

**Gasoline and High Speed Diesel Consumption in
Thailand: A Case Study in Welfare**

by

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Abstract

This article examines the retail pricing policy of gasoline, high speed diesel, and the vehicle tax policy in Thailand between January 2002 and August 2005. The pricing policy of gasoline and high speed diesel is characterized by cross price subsidy from the gasoline consumers to the high speed diesel consumers. The vehicle tax policy is characterized by heavy tax rates that are higher for the gasoline engine vehicles relative to the diesel engine vehicles.

The vehicle tax policy caused considerably greater welfare losses than the pricing policy of gasoline and high speed diesel. The efficient pricing criterion is proposed as a package to correct the welfare losses. The package includes replacements of all the transfer payments items in the price structure of gasoline and high speed diesel by their global pollution components; the replacements of all vehicle taxes by the congestion charges or the 'pay while you drive' vehicle taxes.

In addition, the local pollutions externality, the traffic accidents externality, and other externalities related to the operations of vehicles must be internalized through appropriated control laws. The efficient policy package will generate less tax revenue from gasoline and high speed diesel. Moreover, the government will have to forego the entire vehicle taxes collected under the existing policy. The congestion charges can, however, be designed to offset the revenue deficits.

Keywords: Thailand; gasoline; high speed diesel; vehicles; externalities; welfare

JEL: classification code: H20, H21, Z0

1. Introduction

The transportation sector in Thailand is the largest consumer of petroleum products. Before the year 2005, gasoline and diesel are the two major petroleum products that are consumed in this sector. Gasoline is sold as gasoline 91 (gasoline with octane 91) and gasoline 95 (gasoline with octane 95). Diesel is sold almost entirely as high speed diesel and a small amount of low speed diesel. High speed diesel is the dominant fuel in the transportation sector as its consumption is more than twice the gasoline consumption.

There was a cabinet resolution on December 9, 2003 to eventually replace gasoline 95 with gasohol, a mixture of gasoline and ethanol [29]. After the cabinet resolution, the consumption share of gasohol in the total fuel consumption is still insignificant but its consumption share began to increase sharply towards the end of 2005. Eventually, the consumption of gasohol exceeds the gasoline 95 consumption for the first time in April 2007.

Following the gasohol plan, the cabinet also approved the National Energy Council Committee's energy policy on November 21, 2006 to promote the consumption of biodiesel B5 as a substitute for high speed diesel by expanding the acreage of palm oil and the distribution channels. Before the endorsement of this policy, the consumption share of biodiesel in the total diesel consumption is less than 1 percent. But from February 2007 onwards, the consumption share of biodiesel in the total diesel consumption increased markedly to 7 percent in December 2007.

The fuel consumption patterns in the transportation sector depend on the behavior of the vehicle operators that can be influenced by the government

pricing policy. The effect of the government's pricing policy on the fuel consumption pattern leads to the objectives of this article.

The first objective is to review the Thai government's retail pricing policy of petroleum products and the vehicle tax policy. The scope of the review is limited to the pricing policy of gasoline and high speed diesel and the vehicle tax policy before the emergence of gasohol and biodiesel towards the end of 2005. The second objective is to quantify the effects that these two policies have on welfare and economic costs in Thailand. The third objective is to propose an alternative pricing package for gasoline, high speed diesel, and vehicles for the country.

The article is organized into six parts. The second part reviews the existing retail price structure of gasoline and high speed diesel, the vehicle tax structure. The third part presents the theoretical frame work to quantify the effects that these two policies have on welfare and economic costs. The fourth part presents the estimation results of welfare losses and economic costs. The fifth part proposes an alternative policy package for gasoline, high speed diesel, and vehicles. Finally, summary, conclusions, and recommendations are presented in part six of the article.

2. Review of Retail Price Structure and Existing Vehicle Tax Structure

2.1 Price Structure of Gasoline and High Speed Diesel

The wholesale prices of gasoline and high speed diesel, and other petroleum products, have the same following structure

$$\text{wholesale price} = \text{ex-refinery price} + \text{excise tax} + \text{municipal tax} + \text{oil fund 1} + \text{oil fund 2} + \text{energy conservation fund} + \text{value added tax}$$

The retail price of each product is then determined by adding the marketing

margin and the value added tax to its wholesale price so that

$$\text{retail price} = \text{wholesale price} + \text{marketing margin} + \text{value added tax}$$

At present, there are no retail price components that reflect the externality costs in the existing price structure. The energy conservation fund component in the retail price structure is collected from the gasoline and high speed diesel consumers to finance the energy conservation projects and does not reflect the externality costs of these two products. The excise tax, municipal tax, oil fund 1, oil fund 2, and the value added tax components of the retail price are transfer payment items designed to generate revenue and to manipulate the retail prices.

Table 1 Retail Price Structure of Gasoline and High Speed Diesel in Thailand, March 31, 2005 (baht/liter)

	<i>Gasoline 95</i>	<i>Percent</i>	<i>Gasoline 91</i>	<i>Percent</i>	<i>High Speed Diesel</i>	<i>Percent</i>
ex-refinery price	15.14	68.52	14.65	68.82	16.32	89.70
excise tax	3.69	16.68	3.69	17.31	2.31	12.67
municipal tax	0.37	1.67	0.37	1.73	0.23	1.27
oil fund 1	0.50	2.26	0.30	1.41	0.50	2.75
oil fund 2	0.00	0.00	0.00	0.00	-3.34	-18.37
conservation fund	0.04	0.18	0.04	0.19	0.04	0.22
wholesale price	19.73	89.32	19.04	89.45	16.05	88.24
value added tax	1.38	6.25	1.33	6.26	1.12	6.18
wsp+vat*	21.11	95.57	20.38	95.71	17.17	94.41
marketing margin	0.92	4.14	0.85	4.00	0.95	5.22
value added tax	0.06	0.29	0.06	0.28	0.07	0.37
retail price	22.09	100.00	21.29	100.00	18.19	100.00

*wsp + vat = wholesale price + value added tax

Source: Energy Policy and Planning Office, 2006

Before the deregulation of oil prices in August 1991, the government controls all components of the retail price structure. After 1991, the government

no longer controls the ex-refinery price and the marketing margin components. Their rates are allowed to be determined by the 'market mechanism'.

Even after the oil price deregulation in 1991, the price structure still allows the government to manipulate the wholesale and retail prices of gasoline and high speed diesel by setting the rates of all tax items, oil fund 1, oil fund 2, and the energy conservation fund components at desired levels. The rates for all taxes and the energy conservation fund components are left unchanged for many years and the retail prices are manipulated through the oil fund components.

The retail price structure of gasoline 95, gasoline 91, and high speed diesel on March 31, 2005 is presented in Table 1 to illustrate their price structure. The oil fund component of the retail price structure reflects the nature of the government's pricing policy. The government collects the oil fund 1 contribution from gasoline and high speed diesel consumers and then uses the oil fund 2 component to subsidize the high speed diesel consumers.

2.2 Fleet Structure

Vehicles in Thailand are classified into vehicles under the Motor Vehicle Act, vehicles under the Land Transport Act, and vehicles under the Non Motorized Vehicle Act. The total number of vehicles under the Motor Vehicle Act constitutes 96.3 percent of the total stocks of vehicles in Thailand compared to 3.6 percent for the vehicles under the Land Transportation Act and 0.11 percent for the vehicles under the Non Motorized Vehicle Act on December 31, 2001.¹ The new vehicles under the Motor Vehicle Act constitutes between 97 and 98 percent between January 2002 and August 2005.

¹ Vehicles under the Non Motorized Vehicle Act are vehicles powered by human or animal power.

Table 2 Stocks of Vehicles under the Motor Vehicle Act on December 31, 2001

	Number	percent	percent ¹	% gasoline ²	% diesel ²
Vehicles under Motor Vehicle Act ³	21,760,467	100	100	77.1	21.41
1. Sedan (Not more than 7 Pass.)	2,280,676	10.48	34.96	74.97	15.07
2. Microbus and Passenger Van	583,299	2.68	8.94	10.8	84.04
3. Van and Pick Up	3,341,448	15.36	51.21	5.75	91.85
4. Motor tricycle	2,147	0.01	0.03	57.32	3.29
5. Interprovincial Taxi	388	0	0.01	63.45	17.24
6. Urban Taxi	69,037	0.32	1.06	6.23	0.6
7. Fixed Route Taxi	9,128	0.04	0.14	83.02	0.28
8. Motor tricycle Taxi (Tuk Tuk)	46,821	0.22	0.72	23.13	1.24
9. Hotel Taxi	2,221	0.01	0.03	67.94	9.38
10. Tour Taxi	498	0	0.01	48.34	8.73
11. Car For Hire	538	0	0.01	40.38	43.02
12. Motorcycle	15,236,081	70.02	-	99.96	0.04
13. Tractor	99,449	0.46	1.52	0.8	96.02
14. Road Roller	8,612	0.04	0.13	0.53	98.11
15. Farm Vehicle	77,899	0.36	1.19	3.47	92.44
16. Automobile Trailer	2,225	0.01	0.03	0	0

¹ Percent of total number of vehicles without motorcycle ² Based on averages between March 2006 and December 2008 data ³ See source for definition of each category Total percent of gasoline and diesel engine vehicles do not add up to 100 due to the small amount of other fuel consumption

Source: Compiled from Statistics Sub-Division, Technical and Planning Group, Land Transport Management Bureau, Department of Land Transport

The high proportion of the vehicles under the Motor Vehicle Act is due to the inclusion of motor cycles whose number constitutes about 68 percent of the total number of vehicles in the country. If motor cycles are removed from the list, the vehicles under the Motor Vehicle Act would constitute about 89 percent of the total vehicles compared to about 11 percent for the vehicles under the Land Transportation Act.

Vehicles under the Motor Vehicle Act are further classified into 16 subgroups. Table 2 presents the total stocks of all vehicles under this category on December 2001. The number of motor cycles comprises over 70 percent of the total number of all vehicles under this category. If the number of motorcycles is

excluded from the list, sedans, vans and pick ups become the two major groups of vehicles comprising about 35 percent and 51 percent, respectively, of the total number of vehicles under the Motor Vehicle Act.

Approximately 75 percent of the sedan fleet is powered by gasoline while over ninety percent of the van and pick up fleet are powered by high speed diesel. Almost all of the motorcycles in the country are powered by gasoline. In addition to gasoline and high speed diesel, LPG is used by the majority of motor tricycles but their number constitutes only 0.22 percent of the total number of vehicles under the Motor Vehicle Act.

Table 3 Total Stocks of Vehicles under the Land Transportation Act, December 31, 2001

Vehicles under Land Transport Act	Number	Percent	%gasoline ¹	% diesel ¹
Bus : Total	107,622	13.39	5.15	94.27
Fixed Route Bus	77,944	9.70	2.44	97.19
Non Fixed Route Bus	20,885	2.60	15.14	83.53
Private Bus	8,793	1.09	0.43	99.31
Truck : Total	673,599	83.79	0.05	88.04
Non Fixed Route Truck	90,181	11.22	0.02	66.36
Private Truck	583,418	72.58	0.05	92.50
Small Rural Bus	22,648	2.82	14.05	85.71
Total	803,869	100.00	1.03	88.83

¹based on averages between March 2006 and December 2008 data. Total percent of gasoline and diesel engine vehicles do not add up to 100 due to the small amount of other fuel consumption
Source: Compiled from Statistics Sub-Division, Technical and Planning Group, Land Transport Management Bureau, Department of Land Transport

Buses and trucks are classified under the Land Transportation Act and the distribution of their stocks by vehicle types on December 2001 is presented in Table 3. Trucks constitute over eighty percent of the vehicles under this group.

The vehicles under the Land Transportation Act are predominantly powered by high speed diesel.

II.3 Vehicle Tax Structure

Taxes are collected on the imported vehicles as well as on the locally assembled vehicles. An import tax of mP baht is collected on an imported vehicle with a c.i.f price of P baht, where m is the import tax rate. An excise tax of $P(1+m)e/(1-1.1e)$ is then collected on this vehicle, where e is the excise tax rate.

The interior tax is collected at 10 percent of the excise tax and this tax is remitted to the Ministry of Interior. Finally, the value added tax is collected at 7 percent of the c.i.f price plus import tax, excise tax, and interior tax. The retail price of an imported vehicle with the c.i.f price of P baht, inclusive of all taxes, but not including dealers' profits, is then equal to $1.07P(1+m)/(1-1.1e)$.

The import tax rates are highest for passenger cars at 80 percent and lowest for buses at 40 percent. A major change in the import tax rate occurs in July 2003 when the import tax rate of 60 percent is removed for all trucks. There are more variations in the excise tax rate structure and can be summarized as follows.

The excise tax rates for diesel engine vehicles are considerably lower than the rates for gasoline engine vehicles. For example, the lowest excise tax rate for a 2000 c.c gasoline engine passenger car is still 30 percent compared to the rate of 4 percent for a pick up which is predominantly powered by diesel engine.

The excise tax rate structure is progressive as the rate increases with the engine capacity. In addition, buses with more than 10 seats and trucks in excess of 4000 kilograms are exempted from the excise tax collections. Table 4 presents the import tax and the excise tax structure for the gasoline engine vehicles and diesel engine vehicles.

Table 4 Imports and Excise Tax Rates for Vehicles, January 2002 – August 2005

Import Tax	January 2002-June 2003	July 2003-August 2005
All Passenger_(diesel)	80	80
Van and Pick Up_(diesel)	80	80
All Passenger_(gasoline)	80	80
All Buses	40	40
All Trucks	60	0
All Motor Cycles	60	60
<u>Excise Tax</u>	January 2002-July 2004	August 2004-August 2005
Passenger Cars		
<=2000cc & <=220 hp	35	35
2000<x<2500 & <=220 hp	35	35
2500<x<3000 & <=220 hp	41	40
>3000 & > 220 hp	48	50
Pick up	3	3
PPV		
<=3250cc	18	20
>3250cc	18	50
Double Cab		
<=3250cc	12	12
>3250cc	20	50
Modified		
<=3250cc	n.a.	3
>3250cc	50	50
Buses < 10 seats		
<=2000cc & <=220 hp	35	30
2000<x<2500 & <=220 hp	35	35
2500<x<3000 & <=220 hp	41	40
>3000 & > 220 hp	41	50
Trucks < 4000 Kilogram		
<=3250 cc	3	3
<=3250 cc	18	18
>3250 cc	18	50
Motor Cycles		
2 strokes	5	5
4 strokes	3	3

Source: Customs Department, Excise Department

The effect of the vehicle tax structure is to increase the prices of the gasoline engine vehicles relative to the prices of the diesel engine vehicles and also encourages the purchase of smaller engine vehicles. As an illustration, a gasoline engine passenger car and a pick up truck with the same c.i.f price of P

baht will have different retail prices. The retail price of gasoline engine passenger vehicle, before adding dealers' profit, is 2.87P compared to the price of 2.01P for the pickup truck.

The vehicle tax structure is the same for locally assembled vehicles. However, import tax is not collected for vehicles that have no import contents. The import tax is collected on locally assembled vehicles in the case where there are import contents but the rates are lower than the rates for imported vehicles.

2.4 Some Observations

Reviews of the vehicle tax policy and the retail pricing policy of gasoline and high speed diesel provide a preview that these two policies may have affected the consumption patterns of gasoline and high speed diesel by influencing the vehicle purchasing decisions and the patterns of their fuel demand.

The vehicle tax policy which lowers the prices of diesel vehicles relative to the prices of gasoline vehicles provides incentives for potential new vehicle purchasers to purchase new diesel engine vehicles. The purchase of new diesel engine vehicle is expected to be a contributing factor to the relative increase in the high diesel consumption.

A similar observation was made for the case of Sri Lanka. Clean Air Initiative for Asian Cities [8] reported that the retail price of gasoline was three times the retail price of diesel in a given period, a result of heavy gasoline tax. The gasoline/diesel price ratio offers incentive for automobile consumers to use the diesel engine vehicles rather than the gasoline engine vehicle.

During the reported period, the sales volume of diesel engine vehicles is 5 times the sales volume of gasoline engine vehicles. This is not surprising since the operating cost of a diesel engine vehicle, at this relative price, operating more

than 4,000 km per year, is substantially lower than the operating cost of a gasoline engine vehicle.

3. Theoretical Framework

3.1 Link between Fuel Demand and Vehicle Demand

Discussions in the last section suggest that the demand for gasoline and high speed diesel are linked to the demand for vehicles. Espey [9] provides some formal evidence of a link between the demand for fuels and the demand for vehicles by using meta-analysis to compare several gasoline demand studies published between 1966 and 1997 that cover the period of analysis between 1929 and 1996.

Gasoline prices and income are the common variables in the reviewed gasoline demand studies. Apart from these two common explanatory variables, the surveyed studies differ by the inclusions and exclusions of other variables, the model specifications, data characteristics, and the estimation methods.

One important conclusion from the Espey article is that some measures of vehicle ownership is a variable that significantly explains the demand for gasoline. The exclusion of this variable would be expected to bias the results of the demand studies. Another interesting conclusion is that the linear models yield results that are not significantly different from the log linear models.

On the other side of the coin, there are studies on demand for vehicles that provide some evidence of the links to gasoline demand. Similar to the gasoline demand studies, these vehicle demand studies differ by model specifications, data characteristics, and estimation methods.

Income and vehicle prices are the two common variables that determine the demand for vehicles. In addition to these two common variables, Carlson and

Umble [7], Tishler [30], McManus [16], Beresteanu and Li [6], and Miller and Langer [17] also find that rising gasoline prices significantly affect the automobile demand by causing a shift in demand for automobile towards vehicles with better fuel economy.

3.2 Fuel Demand, Vehicle Demand, and Related Externalities

The use of gasoline and high speed diesel to power vehicles in the transportation sector create externalities referred to as automobile externalities. These externalities result in welfare losses for a given society if they are not internalized through appropriate instruments. The internalization of these externalities depends upon the nature of their sources, the available technology for their abatements, the vehicle performance, and the behavioral responses of vehicle owners to the instruments used to internalize these externalities.

Several studies that discuss these externalities are summarized by Parry, Walls, and Harrington [23]. The sources of automobile externalities discussed in these studies are identified as global pollutions, local air pollutions, traffic congestions, traffic accidents, and other externalities.

Before discussing the sources of these automobile externalities and their internalization it is useful to consider the relationship between fuel consumption, vehicle utilization, fuel economy, and the number of vehicles as suggested by Sweeney [28], Griffin [13], and Batalgi and Griffin [3]. The relationship between these four variables may be represented mathematically for gasoline consumption by

$$QG_t = U_t \cdot E_t \cdot TTV_t \quad (t = 1, 2, \dots, T) \quad (1)$$

where QG_t = gasoline consumption in period t; TTV_t = stocks of vehicles in period t; U_t = average utilization rate of vehicles in kilometer/vehicle in period t;

E_t = average fuel economy of vehicles in liter/kilometer in period t

3.2.1 Global Pollution

Global pollution is caused by the emission of carbon dioxide, the major greenhouse gas that causes global warming. These emissions occur whenever a liter of gasoline or high speed diesel is used to power a vehicle. The global pollution is related to the amount of fuel consumption rather than the distance travelled by vehicles. Unfortunately, the current state of technology does not allow a viable reduction of carbon emissions per liter of fuel consumption [23].

There are several studies that provide estimates of the global warming costs. One well known study by Nordhaus [21] quoted in Parry, Walls, and Harrington [23] estimated the discounted costs of carbon dioxide emissions over their expected atmospheric life of 100 years at \$20 per ton of carbon in 2005 prices. The Nordhaus estimates are compatible with the price of the EU allowances for carbon dioxide emissions between January 2007 to January 2009 that varies between \$5 and \$30 per ton of carbon dioxide equivalent with an average price around \$20 dollar per ton.

According to the United States Environmental Protection Agency [31], carbon dioxide emissions from diesel fuel are higher than emissions from gasoline fuel. The carbon dioxide emissions from diesel fuel were found to be 2,778 grams per gallon of diesel compared to 2,441 grams per ton of gasoline. This translates into emissions of 644.9 grams of carbon dioxide per liter of gasoline and 733.9 gram per liter of diesel. Using the average carbon dioxide emissions costs of \$20 dollar per ton of carbon, and the exchange rate of 35 baht per dollar, the carbon dioxide emissions costs are approximately 0.45 baht/liter for gasoline and 0.51 baht/liter for diesel.

Since the global pollutions are related to fuel consumption, the instrument used to internalize its social costs must be able to reduce the externality by reducing fuel consumption to its optimum level. Equation (1) shows that gasoline consumption can be reduced to its optimum level by a reduction in the utilization rates and/or improving the fuel economy of vehicles.

A simple fuel tax equivalent to the costs of global pollution per liter of fuel is an effective instrument to internalize the global pollution costs for the following reasons. The higher fuel prices are expected to discourage driving by reducing the vehicle utilization rates for the existing vehicle owners. The extent of the utilization rate reductions depend on the existing vehicle owners' behavioral responses to higher fuel prices.

For the potential new vehicle owners in the process of purchasing a new vehicle, evidences presented in the previous section show that higher fuel prices can shift the new vehicle demand towards the more fuel efficient cars which will improve the overall vehicle fuel economy.

3.2.2 Local Pollution Costs

The local pollution costs are caused by the tail pipe emissions of vehicles which contain particulate matter (PM) or fine particles, sulfur dioxide (SO₂), nitrogen oxide (NO₂), volatile organic compound (VOC), and carbon monoxide. These pollutants are detrimental to health but the fine particles are reported to be the major cause of health problems.

Rabl and Spadaro [28] estimated the health costs caused by the tail pipe emissions for France. The estimated health costs caused by the PM_{2.5} emissions are about 86 percent of the total health costs. The study also reports the PM_{2.5} emissions from the diesel engine vehicle to be between 5 to 40 times greater than

the same emissions from the gasoline engine vehicles. International Agency for Research on Cancer [14] also reported the emissions from the tail pipes of diesel engine vehicles to be between two to forty times the emissions from the tail pipes of gasoline engine vehicles of compatible power output.

There are attempts to quantify the environmental costs from the tail pipe emissions. A study by the World Bank Environment Department quoted by Prust [26] estimated the local environmental costs from diesel emissions to be about 4 times the costs from the gasoline emissions in India. Similar estimations from the same study for Thailand reports the environmental costs from diesel emissions to be about 60 percent of fuel use compared to 21 percent for gasoline emissions.

Unlike the case of global pollutions, the local pollutions are related to the distance travelled by the vehicles rather than the fuel consumption. Contrary to the case of global pollutions, there are viable technologies to reduce the vehicle tail pipe emissions that cause local pollutions. The current state of technology allows a reduction of tail pipe emissions regardless of the fuel economy [10]. A tail pipe emission standard, if implemented strictly, is then an effective instrument to internalize the local pollution costs by controlling the tail pipe emission standards to their 'optimum' levels.

Due to the nature of local pollution costs, a fuel tax may not be an effective instrument to internalize the local pollution costs as in the case of the global pollution. The degree of the ineffectiveness of the fuel tax is dependent on the behavioral responses of the vehicle owners to higher fuel prices that can be disaggregated into two parts.

The first part concerns the existing vehicle owners' response to increasing fuel prices by reducing their vehicle utilization rates, or the utilization rate

elasticity, which will reduce the local pollution costs. The second part concerns the potential new vehicle owners' response to increasing fuel prices by increasing their demand towards more fuel efficient vehicles or the fuel economy elasticity. It is this latter part of response that fails to reduce the local pollutions costs.

In the case where the standard control on fuel pipe emissions cannot be strictly implemented for whatever reasons, a fuel tax can be used as its weak substitute. In this case, the local pollution costs in baht per kilometer can be converted to a fuel tax in baht per liter by the vehicles' fuel economy. The more effective will be the fuel tax the larger the utilization elasticity of vehicle owners.

3.2.3 Traffic Congestion Costs

The traffic congestions externality is related directly to the act of driving a vehicle which imposes costs on the other vehicle users that are not internalized. Delay costs from traffic congestions are the most recognizable costs from this externality. Later studies pointed out by Parry, Walls, and Harrington [23] also include the adjustment costs to avoid traffic congestions such as trip rescheduling and changing the traffic mode.

The traffic congestions externality is similar to the local pollutions externality in that it is related to the vehicle utilization rates rather than the fuel consumption. The traffic congestion costs are not uniform across the country but are specific to locations and the time of day.

Due to the nature of this externality, the most effective instrument to internalize its costs is the direct congestion charges or the 'pay while you drive' tax that will have direct effects on the vehicle utilization rates. The charges can be designed to vary by time and locations. The current state of technology such

as the vehicle transponders and the global positioning system offer new options to implement the traffic congestions charges.

The fuel tax would be an ineffective instrument to internalize the traffic congestions externality as in the case of the local pollutions. In addition, the fuel tax has to vary across time of day and locations to reflect differences in the congestion costs which rules out its practical usefulness.

3.2.4 Traffic Accidents and other Externalities

Traffic accidents are related to the number of kilometers travelled by vehicles or the utilization rates rather than to fuel consumption. There are some studies that attempt to quantify the costs of accidents mentioned by Parry, Walls, and Harrington [23].

For the same reasons as in the case of local pollution costs, the internalization of these costs are more effective through the cost per kilometer charge rather through the fuel tax. Using the insurance policy to internalize the traffic accidents has been proposed as an effective internalizing instrument [23].

3.2.5 Oil Dependency and Other Externalities

There are views that dependency on oil exposes a nation like Thailand to oil price volatility, and can affect national security and foreign policy [23]. The controversy on the oil dependency centers on the extent to which oil dependency can be considered as an externality.

In a recent keynote address, Nordhaus [22] presented empirical evidence to support the notion that the international oil market is an integrated market. Within the framework of an integrated market that operates by the total demand and supply of oil, he provided strong arguments that there are no external costs that can be related to oil dependency.

Other externalities related to the use of vehicles are noise pollution, highway damages, and improper disposals of vehicles. These externalities are not related to oil consumption and can be internalized by other policies such as noise control and vehicle weight control rather than by the fuel taxes.

3.2.6 Measuring Welfare Losses

Based on discussions in the previous section, the only component of externality costs that can be effectively internalized by the fuel tax from an efficiency criterion is the global warming component. The costs of local pollutions, traffic congestions, and traffic accidents can be internalized more effectively by other control measures.

Thailand has enacted laws that control the tail pipe emissions from gasoline engine vehicles and diesel engine vehicles [18]. The policy on traffic congestions charges has been mulled but never been implemented. Similarly, there is, as yet, no policy to internalize the traffic accident externality.

In the case where the global warming externality is internalized into the fuel tax and other control policies are effectively implemented to internalize other externalities, there are no needs to collect a vehicle tax from an efficiency point of view. In analyzing the pricing policy of gasoline and high speed diesel and the vehicle tax policy, it will be assumed that appropriate measures can be effectively implemented to internalize the other externality costs.

There are several past studies that investigate the welfare losses in terms of losses in consumer surplus and producer surplus from given government energy policies. The welfare losses in many studies are estimated by assuming a range of elasticity for demand and supply of the energy source under investigation.

Examples of studies that estimate the welfare losses by assuming a range of

price elasticity are Larsen and Shah [15] who investigated the effects of world fossil price subsidies and global carbon emissions on welfare. Freund and Wallich [11] investigated the welfare effects of raising household prices of district heat, electricity and gas in Poland. Montgomery et al. [20] investigated the welfare loss in the gasoline market after hurricanes Katarina and Rita caused damages to the energy infra structure of the Gulf Coast in the United States.

Welfare losses are also estimated from the demand and supply models. An example of these studies is Ahmadian et al. [1] who estimated the welfare effects of raising the prices of gasoline in Iran after a period of low regulated prices. The authors did not assume the values for the demand and supply price elasticity but estimated the welfare effects from the demand and supply models.

It will be argued that the supply of gasoline and high speed diesel for the case of Thailand are perfectly elastic. Before the oil price deregulation in 1991, the government determined all components of the retail prices. The ex-refinery price component determination is based on the import parity principle. According to this principle, if no refineries exist in Thailand, gasoline, high speed diesel, and other petroleum products must be imported into the country to satisfy the local demand.

The Singapore market is the closest market to Thailand and may be considered as the country's supply source. The import price of gasoline or high speed diesel then equals the corresponding Singapore ex-refinery price plus transportation costs, insurance costs, and quality adjustment costs to match the local product specifications. Thailand, as a relatively small country, can import all of the required gasoline and high speed diesel at these prices with negligible effects on the international prices.

Under the import parity principle, the government sets the local ex-refinery prices of gasoline and high speed diesel equal to their corresponding import prices. The import parity principle allows the local ex-refinery prices to be higher than the corresponding Singapore ex-refinery prices by the amount of the transportation costs, the insurance costs, and the quality adjustment costs. If the local refining costs are the same as the Singapore refining costs, a typical refinery in Thailand would earn ‘wind fall’ profit from the differences between the local and the Singapore ex-refinery prices.

As a consequence of the local ex-refinery price determination, the supply of gasoline and high speed diesel at the local refineries are perfectly elastic at their local ex-refinery prices. If the local refineries were to sell their products above these prices, they cannot compete with the imported products.

On the other hand, they have no incentive to sell their products at lower prices since they can sell all of their products at these prices. When the marketing margin, which is also set by the government, and the other transfer payment items are added, the supply of these two products for the final consumers become perfectly elastic at their retail prices.

After the oil price deregulation in 1991, the local ex-refinery prices of gasoline and high speed diesel are still based on the Singapore ex-refinery prices [2]. This is not surprising since the local refineries have no incentive to change the ex-refinery pricing practice which can provide them with easy windfall profits if the refining costs in the two countries are the same². It was also observed that the combined refinery margin and the marketing margin after the oil deregulation remain at approximately the same level as the pre-oil price

² They can, however, suffer losses during the depressed oil markets.

deregulation era. Given the nature of the perfectly elastic supply, the consumption of gasoline and high speed diesel in the country are determined by their demand.

3.3 The Model

The model used to estimate the welfare losses is based on equation (1) in log linear form. The equation for gasoline consumption in log linear form is

$$\text{Log}QGP\text{ERTV}_t = \text{Log}U_t + \text{Log}E_t \quad (t = 1, 2, \dots, T) \quad (2)$$

where $QGP\text{ERTV}_t$ = consumption of gasoline per vehicle

Batalgi and Griffin [3], Batalgi et al. [4] specified the utilization rate as a function of real price of gasoline, real per capita income, and the per capita stock of passenger cars. The stock of passenger cars per capita variable is included in an attempt to capture changes in the utilization rate. The logic behind the inclusion of this variable is that a person who owns two or more cars cannot drive all cars simultaneously so the kilometers travelled per vehicle or the average utilization rate is likely to be less than the utilization rate of a person who owns only one car.

The utilization rate is then expressed as

$$\text{Log}U_t = \text{con}_u + a_u \text{Log}RY_t + b_u \text{Log}RPG_t + c_u \text{Log}TV_t \quad (t = 1, 2, \dots, T) \quad (3)$$

where RY_t = real per capita income; RPG_t = real gasoline price; TV_t = stocks of vehicles per capita

The fuel economy is a function of the same variables that determine the utilization rate. The difference between the two equations is in the distribute lags of these variables to allow for the long gestation period of the vehicle stocks. The fuel economy equation is then expressed as

$$\text{Log}E_t =$$

$$con_e + a_e \text{LogRY}_t + a_{e1} \text{LogRY}_{t-1} + \dots + b_e \text{LogRPG}_t + b_{e1} \text{LogRPG}_{t-1} + \dots + c_e \text{LogTV}_t + c_{e1} \text{LogTV}_{t-1} + \dots$$

$$(t = 1, 2, \dots, T) \quad (4)$$

Equations (3) and (4) are substituted into equation (2) to bypass the unavailable data on fuel economies and utilization rates. One model used by Batalgi [3] to estimate the gasoline consumption per vehicle is a first order autoregressive equation derived from a simple Koyck transformation³

$$\text{LogQGP}ERTV_t = con_g + b_g \text{LogRY}_t + c_g \text{LogRPG}_t + d_g \text{LogTV}_t +$$

$$e_g \text{LogQGP}ERTV_{t-1} \quad (t = 1, 2, \dots, T) \quad (5)$$

where all the coefficients are appropriately defined.

Pock [24] also follows the Sweeney et al. approach to study the gasoline demand and the diesel demand in Europe but modified the gasoline consumption per vehicle into gasoline consumption per gasoline engine vehicle. The demand for gasoline is specified by the equation

$$\text{LogQGP}ERTVG_t = \alpha_g + \beta_g \text{LogRY}_t + \gamma_g \text{LogRPG}_t + \delta_g \text{LogTVG}_t +$$

$$\epsilon_g \text{LogTVD}_t + \epsilon_g \text{LogQGP}ERTVG_{t-1} \quad (t = 1, 2, \dots, T) \quad (6)$$

where $QGP}ERTVG_t$ = consumption of gasoline per gasoline engine vehicle;

TVG_t = stock of gasoline engine vehicles per passenger; TVD_t = stock of diesel engine vehicles per passenger

The disaggregation of vehicle stocks into the stocks of gasoline engine vehicles and the stocks of diesel engine vehicles is an attempt to capture the effects of the increasing share of diesel engine vehicles on gasoline consumption

³ Batalgi also used two other models to estimate the gasoline consumption per vehicle. See Batalgi [3] pp.120-121.

in Europe. Both variables were found by Pock to significantly affect the demand for gasoline and diesel.

The model for gasoline and high speed diesel consumption in this article is an expanded version of equation (2). The vehicles are aggregated into gasoline engine vehicles and diesel engine vehicles as in the Pock study but with some differences in the utilization rate and the fuel economy equations.

The utilization rate for gasoline engine vehicles is expressed as

$$\begin{aligned} \text{Log}UG_t = & \\ & \text{con}_{gu} + a_{gu}\text{Log}RY_t + b_{gu}\text{Log}RPG_t + c_{gu}\text{Log}TVG_t + d_{gu}\text{Log}TVD_t + \\ & e_{gu}\text{Log}RPD_t \quad (t = 1, 2, \dots, T) \quad (7) \end{aligned}$$

where UG_t = utilization rate of gasoline engine vehicles; RPD_t = real high speed diesel price

The inclusion of real high speed diesel retail price as an exogenous variable is to account for the possibility that an existing vehicle owner may own a gasoline engine vehicle as well as a diesel engine vehicle. In this case, this owner can react to a fall in the high speed diesel price by increasing the utilization rate of his diesel engine vehicle and reducing the utilization rate of his gasoline engine vehicle.

In the fuel economy equation, the coefficients of the lagged exogenous variables are unrestricted for a given period and then their coefficients in later periods are assumed to decline geometrically by the Koyck specification. The fuel economy of gasoline engine vehicles is then expressed as

$$\begin{aligned} \text{Log}EG_t = & \text{con}_{ge} + a_{ge1}\text{Log}RY_t + a_{ge2}\text{Log}RY_{t-1} + \dots + a_{ges}\text{Log}RY_{t-s} + \\ & \frac{a_{geL}}{1-\lambda_1L}\text{Log}RY_{t-s-1} + b_{ge1}\text{Log}RPG_t + b_{ge2}\text{Log}RPG_{t-1} + b_{ges}\text{Log}RTG_{t-s} + \end{aligned}$$

$$\begin{aligned}
& \frac{b_{geL}}{1-\lambda_2L} \text{LogRTG}_{t-s-1} \dots + c_{ge1} \text{LogTVG}_t + c_{ge2} \text{LogTVG}_{t-1} + \\
& \dots + c_{ges} \text{LogTVG}_{t-s} + \frac{c_{geL}}{1-\lambda_3L} \text{LogTVG}_{t-s-1} + d_{ge1} \text{LogRPD}_t + d_{ge2} \text{LogRPD}_{t-1} + \\
& d_{ges} \text{LogRPD}_{t-s} + \frac{d_{geL}}{1-\lambda_4L} \text{LogRPD}_{t-s-1} + e_{ge1} \text{LogTVD}_t + e_{ge2} \text{LogTVD}_{t-1} + \\
& \dots + e_{ges} \text{LogTVD}_{t-s} + \frac{e_{geL}}{1-\lambda_5L} \text{LogTVD}_{t-s-1} \quad (8)
\end{aligned}$$

where EG_t = fuel economy of gasoline engine vehicles; $0 < \lambda_i < 1 \quad i = 1, 2, \dots, 5$;

L_i = lag operator $i = 1, 2, \dots, 5$

When equations (4) and (5) are substituted into equation (2) and using the Koyck transformation, the gasoline consumption equation becomes a distributive lag autoregressive equation

$$\begin{aligned}
\text{LogQGPRTVG}_t = & \text{con}_G + \alpha_{G1} \text{LogRY}_t + \alpha_{G2} \text{LogRY}_{t-1} + \dots + \alpha_{Gs} \text{LogRY}_{t-s} + \\
& \alpha_{GL} \text{LogRY}_{t-s-1} + \beta_{G1} \text{LogRPG}_t + \beta_{G2} \text{LogRPG}_{t-1} + \dots + \beta_{Gs} \text{LogRTG}_{t-s} + \\
& \beta_{GL} \text{LogRTG}_{t-s-1} + \gamma_{G1} \text{LogTVG}_t + \gamma_{G2} \text{LogTVG}_{t-1} + \dots + \gamma_{Gs} \text{LogTVG}_{t-s} + \\
& \gamma_{GL} \text{LogTVG}_{t-s-1} + \delta_{G1} \text{LogRPD}_t + \delta_{G2} \text{LogRPD}_{t-1} + \dots + \delta_{Gs} \text{LogRPD}_{t-s} + \\
& \delta_{GL} \text{LogRPD}_{t-s-1} + \varepsilon_{G1} \text{LogTVG}_t + \varepsilon_{G2} \text{LogTVG}_{t-1} + \dots + \varepsilon_{Gs} \text{LogTVG}_{t-s} + \\
& \varepsilon_{GL} \text{LogTVG}_{t-s-1} + \epsilon_{G1} \text{LogTVD}_t + \epsilon_{G2} \text{LogTVD}_{t-1} + \dots + \epsilon_{Gs} \text{LogTVD}_{t-s} + \\
& \epsilon_{GL} \text{LogTVD}_{t-s-1} + \sum_{i=1}^5 \eta_{Gi} \text{LogQGPRTVG}_{t-i} \quad (9)
\end{aligned}$$

where all the coefficients are appropriately defined

Similarly, the high speed diesel consumption equation is specified as

$$\begin{aligned}
\text{LogQGPRTVD}_t = & \text{con}_D + \alpha_{D1} \text{LogRY}_t + \alpha_{D2} \text{LogRY}_{t-1} + \dots + \alpha_{Ds} \text{LogRY}_{t-s} + \\
& \alpha_{DL} \text{LogRY}_{t-s-1} + \beta_{D1} \text{LogRPG}_t + \beta_{D2} \text{LogRPG}_{t-1} + \dots + \beta_{Ds} \text{LogRTG}_{t-s} + \\
& \beta_{DL} \text{LogRTG}_{t-s-1} + \gamma_{D1} \text{LogTVG}_t + \gamma_{D2} \text{LogTVG}_{t-1} + \dots + \gamma_{Ds} \text{LogTVG}_{t-s} + \\
& \gamma_{DL} \text{LogTVG}_{t-s-1} + \delta_{D1} \text{LogRPD}_t + \delta_{D2} \text{LogRPD}_{t-1} + \dots + \delta_{Ds} \text{LogRPD}_{t-s} + \\
& \delta_{DL} \text{LogRPD}_{t-s-1} + \varepsilon_{D1} \text{LogTVG}_t + \varepsilon_{D2} \text{LogTVG}_{t-1} + \dots + \varepsilon_{Ds} \text{LogTVG}_{t-s} +
\end{aligned}$$

$$\begin{aligned} & \epsilon_d \text{LogTVG}_{t-s-1} + \epsilon_{D1} \text{LogTVD}_t + \epsilon_{D2} \text{LogTVD}_{t-1} + \dots + \epsilon_{Ds} \text{LogTVD}_{t-s} + \\ & \epsilon_{DL} \text{LogTVD}_{t-s-1} + \sum_{i=1}^5 \eta_{Di} \text{LogQGPVRTVD}_{t-i} \quad (10) \end{aligned}$$

where $QGPVRTVD_t$ = consumption of high speed diesel per diesel engine vehicle

In order to capture the effects of vehicle tax policy that varies across vehicle types on gasoline and high speed diesel consumption, the gasoline engine vehicles in the model are disaggregated into passenger cars, motor cycles, buses and trucks, and motor tricycles. The total stocks of gasoline engine vehicle in period t is then the sum of the stocks of gasoline engine passenger vehicles and gasoline engine bus and trucks

$$TVG_t = PASSG_t + MTAG_t + MVAG12_t + MVAGOTHER_t \quad (11)$$

where

$PASSG_t$ = per capita stocks of gasoline engine passenger cars; and

$$PASSG_t = MVAG1_t + MVAG2_t + MVAG3_t + MVAG4_t + MVAG5_t + MVAG6_t + MVAG7_t + MVAG9_t + MVAG10_t + MVAG11_t \quad (12)$$

where $MVAG_{it}$ = per capita stocks of gasoline engine vehicles in category i under the Motor Vehicle Act listed in Table 2 $i = 1,2,3,4,5,6,7,9,10,11$; $MTAG_t$ = per capital stocks of gasoline engine buses and trucks under Land Transportation Act; $MVAG12_t$ = per capita stocks of motor cycles; $MVATOTHG_t$ = remaining per capita stocks of gasoline engine vehicles

Since the model is in log linear form, equation (11), which is homogeneous of degree one, must be expressed in its equivalent share equation

$$\text{LogTVG}_t = a_{VG} \text{LogPASSG}_t + b_{VG} \text{LogMTAG}_t + c_{VG} \text{LogMVA1G12}_t + d_{VG} \text{LogMVAOTHG}_t \quad (13)$$

where the share of each vehicle category in the total stocks must sum to unity

$$a_{VG} + b_{VG} + c_{VG} + d_{VG} = 1 \quad (14)$$

Euler's theorem may be applied to equation (11) to justify equation (13)

$$\begin{aligned} TVG_t = & PASSG_t \cdot \frac{dTVG_t}{dPASSG_t} + MTAG_t \cdot \frac{dTVG_t}{dMTAG_t} + MVA1G12_t \cdot \frac{dTVG_t}{dMVA1G12_t} + \\ & MVAOTHG_t \cdot \frac{dTVG_t}{dMVAOTHG_t} \quad (15) \end{aligned}$$

which may be shown to be equivalent to the coefficient restrictions in equation (14).

The total stocks of diesel engine vehicles is the sum of diesel engine passenger vehicles, diesel engine bus and trucks, and other vehicles

$$TVD_t = PASSD_t + MTAD_t + MVADOTHD_t \quad (16)$$

where

$PASSD_t$ = per capita stocks of diesel engine passenger cars

$$PASSD_t = MVAD1_t + MVAD2_t + MVAD3_t + MVAD4_t + MVAD5_t + MVAD6_t + MVAD7_t + MVAD9_t + MVAD10_t + MVAD11_t \quad (17)$$

$MVAD_{it}$ = per capita stocks of diesel engine vehicles in category i under the Motor Vehicle Act listed in Table 2 $i = 1,2,3,4,5,6,7,9,10,11$; $MTAD_t$ = per capita stocks of diesel engine buses and trucks under Land Transportation Act; $MVADOTHD_t$ = remaining per capita stocks of diesel engine vehicles

As in the case of gasoline, equation (16) can be expressed as

$$\text{Log}TVD_t = a_{VD}\text{Log}PASSD_t + b_{VD}\text{Log}MTAD_t + c_{VD}\text{Log}MVAOTHD_t \quad (18)$$

where

$$a_{VD} + b_{VD} + c_{VD} = 1 \quad (19)$$

The stocks of vehicles in period t consist of the existing vehicles purchased in previous periods and the new vehicles purchased in this period. An existing owner who owns only one gasoline vehicle has no option for fuel substitutions except for the case where he also owns a diesel engine vehicle. An increase in the gasoline price for a single gasoline engine vehicle can, however, influence the utilization rate of his gasoline engine vehicle.

A potential new vehicle owner planning to purchase a vehicle in period t can factor in the fuel options into his purchasing decision. For a given relative price between the gasoline engine vehicle and the diesel engine vehicle, an increase in the relative price of gasoline to high speed diesel provides additional incentive to purchase the diesel engine vehicle and contribute to the increase in the high speed diesel consumption.

The number of new gasoline engine passenger vehicles in period t is specified by a first order autoregressive equation

$$\begin{aligned} \text{LogNPASSG}_t = & \\ & \text{con}_{pg} + a_{pg}\text{LogPMVAG}_t + b_{pg}\text{LogPMVAD}_t + c_{pg}\text{LogRPG}_t + \\ & d_{pg}\text{LogRPD}_t + e_{pg}\text{LogRY}_t + f_{pg}\text{LogPASSG}_{t-1} \quad (21) \end{aligned}$$

where NPASSG_t = new per capita stocks of gasoline engine passenger cars purchased in period t ; PMVAG_t = price of gasoline engine passenger cars; PMVAD_t = price of diesel engine passenger cars

The stocks of gasoline engine passenger vehicles in period t is the sum of the new gasoline engine vehicles from the previous periods and takes the form of a general distributed lag autoregressive equation

$$\begin{aligned} \text{LogPASSG}_t = \sum_{i=1}^T \text{LogNPASSG}_t = & \text{con}_{pgT} + \sum_{i=0}^T a_{pgi}\text{LogPMVAG}_{t-i} + \\ & \sum_{i=0}^T b_{pgi}\text{LogPMVAD}_{t-i} + \sum_{i=0}^T c_{pgi}\text{LogRPG}_{t-i} + \sum_{i=0}^T d_{pgi}\text{LogRPD}_{t-i} + \\ & \sum_{i=0}^T e_{pgi}\text{LogRY}_{t-i} + \sum_{i=1}^T f_{pgi}\text{LogPASSG}_{t-i} \quad (22) \end{aligned}$$

Over 99 percent of the motor cycles are powered by gasoline engine and its stocks in period t are represented by

$$\begin{aligned} \text{LogMVAG12}_t = & \\ \sum_{i=1}^T \text{LogNMVAG12}_t = & \text{con}_{pm} + \sum_{i=0}^T a_{pmi}\text{LogPMVAG12}_{t-i} + \\ \sum_{i=0}^T b_{pmi}\text{LogRPG}_{t-i} + & \sum_{i=0}^T c_{pmi}\text{LogRY}_{t-i} + \sum_{i=0}^T d_{pmi}\text{LogMVAG12}_{t-i} \quad (23) \end{aligned}$$

where NMVAG12_t = new per capita stocks of motorcycles purchased in period t

The stocks of gasoline engine bus and trucks are less than 2 percent of the total stocks of bus and trucks and are represented by

$$\begin{aligned} \text{LogMTAG}_t = \sum_{i=1}^T \text{LogNMTAG}_t = & \text{Logc}_{tbg} + \sum_{i=0}^T a_{bgi}\text{LogRY}_{t-i} + \\ \sum_{i=0}^T b_{bgi}\text{LogPMTA}_{t-i} + & \sum_{i=0}^T c_{bgi}\text{LogRPG}_{t-i} + \sum_{i=1}^T d_{bgi}\text{LogMTAG}_{t-i} \quad (24) \end{aligned}$$

where NMTAG_t = new per capita stocks of gasoline engine buses and trucks purchased in period t ; PMTAG_t = price of gasoline engine buses and trucks

The stocks of other remaining per capita stock of gasoline engine vehicles are represented by

$$\begin{aligned} \text{LogMVAGOTHG}_t = & \\ \sum_{i=1}^T \text{LogNMVAGOTG}_t = & c_{got} + \sum_{i=0}^T a_{goi}\text{LogRY}_{t-i} \quad (25) \end{aligned}$$

The stocks of diesel engine passenger vehicles are represented by

$$\begin{aligned} \text{LogPASSD}_t &= \sum_{t=1}^T \text{LogNPASSD}_t = \text{con}_{pdT} + \sum_{i=0}^T a_{pdi} \text{LogPMVAG}_{t-i} + \\ &\sum_{i=0}^T b_{pdi} \text{LogPMVAD}_{t-i} + \sum_{i=0}^T c_{pdi} \text{LogRPT}_{t-i} + \sum_{i=0}^T d_{pdi} \text{LogRPD}_{t-i} + \\ &\sum_{i=0}^T e_{pdi} \text{LogRY}_{t-i} + \sum_{i=1}^T f_{pdi} \text{LogPASSD}_{t-i} \quad (26) \end{aligned}$$

where NPASSD_t = new per capita stocks of diesel engine passenger cars purchased in period t

About 98% of trucks and buses are powered by diesel engine and their stocks are represented by

$$\text{LogMTAD}_t =$$

$$\begin{aligned} \sum_{t=1}^T \text{LogNMTAD}_t &= c_{tbd} + \sum_{i=0}^T a_{bdi} \text{LogRY}_{t-i} + \sum_{i=0}^T b_{bdi} \text{LogPMTA}_{t-i} + \\ \sum_{i=0}^T c_{bdi} \text{LogRPD}_{t-i} &+ \sum_{i=1}^T d_{bdi} \text{LogMTAD}_{t-i} \quad (27) \end{aligned}$$

where NMTAD_t = new per capita stocks of diesel engine buses and trucks purchased in period t ; PMTAD_t = price of diesel engine buses and trucks

The remaining stocks of other diesel engine vehicles are represented by

$$\text{LogMVADOTHD}_t =$$

$$\sum_{t=1}^T \text{LogNMVADOTHD}_t = \text{Log}c_{dot} + \sum_{i=0}^T a_{doi} \text{LogRY}_{t-i} \quad (28)$$

3.2 The Data

A monthly model will be constructed and estimated from the available data between January 2002 and August 2005. Data for gasoline and high speed diesel consumption are published monthly by the National Energy and Policy Office. The price structure of gasoline and high speed diesel are published on a daily basis and are used to construct the monthly prices.

The gasoline 95 retail prices are slightly higher than the gasoline 91 retail prices and the two prices exhibit perfect correlation during the period of analysis, which is not surprising, since they are the same product that differs only in the number of octane content. The consumption of gasoline 95 and gasoline 91 is aggregated into single gasoline consumption and its retail prices are presented as the average prices of gasoline 95 and gasoline 91 weighted by their consumption.

The monthly c.i.f import prices of passenger cars, motor cycles, buses and trucks are available at the Ministry of Commerce and are used to construct proxies for their retail prices from their tax structure. The number of vehicles by categories and by fuel types is taken from the data published by the Land Transport Department of the Transportation Ministry.

There are no direct data on the monthly GDP, so a proxy variable that is highly correlated with GDP is required. The money supply will be considered as a possible proxy variable for the monthly GDP. The relationship between money supply and GDP has been studied extensively for many countries with varying results.

In the United States, a high correlation between the money supply and GDP was observed in the seventies. However, the changes over time in banking accounts, the proliferation of financing companies, and more widespread investment among consumers (stock and bond investments which are not captured in M1 and M2 aggregates) break down the high correlation between money supply and GDP [5].

An excerpt from a letter written by Milton Friedman, published by the Wall Street Journal on April 7, 2005 may be quoted to explain this phenomenon [12]

“The short-run correlation between M2 growth and nominal GDP growth depends importantly on the nature of monetary policy and money demand. If variation in M2 is driven mainly by destabilizing monetary policy (as in the 1970s, or in the case of a hyperinflation), then we expect to see a close correlation between M2 and GDP growth. If we are in an era of relative price stability, then we expect to see the effects of shifts in money demand. We should not be surprised to see M2 and GDP growing in different directions much of the time.”

Outside of the United States, correlation between the money supply and GDP was also observed in the Euro area [25]. In the case of Japan, a positive correlation between money supply and income was observed until after the mid nineties, when the correlation began to break down [19].

The foregoing review of the money supply-GDP relationship suggests that the correlation between these two variables may not hold for all periods. The qualification of money supply as a proxy variable for GDP thus depends upon the robustness of their correlation during the period of analysis.

4. Estimation Results

4.1 Relationship between M1 and GDP

The M1 money supply is selected as a possible proxy for the GDP variable. When the unit root test is performed on the annual real per capita M1 (RM1) and real per capita GDP (RGDP), the null hypothesis that each variable has a unit root cannot be rejected. The results of the unit root test imply that the relationship between real M1 and real GDP must be tested for their cointegration to avoid possible spurious correlation.

Table 5 Unrestricted Cointegration Rank Test (Trace) for Relationship between Per Capital Real M1 and Per Capita Real GDP

	LogRGDP		
coefficient	1.09		
standard error	0.02		
t-statistics	59.34		
Hypothesized no. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.**
None *	29.40	12.32	0.0000

*denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-aug-Michelis (1999) p-values

The VAR method is used to test for cointegration between the annual real per capita M1 and the annual real per capita GDP between the period 1992 and 2005. The relationship between the two variables derived from the Johansen

cointegration test and their unrestricted cointegration rank test (trace) are presented in Table 5.

The tests provide evidence that there is a robust relationship between the per capita real M1 and the real per capita GDP. The real monthly money supply M1 will be used as a proxy variable for the monthly real GDP between January 2002 and August 2005 in the model estimations.

4.2 Model Estimation Results

The VAR method is used to estimate all of the equations in the model presented in section 3.1 except for the average vehicle share equations (13) and (18) that are estimated by the OLS method. The VAR estimation method is capable of capturing the distributive lags and autoregressive process and avoids the endogeneity problem posed by the simultaneous equation system.

The gasoline vehicle share equation is estimated to be

$$\begin{aligned} \text{LogTVG}_t = & \\ & 0.37 + 0.11\text{Log PASSG}_t + 0.00\text{Log MTAG}_t + 0.88\text{LogMVA1G12}_t + \\ & \quad (\text{Pr}=0.00) \quad (\text{Pr}=0.13) \quad (\text{Pr}=0.00) \\ & 0.00\text{LogMVAOTHG}_t \\ & (\text{Pr}=0.00) \quad R^2_{\text{adj}} = 1.00 \end{aligned} \quad (29)$$

$$\begin{aligned} \text{LogTVD}_t = & 0.57 + 0.82\text{Log PASSD}_t + 0.14\text{Log MTAD}_t \\ & \quad (\text{Pr}=0.00) \quad (\text{Pr}=0.00) \\ & +0.04\text{LogMVAOTH}_t \quad R^2_{\text{adj}} = 1.00 \\ & (\text{Pr}=0.00) \end{aligned} \quad (30)$$

The estimation results of the cointegration vector tests and their unrestricted cointegration rank tests are presented in Table 6 and Table 7. If the behavioral equations of the total stocks of gasoline engine and diesel engine vehicles are not considered, the own price elasticity of gasoline and high speed diesel from the gasoline and high speed diesel consumption equations are rather

inelastic at -0.45 and -0.31 respectively. These results are compatible with the other elasticity studies surveyed by Esprey.

Table 6 Estimation Results of Cointegration Vector Tests*

	Log(RPG)	Log(RM1)	Log (TVG)	Log (TVD)	Log (RPDT)
1. Log (QGPRTVG)	-0.43	0.38	0.65	-2.76	0.09
standard error	-0.05	0.09	0.11	-0.14	0.04
t-statistics	-8.64	4.10	5.65	-19.21	2.59
	Log(RPD)	Log (RM1)	Log (TVD)	Log(TVG)	C
2. Log (QDPRTVD)	-0.31	0.37	3.37	-1.97	14.17
standard error	-0.06	0.23	1.43	-1.14	
t-statistics	-4.79	1.63	2.36	-1.73	
	Log(PMVAG/PMVAD)	Log(RM1)	C		
3. Log(PASSG)	-0.09	1.09	1.79		
standard error	-0.03	0.06			
t-statistics	-2.95	17.77			
	Log(PMVAD/PMVAG)	Log(RM1)	Log(RPGT)	C	
4. Log(PASSD)	-0.05	0.22	0.38	-2.71	
standard error	-0.02	0.05	0.03		
t-statistics	-3.13	4.61	10.97		
	Log(RM1)	C			
5. Log(MVAG12)	1.03	3.47			
standard error	0.06				
t-statistics	17.33				
	Log(RM1)	Log(PMTA)	C		
6. Log(MTAG)	0.96	-0.93	-0.37		
standard error	0.18	-0.21			
t-statistics	5.43	-4.52			
	Log(RM1)	Log(PMTA)	C		
7. Log(MTAD)	3.05	-2.67	23.77		
standard error	0.58	-0.56			
t-statistics	5.22	-4.80			
	Log(RM1)	C			
8. LogMVAGOTH	0.05	-8.29			
standard error	0.02				
t-statistics	2.38				
	LogPCRM1T	C			
9. Log(MVADOTH)	0.30	-4.68			
standard error	0.04				
t-statistics	6.93				

*The coefficients are derived by the Johansen method

The gasoline price variable has no significant effect on the high speed diesel consumption while the high speed diesel price has a small but significant

effect on the gasoline consumption with the cross price elasticity of 0.1. The gasoline and the high speed diesel price variables have no significant effects on the stocks of gasoline engine vehicles while the gasoline price variable has a significant effect on the high speed diesel vehicle stocks.

The significant vehicle stocks variables in the gasoline and high speed diesel equations are compatible with the Esprey survey results that some measures of vehicle ownership significantly affect the gasoline demand and also, in this case, the high speed diesel demand.

Table 7 Unrestricted Cointegration Rank Test (Trace)

	Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.**
1.LOGQGPervag	None *	211.06	83.94	0.0000
2.LOGQDPervad	None *	143.09	76.97	0.0000
3. LOGPASSG	None *	41.44	35.19	0.0093
4. LOGPASSD	None *	67.61	54.08	0.0020
5. LOGMVAG12	None *	32.02	20.26	0.0008
6. LOGMTADT	None *	48.23	35.19	0.0012
7. LOGMTAGT	None *	68.68	35.19	0.0000
8. LOGMVAGOTH	None *	25.35	20.26	0.0091
9. LOGMVADOTH	None *	23.21	20.26	0.0191

*denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-aug-Michelis (1999) p-values

The relative prices of gasoline engine and diesel engine passenger vehicles have rather small effects on the stocks of gasoline engine passenger vehicles and the diesel engine passenger vehicles. In contrast, the buses and trucks are more price and income elastic than the passenger vehicles.

The reduced form equations for gasoline and high speed diesel consumption per vehicle may be derived from the behavioral equations as

$$\begin{aligned}
 \text{LogQGPervag}_t = & \\
 & -1.65 - 1.29\text{LogRPG} + 0.09\text{LogRPD} - 0.13\text{LogPMVAG/PMVAD} + \\
 & 1.02\text{LogPMTA} - 0.64\text{LogRM1} \quad (31)
 \end{aligned}$$

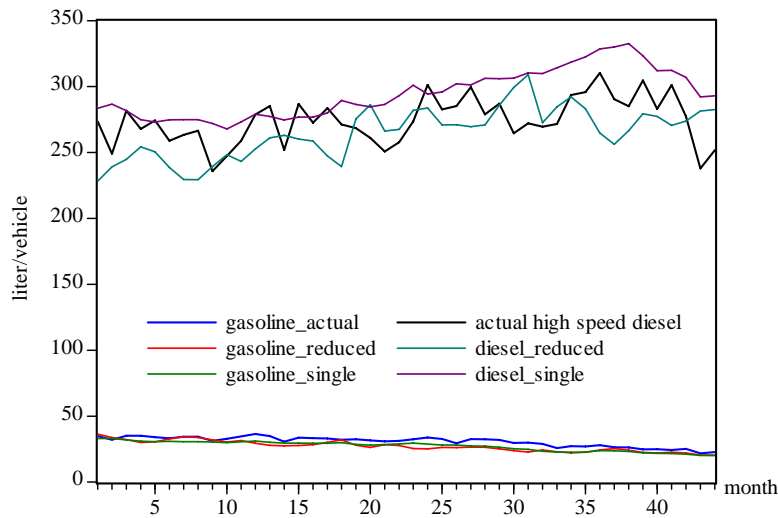
$$\begin{aligned} \text{Log}QGP\text{ERVAD}_t = & \\ & 11.89 + 0.98\text{Log}RPG - 0.31\text{Log}RPD - 0.13\text{Log}PMVAD/PMVAG - \\ & 1.24\text{Log}PMTA + 0.41\text{Log}RM1 \quad (32) \end{aligned}$$

The gasoline's own price elasticity is now more price elastic at -1.24 which can be explained by the diesel engine passenger vehicle behavioral equation. Increases in the gasoline prices tend to increase the diesel engine passenger stocks which increase the total diesel engine vehicle stocks. The increases in the diesel engine vehicle stocks then decrease the gasoline consumption per gasoline engine vehicle.

Gasoline appears to be an 'inferior' goods in the reduced form equation. This can also be explained by the relatively larger income elasticity of the diesel engine buses and trucks. Increases in income lead to increases in the diesel engine bus and truck stocks that tend to decrease the gasoline consumption.

The price elasticity of high speed diesel equation is still inelastic at -0.31 in the reduced form equation since there are no feed back effects from the vehicle behavioral equations. However, the cross price elasticity with gasoline is larger in the reduced form equation because high gasoline prices tend to increase the stocks of diesel engine passenger stocks and thus increase the high speed diesel consumption per vehicle.

The actual value of gasoline and high speed diesel consumption per vehicle is compared with the simulated consumption from the single equation and the reduced form equation in Figure 1. The coefficient of variation is 0.12 for the single equation and 0.14 for the reduced form gasoline equation. The coefficient of variation is 0.095 for the single equation and 0.088 for the high speed diesel reduced form equation.

Figure 1 Actual and Simulated Fuel Consumption, January 2002-August 2005

5. Welfare Losses from Retail Pricing and Vehicle Tax Policy

The welfare losses in gasoline consumption are caused by the divergences between its efficient consumption and actual consumption influenced by the gasoline and high speed diesel pricing policy, and the vehicle tax policy. The efficient consumption of gasoline and high speed diesel can be achieved under the following conditions:

- a) global pollution costs are internalized through the gasoline and high speed diesel taxes
- b) local pollution costs are controlled at their 'optimum' levels by appropriate control laws
- c) traffic congestion charges are collected directly from the vehicle owners
- d) other automobile externality costs are controlled by appropriate control laws

The efficient prices of gasoline and high speed diesel are estimated by adding the global pollution costs to their ex-refinery prices and marketing margins. The efficient prices of vehicles are their border prices. The average real

prices for gasoline, high speed diesel, and vehicles between January 2002 and August 2005 are presented in Table 8.

Table 8 Average Retail and Efficient Prices of Fuels and Vehicles, Jan 2002– Aug 2005

	Gasoline	High Speed Diesel	GE Vehicles	DE Vehicles	Buses & Trucks
retail	16.84	14.26	322.76	156.3	205.73
border	11.64	11.69	95.8	95.8	98.2
global pollution cost	0.45	0.51	-	-	-
efficient	12.09	12.11	95.8	95.8	98.2
transfer payments	5.2	2.57	226.96	60.5	107.53

GE = gasoline engine; DE = diesel engine; fuel prices and global pollution costs are in baht/liter; vehicle prices are in index form

The average gasoline retail price is about 39.3 percent higher than its efficient price while the high speed diesel retail price is about 17.8 percent higher than its efficient price. The distortions in the vehicle retail prices are relatively larger than the retail fuel price distortions. The vehicle tax policy results in the largest price distortions for gasoline engine vehicles as their retail price index is about 3.4 times their efficient price index. The ratio of retail price to efficient price is lower for buses and trucks at 2.1 and the diesel engine vehicles have the smallest ratio of 1.63.

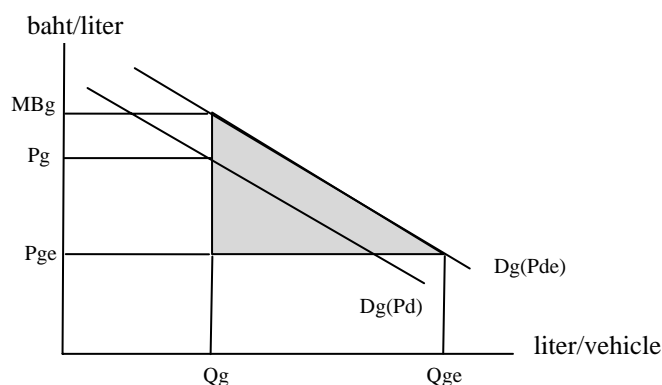
5.1 Welfare Losses from Gasoline and High Speed Diesel Pricing Policy: Scenario 1

Welfare losses from gasoline and high speed diesel pricing policy are estimated from the reduced form equations of gasoline and high speed diesel consumption by setting all the vehicle prices equal to their efficient prices and the fuel prices equal to their actual prices.

The conceptual framework for the estimation of welfare losses is presented in Figure 2 for the case of gasoline. D_g (P_d) is the demand for gasoline when high speed diesel is priced at its actual retail level, P_d , and all vehicle prices are

equal to their efficient prices. $D_g(P_{de})$ is the gasoline demand when high speed diesel is priced at its efficient price, P_{de} , and all vehicles are priced at their efficient prices.

Figure 2 Welfare Losses from Gasoline Pricing Policy



The actual consumption of gasoline at its retail price P_g is Q_g liter/vehicle which is less than the efficient consumption of Q_{ge} liter/vehicle when gasoline and high speed diesel are priced at their efficient levels. Since the marginal benefit of the marginal Q_g liter/vehicle, MB_g , is greater than its social marginal social cost as reflected by P_{ge} , the welfare losses caused by the pricing policy of gasoline and high speed diesel are equal to the shaded area.⁴ The welfare losses for high speed diesel can be estimated by using the same analytical framework.

Although the efficient prices of gasoline and high speed diesel are approximately equal, the retail price of gasoline is about 19 percent higher than the high speed diesel retail price which encourages increases in the stocks of diesel engine passenger vehicles by about 10 percent over its efficient stocks.

The overall effects of the pricing policy are the under consumption of gasoline and over consumption of high speed diesel. Table 9 presents the welfare losses from the pricing policy for gasoline and high speed diesel. The welfare

⁴ The marginal benefit can be estimated from the actual consumption, the efficient consumption, and the gasoline own price elasticity.

losses are about 6.8 percent of the retail price for gasoline and 7.2 percent for high speed diesel.

Table 9 Average Welfare Losses from Gasoline and High Speed Diesel Pricing Policy, January 2002 – August 2005

	Gasoline	High speed Diesel
retail price (baht/liter)	16.84	14.20
efficient price (baht/liter)	12.09	12.11
'actual' per capita stocks of vehicles*	0.36	0.11
efficient per capita stocks of vehicles	0.36	0.10
'actual' consumption (liter/vehicle)*	14.22	585.74
efficient consumption (liter/vehicle)	21.94	434.40
welfare losses (baht/vehicle)	1.14	1.02
percent of retail price	6.77	7.16

*estimated from reduced form equations by letting fuel prices equal to actual retail prices and vehicle prices equal to efficient prices

The retail pricing policy of gasoline and high speed diesel has implications on their economic costs. The ratio of P_g to P_d , the marginal rate of substitution, is 1.19 which is greater than the ratio of P_{ge} to P_{de} , the marginal rate of transformation, which is approximately 1 between January 2002 and August 2005.

From the point of view of the utility maximizing consumer, a liter of high speed diesel can be exchanged for 0.84 liter of high gasoline. If there is a marginal decrease of 1 liter in the refining of high speed diesel, there would be an increase in the gasoline output of 1 liter. There is thus an extra 0.16 liter of gasoline in the country which is worth $(0.16)(12.09)$ or 1.93 baht. This is the economic cost or the opportunity cost for each liter of high speed diesel that is refined and consumed over the efficient level.

5.2 Welfare Losses from Vehicle Tax Policy: Scenario 2

The welfare losses from the vehicle tax policy are estimated from the effects that it has on gasoline and high speed diesel consumption. This is done by setting the gasoline price and the high speed diesel price equal to their efficient levels and the vehicle prices equal to their actual levels.

Table 10 Average Welfare Losses from Vehicle Tax Policy, Jan 2002 – Aug 2005

	Gasoline	High speed Diesel
retail price (baht/liter)	16.84	14.20
efficient price (baht/liter)	12.09	12.11
'actual' per capita stocks of vehicles*	0.36	0.08
efficient per capita stocks of vehicles	0.36	0.10
'actual' consumption (liter/vehicle)*	41.89	196.78
efficient consumption (liter/vehicle)	21.94	434.40
welfare losses (baht/vehicle)	3.51	1.06
percent of retail price	20.85	7.45

*estimated from reduced form equations by letting fuel prices equal to efficient prices and vehicle prices equal to actual prices

The simulation results show that the efficient stocks of gasoline engine vehicles under the vehicle tax policy and the efficient vehicle pricing scenario are approximately equal. However, the stocks of diesel engine vehicles under the vehicle tax policy are about 25 percent less than the stocks under the efficient vehicle pricing scenario. This can be explained by the diesel engine buses and trucks that have relatively large price elasticity. The high tax rate decreases the stocks of diesel engine buses and trucks which decrease the total stocks of diesel engine vehicles.

The actual stocks of diesel engine vehicles that are less than their efficient stocks tend to increase the gasoline consumption and decrease the high speed

diesel consumption from their efficient levels. Table 10 presents the average welfare losses between January 2002 and August 2005 from the vehicle tax policy.

The welfare losses for gasoline from the vehicle tax policy are about three times the welfare losses from the pricing policy. The welfare losses for high speed diesel from the vehicle tax policy are about 4 percent greater than the welfare losses from the pricing policy. The larger welfare losses from the vehicle tax policy relative to the pricing policy are not surprising considering the higher tax rates on vehicles.

5.3 Welfare Losses from Pricing Policy and Vehicle Tax Policy: Scenario 3

The welfare losses from the pricing policy and the vehicle tax policy considered as a package are estimated by setting the fuel prices and the vehicle prices equal to their actual prices. The policy package has negligible effects on the stocks of gasoline engine vehicles as their actual and efficient stocks are essentially the same. The policy package, however, causes the stocks of diesel engine to be less than the efficient stocks by about 10 percent.

The decreases in the stocks of diesel engine vehicles under the pricing and vehicle tax policy package are less than the decreases than the effects from only the vehicle tax policy in scenario 2. This can be explained by the higher gasoline price which tends to increase the stocks of diesel engine vehicles. The overall effects of the package policy cause over consumption of gasoline and under consumption of high speed diesel as in scenario 2 but to a lesser extent. Table 11 presents the welfare losses from the package policy.

Table 11 Average Welfare Losses from Vehicle Tax Policy and Pricing policy, Jan 2002 – Aug 2005

	Gasoline	High speed Diesel
retail price (baht/liter)	16.84	14.20
efficient price (baht/liter)	12.09	12.11
'actual' per capita stocks of vehicles*	0.36	0.09
efficient per capita stocks of vehicles	0.36	0.10
actual consumption (liter/vehicle)*	27.17	264.79
efficient consumption (liter/vehicle)	21.94	434.39
welfare losses (baht/vehicle)	1.28	1.03
percent of retail price	7.59	7.24

*estimated from reduced form equations by setting fuel prices and vehicle prices equal to their actual prices

5.4 Revenue Consideration

The implementation of efficient pricings for gasoline, high speed diesel, and vehicles in place of the existing policy inevitably affect the government tax revenue. It can be seen from Table 8 that the tax on gasoline and high speed diesel will decrease by 4.75 baht/liter and 2.06 baht/liter respectively. In addition, there will be no taxes collected on vehicle under the efficient pricing criterion.

Table 12 presents the comparison between the simulated actual revenue from all transfer payments items and the simulated revenue under the efficient pricing policy. The tax revenue from gasoline and high speed diesel are estimated from the global pollution tax of 0.45 baht/liter for gasoline and 0.51 baht/liter for high speed diesel. The tax revenue from gasoline and high speed diesel consumers under the efficient pricing policy will decrease by about 2.9 billion baht/month and 2.4 billion baht/month respectively.

**Table 12 Average Tax Revenue under Actual and Efficient Pricing,
January 2002- August 2005**

	Simulated Actual	Simulated Efficient	Difference
	million baht/month	million baht/month	million baht/month
Gasoline	3177.46	223.88	-2953.58
High Speed Diesel	3843.48	1434.12	-2409.35
Passenger Vehicles	2138.30	-	-2138.30
Buses and Trucks	679.34	-	-679.34
Total	9838.57	1658.00	-8180.57

The import tax and excise tax for vehicles are combined as an effective tax rate to estimate the losses in revenue. The tax rate for passenger vehicles are the average rates between gasoline engine vehicles and diesel engine vehicles weighted by their numbers. The tax rates for buses and trucks are similarly estimated. The tax rates are then applied to the import value of passenger vehicles and buses and trucks.

Since there are no taxes collected from vehicles under the efficient pricing policy, the government will have to forego about 2.8 billion baht in tax revenue from vehicles so the total revenue deficit will be approximately 8.18 million baht/month.

Under the efficient pricing criterion, the congestion charges will be collected from the vehicle users. If the congestion charges are computed for the purpose of offsetting the revenue deficit, the average charges must be 291 baht per vehicle per month based on the number of efficient vehicle stocks under the efficient pricing criterion in order to generate 8.18 billion baht per month.

Using the average gasoline and high speed diesel consumption/vehicle, the congestion charges are equivalent to 13.25 baht/liter for the gasoline vehicle users and 0.67 baht/liter for the diesel vehicle users. The congestion charges

calculated in this manner are not the 'optimum' charges. The determination of the optimum congestion charges, however, lies outside the scope of this article.

6. Summary, Conclusions, and Recommendations

The consumption of gasoline and high speed diesel in Thailand are influenced by their pricing policy and the vehicle tax policy. The government mainly used the oil fund component in the price structure of these two petroleum products to manipulate their retail prices. The effects of the price manipulations are the cross price subsidy for the high speed diesel consumers at the expense of the gasoline consumers. The vehicle tax structure is characterized by the heavy tax rates on vehicles that bias the purchase of new vehicles towards the diesel engine vehicles relative to the gasoline engine vehicles.

The efficient pricing criterion is to price gasoline, high speed diesel, and vehicles at their social marginal economic costs. The social marginal economic costs for gasoline and high speed diesel are their private costs which are the sum of their ex-refinery prices, marketing margins, and the global pollution costs that are internalized through the fuel taxes. The fuel tax is not an effective instrument to internalize other externalities related to the uses of vehicles. These externalities can be internalized through appropriate control laws so there will be no taxes collected on vehicles under the efficient pricing criterion.

Simulations of the monthly models find that the pricing policy of gasoline and high speed diesel in isolation caused under consumption of gasoline and over consumption of high speed diesel which resulted in welfare losses in the form of consumer surplus and increases in the economic costs of these two fuels.

In contrast, the vehicle tax policy in isolation caused over consumption of gasoline and under consumption of high speed diesel. These seemingly

contradictory results can be explained by the vehicle tax structure that caused the actual stocks of gasoline engine vehicles to be approximately equal to their efficient levels but the actual stocks of diesel engine vehicles to be less than their efficient levels.

The effect of the vehicle tax policy on the relative stocks of the gasoline engine vehicles and the diesel engine vehicles tend to increase the gasoline consumption and decrease the high speed diesel consumption. The welfare losses from the vehicle tax policy are considerably greater than the welfare losses from the pricing policy.

When the pricing policy and the vehicle tax policy are considered as a policy package, the effects are over consumption of gasoline and under consumption of high speed diesel but to a lesser extent than when the vehicle tax policy is considered in isolation.

The government will collect fewer taxes from gasoline and high speed diesel and will forego all of the vehicle taxes under the efficient pricing criterion which leaves a deficit of approximately 8.18 billion baht per month. In order to offset the revenue deficit, the government must collect an average congestion charges or the 'pay while you drive tax' of about 219 baht per vehicle per month. An example of the policy to replace the vehicle taxes by the congestion charges is the case of the Netherlands.⁵

In order to implement the efficient pricing criterion, it is important to consider the optimum congestion charges and their effects on the vehicle utilization rates and the generated revenue. The implementation of the congestion

⁵ The Netherlands government is planning to replace the MRB vehicle tax and the vehicle sales tax by the congestion charge in 2011. See Victoria Transport Institute, "Road Pricing, Congestion Pricing, Toll Roads and Hot Lanes", TDM Encyclopedia, 2010, <http://www.vtpi.org/tdm/tdm35.htm>

charges may start as a pilot project for some areas of Bangkok where there are serious traffic congestions.

The efficient pricing criterion must be implemented as a package. The transfer payment items in the price structure of gasoline and high speed diesel must be removed and replaced by the global pollution costs components. The vehicle taxes are to be removed and replaced by the congestion charges.

The analogy of gasoline and high speed diesel case study can be applied to gasohol and biodiesel that will eventually become the two major fuels in the transportation sector. The pricings of gasohol and biodiesel should be reviewed along with the taxes on vehicles that are powered by these two fuels. The new issue that emerged from the production and consumption of gasohol and biodiesel that need to be addressed are the effects that they have on the food supply.

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