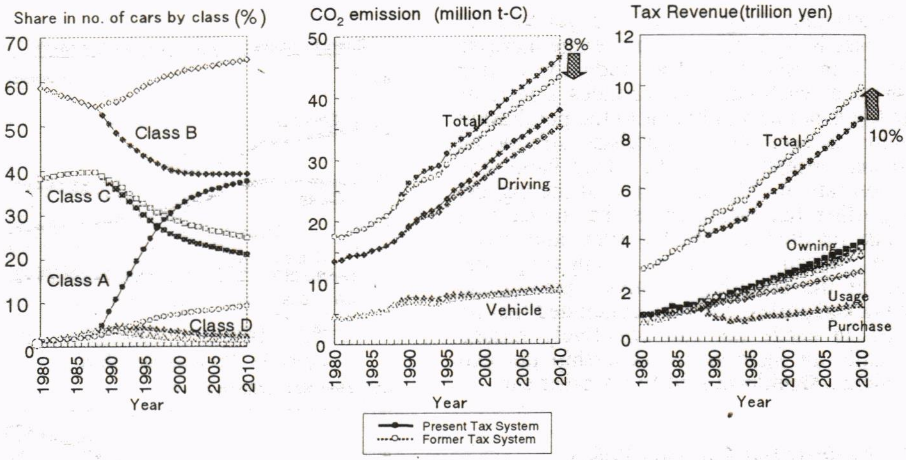

Figure 4. Forecast of current tax and pre-1989 tax reform rates. (Hayashi et al, 2001)

For the case where in the owning tax rate is doubled for all classes, CO_2 emission decreases by 10% while the total revenue increases by 30% in the year 2010. This policy scenario comparatively yields the highest total revenue than the others. The decrease in CO_2 however is less significant as compared to that of Policy 2. Given the above schemes, it can be said that Policy 2 is the most environmentally efficient as it attains significant CO_2 reduction at a lower overall increase in tax burden. Comparing these results to that of the sensitivity test runs, it shows that preferential change in, say, ownership tax is more effective than a uniform increase across all classes. It should be noted however that even though a particular preferential taxation scheme seem to yield obvious result, calculation of the effects is not as straight forward as it has to go through several choice models different emission components can be readily calculated. Further combinations based on the principle of preferential taxation are expected to yield even more promising forecasts.

5.2.3 Application to Another Country

In a parallel study for developed countries, the model system was calibrated for Germany using car ownership data from 1970 to 1996. As compared to Japan, the car taxation system in Germany charges a lower owning tax yet imposes higher purchasing and usage (fuel) taxes. Both countries have a local car manufacturing industry and are together classified as among the high fuel tax levying countries. Cars in Germany are classified into three classes as shown in Table 3. The results of modeling for the case of Germany have also identified the difference between owning tax and cost of current car to be the most significant parameter in the disposal repurchase modeling. This can be rationalized by the impracticability of keeping an old car at a cost that is higher than its present value. As to the car class choice model, owning tax likewise observed to be the most significant among the other taxes. A decrease in travel distance due to an increase in fuel tax was also observed thus confirming the significant role of fuel taxation in emissions reduction. Forecast of revenue likewise indicates the potentials of fuel tax in revenue collection. These results somehow verify the observed general effects of the different taxes in the initiatory study.

6. MODELING REQUIREMENTS AND CONSIDERATIONS

6.1 Data Requirement

A basic concern in the development of the model system is the availability of adequate data. The required data are classified into five levels, namely: 1) the study area; 2) household data, 03) vehicle cost; 4) tax systems; and 5) air quality management. Basic information on the study area includes its socio-economic profile, motor vehicle registration, trip demand by mode and general traffic situation, most of which are available from transportation related agencies. Household information on the other hand, comprises car ownership, household profile, trip pattern and trip length, among others. Such are available from recent household interview survey database and trip demand studies. Vehicle cost basically includes fuel consumption rate and vehicle costs throughout the stages of purchasing, owning, using and decommissioning. Tax systems comprise a historical review of vehicle-related taxation policies and fees to include purchase tax, registration fees, fuel tax and road user's tax, among others. Air quality management, on the other hand, includes motor vehicle emission inventories, ambient air quality and adoption of air pollution load estimation models.

As developing countries are yet in the process of creating an extensive transportation database, historical data that is required in developing the model may not be that readily available. Parameters that are deemed to be difficult to secure includes vehicle age, decommissioning statistics, average driving distance per car class and taxation cost by car ownership stage per car class. Expected complexities on vehicle age will be partly due to the importation of second hand engines and vehicles while that on taxation cost will be due to complexities of the taxation system itself. Modeling parameters such as vehicle registration, fuel cost, taxes and fees are preferably needed in an annual historical format. In case inadequate vehicle fleet historical data as required in the vehicle fleet matrix (Table 1), data gathered through the conduct of perception interview survey might be required for vehicle class and usage/disposal choice modeling. if ever similar study is not available. Since it was identified in the initiatory study that lack of data is among the major difficulties in modeling, reformulation of the model system to suit on whatever minimum available data is deemed necessary (Hayashi et al, 2000). An input-output model framework is presented in Figure 5.

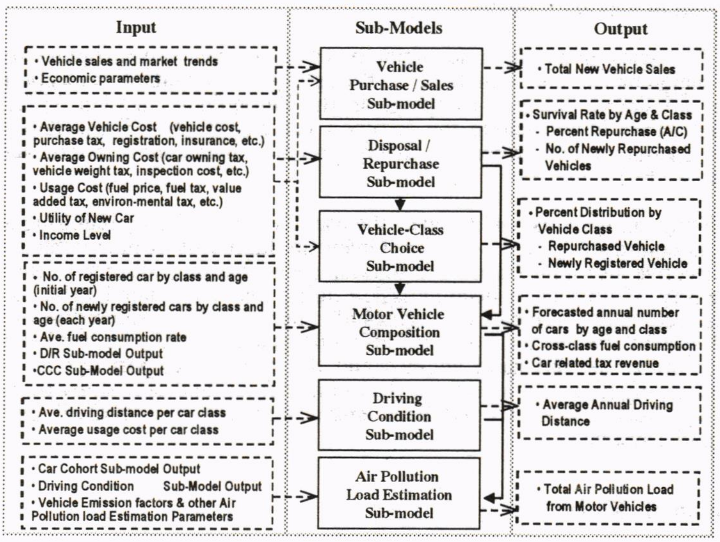

Figure 5. Input-Output Model Framework

6.2 Modeling Considerations

The model system to be formulated for developing countries will be a modification of the initiatory model system that was calibrated for the case of Japan. The sub-models will be different among countries as modeling depends on whatever data or related studies are available from each study area. For the case of the air pollution load estimation sub-model for instance, it is proposed that the model system will utilize existing air pollution load estimation concepts and techniques being used by each studied country. Among the more common air pollution load estimation tools is that which uses motor vehicle emission factors.

The existing vehicle classification system in each country is also a major consideration in modeling. Initial examination shows that all countries adopt differing vehicle classification systems for vehicle registration, taxation and emission estimation. Although vehicle owners provide vehicle specifications upon registration, summary statistics are often limited to parameters like vehicle type, fuel type and registration type. Further, existing emission factors are only limited to a select type of vehicles. Practical modeling considerations include accuracy, simplicity, applicability and flexibility of the model system. Accuracy refers to the model's predictive performance while simplicity is dependent on the amount and availability of the required input. Applicability on the other hand refers to the vastness of the model's application while flexibility refers to its ability to cater and adopt further modeling developments.

7. ISSUES, CONCERNS AND TRENDS

The primary concern of the motor vehicle taxation system is to safeguard government revenue, ideally for related budget allocation, in the light of environmental protection and equity considerations. Given this framework, a number of issues and related trends were identified for consideration in the formulation of the taxation model system in developing countries.

7.1 Taxation and promotion of cleaner vehicles

The volume of emission of vehicles given the same engine types can be basically attributed to vehicle operation, engine maintenance, and vehicle age. Though there are vehicle inspection related programs like the anti-smoke belching campaign in the Philippines, taxation or fee system on inspection-maintenance is not among the common vehicle charges. These imply that a charging scheme to encourage car owners to undergo regular maintenance is not yet widely practiced among the studied countries.

It is also noted that the existing tax systems tend to favor the use of old vehicles by requiring a lower registration charge as compared to new vehicles. Given the high cost of new vehicles and the absence of an effective decommissioning program, such charging system further aggravates the low propensity of owners to decommission aging and dilapidated vehicles. Policies on importation of secondhand vehicles or engines also need to be considered in the formulation of the model system. Issues and concerns affecting stakeholders, like the local vehicle manufacturers that utilize second hand engines and the public transport operators which uses secondhand buses, significantly affect the fleet composition and emissions from the public transport sector. Treatment of second hand engines should be identified and formulated to fit into the model system.

7.2 Taxation and promotion of cleaner fuel

In most developing countries, lead content in gasoline and sulfur content in diesel fuel are much higher compared with those in developed countries. Recent efforts in the region being studied include programs promoting the use of unleaded gas and policy directions aiming to reduce sulfur in diesel fuel. The use of unleaded gasoline and low-sulfur diesel can be promoted through differential taxation and by imposing of fuel price surcharges based on lead and sulfur content of gasoline and diesel fuel, respectively. Such schemes have been adopted in the region to encourage the use of the unleaded over the leaded gas. However, while the current fuel-pricing scheme is generally bent towards the promotion of cleaner fuel, the pricing scheme, is generally promoting diesel over that of gasoline. This is further aggravated by the bias in favor of diesel powered vehicles in the imposition of excise and registration taxes wherein it is charged with lower fee as compared to that of a gasoline powered engine of the same engine displacement.

7.3 Taxation, transportation developments and forecasting

A pressing concern in the current tax system of the studied countries is its flexibility to adjust to car ownership-related social and technological developments and concerns. The emergence of new vehicle types for example have caused complexity in differentiating car from a utility vehicle as engine features and vehicle usage tend to overlap. The introduction of hybrid cars and advancements in fuel technology are also expected to complicate tax schemes utilizing vehicle classification by fuel type. Further, concepts like user pay principle have raised equity issues to on-road tax schemes that charge a cheaper tax to a truck than a medium size private car. These developments in the transportation industry make long-term forecasting difficult as emission properties and taxation scenarios become less predictable.

7.4 Taxation and Motorization Trends

The studied countries are currently on the process of cutting down the duties on fully assembled cars and commercial vehicles coming from within the Southeast Asian region. This is in part due to a commitment to gradually liberalize the automotive industry toward the establishment of the ASEAN Free Trade Area (AFTA) by the year 2003. Under the AFTA rules, products that are part of the liberalization process should have a maximum tariff of 20 per cent. This liberalization scheme is expected to significantly impact the motor vehicle industry in the region.

Though economic development and population growth basically influences the rate of motorization, economic policies such as taxation dictates the type of motorization. In the Philippines for instance, the popularity of Asian Utility Vehicles aside from its being what the market wants, can be attributed to its being excise tax exempt. In Thailand, the 70% of the four-wheel vehicle sales being pick-up, likewise is a reflection of its tax structure system favoring such type of vehicle. An examination of the historical vehicle registration data, in the case of the Philippines, shows that, an increase in the difference between gasoline and diesel fuel prices triggers the growth rate of diesel-powered vehicle to outpace that of gasoline. It further shows that a stable difference in fuel cost tends to equalize the diesel and gasoline fueled vehicle registration growth rates. These indicate the influence of fuel cost to the choice between a diesel and a gasoline-powered vehicle in the market, thus hinting the potential of fuel tax even in influencing the choice of vehicle.

8. SUMMARY AND CONCLUSION

8.1 Model Formulation and Observed Trends

A model system designed to evaluate the effect of car-related taxation scheme to the total Life Cycle CO_2 emission and the total tax revenue was initially developed for the case of Japan. The system basically determines the effect of changing the weight of the tax components of the different stages of car ownership, to the changes in the car class mix and the car users' driving pattern and behavior towards car class purchasing choice and decommissioning. Encouraging results of the study leads to the development of a modified model system designed for possible application in other countries. The modified model system is comprised of six sub-models namely: (a) Motor Vehicle Composition, (b) Vehicle Sales and Purchase, (c) Disposal-Repurchase Choice, (d) Vehicle Class Choice, (e) Driving Condition and (f) Air Pollution Load Estimation Sub-models.

The worsening air pollution in most urban areas in nearby Southeast Asia leads to the examination of the viability of the model system in developing countries. With suspended particulate matter as the most significant pollutant, the proposed model system will instead forecast the total emission load of criteria pollutants, being more critical than the Life Cycle CO_2 emissions. An examination of the existing tax systems identifies the complexity in vehicle classification, too many differing tax schemes, and existence of some environmentally inconsistent taxation policies as among the common pressing problems. Altogether, these make the tax system inefficient, marred with loopholes and complicated to implement. The countries being studied however are currently going through tax reforms parallel to the AFTA liberalization principles.

Motor vehicle registration generally shows an increasing motorization trend. Significant fraction of the vehicle fleet is comprised of tax-favored vehicles like the AUV in the Philippines and the utility pick-up in Thailand. The increasing rate of diesel vehicle registration is also attributed to the lower excise tax added to the cost of diesel fuel. These trends show the significant influence of vehicle-related taxation on the vehicle composition, thus hinting the viability of the model system. The need for a car taxation analytical tool given the expected tax reform and the benefit of the model system in dealing with the identified issues and concerns further endorses the viability.

8.2 Pointers Based on Initial Findings

The modeling results for the case of Japan and the forecasting analysis for different taxation scenarios as verified by the preliminary study for the case of Germany have established the general effects of different tax categories. Applying these results in relation to global trends and observed conditions in the studied developing countries, yields the following general guiding principles and possible action points that are perceived to be useful to consider in the Southeast Asian transport-environmental tax reform:

- Impositions of a combination of a decrease in purchase tax and an increase in ownership taxes, being significant influences in repurchase and disposal, can increase the propensity to decommission old and dilapidated vehicles.
- Likewise, owning tax, being a significant influence in vehicle class choice, is a potential fiscal approach in promoting the use of more environment-friendly vehicles.
- Fuel tax on the other hand, significantly influences the travel behavior of road users. An increase in fuel tax is expected to reduce the annual average travel distance triggered by the tendency to save on fuel cost.
- Reduction of emissions due to driving is significantly influenced by the usage cost. With using stage being the dominant source of emissions among the stages of car ownership, an increase in fuel tax can lead to considerable reduction of emissions.
- Fuel taxation is likewise a major source of financing to cover that of road and highway construction and maintenance. As current fuel taxation revenue is insignificant in covering the transport expense, transportation tends to compete for funding from the national budget. An increase in fuel tax is viewed as a sound effort towards a sustainable transport concept wherein transport finances transport.
- The effects of car related taxation can be optimized, particularly its influence in choice, by imposing preferential taxation. This is applicable to both vehicle and fuel taxes so as to make the preferred alternative more attractive for consumers than the other choices.
- Finally, as different combination of tax schemes yield a wide range of effects, the model system is perceived to be a potentially efficient tool in optimizing the impact of fuel taxes.

8.3 Final Remarks

It should be noted that the study primarily promotes an approach of integrating fiscal policy related considerations in an attempt to come up with a comprehensive taxation analysis tool. This approach is embodied by the general model structure. The usefulness of this model structure is not restricted to the use of particular modeling techniques in generating the sub-models. In developing countries, data gathering is among the critical activities in model formulation. The general model structure however is perceived to be flexible enough to encompass innovations brought about by data constraints. A practical approach for instance, is to formulate sub-models commensurate to the data available in a country-to-country basis. This may involve integration of existing modeling concepts and results of related studies to fill in the possible data gaps. Problems of incompatible vehicle classification system can be dealt with by aggregating vehicle categories to normalize the classification differences. Further, the use of studies utilizing perception surveys is being viewed as an alternative disposal/repurchase choice modeling database. on cases wherein adequate choice modeling parameters are not available.

The proposed model system is deemed capable to forecast vehicle composition, tax revenues, and vehicle emissions given different taxation scenarios. Other potential applications of the model system include that in the formulation and evaluation of taxation policies as well as formulation of air pollution abatement strategies. Parallel activities through continuing research are currently being conducted towards the development of a taxation model system not only for the developing countries in Southeast Asia but also to both developed and developing countries in other regions. The model system is further envisioned to include the consideration of traffic and motorization related regulatory policies.

REFERENCES

a) Books and Books chapters

Morisugi, H. and E. Ohno. (1996) NO_x reduction effects of the policy to reduce diesel automobiles and its influence on price changes. **Transport, land-use and the environment** (Y. Hayashi and J. Roy eds.), Kluwer Academic Publishers, 171-190.

b) Journal papers

Bunch, D.S., M. Bradley, T.S. Golob, R. Kitamura and G.P. Occhiuzzo (1993) Demand for clean-fuel vehicles in California: A discrete-choice stated preference pilot project. **Transportation Research 27A(3)**, 237-253.

DeLuchi, M.A., Q. Wang, and D. Sperling (1989) Electric Vehicle Performance, Life-cycle costs, Emissions and Recharging Requirements. **Transportation Research-A, 23A(3)**, May 1989, 255-278.

Gronau, R. (1994) Fuel taxes and road-user charges in LDCs –some lessons from sub-Saharan African. **Journal of Transport Economics and Policy, 41**.

Hayashi, Y., Kato, H., Teodoro, R.R. (2001) A model system for the assessment of the effects of car and fuel green taxes on CO_2 emission. **Transportation Research-D(6),** 123-139.

Koopman, G.J. (1995) Policies to reduce CO_2 emissions from cars in Europe –a partial equilibrium analysis. **Journal of Transport Economics and Policy, 42**.

Kurani, K.S., T. Turrentine and D. Sperling. (1996) Testing electric vehicle demand in 'Hybrid Households' using a reflexive survey. **Transportation Research 1D(2),** 131-150.

Sperling, D., W. Setiawan, and D. Hungerford. (1995) The target market for methanol fuel. **Transportation Research 29A(1)**, 33-49.

Sterner, T.; C. Dahl and M. Franzen.(1992) Gasoline tax Policy, carbon emissions and the environment. **Journal of Transport Economics and Policy, 39**.

Villoria, O. and R.V.R. Teodoro (1998) Initial development of an estimation tool for vehicle-attributed air pollution. **Transportation Science Society of the Philippines Journal, Vol. 2**.

c) Papers presented to conferences

Hayashi, Y., Kato, H., Teodoro, R.R. (2000) Car tax analysis model system for emissions forecasting in Japan and an assessment of its viability for developing countries. **Proceedings of the 3rd Regional Symposium on Infrastructure Development in Civil Engineering,** Tokyo Institute of Technology, Ookayama, Tokyo, Japan, 4-6 December 2000.

d) Other documents

Asian Development Bank (1992) "Vehicle Emission Control Planning Project for Metro-Manila". Environmental Management Bureau, Manila, Philippines.

Metschies, G.P. (1999) Pricing Policies for Diesel, Fuel and Gasoline in Developing Countries and Global Motorization Data. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Abteilung Umweltmanagement, Wasser, Energie, Transport.

Rainbow, R. (1997) "Study on the Rationalization of Motor Vehicle Taxation in the Philippines". Department of Finance, Manila, Philippines.