Demand for Gasohol and Pricing Policy in Thailand

Piyawan Suksri[*]

Abstract

Thailand's gasohol market has grown from 2.6 million liters in 2003 to approximately 4,383 million liters in 2010. Whether a pricing policy, among other demand stimulating measures, does actually play an important role in boosting gasohol demand is evaluated. This paper estimates gasohol and gasoline demand. Price elasticity of gasohol demand with its price structure is then used to examine the effectiveness of price and tax measures. The study finds that gasohol is price inelastic in the short run; that is, price and tax measures have limited impact on increasing gasohol consumption in the short term. Therefore, together with the pricing policy, other measures such as mandate of gasohol use, E85 market penetration and boosting consumers' confidence must be conducted along to further raise the gasohol consumption.

Keyword: gasohol demand; price elasticity of gasohol

บทคัดย่อ

ตลาดแก๊สโซฮอล์ในประเทศไทยได้ขยายตัวอย่างมากนับตั้งแต่ที่มีการเริ่มใช้ในปี 2003 ในปีนั้นมีการบริโภคประมาณ 2.6 ล้านลิตร และเพิ่มขึ้นอย่างรวดเร็วเป็น 4,383 ล้านลิตรในปี 2010 เพื่อที่จะศึกษาว่าในบรรดามาตรการกระตุ้นการใช้แก๊สโซฮอล์ มาตรการด้านราคาเป็น มาตรการที่มีบทบาทสำคัญในการเพิ่มการบริโภคแก๊สโซฮอล์หรือไม่ การศึกษานี้จึงได้ทำการ ประมาณการสมการอุปสงค์ของแก๊สโซฮอล์และอุปสงค์ของแก๊สโซลีนโดยรวม (น้ำมันเบนซิน

---

[*] Ph.D student, Graduate School of Business and Commerce, Keio University.

รวมกับแก๊สโซฮอล์) จากนั้นใช้ความยืดหยุ่นต่อราคาและโครงสร้างราคาของแก๊สโซฮอล์ในการ ประเมินความมีประสิทธิภาพของมาตรการด้านราคาและภาษีต่างๆ การศึกษาพบว่าในระยะสั้น การบริโภคแก๊สโซฮอล์ไม่ยืดหยุ่นต่อราคา นั่นคือ มาตรการด้านราคามีผลที่จำกัดในการเพิ่มการ บริโภคแก๊สโซฮอล์ในระยะสั้น ดังนั้นเพื่อเพิ่มปริมาณการบริโภคแก๊สโซฮอล์ให้มากขึ้น มาตรการด้านอื่นๆ เช่น การบังคับใช้แก๊สโซฮอล์ การเจาะตลาดของ E85 และการเพิ่มความ เชื่อมั่นของผู้บริโภคที่มีต่อแก๊สโซฮอล์ เป็นสิ่งที่ควรจะกระทำควบคู่กับมาตรการด้านราคา

คำสำคัญ: อุปสงค์ของแก๊สโซฮอล์ ความยืดหยุ่นต่อราคาของแก๊สโซฮอล์

1. Introduction

Thailand is among a number of countries, which rely mostly on oil import to meet domestic demand. Thailand's crude oil import dependency rate is very high, approximately 80%. Since 2000 the world oil price has rapidly increased. In 2005 it skyrocketed to 70 US dollars a barrel and in 2008 it peaked at more than 130 dollars a barrel. As a result, the value of Thailand's crude oil import has remarkably risen. This in turn substantially affects Thai economy that depends mostly on crude oil import.

Thailand's government therefore launched a package of energy policies to reduce dependency on energy import and increase the country's energy use efficiency in 2003. One strategic plan is to develop biofuels, ethanol and biodiesel, in which utilization of both fuels is targeted at 3 million liters/day each (DEDE, 2005). Later the Ministry of Energy announced a 15-year energy plan (2008-2022) aiming at the 20% replacement of renewable energy in the final energy consumption in 2022. In terms of ethanol promotion, the plan is divided into 3 phases: 1) short run plan (2008-2011) with the utilization target of 2.96 million liters a day; 2) intermediate run plan (2012-2016) 6.2 million liters/day; and 3) long run plan (2017-2022) 9 million liters/day (DEDE, 2010).

Due to the bottleneck of biodiesel supply, bioethanol is much more speedily promoted through various measures in both demand and supply sides. On supply side, fuel ethanol producers can request investment promotion privileges from Board of Investment.

Those privileges are machinery import duty exemption and corporate income tax exemption for 8 years. In terms of feed stock, which is sugarcane and cassava, an increase in productivity rather than plantation area expansion is the main target. In Thailand ethanol is blended with gasoline, known as gasohol. Through demand stimulating measures, gasohol prices are set lower than gasoline prices via lowering taxes and the oil fund. TV commercials supported by the Ministry of Energy are also launched to create consumers' confidence on gasohol quality. In 2007 the Department of Energy Business announced the Notification of Characteristics and Specifications of Gasohol (E10, E20 and E85) to standardize gasohol quality. Also, with cooperation from car makers the Ministry of Energy has listed car models that can be fuelled with gasohol to increase confidence among car users.

As a result, the market for gasohol has grown from 2.6 million liters in 2003 to 4,383 million liters in 2010. When calculating ethanol consumed, currently 454 million liters of bioethanol is domestically utilized in 2010 or 1.24 million liters/day. This number is still far below the target the government has set (3 million liters a day in 2011). Moreover, according to a personal communication with an official of Energy Policy Planning Office (EPPO), energy policy makers were facing a slowdown of the increase in gasohol use. Whether the utilization of ethanol in 2011 will meet the target or not depends substantially on the consumption pattern until now.

A study on nature and characteristics of demand for gasohol is thus crucial to determine which factor influences or stimulates the demand. This will help Thailand's policy makers develop sound pricing and taxation policies.

2. Thailand's ground transportation fuel consumption

Transport sector consumes 36% of final energy demanded; while, industry sector consumes 36% and others 28% (DEDE, 2009). Seventy-nine percent (79%) out of transport sector fuel consumption is that of land transport in which 99.5% of it is used in road transport leaving 0.5% for railway (Ministry of Transport, 2009).

The main fuels used in road transport are gasoline and diesel. The ratio of diesel to gasoline use in Thailand has been more or less constant at 2.5 for more than 20 years. This is because diesel is mostly used in goods transport and public passenger transport; whereas, gasoline is mostly used for personal transport. Apart from gasoline and diesel, NGV (Natural Gas for Vehicles) and LPG (as vehicle fuel) are also other road transport fuel choices. After the recent spike in oil prices, NGV was introduced in 2004 with the consumption of 1,000 MMSCF (million standard cubic feet). The consumption of NGV rose to 52,195 MMSCF in 2009 or 52 times. As for LPG, the use of LPG (as vehicle fuel) has risen to 666 thousand tons in 2009, more than four times that of 2000.

Gasoline in Thailand's current market consists of 2 types, regular gasoline and premium gasoline. Regular gasoline is unleaded gasoline with research octane number 91 (ULG 91). Premium gasoline is unleaded gasoline with research octane number 95 (ULG 95). MTBE (methyl tertiary butyl ether) is used as an octane enhancer and blended with regular gasoline to produce premium gasoline. After bioethanol was commercialized in 2004, it is used as an octane enhancer instead of MTBE, which is believed to be carcinogenic, and blended with regular gasoline to get gasohol 95. Later since 2007, ethanol has also been blended with regular gasoline without enhancing octane number, forming gasohol 91. When 10% of ethanol is blended, it is called E10. E20 is 20% ethanol blend and E85 is 85% ethanol blend. Currently, Thailand has E10 for both octane 91 and 95 but has E20 and E85 for only octane 95[†]. Since E20 was first launched to the market in January 2008 and E85 in September of the same year, the consumption of both fuels is still very minimal. Therefore, only E10 is considered in this study.

[†] Compared to Brazilian Proalcohol program, which was launched at the end 1975, it compulsorily required a 10% blend of anhydrous ethanol (ethanol 99.5% or higher) with 90% of gasoline, or E10, without car engine alteration needed. Thai government also wanted to mandate E10 in 2007 but failed and the implementation has been postponed so far. Recently Brazil's mandatory blend is 20-24%. Moreover, Brazil also voluntarily uses hydrous ethanol (95% alcohol with 5% water) in modified car engine; while, Thailand does not.

3. Literature review

Demand for transport fuels

The demand for transport fuels is theoretically derived from the demand for transport services, for which vehicles and fuels are inputs (Banaszak et al., 1999). Some studies estimate gasoline demand as a function of the existing vehicle stock, vehicle utilization (i.e., distance driven) and fuel economy (i.e., gasoline used per kilometer driven) (Green, 1979; and Leung and Vesenka, 1987, cited in Banaszak et al., 1999). Unfortunately, the above estimation method requires initial estimation of those variables. With this difficulty and the argument that both fuel utilization and efficiency are already reflected in income and fuel prices (Al-Faris, 1992, p.215, cited in Banaszak et al., 1999), fuel demand is generally estimated as a function of income and price.

The study in demand for petroleum products that has been conducted extensively in various countries is the study aiming at finding short-run (SR) and long-run (LR), own-price and cross-price, and income elasticities of the gasoline demand by means of employing co-integration technique and error correction model. This method is used for Denmark data by Bentzen (1994), Kuwait data by Eltony and Al-Mutairi (1995), India data by Ramanathan (1999), Brazil data by Alves and Bueno (2003) and South Africa data by Akinboade et al. (2008).

Eltony and Al-Mutairi (1995) study demand for gasoline in Kuwait between 1970 – 1989 and find that the LR price elasticity of gasoline demand is -0.46 which is greater than that of SR (-0.37). This indicates that gasoline demand is price inelastic in both short run and long run. Besides, the long run income elasticity (0.92) is much higher than the short run (0.47). Finally, the error correction term is significant and has a value of 0.52, indicating that gasoline consumption adjusts toward its long run level with 52% of the total adjustment in the first year.

Alves and Bueno (2003) use the same techniques analyzing Brazilian data of 1974 – 1999 and include ethanol price to estimate cross-price elasticity. The study finds that the own

price long run elasticity for gasoline demand is -0.46, which is equal to that of Kuwait (Eltony and Al-Mutairi, 1995) and close to an -0.319 estimate for India (Ramanathan, 1999). The gasoline demand in Brazil is not only price inelastic but also income inelastic with elasticity of 0.48. As for cross-price elasticity, even though it is positive, its value is low. The authors explained this by the relatively high costs related to automobile engine alteration from gasoline use to alcohol use. In terms of short run elasticity, both coefficients of gasoline and alcohol do not significantly differ from zero; thus, Alves and Bueno infer that gasoline demand is perfectly inelastic in the short run.

Analysis on the demand and supply of "ethanol"

Ethanol has been increasingly studied in the economic context recently other than environmental perspective. Rask (1998)'s analysis on U.S. ethanol demand and supply employs data of 1988 – 1993 to estimate both ethanol demand and supply functions by means of 2SLS Tobit estimation and finds that the own price elasticity of ethanol supply is 0.75 and that of ethanol demand is -0.37. Rask concludes that both own price responses are relatively inelastic which implies that supply or demand shocks to the industry are transmitted more to price than to quantity sold. Based on the very low own price demand elasticity (-0.37) compared to that of supply (0.75), Rask believes that ethanol is being over-subsidized and ethanol retailers are receiving a larger share of government subsidy than consumers.

Luchansky and Monks (2009) updates Rask's work by using more recent data (1997-2006). The study finds that the ethanol supply price response is inelastic (ranging from 0.224 to 0.258); while, that of demand is very price elastic (-1.605 to -2.915) which is opposite to that of Rask's work. The authors deduce that the instability of demand-side ethanol price elasticity may be caused by the availability of ethanol substitute such as MTBE in the market in the way that as the number of substitutes increase, the good become more elastic. Furthermore, Luchansky and Monks (2009) estimates ethanol demand and supply equations by initially setting corn price as an exogenous variable (same as Rask's work) and later as an endogenous variable to see if ethanol quantity demanded affects corn price and in turn if the corn price affects the ethanol quantity itself. They find that ethanol production does affect

corn price; whereas, corn price does not consistently significantly determine ethanol production; the sole significant result of the latter is the case of corn price set as an exogenous variable with elasticity of 0.121. This result is contrast to Rask's study in which corn elasticity is -3.03. This can be viewed that in the past corn prices played an important role in determining ethanol production. However, now, given the current clean air requirements and other government regulations requiring ethanol use, ethanol production now seems to play a role in determining corn price.

"Gasohol" as final product

Gasohol, a fuel blend of ethanol and gasoline, is of importance in terms of being a final product consumers directly face. Anderson (2006) estimates demand for E85 as a function of retail E85 and gasoline prices by using data for E85 sales at fueling stations in Minnesota. He finds that E85 demand is highly price elastic, with an own-price elasticity of -13 and a gasoline-price elasticity of -16 at sample mean price levels. He estimates that around 40-50 percent of current E85 consumers are fuel switchers and they are indifferent between the two fuels when the relative prices of gasoline to E85 is about 1.05-1.15. These ratios are smaller than (supposed to be equal to) the EPA-tested fuel economy ratio between the two fuels but consistent with reports on E85 fuel economy in the Minnesota popular press.

Substitutability between fuels

Another study by Banaszak et al. (1999) examines demand for gasoline and diesel in Korea and Taiwan during 1973-1992 and estimates price and income demand elasticities in each country. The result is used to forecast the consumption of two fuels until 2010. Authors believe that different pricing policies in the two countries in which Korea levies substantially higher tax on gasoline than diesel; while, Taiwan do not, results in Korea using twice as much diesel as gasoline; however, Taiwan consumes more gasoline. Banaszak et al. create a model for each country consisting of two parts; 1) total demand for gasoline and diesel together which is a log-linear function of weighted average prices of the two fuels, GDP and total consumption in the previous year and 2) market share of gasoline out of total consumption which is a log-linear function of price difference between gasoline and diesel, GDP and the

market share in the previous year. The authors use the iterative non-linear three-stage least square as an estimation method. With the use of log-linear form, short run demand elasticities can be directly derived from the coefficients. Long run elasticities are then easily calculated as the short run elasticity divided by 1 minus the coefficient of the lagged explanatory variable.

The study finds that demand for petroleum products is generally price inelastic and the price elasticity is lower in Taiwan (higher income country). Income has a relatively larger effect on aggregate transport fuel demand than on whether fuel is gasoline or diesel. Income elasticities in this study which employs data of recent high-income years are lower than those of previous studies that use data in earlier years (lower income). This supports the hypothesis that income elasticities are lower in higher income countries.

I therefore estimated demand for gasohol and gasoline by applying the same model used by Banaszak et al. to see how pricing measures favoring gasohol over gasoline affects their consumption. The price elasticity of demand for gasohol was directly estimated from the demand equation. Then, the price elasticity is used to evaluate the pricing policy.

4. Price measures to promote gasohol consumption in Thailand

Gasohol is highly promoted through a price difference between its price and gasoline (ULG)'s prices. The price ratio of gasoline 95 to gasohol 95 was 1.04 (price gap of 0.75 baht/liter or 3-4% cheaper) in November 2004. The price ratio had been gradually raised to 1.14 (price gap of 4 baht/liter or 12% cheaper) at the end of 2007, but increased rapidly during the latter half of 2008 and peaked at 1.71 (price gap of more than 12 baht/liter or 42% cheaper) in January 2009, before gradually decreasing to 1.28 (around 9 baht/liter in 2010). As for gasohol 91, the price ratio of gasoline 91 to gasohol 91 was 1.06 in February 2007 (price gap of 1.5 baht/liter or 6% cheaper), increased up to 1.33 in December 2008 (price gap of more than 5 baht/liter or 25% cheaper), and then gradually declined to 1.18 (price gap of around 5 baht/liter or 15% cheaper) at the end of 2010. This reflects the government's attempt to stimulate gasohol use among consumers.

A reduction in relevant taxes is the measure that the government has chosen to make a price gap attractive to consumers. There are 4 taxes and funds directly levied on gasoline and gasohol. First is an excise tax levied on gasoline products, or commonly known as gasoline tax. Second is municipal tax, which is 10% of the excise tax. A gasoline tax rate and a municipal tax rate are single rates for all kinds of gasoline products. But to promote the use of gasohol, ethanol mixed in gasohol is tax-exempted. For instance, E10's gasoline and municipal taxes are 10% less than those of gasoline. For E85, gasoline and municipal taxes levied on it are 85% cheaper.

Third is money collected to the oil fund. Oil fund is the fund that was established in 1979 and has an objective to stabilize domestic petroleum product prices when the world oil price fluctuates. Every petroleum product is taxed with different rates to oil fund. Earlier almost money in oil fund had been used to subsidize LPG, the only petroleum product that is still being regulated. Recently, oil fund has also been used to subsidize gasohol products by means of taxing gasoline products with high oil fund rates but taxing gasohol products with low oil fund rates or even allocating money from oil fund to some gasohol products such as E20 and E85 to lower their prices.

Lastly, the fourth item is money collected to the energy conservation fund. Energy conservation fund was established in 1992 in order to provide financial assistance to support activities that help promote energy conservation, efficient use of energy, development and use of renewable energy sources, development of energy conservation technology as well as environmental protection. All petroleum products are subject to transfer money to the energy conservation fund.

Table 1 shows special tax treatment for gasohol resulting in lower selling prices compared to those of gasoline products

Table 1

Price Structure of Gasoline and Gasohol as of July 15, 2010

Unit: baht/liter

	ULG95	ULG91	Gasohol 95 (E10)	Gasohol 91 (E10)	Gasohol 95 (E20)	Gasohol 95 (E85)	Special Treatment For Gasohol
Ex-refinery Price (average)	17.3836	16.9402	18.0081	17.7902	18.5395	21.1040	
Excise Tax	7.0000	7.0000	6.3000	6.3000	5.6000	1.0500	Tax exemption for ethanol mixed in gasohol
Municipal Tax (10% of excise tax)	0.7000	0.7000	0.6300	0.6300	0.5600	0.1050	
Oil Fund	7.5000	6.7000	2.8000	1.4000	-0.4000	-11.0000	Special fund rate for gasohol
Energy Conservation Fund	0.2500	0.2500	0.2500	0.2500	0.2500	0.2500	None
Wholesale Price	32.8368	31.5902	27.9881	26.3702	24.5495	11.5090	
VAT(7%)	2.2986	2.2113	1.9592	1.8459	1.7185	0.8056	
Wholesale Price ＋ VAT	35.1354	33.8015	29.9473	28.2161	26.2679	12.3147	
Marketing Margin	4.5383	1.1575	1.2082	1.4242	2.4973	6.0798	
VAT(7%)	0.3209	0.0810	0.0846	0.0997	0.1748	0.4256	
Retail Price	40.04	35.04	31.24	29.74	28.94	18.82	

Source: Energy Policy Planning Office (EPPO), Ministry of Energy, Thailand

Currently a gasoline tax rate is 7 baht/liter (raised from 5 baht/liter, effective since May 2009) and a municipal tax rate is 0.7 baht/liter (10% of the excise tax rate). Since excise tax and municipal taxes are exempted for ethanol, a gasoline tax rate and a municipal tax rate for E10 is 6.3 and 0.63 baht/liter, respectively. Money collected to the energy conservation fund was exempted earlier for ethanol blended in gasohol. However, the exemption has been removed recently resulting in the same amount of the energy conservation fund rate for all fuel types.

Differences in tax and fund rates above cannot make gasohol prices more attractive than gasoline. Oil fund has become the tool that plays an important role in widening their price gap. Special fund rates are set for gasohol products. Table 2 depicts the oil fund rates for all gasoline types. Mostly oil fund rates for gasohol are lower than one fourth of those of gasoline.

Table 2

Average Oil Fund Rate, 2004-2010

Unit: baht/liter

	ULG 95	ULG 91	Gasohol 95			Gasohol 91
			(E10)	(E20)	(E85)	
2004	0.57	0.37	0.11			
2005	1.28	1.03	0.13			
2006	2.70	2.50	0.84			
2007	3.67	3.37	0.85			
2008	3.78	3.31	0.77	-0.21		0.28
2009	6.65	4.86	1.54	-0.97	-6.86	0.92
2010	7.50	6.63	2.72	-0.41	-10.90	1.44

Source: Energy Policy Planning Office (EPPO), Ministry of Energy, Thailand

As a result, at July 15, 2010 the price of gasohol 95 is 8.8 baht/liter cheaper than that of gasoline 95. By the same token, the price of gasohol 91 is 5.3 baht/liter cheaper compared to that of gasoline 91.

The pricing policy to increase a gap between gasoline and gasohol prices has been believed to boost gasohol consumption. Gasohol market share has substantially increased especially the case of premium gasoline. Premium E10's sales rose up to more than half of the total premium gasoline sales in 2007, 87% in 2008 and 92% in 2009 and 2010 (Table 3). However, this is indeed a result of all demand stimulating measures, not only a price measure.

Whether the price measure actually performs well in boosting gasohol demand must be quantitatively evaluated.

Table 3

Sale of Gasoline by Type, 2003 – 2010

Unit: million liters

Gasoline Type	2003	2004	2005	2006	2007	2008	2009	2010
Regular	4,550	4,631	4,362	4,559	4,712	4,311	4,292	4,509
- ULG 91	4,550	4,631	4,333	4,464	4,467	3,388	2,877	2,958
- E10	0	0	29	94	244	924	1,415	1,552
Premium	3,085	3,029	2,886	2,656	2,625	2,809	3,233	2,908
- ULG 95	3,082	2,970	2,240	1,471	1,107	341	177	77
- E10	2.6	59	646	1,185	1,519	2,439	2,972	2,692
- E20	0	0	0	0	0	29	83	137
- E85	0	0	0	0	0	0.02	0.25	2.11
Total	7,635	7,660	7,248	7,215	7,337	7,120	7,524	7,417

Note: E20 was first sold in January 2008; E85 in September 2008. Both E20 and E85 are Octane 95
              products. There have not been Octane-91 E20 and E85 so far.

Source: Department of Energy Business (DOEB), Ministry of Energy, Thailand

In this paper I adopt the approach of Banaszak et al.(1999) to estimate the gasoline and gasohol demand in Thailand and analyze how different pricing policies affect the consumption of both fuels. The estimation method is OLS and is performed by using EViews software (version 5).

The model used here first estimates the total demand for gasoline and gasohol together (TC) for the period of 1991 – 2010 by using national monthly data, totally 232 sets of data. Since Thailand started to commercialize gasohol in the end of 2004, data before

November 2004 is data of gasoline alone. TC_t is estimated as a log-linear function of the weighted average of gasoline and gasohol prices (P_t), real GDP in which Manufacturing Production Index (MPI) is used as a proxy for its monthly value (GDP_t), and the total consumption of both fuels in the previous month (TC_{t-1}) as follows:

$$\ln(TC)_t = a_0 + a_1 \ln(P)_t + a_2 \ln(GDP)_t + a_3 \ln(TC)_{t-1} \qquad (1)$$

where

$$P_t = \left[(GL/TC)_t \bullet PGL_t\right] + \left[(GH/TC)_t \bullet PGH_t\right] \qquad (2)$$

and

GL   = gasoline consumption

GH   = gasohol consumption

TC   = total gasoline and gasohol consumption

PGL   = real gasoline price (weighted average of regular and premium gasoline prices)

PGH   = real gasohol price (weighted average of regular and premium gasohol prices)

Next step is to estimate gasohol demand through its market share out of total consumption of both fuels. The gasohol demand is estimated as a function of a price ratio of gasoline price to gasohol price, real gross domestic product, and the share of gasohol in the preceding month. Using a price ratio (PGL/PGH) instead of a price difference (PGL-PGH) that is employed in Banaszak et al.'s paper is to make its regression coefficient comparable with other countries' study since each country has a different currency unit. Besides, Manufacturing Production Index (MPI) is also used as a proxy for real monthly GDP again. The estimated regression equation for gasohol demand is shown in equation (3).

$$\ln(GH/TC) = b_0 + b_1 \ln(PGL/PGH) + b_2 \ln(GDP) + b_3 \ln(GH/TC)_{t-1} \qquad (3)$$

As for data, I obtained gasoline and gasohol sales volume data from Department of Energy Business, their prices from Energy Policy and Planning Office, some missing price information from Department of Internal Trade, Ministry of Commerce, CPI from Bureau of Trade and Economic Indices, Ministry of Commerce, and MPI from Bank of Thailand. CPI is used to convert nominal prices to real prices. Most of the data used in this study are found online except for some missing price data that I had to receive directly from the government unit. All data used is summarized in Table 4.

Table 4

Summary Statistics for Thai Gasoline and Gasohol Markets

Variable	Period	Mean	Maximum	Minimum	Range
Monthly total gasoline consumption (TC), million liters	Mar 91 – Jul 10	557.2	691.3	309.1	382.2
Monthly weighted all-grade average prices (P) (between gasoline prices and gasohol (E10) prices), baht/liter	Mar 91 – Jul 10	27.9	38.5	7.8	30.7
Real GDP (MPI as a proxy, MPI = 100 in 2000) (GDP)	Mar 91 – Jul 10	115.6	235.9	54.1	181.8
Monthly gasohol consumption, million liters,	Nov 04 – Jul 10	201.8	391.0	6.6	384.4
Gasohol market share (GH/TC)	Nov 04 – Jul 10	0.33	0.59	0.01	0.58
Monthly weighted all-grade gasoline prices (PGL), baht/liter	Nov 04 – Jul 10	28.1	41.0	18.9	22.1
Monthly weighted all-grade gasohol (E10) prices (PGH), baht/liter	Nov 04 – Jul 10	27.8	36.6	16.7	19.8
Price ratio (PGL/PGH), baht/liter	Nov 04 – Jul 10	1.08	1.30	1.01	0.29
CPI (CPI = 100 in Mar 1991)	Mar 91 – Jul 10	148.7	196.9	100	96.9

Note: All prices are nominal prices and CPI is used to calculate real prices, which are used in the regression.

5. Effectiveness of price measures for the quantity target

Estimation results[‡] appear in Table 5. All coefficients have a correct sign and almost all are significant with 99% confidence except for the constant term and GDP coefficients in the gasohol equation which are insignificant. Banaszak et.al reported the same outcome that coefficient of income (GDP) was insignificant in the share equation for Korea. Given this result, one can say that income does not play a role in splitting gasoline-gasohol consumption in Thailand so far. An increase in a price ratio of gasoline to gasohol positively influences gasohol consumption share, that is, the higher the price ratio is, the more gasohol is consumed. Gasohol's market share in the previous period also positively affects the market share in the current period.

Table 5

Estimated Total Consumption and Gasohol Market Share Equations

Dependent Variable	Constant	Weighted Average Price (P)	Gasoline-Gasohol Price Ratio (PGL/PGH)	Real GDP (MPI as proxy) (GDP)	Lagged TC	Lagged Gasohol Market Share	Adjusted R-squared	Monthly Obser-vation
TC (total demand)	0.775*** (5.838)	-0.196*** (-6.174)		0.201*** (6.126)	0.801*** (24.640)		0.9282	232
GH/TC (gasohol share)	-1.216 (-1.433)		0.679*** (2.508)	0.199 (1.322)		0.877*** (22.384)	0.9924	68

Note: 1) Values of t-statistics are in parentheses.
2) Both equations use Newey-West robust HAC (heteroscedasticity- and autocorrelation- consistent) standard errors to account for heteroscedasticity and autocorrelation problems.
3) *** Coefficients are significant with 99 percent confidence.

[‡] I use the Breusch-Godfrey Serial Correlation LM Test to detect autocorrelation instead of Durbin-Watson stat since the LM test allows for nonstochastic regressors such as the lagged values of the regressand (Y_{t-1}) while Durbin-Watson stat is often around 2 in this case, which would suggest that there is no autocorrelation in such models; resulting in a built-in bias (Gujarati, 2003 p.471). As for heteroscedasticity, I use White heteroscedasticity test. I find that the total consumption or total demand equation faces autocorrelation problem; whereas, gasohol market share equation suffers from both autocorrelation and heteroscedasticity. I therefore use Newey-West robust HAC (heteroscedasticity- and autocorrelation- consistent) standard errors to correct OLS standard errors to account for the problems in both equations.

As for the total consumption equation, as expected, the prices are found to have a negative relationship with the consumption; while, income and consumption in the last period have a positive effect.

The corresponding coefficients from the equations provide direct estimates of short-run price and income elasticities. The long run elasticity can be then calculated as follow: the short run elasticity divided by 1 minus the coefficient of the lagged dependent variable. Short run and long run, price and income elasticities for total gasoline demand and gasohol consumption share are summarized in Table 6.

Table 6

Estimated Elasticities

	Price	Income
Total demand	(weighted price)	
Short-run	-0.196	0.201
Long-run	-0.985	1.010
Gasohol share	(price ratio)	
Short-run	0.679	Insignificant
Long-run	5.520	

Short-run price and income elasticities in the total demand equation are very low, that is, total demand for both gasoline and gasohol is extremely price and income inelastic in the short run. Long-run elasticities are much higher; around a unit; as a result, demand for total consumption is price and income unit elastic in the long run.

When considering gasohol consumption share equation, its short-run price elasticity is 0.679 or price inelastic; while, the long-run price elasticity is found relatively elastic. A current gasohol share in 2010 is around 60% (4,383 liters out of 7,414 liters of total gasoline product consumption). That is, there is much room to increase gasohol consumption in the long run with this price gap measure. Nevertheless, in the short run we cannot expect extensive effectiveness because of the price inelasticity in the short run.

6. Conclusion and policy implications

Thailand's gasohol market and fuel ethanol market has been commercially developed together since 2004. Gasohol consumption has increased consecutively year by year. Estimation of gasohol demand together with estimation of total gasoline demand in this paper has introduced a quantitative analytic method to Thailand's alternative energy market analysis. The estimation of total gasoline demand in a long period (Mar 1991 – Jul 2010), which includes gasohol consumption since Nov 2004, found that gasoline demand is rather both price and income inelastic in the short run, -0.196 and 0.201 respectively. In the long run, gasoline demand is price unit elastic (-0.985) as well as income unit elastic (1.010).

As for the gasohol demand alone, the income elasticity of gasohol consumption is insignificant. The income coefficient here means a change in income would result in a change in gasohol consumption share. An income coefficient with a positive sign, that is, an increase in income leading to a larger share of gasohol, implies that with higher income people tends to consume more gasohol. Vice versa, a negative sign of income coefficient specifies that with more income people are likely to consume more gasoline (lower gasohol market share). In this case, it would indicate that gasohol is an inferior good. But since the income coefficient here is not significant, one can say that income so far does not influence people's decision on whether they would consume gasoline or gasohol.

The elasticity of gasohol market share with respect to the price ratio of gasoline to gasohol is equal to 0.679 in the short run; the gasohol demand is price inelastic in the short term. That is, the price measure is not effective in boosting gasohol consumption. This is because price is not the only factor that affects consumers' decision. Many people pay attention on the product's characteristics and quality since gasohol is not a perfect substitute for gasoline. Apart from a lower heating value, which results in lesser fuel economy, gasohol (because of ethanol) is corrosive to certain auto parts. Furthermore, some people believe it would damage the engine. This is partly true for old cars that run on a carburetor system. Consumers' confidence is thus another major issue to deal with. Nonetheless, in the long run

gasohol is relatively elastic due to the long-term price elasticity of 5.520. Therefore, there is space to boost gasohol consumption through price measures in the long term.

It is worthwhile to be noted that the elasticity of gasohol demand with respect to the price ratio of gasoline to gasohol here is not exactly the same as the elasticity of gasohol demand with respect to its own price. What I am interested here is relative price elasticity, neither own-price elasticity nor cross-price elasticity. A price ratio of gasoline to gasohol is a relative price of a cross price in terms of an own price. An increase in the price ratio must be originated from a rise in gasoline price or a decline in gasohol price, whichever or both. A limited change in gasohol demand resulting from a change in price ratio can be therefore justified as relative price inelasticity of demand, or in general can be justified as price inelasticity of demand since people are likely to consider relative prices rather than absolute prices.

Due to the price inelasticity in the short run it is difficult to raise the gasohol market share only by means of pricing measures. The target of 2.96 million liters of ethanol utilization in 2011, more than double what is currently consumed (1.24 million liters/day in 2010) seems impossible with the current consumption pattern.

Therefore, besides price measures, other demand stimulating means must be conducted along with. The mandate of blending 10% of ethanol in gasoline or E10 will definitely be one way to increase ethanol use. The use of E10 does not require car engine alteration; while, a higher blend needs. However, although all gasoline is substituted by E10, the largest ethanol utilization amount would be 2 million liters/day if the consumption of E20 and E85 remains unchanged. It is still far from the target. Besides, there will appear many problems if E10 is mandated. One of them is that there are a number of old cars running with a carburetor system, which gasohol is not recommended for. This was one of the reasons why the mandate of E10 octane 95 that was set to implement since January 2007 was abolished. To accommodate the mandate, one of the solutions could be giving price incentive to those who still use an old car to buy a new car or a second-hand car that E10 can be used.

Another way to increase ethanol utilization is through E20 and E85 gasohol consumption. As mentioned above that E20 was launched since January 2008, its sales have increased from 29 million liters in 2008 to 83 million liters in 2009 and to 137 million liters in 2010. As for E85, it first came to the market in September 2008. Its consumption in 2010 was 2 million liters, increased from 0.25 million liters in 2009. We can see that E85 consumption is still far from that of E20 and E10. One of the reasons is a limited number of E85 cars and gas stations in the market. The cars that can use E85 are only FFV or Flexible Fuel Vehicle, which have been imported from abroad around 2,000 cars during 2009-2010. In terms of gas station, there are only 6 gas stations that sell E85 and most stations are located in Bangkok, resulting in 90% of E85 sales in Bangkok in 2010. On the other hand, there exist more than 370 E20 gas stations in 2010. Moreover, new cars sold after 2008 can use gasohol up to E20. The market penetration of FFV and an increase in E85 gas stations will definitely result in a higher ethanol consumption level to meet the set target.

The government has set various measures to stimulate use of E20 cars and FFVs. For instance, an excise tax for car levied on E20 car and FFV was reduced up to 50%. There will be another imported 1,000 FFVs in 2011 with an import duty reduction from 80 percent to 60 percent. Besides, to promote domestic FFV production, import duties on auto parts that are not available domestically are exempted for 3 years since 2011. Moreover, we may reduce other relevant taxes to give incentive to consumers to buy these eco-cars. For example, in Japan apart from a reduction in related taxes when an eco-car is bought, an annual car tax is also lowered for a couple years after purchase. With these measures, the market penetration of FFV, in turn, surge of ethanol utilization can be expected in the near future.

Consumers' confidence in gasohol quality is another factor that affects a consumer's decision to use or not to use gasohol, other than its relative price. Although Ministry of Energy has launched gasohol quality standard together with tons of TV commercial to create consumers' confidence on gasohol's quality since 2006 including words by car makers that the use of gasohol will not affect their cars, a survey conducted by Thailand's National Statistical Office in May 2007 finds that 60% of nationwide samples have no confidence about

effects of gasohol use on engine. Since gasohol is a new product in the market, of course, it will take some time for consumers to understand the product's characteristics and quality. The product itself has been gradually improved in terms of quality. We can see now that many petroleum companies have launched their new gasohol products with claimed better quality. This will partly raise consumers' confidence on gasohol.

The pricing policy and all above-mentioned measures have so far resulted in 60 percent market share of gasohol and with those measures it is expected that the consumption of gasohol will further increase in the near future. However, gasoline and gasohol are not the only energy choices for gasoline cars. After NGV and LPG have been introduced to the market as alternative energy, a number of consumers have equipped NGV/LPG systems in their cars. Those consumers mainly use NGV/LPG but use gasoline or gasohol only for engine start-up. A hybrid car is also another choice that uses less gasoline or gasohol. The number of hybrid cars sold in 2010 has almost reached 10,000 cars despite the fact that there were less than 200 hybrid cars in 2006. This may be one of the reasons preventing gasohol consumption to reach the target. Those who are concerned with consumers' benefit may argue that consumers will have more benefit due to more choices for their consumption.

Nonetheless, no matter its utilization will reach the target or not, ethanol has gradually paced its steps on an alternative energy's historical page of Thailand. Alternative energy especially renewable energy is a long-term policy. To develop a well-established ethanol industry and market, both strong demand and supply are pre-requisite conditions. This paper has explored the demand side; while the supply side must be systematically analyzed in the future research.

References

Akinboade, O.A., Ziramba, E., and Kumo, W.L. (2008) The Demand for Gasoline in South Africa: An Empirical Analysis Using Co-Integration Techniques, *Energy Economics*, 30, pp.3222-3229.

Alves, Denisard C.O. and Bueno, Rodrigo De Losso da Silveira. (2003) Short-Run, Long-run and Cross Elasticities of Gasoline Demand in Brazil, *Energy Economics*, 25, pp.191-199.

Anderson, S. T. (2006) The Demand for E85 Ethanol, Research report. University of California Energy Institute. Available at http://www.ucei.berkeley.edu/gasoilmarkets/Papers/2-Anderson.pdf (accessed 21 July 2009).

Banaszak, Sara et al. (1999) Demand for Ground Transportation Fuel and Pricing Policy in Asian Tigers: A Comparative Study of Korea and Taiwan, *Energy Journal*, 20(2), pp.145-165.

Bentzen, J. (1994) An Empirical Analysis of Gasoline Demand in Denmark Using Co Integration Techniques, *Energy Economics*, 16, pp.139-143.

Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. (2005) Ethanol Policy and Strategies, Powerpoint presentation (in Thai). 1 December 2005. Rama Gardens Hotel, Bangkok.

Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. (2009) Notification of Department of Alternative Energy Development and Efficiency, re: Guideline for FFV Import Duty Reduction Application 2009 (in Thai).

Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. (2010) Ethanol and Biodiesel Situation in Thailand, Powerpoint presentation (in Thai). 25 August 2010.

Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. Ethanol (in Thai). Available at http://www.dede.go.th/dede/index.php?option=com_content&view=article&id=886%3A2010-10-15-09-18-18&catid=61%3A2010-04-06-09-22-58&Itemid=68&lang=en (accessed 8 February 2011).

Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. Share of Final Energy by Sector 2009. Available at http://www.eppo.go.th/info/1summary_stat.htm (accessed 8 February 2011)

Department of Energy Business (DOEB), Ministry of Energy. Statistics. Available at http://www.doeb.go.th/information/information.htm (accessed 8 February 2011)

Eltony, M N and Al-Multairi, N H. (1995) Demand for Gasoline in Kuwait, *Energy Economics*, 17, pp.249-253.

Energy Conservation Promotion Act B.E.2535 (1992).

Energy Policy and Planning Office (EPPO), Ministry of Energy. (2003) National Energy Strategies, Thailand Energy Policy and Measures 2003 (in Thai). Bangkok: Energy Policy and Planning Office. Available at http://www.eppo.go.th/doc/report-2546/4-strategies.html (accessed 30 June 2009)

Energy Policy and Planning Office (EPPO), Ministry of Energy. 2004. Oil Fund (in Thai). Available at http://www.eppo.go.th/petro/oilfund.html (accessed 25 October 2009).

Energy Policy and Planning Office (EPPO), Ministry of Energy. Energy Database. Available at http://www.eppo.go.th/info/index.html

Gujarati, D. N. (2003): *Basic Econometrics* (Singapore: McGraw-Hill).

Luchansky, M. S. and Monks, J. (2009) Supply and Demand Elasticities in the U.S. Ethanol Fuel Market, *Energy Economics*, 31, pp.403-410.

Ministry of Finance (2007): Notification of the Ministry of Finance of the Kingdom of Thailand, re: Excise Tax Rate Reduction (No.80) (in Thai).

Ministry of Finance (2011): Notification of the Ministry of Finance of the Kingdom of Thailand, re: Excise Tax Rate Reduction (No.87) (in Thai).

Ministry of Finance (2011): Notification of the Ministry of Finance of the Kingdom of Thailand, re: Import Duty Reduction and Exemption (No.19) (in Thai).

Ministry of Transport (2009): Fuel Consumption in Transport Sector by Transport Mode, 2000-2009 (in Thai). Available at http://vigportal.mot.go.th/portal/site/PortalMOT/stat/index20URL/ (accessed 8 February 2011).

Ramanathan, R. (1999) Short- and Long-Run Elasticities of Gasoline Demand in India: An Empirical Analysis Using Cointegration Techniques, *Energy Economics*, 21, pp.321-330.

Rask, K. N. (1998) Clean Air and Renewable Fuels: the Market for Fuel Ethanol in the US from 1984 to 1993, *Energy Economics*, 20, pp.325-345.

Standing Committee on Energy, House of Representatives, National Assembly of Thailand. (2004) *Renewable Energy in Thailand: Ethanol and Biodiesel*. Translated from Thai by Alternative Energy Development and Efficiency Department, Ministry of Energy (Bangkok: Plan Printing).