The Role of the Oil Fund in Thailand: Past, Present, and Future

Final Report

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1. Introduction

The first energy crisis in 1973 caused unprecedented increases in the international oil prices. Thailand is one of the oil importing countries that was affected by the first energy crisis. The first energy crisis was a significant factor that led to the Oil Shortage Prevention Act in 1973 that empowers the prime minister to issue measures to prevent the oil shortage. This led to the establishment of the Oil Stabilization Fund in the same year that requires the oil traders to make contributions to the Fund at the designated rates. The compensations to the fuel oil traders at certain periods are then drawn from the Oil Stabilization Fund.

Another version of the Oil Stabilization Fund (Foreign Exchange) was set up in 1978 with the objective of collecting the windfall profits of the oil traders from the baht appreciation. Later, the government decided to integrate the 1973 Oil Stabilization Fund with the 1978 Oil Fund Stabilization (foreign exchange) in 1979 when there were sharp increases in the international oil prices. The objectives of the 1979 Oil Stabilization Fund are to prevent oil shortage and to maintain the oil price level to lessen the effects of the oil price increases in the domestic economy.

When the Yingluck 1 government came into power and delivered the policy statement to the Parliament on August 23, 2011, the topic of energy price stabilization has been included as one of the energy policy package (Yingluck, 2011). The policy number 3.5.3 states the government's intention to

> *"regulate the energy price appropriately, justly, and to strive for the energy prices that reflect their true costs. This may be achieved by utilizing the oil fund as an instrument to stabilize the energy prices. The energy price subsidies will be considered for specific groups. The government will also promote the utilization of natural gas in the transportation sector, the utilization of gasohol and biodiesel in the household sector."*

After the policy statement has been delivered there are no further clarifications given on either the concept of energy price stabilization or the methods of its implementation. The energy price stabilization policy raises an interesting issue on the nature of the cost/benefit of the price stabilization policy.

The unclear nature of the cost/benefit of the price stabilization policy leads to the objectives of this paper. The first objective is to review the policy implications from the actual utilization of the oil fund. The second objective is to propose a price stabilization option from an efficiency criterion that utilizes the oil fund as a stabilizing instrument.

The paper is organized around six sections. The next section reviews the past patterns of the oil fund utilization. The third section presents a theoretical model for the optimum utilization of the oil fund as a price stabilization instrument. The criterion for the application of the theoretical model for the case of Thailand is then discussed in section 4. The implementation of price stabilization is illustrated in section five. The final section presents the summary and conclusions of the report.

2. Role of Oil Fund in the Oil Price Structure of Major Petroleum Products

Before 2006, gasoline and high speed diesel were the two major petroleum products with the largest consumption in Thailand. At the end of 2006, gasoline and diesel constituted about 18 percent and 47 percent of the total petroleum products respectively. The dependence on these two products led to a cabinet resolution on December 9, 2003 to eventually replace gasoline octane 95 with gasohol, a mixture of gasoline and ethanol (NEPO, 2006). The available options for the gasohol consumers are a mixture containing 10 percent ethanol and 90 percent gasoline (E10), a mixture containing 20 percent ethanol and 80 percent gasoline (E20), and a mixture containing 85 percent ethanol and 15 percent gasoline (E85).

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 as a substitute for high speed diesel by expanding the acreage of palm oil and the distribution channels. Initially, the biodiesel proportion is set at 5 percent biodiesel and 95 percent high speed diesel (B5). From February 2008, the government mandates that the remaining high speed diesel is blended with 2 percent biodiesel (B2). The proportion of biodiesel in high speed diesel is then increased to 3 percent in June 10, 2010 (B3). After the emergence of biodiesel, the consumption of pure high speed diesel became insignificant after June 2010.

Table 1 Consumption of Major Petroleum Products in Thailand, September, 2012

Petroleum Products	Million liters/day	percent	Percent of total consumption
Gasoline			
Gasoline octane 91	7.88	98.72	
Gasoline octane 95	0.10	1.28	
Total gasoline	7.98	100.00	11.07
Gasohol			
E10 octane 91	5.85	47.55	
E10 octane 95	5.24	42.59	
E20	1.10	8.90	
E85	0.12	0.96	
Total gasohol	12.31	100.00	17.08
Diesel			
B2, B3, B5	50.19	96.93	
High Speed Diesel	1.59	3.07	
Total diesel	51.78		71.85
Total consumption	72.07		100.00

Source: Department of Energy Business, Energy Ministry

Table 1 compares the consumption between gasoline, gasohol, high speed diesel, and biodiesel for September 2012. Diesel is still the major petroleum products with biodiesel constituting about 97 percent of the total diesel consumption. The consumption of gasohol exceeds the gasoline consumption with E10 constituting about 90 percent of the total gasohol consumption. Gasoline octane 91 is now the major product with about 99 percent share in the total gasoline consumption.

2.1 Oil Price Structure before the Emergence of Gasohol and Biodiesel, 2004-2006

The wholesale and retail price of the petroleum products are published daily by the National Energy Policy Office (NEPO). The wholesale oil price structure of a given petroleum product is given by the identity

(2.1) $wholesale\ price =$
$ex - refinery\ price + excise\ tax + municipal\ tax + conservation\ fund + value\ added\ tax +$
$+ oil\ fund$

The marketing margin is then added to the wholesale price to obtain the retail price given by

(2.2) $retail\ price = wholesale\ price + marketing\ margin + value\ added\ tax$

The ex-refinery price and the marketing margin are the only two components in the price structure that are determined by the market force and reflect the production and distribution costs of a given petroleum product. The remaining price components in the price structure, including the oil fund, are transfer payment items that are controlled by the government. The municipal tax rate is directly related to the excise tax and its rate is set at ten percent of the excise tax. The conservation fund is collected at a designated rate and is used to finance the energy conservation projects under the jurisdiction of the energy ministry.

There are two collections for the value added tax. The first collection is on the wholesale price and its rate is set at 7 percent of the whole sale price. The rate for the second collection is also 7 percent collected on the marketing margin. Table 2 presents the summary statistics for the components of the daily price structure of gasoline octane 95, gasoline octane 91, and high speed diesel between July 2004 and December 2006. The level fluctuations in each component are indicated by its variance to mean ratio.

The oil fund component, especially for high speed diesel, exhibits the largest fluctuations among the transfer payment components during this period. The larger fluctuations in the oil fund component imply that it is utilized as a major price manipulating instrument during this period.

Table 2 Fluctuations in the Daily Retail Price Structure of Gasoline and High Speed Diesel, July 31, 2004 - December 31, 2006

Petroleum Products	P_exr	ET	MT	OF	CF	P_ws	VAT	P_ws+VAT	MM	VATM	P_ret
Gasoline 95											
mean	16.42	3.68	0.37	2.09	0.04	22.59	1.58	24.18	1.23	0.09	25.49
variance	5.57	0.00	0.00	1.19	0.00	7.74	0.04	8.86	0.93	0.00	7.58
variance/mean	0.34	0.00	0.00	0.57	0.00	0.34	0.02	0.37	0.76	0.05	0.30
maximum	23.72	3.69	0.37	3.46	0.04	29.32	2.05	31.37	3.20	0.22	30.19
minimum	11.08	3.69	0.37	-1.29	0.04	15.67	1.10	16.77	-4.51	-0.32	17.79
Gasoline 91											
mean	15.95	3.68	0.37	1.88	0.04	21.92	1.53	23.45	1.15	0.08	24.68
variance	5.66	0.00	0.00	1.21	0.00	7.93	0.04	9.07	0.90	0.00	7.62
variance/mean	0.35	0.00	0.00	0.64	0.00	0.36	0.03	0.39	0.78	0.05	0.31
maximum	23.23	3.69	0.37	3.26	0.04	28.62	2.00	30.63	2.73	0.19	29.39
minimum	10.44	3.69	0.37	-1.57	0.04	14.85	1.04	15.89	-4.57	-0.32	16.99
H Diesel											
mean	17.57	2.09	0.21	0.06	0.04	19.97	1.39	21.36	1.13	0.08	22.56
variance	5.06	0.15	0.00	4.85	0.00	14.57	0.08	16.79	0.45	0.00	17.56
variance/mean	0.29	0.07	0.01	86.90	0.00	0.73	0.06	0.79	0.40	0.03	0.78
maximum	21.64	3.06	0.31	2.50	0.04	25.63	1.79	27.43	2.85	0.20	27.94
minimum	9.89	1.21	0.12	-6.00	0.04	12.59	0.13	13.47	-1.20	-0.08	14.59

P_exr = ex-refinery price; ET = excise tax; MT = municipal tax; OF = oil fund; CF = oil conservation fund; VAT = value added tax; P_ws = whole sale price; MM = marketing margin; VATM = value added tax on marketing margin; P_ret = retail price
Source: Calculated from the daily price structure announced on the web site https://www.eppo.go.th

By observing the range of the oil fund, as indicated by its maximum and the minimum value, it is evident that the oil fund has been utilized to manipulate a price increase as well as a price decrease. A positive value of the oil fund indicates its use to manipulate a price increase whereas a negative value indicates its use to manipulate a price decrease. Since the average oil fund component is positive during this period, there is, on average, a surplus in the oil fund account of gasoline and high speed diesel during this period.

The effects of the oil fund on the costs and the retail prices of gasoline and high speed diesel are observed by removing the oil fund component from the price structure. Table 3 presents a comparison between the costs and retail prices of gasoline and high speed diesel with and without the oil fund component. The comparison shows that the inclusion of the oil fund component in the price structure increases the fluctuations in the costs and the retail prices of gasoline and high speed diesel. The largest fluctuations in the costs and the retail price are observed for high speed diesel.

Table 3 Price Structure of Gasoline and High Speed Diesel With and Without Oil Fund, July 31, 2004 - December 31, 2006

Petroleum Products	P_retail	P_retail *	P_ex-refinery+marketing margin	P_ex-refinery+marketing margin+oil fund
Gasoline 95				
mean	25.49	23.40	17.64	19.73
variance	7.58	4.83	4.15	6.65
var/mean	0.30	0.21	0.24	0.34
Gasoline 91				
mean	24.68	22.80	17.10	18.99
variance	7.62	4.84	4.15	6.68
variance/mean	0.31	0.21	0.24	0.35
High Speed Diesel				
mean	22.56	22.51	18.70	18.75
variance	17.56	6.30	5.06	15.49
var/mean	0.78	0.28	0.27	0.83

* The retail price without the oil fund component
Source: Calculated from the daily price structure announced on the web site https://www.eppo.go.th

The nature of the correlation between the oil fund component and the costs will shed some light on the oil fund utilization policy during this period. A positive correlation between the two variables would suggest that the oil fund component is utilized as a progressive tax instrument where the tax rate varies directly with the costs. On the other hand, a negative correlation would suggest that the oil fund is utilized as a price stabilizing instrument.

The regression results of the oil fund on the costs of gasoline and high speed diesel are presented in Table 4. Even though the regression equations have a rather low explanatory power, the equations show a positive and significant correlation between the oil fund and the costs for3 gasoline and high speed diesel during this period.

Table 4 Regression Results of Oil Fund on Oil Costs, July 2004 – December 2006

Petroleum Products	Coefficient	Std. Error	t-Statistic	Prob.	R^2_{adj}	N
Gasoline 95						
P_ex-refinery+Marketing margin	0.15	0.03	4.45	0.00	0.08	218
C	-0.63	0.61	-1.02	0.31		
Gasoline 91						
P_ex-refinery+Marketing margin	0.16	0.04	4.50	0.00	0.08	218
C	-0.82	0.61	-1.36	0.18		
High Speed Diesel						
P_ex-refinery+Marketing margin	0.55	0.06	9.94	0.00	0.31	218
C	-10.19	1.04	-9.81	0.00		

The regression results support the notion that the oil fund was utilized as a tax instrument rather than a price stabilizing instrument during this period. It appears that the utilization of the oil fund as a tax instrument has destabilizing effects on the costs and the retail prices of gasoline and high speed diesel during this period.

2.2 Oil Price Structure After the Emergence of Gasohol and Biodiesel, 2007-2012

The price structure of gasoline, high speed diesel, gasohol, and biodiesel for the period 2007 through 2012 are presented in Table 5. There are marked increases in the costs, retail prices, and the oil fund component of gasoline and high speed diesel over the previous period. The increases in the costs are largely the results of the increases in the ex-refinery prices of gasoline and high speed diesel. The costs and the retail prices of these two products also exhibit considerably larger fluctuations than the previous period. It is also observed that the oil fund for gasoline 91 is always positive during this period which means that the oil fund was never utilized to manipulate a decrease in its retail price.

The average oil fund component is negative for the E20, E85, and B5 and positive for the remaining E10 octane 95 (E10_95) and E10 octane 91(E10_91). In contrast to the oil fund component of gasoline 91, the oil fund component of E85 is always negative. The negative oil fund for E85 means that it was utilized to manipulate only a price decrease for E85 throughout the period. The patterns of the oil fund components suggest some form of cross price subsidies among the petroleum products during this period.

Table 5 Daily Retail Price Structure of Gasoline, High Speed Diesel, Gasohol, and Biodiesel, January 2007 - September 2012

Petroleum Products	P_exr	ET	MT	OF	CF	P_ws	VAT	P_ws+VAT	MM	VATM	P_ret
Gasoline 95											
mean	20.19	5.72	0.57	5.23	0.35	32.07	2.24	34.31	4.12	0.29	38.72
variance	19.18	2.49	0.02	5.48	0.06	26.17	0.13	29.97	3.97	0.02	39.39
variance/mean	0.95	0.44	0.04	1.05	0.18	0.82	0.06	0.87	0.97	0.07	1.02
max	31.24	7.00	0.70	7.50	0.75	41.96	2.94	44.90	8.46	0.59	49.44
min	8.39	3.69	0.37	-0.81	0.04	17.20	1.20	18.40	-0.85	-0.06	25.19
Gasoline 91											
mean	19.72	5.72	0.57	4.55	0.35	30.92	2.16	33.08	1.63	0.11	34.83
variance	19.40	2.49	0.02	3.99	0.06	26.93	0.13	30.84	0.61	0.00	30.98
variance/mean	0.98	0.44	0.04	0.88	0.18	0.87	0.06	0.93	0.37	0.03	0.89
max	30.82	7.00	0.70	7.10	0.75	41.11	2.88	43.99	4.97	0.35	44.55
min	7.95	3.69	0.37	0.00	0.04	16.76	1.17	17.93	-0.56	-0.04	20.79
H Diesel											
mean	21.47	2.58	0.26	0.55	0.26	25.12	1.76	26.88	1.35	0.09	28.32
var	26.68	4.90	0.05	1.77	0.05	16.09	0.08	18.42	0.67	0.00	16.18
variance/mean	1.24	1.90	0.19	3.26	0.20	0.64	0.04	0.69	0.50	0.03	0.57
max	38.47	5.31	0.53	2.80	0.75	40.95	2.87	43.82	8.92	0.62	44.24
min	11.12	0.01	0.00	-13.50	0.04	10.54	0.74	11.28	-3.61	-0.25	14.29
E10_95											
mean	20.54	4.87	0.49	1.65	0.22	27.76	1.94	29.70	1.64	0.11	31.46
var	15.51	4.09	0.04	0.97	0.00	26.70	0.13	30.56	0.44	0.00	28.63
variance/mean	0.76	0.84	0.08	0.59	0.02	0.96	0.07	1.03	0.27	0.02	0.91
max	30.11	6.30	0.63	3.30	0.25	37.03	2.59	39.62	4.89	0.34	40.73
min	9.97	0.02	0.00	-1.13	0.04	12.59	0.88	13.47	-0.32	-0.02	16.29
E10_91											
mean	20.29	4.86	0.49	0.53	0.22	26.39	1.85	28.24	1.76	0.12	30.12
var	15.65	4.10	0.04	0.98	0.00	21.65	0.11	24.79	0.44	0.00	23.70
variance/mean	0.77	0.84	0.08	1.86	0.02	0.82	0.06	0.88	0.25	0.02	0.79
max	29.92	6.30	0.63	2.80	0.25	35.21	2.46	37.67	6.43	0.45	38.98
min	9.77	0.02	0.00	-10.30	0.04	11.07	0.77	11.84	-0.18	-0.01	15.49
E20											
mean	21.04	4.62	0.46	-0.83	0.25	25.54	1.79	27.33	2.38	0.17	29.88
var	13.96	3.29	0.03	0.63	0.00	19.61	0.10	22.46	0.59	0.00	22.80
variance/mean	0.66	0.71	0.07	-0.76	0.00	0.77	0.05	0.82	0.25	0.02	0.76
max	28.88	6.30	0.63	1.40	0.25	32.55	2.28	34.83	4.52	0.32	37.98
min	11.44	0.02	0.00	-3.23	0.05	11.65	0.82	12.46	-0.10	-0.01	14.99
E85											
mean	22.13	1.04	0.10	-11.23	0.25	12.29	0.86	13.15	6.92	0.48	20.55
var	6.21	0.07	0.00	5.72	0.00	4.14	0.02	4.73	8.28	0.04	4.48
variance/mean	0.28	0.07	0.01	-0.51	0.00	0.34	0.02	0.36	1.20	0.08	0.22
max	31.92	5.60	0.56	-0.81	0.25	28.57	2.00	30.57	12.53	0.88	34.14
min	16.26	0.75	0.08	-13.60	0.25	9.22	0.65	9.87	-4.27	-0.30	14.29

B5											
mean	20.17	3.15	0.32	-0.57	0.20	23.27	1.63	24.90	1.51	0.11	26.51
var	26.15	3.09	0.03	1.27	0.01	22.22	0.11	25.44	0.90	0.00	21.57
variance/mean	1.30	0.98	0.10	-2.23	0.04	0.96	0.07	1.02	0.60	0.04	0.81
max	38.57	5.04	0.50	1.49	0.75	39.73	2.78	42.51	5.28	0.37	43.54
min	11.57	0.01	0.00	-4.05	0.04	13.19	0.92	14.12	-2.98	-0.21	16.84

P_exr = ex-refinery price; ET = excise tax; MT = municipal tax; OF = oil fund; CF = oil conservation fund; VAT = value added tax; P_ws = whole sale price; MM = marketing margin; VATM = value added tax on marketing margin; P_ret = retail price

The effects of the oil fund on the costs and retail prices of the petroleum products are presented in Table 6. In contrast to the previous period, the oil fund component has been found to reduce the fluctuations in the costs and the retail prices of all the petroleum products. The regression results of the oil fund on the costs of the petroleum products presented in Table 7 support the price stabilizing effects of the oil fund as all of the costs coefficients in the equations of all products are negative and significant.

Table 6 Stabilizing Feature of Oil Fund, January, 2007 - September, 2012

	P_ret	P_ret w/o OF	P_exr+MM	P_exr+MM+OF
Gasoline 95				
mean	38.72	33.12	24.31	29.54
variance	39.39	33.81	19.47	21.07
variance/mean	1.02	1.02	0.80	0.71
Gasoline 91				
mean	34.83	29.96	21.35	25.91
variance	30.98	28.47	19.27	18.55
variance/mean	0.89	0.95	0.90	0.72
E10_95				
mean	31.46	29.80	22.17	23.83
var	28.63	27.05	15.05	14.43
variance/mean	0.91	0.91	0.68	0.61
E10_91				
mean	**30.12**	**29.59**	**22.05**	**22.58**
variance	23.70	27.26	15.21	11.89
variance/mean	0.79	0.92	0.69	0.53
E20				
mean	29.88	30.71	23.42	22.59
variance	22.80	25.40	13.93	12.87
variance/mean	0.76	0.83	0.59	0.57
E85				
mean	20.55	31.79	29.04	17.81
variance	4.48	14.72	13.56	3.50
variance/mean	0.22	0.46	0.47	0.20
H Diesel				
mean	28.32	27.78	22.83	23.37
variance	16.18	21.19	24.99	21.87
variance/mean	0.57	0.76	1.09	0.94
Biodiesel				
mean	26.51	27.08	21.68	21.11
variance	21.57	26.77	23.33	20.45
variance/mean	0.81	0.99	1.08	0.97

Since the average oil fund component is positive for some products and negative for the remaining products it is possible to have either a surplus or a deficit in the oil fund account in a given period. As an illustration of an oil fund account status, the average oil fund component for September 2012 is applied to the average consumption of gasoline, high speed diesel, gasohol, and biodiesel in the same month.

The status of the oil fund account balance presented in Table 8 shows that the gasoline 91 consumers are the largest contributors to the oil fund account at 84 percent of the total contributions. At the other extreme, the biodiesel consumers are the largest recipients of the subsidy from the oil fund account at 72 percent of the total subsidy.

Table 7 Relationship between Oil Fund and Oil Costs, January 2007 – September 2012

Petroleum Products	Coefficient	Std. Error	t-Statistic	Prob.	R^2_{adj}	N
Gasoline 95						
P_exr+MM	-0.10	0.01	-7.06	0.00	0.03	1364
C	7.66	0.35	21.94	0.00		
Gasoline 91						
P_exr+MM	-0.03	0.01	-2.55	0.01	0.00	1364
C	4.83	0.26	18.86	0.00		
High Speed Diesel						
P_exr+MM	-0.10	0.01	-14.59	0.00	0.13	1364
C	2.78	0.16	17.73	0.00		
E10_95						
P_exr+MM	-0.05	0.01	-7.71	0.00	0.04	1341
C	2.81	0.15	18.40	0.00		
E10_91						
P_exr+MM	-0.14	0.01	-24.48	0.00	0.31	1341
C	3.65	0.13	28.20	0.00		
E20						
P_exr+MM	-0.05	0.01	-7.71	0.00	0.04	1341
C	2.81	0.15	18.40	0.00		
E85						
P_exr+MM	-0.58	0.01	-59.38	0.00	0.80	872
C	5.66	0.29	19.74	0.00		
B5						
P_exr+MM	-0.09	0.01	-14.19	0.00	0.15	95
C	1.20	0.13	9.35	0.00		

Table 8 Oil Fund Balance, September 2012

Petroleum Products	million liters	oil fund	oil fund balance	Percent
Gasoline 91	236.40	5.68	1341.57	84.42
E10 octane 95	157.20	1.28	200.43	12.61
High Speed Diesel	47.70	0.55	26.24	1.65
Gasoline 95	3.00	6.98	20.93	1.32
Total Contribution			1589.16	100.00
Biodiesel	1505.70	-0.45	-677.57	71.72
E10 octane 91	175.50	-1.03	-179.89	19.04
E20	33.00	-1.31	-43.23	4.58
E85	3.60	-12.23	-44.01	4.66
Total Subsidy			-944.69	100.00
Balance			644.47	

* calculated from Table 1 **average value for September 2012

In spite of the subsidy, there is a surplus in oil fund account for these petroleum products in this month which is largely due to the contributions of the gasoline 91 consumers. It appears that the stabilizing effects of the oil fund also result in the cross price subsidies mainly between the gasoline 91 consumers and the biodiesel consumers in this period.

3. Role of the Oil Fund: To Stabilize or not to Stabilize?

The following observations may be made from the reviews of the oil fund utilization in the previous section:

1) The oil fund has been utilized as an instrument to manipulate a decrease as well as an increase in the costs and the retail prices of the petroleum products.
2) The oil fund has a stabilizing as well as a destabilizing effect on the costs and the retail prices of the petroleum products.
3) The oil fund account can be in either surplus or deficit in a given period.
4) The oil fund utilization resulted in cross price subsidies among the petroleum product consumers.

This section discusses the role of the oil fund as a price stabilization instrument and its effects on social welfare. The section starts with a review of the past studies on price stabilization. A 'one way' price stabilization approach that utilizes the oil fund as a price stabilization instrument is then analyzed as a potential alternative to the existing 'two way' price stabilization.

3.1 Past Studies on Price Stabilization and Social Welfare

One of the earliest studies on the effect of price stabilization on social welfare is the study by Waugh (1944) who investigated the effects of price stabilization on consumers' welfare. Based on a specific case of a stationary demand curve, Waugh concluded that consumers are the losers from price stabilization where the commodity price in question is stabilized at its arithmetic mean.

On the other side of the coin, Oi (1961) studied the effects of price stabilization on the producers' welfare for competitive firms. Based on an assumption of a stationary supply curve, Oi concluded that the producers are the losers from price stabilization where the commodity price is stabilized at its arithmetic mean.

Massel (1969) integrated the Waugh model with the Oi model by allowing shifts in both the demand and supply of the commodity to determine the changes in the market prices. His model requires a price stabilization instrument which is assumed to be the buffer stock of the commodity in question. The model used to integrate the Waugh and Oi models is a simple linear demand and supply equations represented by

(3.1) $Supply\colon\ s = \alpha p + x \qquad \alpha > 0$

(3.2) $Demand\colon\ d = -\beta p + y \qquad \beta > 0$

where s = supply; d = demand; P = price; x = demand shift variable; y = supply shift variable

It is assumed that the factors that cause the shifts in demand and supply through the shift factors x and y are jointly distributed random variables with means μ_x and μ_y, and variances σ_{xx} and σ_{yy}, respectively. The two shift variables are also assumed to be independent so the covariance σ_{xy}, is zero. The commodity price is stabilized at its arithmetic mean that is known with certainty.

The model is used to derive the expected value of the change in producer surplus, EΔPS, and the expected value of the change in consumer surplus, EΔCS, from price stabilization which are represented by the equations

(3.3) $E\Delta PS = \frac{(\alpha+2\beta)\sigma_{xx}-\alpha\sigma_{yy}}{2(\alpha+\beta)^2}$

and

(3.4) $E\Delta CS = \frac{(\beta+2\alpha)\sigma_{yy}-\beta\sigma_{xx}}{2(\alpha+\beta)^2}$

The expected total change in social welfare, $E\Delta G_b$, is then the sum of the expected changes in the consumer surplus and the expected changes in the producer surplus which equals

(3.5) $E\Delta G_b = \frac{\sigma_{xx}+\sigma_{yy}}{2(\alpha+\beta)}$

or

(3.6) $E\Delta G_b = \frac{(\alpha+\beta)\sigma_{pp}}{2}$

where σ_{pp} is the variance of the commodity price.

One important conclusion from equation (3.6) is that society gains from price stabilization. However, consumers and producers cannot gain simultaneously from price stabilization as apparent from equations (3.3) and (3.4). It must be noted that the storage costs of the buffer stock are ignored in the Massel model.

Some authors in later studies have avoided using consumer surplus as an indicator of a consumer's welfare and adopt the utility approach to study the effects of price stabilization on consumers' welfare. As an example, Turnovsky (1980) used an indirect utility function to study the effects of price stabilization on consumers' welfare. Whereas the consumer surplus approach implies relatively little information on risk attitude (Hanoch, 1974) the utility approach allows consideration of a consumer's risk taking preference in the analysis. Since the gains and losses of consumer surplus in the Waugh model receive equal weight, it implicitly assumes a risk neutral attitude of a consumer.

The general conclusion reached by Turnovsky is consistent with the Waugh conclusion in that a consumer prefers price instability over price that is stabilized at the arithmetic mean. The preference for price instability tends to increase with the increase in price elasticity and the income elasticity. It was also found, not surprisingly, that the preference for price instability declines with the degree of risk aversion.

Even though the utility approach avoids the controversy of using consumer surplus as an indicator of consumer welfare, it introduces some complications in the model if one wants to integrate the benefits of consumers and producers from price stabilization. Willig (1976) investigated the consumer surplus controversy and concludes that the errors from the measurement of consumer surplus from an ordinary demand curve are relatively small. The Willig article may have tempered the consumer surplus controversy and many subsequent applied researches have used consumer surplus as an indicator of social welfare

There are alternative models that investigate the effects of price stabilization on social welfare. Turnovsky (1978) compared the linear Massel model with the other types of models surveyed from other studies. The models surveyed are the nonlinear models with additive stochastic variables, nonlinear models with multiplicative stochastic variables, and models with alternative supply equation specifications. It was found that the nonlinearity of the models and the nature of the stochastic components of the models do not change the basic conclusion that price stabilization increases social welfare. The differences between the models are mainly in the details of the distribution of welfare between the consumers and the producers.

The Massel model implicitly assumes that the commodity prices are known with certainty. This assumption is relaxed in some studies that allow the producers to react to the expected prices rather than the actual prices. The two models considered are the adaptive expectations model and the rational expectations model. These models were also found to have the same basic conclusion that price stabilization increases social welfare. In addition, the benefits of price stabilization are greater when producers react to the expected prices rather than the actual prices.

In a later study, Akiyama and Kawai (1985) modified the Massel model to include the role of the buffer stock in the model. Two types of buffer stocks are considered in the model, a private inventory of the producers and the official buffer stock. The private inventory is set up to generate possible profits while the official buffer stock is used as an instrument for price stabilization. The producers are price takers and are allowed to react to the expected price as well as the actual price. This allows the producers to adjust their output when the expected prices differ from the actual prices. The holding or storage costs of the buffer stock, ignored in the Massel model, are now incorporated into the model. The stabilized price is selected such that the buffer stock is in balance.

The conclusions of the Akiyama and Kawai model confirm the basic conclusion from the Massel model in that the consumers and producers, now including the inventory holders, jointly gain from price stabilization. However, the buffer stock authority is the loser in the price stabilization scheme which is not surprising. Even though the buffer stock balances itself over time, the buffer stock authority has to absorb holding costs which are assumed to increase at an increasing rate.

3.2 Oil Fund as a Price Stabilization Instrument and Social Welfare: A Graphical Analysis

In this section the buffer stock is replaced by the oil fund as a price stabilization instrument. This eliminates the issue of the storage costs of the buffer stock. A graphical analysis is presented below to model the effects that the oil fund utilization has on social welfare. Initially, the oil fund is utilized as a 'two way' price stabilization instrument to manipulate a price increase as well as a price decrease for a given petroleum product.

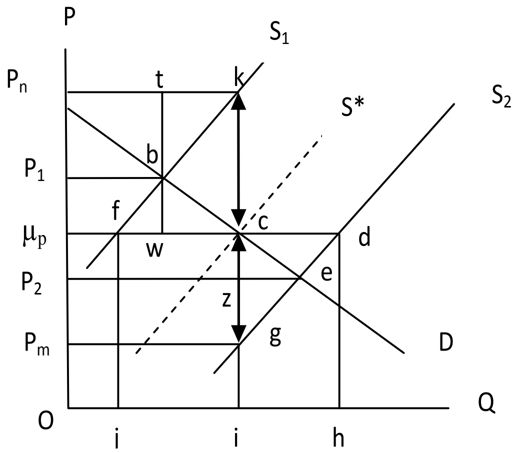

Figure 1 Oil Fund Utilization and Social Welfare: A Case of Stationary Demand

Under this framework, the oil fund authority determines the target price for stabilization and collects a per unit contribution into the oil fund account in a period where the market price is below the 'target' price and provides a per unit subsidy from the oil fund account when the market price exceeds the 'target' price. The effects of the oil fund on social welfare are analyzed initially for the case of a stationary demand D of a given petroleum product in Figure 1.

Under this assumption, the price fluctuations of a given petroleum product are caused by the shifts in its supply. Consider two prices, P_1 when the supply is S_1, and P_2 when the supply is S_2 and let the arithmetic mean price of the petroleum product, μ_p, be the target price for stabilization.

When the price is P_1, a per unit subsidy equal to kc is provided from the oil fund account to the oil traders which shifts the supply curve from S_1 to S*. The total subsidy received by the oil traders equals the area $P_n kc\mu_p$ and the market price falls from P_1 to μ_p as a result of the subsidy. The net price received by the oil traders equals P_n which increases the producer surplus by the area $P_1 bkP_n$ and also increases the consumer surplus by the area $P_1 bc\mu_p$. The total gains in social welfare from the subsidy are then the sum of the areas $P_1 bkP_n$ and $P_1 bc\mu_p$.

Conversely, the oil fund equal to cg is collected from the oil traders when the market price is P_2 which generates revenue equal to the area $\mu_p cgP_m$ for the oil fund account. The oil fund collection shifts the supply curve from S_2 to S* which increases the market price from P_2 to the target price μ_p. The net price P_m received by the oil traders decreases their producer surplus by the area $P_2 egP_m$ which consists of the oil traders' tax burden $P_2 zgP_m$ and the losses equal to the area zeg from a reduction of ze units of output.

The increase in price from P_2 to μ_p also reduces the consumer surplus by the area $\mu_p ceP_2$ which consists of the consumers' tax burden $\mu_p czP_2$ and the losses from output reduction equal to the area cez. The total losses in social welfare from price stabilization are then equal to the area

$\mu_p$cegP$_m$. It is seen that the losses in social welfare from price stabilization when the market price is P_2 are greater than the gains when the market price is P_1 by the sum of the areas kcb and ceg. The oil fund account is expected to be in balance since the per unit subsidy kc equals the per unit collection cg and the consumption in each case is equal at i units.

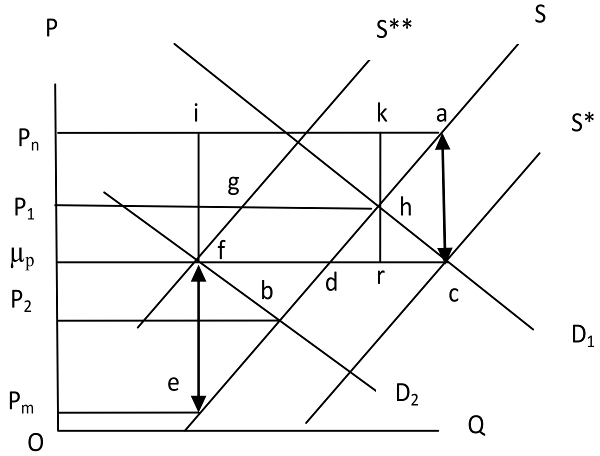

Figure 2 Price Stabilization and Social Welfare: A Case of Stationary Supply

The effect of the oil fund utilization on social welfare for the case of a stationary supply S is illustrated in Figure 2. When the market price is P_2 an oil fund collection equal to fe shifts the supply curve to S** which generates a revenue equal to the area $\mu_p$feP$_m$. The oil fund collection increases the market price from P_2 to the target price μ_p but the net price P_m received by the oil traders decreases the producer surplus by the area P_2beP$_m$. The stabilized price μ_p also decreases the consumer surplus by the area $\mu_p$fbP$_2$ so social welfare is reduced by the area $\mu_p$fbeP$_m$.

When the market price is P_1 a per unit subsidy from the oil fund account equal to ac is provided to the oil traders which amounts to a total subsidy of P$_n$acμ_p. The subsidy shifts the supply curve from S to S* so the market price P_1 falls to the target price μ_p. The net price P_n received by the oil traders increases the producer surplus by the area P$_n$ahP$_1$ and increases the consumer surplus by the area P$_1$hcμ_p so social welfare is increased by the area P$_n$ahcμ_p. It is easily seen that the gains in social welfare from price stabilization when the market price is P_1 are greater than the losses when the market price is P_2 so it seems possible that society can gain from price stabilization in the case of a stationary supply.

However, the oil fund account will be in deficit by the amount equal to the area iacf which must be regarded as the cost of price stabilization. Even though the per unit subsidy equals the per unit collection, the oil fund account is still in deficit because the consumption under the oil fund collection is less than the consumption under the subsidy. As pointed out by authors such as Samuelson (1970) and Choi and Johnson (1992), price stabilization is a feasible option only if society can bear the costs of price stabilization which, in this case, is reflected in the oil fund account deficit.

The costs of price stabilization or the oil fund account deficit must be added to the gains of consumers and producers to obtain net gains (losses) from price stabilization. It is easily seen from Figure 2 that society will lose from price stabilization if it has to pay for the costs of price stabilization.

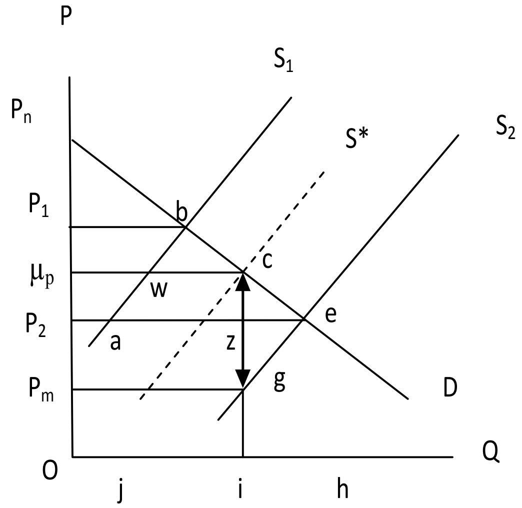

Figure 3 One Way Price Stabilization: Case of a Stationary Demand

A logical remedy to the oil fund deficit is to devise a price stabilization option that can improve social welfare without causing a deficit in the oil fund account. This objective can be accomplished through a 'one way' price stabilization. In this option, a target price for price stabilization is selected and the oil fund is collected when the market price falls below the target price. No oil fund will be collected and no subsidy is provided whenever the market price rises above the target price. An important feature of this approach is the reimbursements of the oil fund collections to the oil traders at the end of a given period.

The effects of the oil fund utilization in a one way price stabilization on social welfare is presented initially for a stationary demand case in Figure 3. As in the previous case, the target price for price stabilization is selected as μ_p, the arithmetic mean of P_1 and P_2. During the period where the market price P_2 is below the target price μ_p, an oil fund collection equal to cg is collected from the oil traders which generates revenue equal to the area $\mu_p cgP_m$ for the oil fund account. The oil fund collection shifts the supply curve from S_2 to S* and the net price received by the oil traders, P_m, causes a reduction in the producer surplus equal to the area P_2egP_m.

The oil fund collection also reduces the consumer surplus by the area $\mu_p ceP_2$. When the supply curve shifts from S_2 to S_1 and the price is allowed to increase from μ_p to P_1, the consumer surplus is reduced further by the area P1bcμ_p so the total losses in the consumer surplus equal the area P_1beP_2. Essentially, a one way price stabilization has the same effect as scheduling a natural price increase from P_2 to P_1 into two phases, from P_2 to μ_p in the first phase, and then from μ_p to P_1 in the second phase.

Without a one way price stabilization the price also increases by the market force from P_2 to P_1. If the duration of the price stabilization is sufficiently short, say one month, so that the inter-temporal costs can be assumed to be insignificant, the consumers are essentially unaffected by a one way price stabilization.

The feature of a one way price stabilization ensures a surplus in the oil fund account equal to the area $\mu_p cgP_m$. The surplus in the oil fund account can be used to compensate for the losses of P_2egP_m in the producer surplus. The balance in the oil fund account after the reimbursement of the oil fund collection is then the difference between the area $\mu_p czP_2$ and the area zeg.

Intuitively, it can be argued that the oil fund account remains in surplus after the reimbursements to the oil traders. This is because the marginal revenue at the price P_2 is less than the marginal cost as reflected by the supply curve. Even though μ_p may not be the price that equate marginal cost with marginal revenue a reduction in output by increasing the price from P_2 to μ_p tends to increase the net revenue which means that the area $\mu_p czP_2$ is greater than the area zeg. The surplus remaining in the oil fund account after the reimbursements means that society does gain from a one way price stabilization.

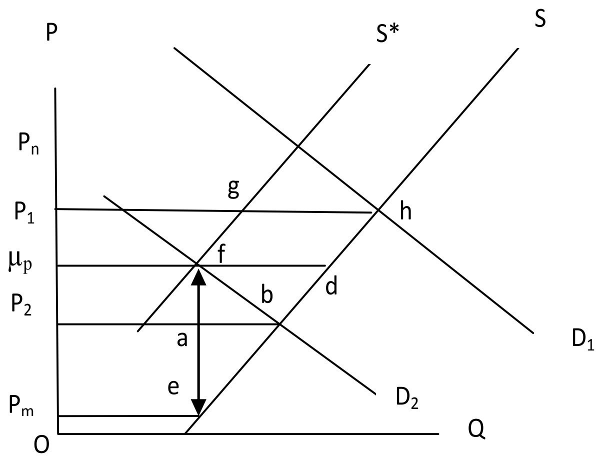

Figure 4 One Way Price Stabilization: Case of a Stationary Supply

The effects of a one way price stabilization on social welfare for the case of a stationary supply are illustrated in Figure 4. The oil fund collection of fe when the market price is P_2 shifts the supply curve S to S* and generates revenue for the oil fund account equal to the area $\mu_p feP_m$. The oil fund collection reduces the producer surplus equal to the area $P_2 beP_m$ and reduces the consumer surplus equal to the area $\mu_p fbP_2$ so social welfare is decreased by the area $\mu_p fbeP_m$.

When the demand curve D_2 shifts to D_1 and the market price increases to P_1 the oil fund collection is removed and the market price is allowed to stand at P_1. As in the case of a stationary demand, the loss of the consumer surplus when the commodity price increases from P_2 to P_1 is essentially the same whether or not there is one way price stabilization. It can also be shown that society gains from a one way price stabilization when the surplus $\mu_p feP_m$ in the oil fund account is reimbursed to the oil traders..

3.3 Integration of the Graphical Analysis

A model is constructed in this section to integrate the graphical analysis presented in the previous section. The integration allows the price fluctuations to come from a simultaneous shift in demand and supply that can be considered by modifying the Massel model. The section starts with an analysis of the effects that a two way price stabilization has on social welfare followed by a derivation of an 'optimum' target price for stabilization. The model is then extended to analyze the effects of a one way price stabilization on social welfare.

3.3.1 A Two Way Price Stabilization[1]

The model below is based on the equations (3.1) and (3.2) in the original Massel model. The equilibrium price of a given petroleum product, P_e, can be solved from equations (3.1) and (3.2) which equals

[1] The Mathcad v.14.0 software is used to execute the calculations in this section. The calculation details are not provided due to their length and only the end results are given. The calculation file that requires the Mathcad software to open is available upon request to the author at thiraphongv@yahoo.com.

(3.7) $P_e = -\left(\frac{x-y}{\alpha+\beta}\right)$
and has the expected value
(3.8) $EP_e = \mu_p = -\left(\frac{\mu_x-\mu_y}{\alpha+\beta}\right)$
The corresponding equilibrium quantity,q_{de} is then equal to
(3.9) $q_{de} = q_{se} = \left(\frac{\beta x+\alpha y}{\alpha+\beta}\right)$

In order to have a positive price and quantity it is necessary to have the following constraints: $y > 0; x < 0; x < y;\ \mu_x < \mu_{y;}\ \beta x + \alpha y > 0$. The target price for stabilization, P_s, in a two way price stabilization is initially set around the arithmetic mean price as represented by
(3.10) $P_s = -\left(\frac{\mu_x-\mu_y}{\alpha+\beta}\right).(1+\theta)$
where θ can take on any feasible value in a two way price stabilization. The quantity demanded at the target price is given by
(3.11) $q_{d\mu p} = \frac{(\beta+\beta\theta)\mu_x+(-\beta-\beta\theta)\mu_y+(\beta+\alpha)y}{\alpha+\beta}$

In order to sustain the target price an oil fund collection or a subsidy from the oil fund account is required to equate the quantity demand with the quantity supply at the target price. The net price, P_{net}, received by the oil traders required to match the quantity supply with the quantity demand is solved from the equation
(3.12) $\alpha.P_{net} + x = \frac{(\beta+\beta\theta)\mu_x+(-\beta-\beta\theta)\mu_y+(\beta+\alpha)y}{\alpha+\beta}$
which gives the net price equal to
(3.13) $P_{net} = \frac{\beta[\mu_x-\mu_y-x+y+\theta(\mu_x-\mu_y)]-\alpha(x-y)}{\alpha(\alpha+\beta)}$

The oil fund collection/subsidy, t, required to equate the quantity demand with the quantity supply at the target price is the difference between the target price and the net price which equals
(3.14) $t = -\frac{(\theta+1)\mu_x+(-\theta-1)\mu_y+y-x}{\alpha}$

The net cash flow of the oil fund account, CF, the costs of price stabilization, is the product between the oil fund and the quantity demanded at the stabilized price and has the expected value
(3.15) $ECF = -\frac{(\alpha+\beta)\sigma_{yy}+[\beta(\mu_x-\mu_y)^2]\theta^2+[(\mu_x-\mu_y)(\beta\mu_x-\alpha\mu_y)]\theta}{\alpha(\alpha+\beta)}$

The effect of price stabilization on producer surplus, ΔPS, is the sum of the rectangle area $P_n$tbP_1 and the triangle area tkb in figure 1 or the rectangle area $P_n$khP_1 and the triangle area kah in Figure 2. The rectangle area is given by $(p_{net} - p_e)(q_{de})$ and the triangle area is given by 0.5 $(p_{net} - p_e)(q_{d\mu p} - q_{de})$ so their sum is equal to 0.5 $(p_e - p_{net})(q_{de} + q_{\mu p})$. Substituting and taking expected value gives expected changes in the producer surplus equal to
(3.16) $\Delta PS = \frac{(-\beta^{2)}\sigma_{xx}+(\beta^2+2\alpha\beta)\sigma_{yy}+[\beta^2(\mu_x-\mu_y)^2]\theta^2+[2\beta(\mu_x-\mu_y)(\beta\mu_x+\alpha\mu_y)]\theta}{2\alpha(\beta+\alpha)^2}$

Similarly, the effect of price stabilization on consumer surplus is the sum of the rectangle area P_1bwμ_p and the triangle area bcw in Figure 1 or the rectangle area P_1hrμ_p and the triangle area hcr in Figure 2. The rectangle area is given by $(p_e - \mu_p)(q_{de})$ and the triangle area is given by 0.5 $(p_e - \mu_p)(q_{d\mu p} - q_{de})$ so their sum equals 0.5 $(p_e - \mu_p)(q_{de} + q_{\mu p})$. Substituting and taking expected value gives the expected changes in the consumer surplus equal to

$$(3.17)\ E\Delta CS = \frac{(-\beta)\sigma_{xx}+(\beta+2\alpha)\sigma_{yy}+[\beta(\mu_x-\mu_y)^2]\theta^2+[2(\mu_x-\mu_y)(\beta\mu_x+\alpha\mu_y)]\theta}{2\alpha(\beta+\alpha)^2}$$

The expected changes in social welfare is the sum of the expected changes in the producer surplus, the expected changes in the consumer surplus, and the expected changes in the oil fund net cash flow which equals

$$(3.18)\ E\Delta NSW = -\frac{[\beta(\mu_x-\mu_y)^2]\theta^2+\beta(\sigma_{xx}+\sigma_{yy})}{2\alpha(\alpha+\beta)}$$

The optimum value of θ is obtained by setting the derivative of EΔNSW with respect to equal to zero and solve for which gives the optimum value of equal to zero. The optimum target price is thus the arithmetic mean price which gives the optimum change in producer surplus, consumer surplus, and the net cash flow equal to[2]

$$(3.19)\ E\Delta PS = \frac{\beta(\beta+2\alpha)\sigma_{yy}-\beta^2\sigma_{xx}}{2\alpha(\beta+\alpha)^2}$$

$$(3.20)\ E\Delta CS = \frac{(\beta+2\alpha)\sigma_{yy}-\beta\sigma_{xx}}{2(\beta+\alpha)^2}$$

$$(3.21)\ ECF = -\frac{\sigma_{yy}}{\alpha}$$

$$(3.22)\ E\Delta NSW = -\frac{\beta(\sigma_{xx}+\sigma_{yy})}{2\alpha(\alpha+\beta)}$$

Contrary to the Massel model, equations (3.19) and (3.20) show that it is possible for the oil traders and the oil consumers to be gainers or losers from price stabilization at the same time. Equation (3.21) confirms that a two way price stabilization that utilizes the oil fund as a price stabilization instrument results in deficit as discussed in the graphical analysis. The deficit in the oil fund is expected to increase with the level of demand fluctuations in the long run.

For comparison, the difference between the change in the producer surplus under the oil fund, as given by equation (3.19), and the corresponding change in producer surplus under the buffer stock, as given by equation (3.3) in the Massel model, $E\Delta PS_{fb}$, may be shown to equal

$$(3.23)\ E\Delta PS_{fb} = \frac{\beta(\sigma_{yy}-\sigma_{xx})}{2\alpha}$$

Ignoring the costs of price stabilization, equation (3.23) shows that, the oil fund is a more effective instrument than the buffer stock in the improvement of producer surplus if the demand fluctuations are greater than the supply fluctuations. Similarly, comparison of equation (3.20) with equation (3.4) shows that the effect of price stabilization on the consumer surplus is the same regardless of the choice of the price stabilization instrument.

It is also observed that the oil fund is a more effective price stabilization instrument for improving social welfare when price fluctuations come from the demand side. The buffer stock is a more effective price stabilization instrument for improving social welfare only when the price fluctuations come from the supply side.

When the costs of price stabilization or the deficit in the oil fund account is considered it is apparent that a two way price stabilization that utilize the oil fund as a price stabilizing instrument decreases social welfare. This is evident from equation (3.22) where the expected change in social welfare is always negative and worsens with the degree of price fluctuations. A two way price stabilization that utilizes the oil fund as a price stabilization instrument is not, therefore, a feasible price stabilization option from the social welfare criterion.

3.3.2 An Alternative Option: A One Way Price Stabilization

[2] It can similarly be shown that the arithmetic mean price is also the optimum target price for price stabilization that utilizes buffer stock as a price stabilization instrument in the original Massel model.

In a one way price stabilization, a one way oil fund collection requires that the target price or the arithmetic mean price must be greater than the equilibrium price which requires the constraint

$$(3.24)\ -\left(\frac{\mu_x-\mu_y}{\alpha+\beta}\right) > -\left(\frac{x-y}{\alpha+\beta}\right)$$

The quantity demanded at the stabilized price, $q_{d\mu p}$, which must also be positive is equal to

$$(3.25)\ q_{d\mu p} = \frac{\beta\mu_x-\beta\mu_y+\beta y+\alpha y}{\alpha+\beta}$$

and satisfies the constraint

$$(3.26)\ \beta y + \alpha y > \beta\mu_y - \beta\mu_x$$

The quantity supplied at the net price received by the producers must match the quantity demanded at the target price so that

$$(3.27)\ q_{d\mu p} = \alpha p_{net} + x$$

and the net price, which must be positive, is found to equal

$$(3.28)\ p_{net} = \frac{\beta\mu_x-\beta\mu_y-\beta x-\alpha x+\beta y+\alpha y}{\alpha(\alpha+\beta)}$$

with the constraint

$$(3.29)\ \beta\mu_x - \beta\mu_y > \beta x + \alpha x - \beta y - \alpha y$$

A positive oil fund collection is then difference between the target price and the net price received by the oil traders which equals

$$(3.30)\ t = -\frac{\mu_x-\mu_y-x+y}{\alpha}$$

and satisfies the constraint

$$(3.31)\ \mu_y - \mu_x > y - x$$

The oil fund cash flow is the product between the oil fund collection and the quantity demanded at the target price and has the expected value

$$(3.32)\ ECF = \frac{\beta(\sigma_{xx}+\sigma_{yy})+(\mu_x-\mu_y-x+y)(\beta x-2\beta y-\alpha y)}{\alpha(\alpha+\beta)}$$

The first parenthesis is always positive; the second and third parenthesis can be shown from the required parameter constraints to be negative so the oil fund cash flow is expected to be in surplus as required in a one way price stabilization. The oil fund surplus is reimbursed to the oil traders at the end of a given period.

The losses in the producer surplus from a one way price stabilization is the sum of the rectangle area P_2zgP_m and the triangle area zeg in Figure 3 or the sum of the rectangle area P_2aeP_m and the triangle area abe in Figure 4 which equals $0.5\,(p_{de} - p_{net})(q_{de} - q_{d\mu p})$. Substituting for the price and quantity variables and taking expected value give the expected value of the losses in the producer surplus equal to

$$(3.33)\ E\Delta PS = \frac{\beta^2(\sigma_{xx}+\sigma_{yy})-2\beta y(\mu_x-\mu_y-x+y)(\beta+\alpha)}{2\alpha(\alpha+\beta)^2}$$

When the surplus in the stabilization cash flow is reimbursed to the oil traders, the expected gains to society, ESW, are then the sum of the oil fund account surplus and the losses in the producer surplus which equal

$$(3.34)\ ESW = \frac{[\beta(\sigma_{xx}+\sigma_{yy})(\beta+2\alpha)]+2(\beta+\alpha)(\beta x-\beta y-\alpha y)(\mu_x-\mu_y-x+y)}{2\alpha(\alpha+\beta)^2}$$

It can be shown that the price variance, σ_{pp}, is given by

$$(3.35)\ \sigma_{pp} = \frac{(\sigma_{xx}+\sigma_{yy})}{(\alpha+\beta)^2}$$

so the gains in social welfare can be expressed as

$$(3.36)\ ESW = \frac{[\beta(\beta+\alpha)(\beta+2\alpha)]\sigma_{pp} + 2(\mu_x - \mu_y - x + y)(\beta x - \beta y - \alpha y)}{2\alpha(\alpha+\beta)}$$

The benefits of a one way price stabilization in (3.36) come from two sources that can be shown to be always positive. The first source of benefit is represented by the product between the terms in the bracket and the price variance which is always positive and increases with the degree of price fluctuations. The second source of benefit comes from the difference between the stabilized price and the equilibrium price as represented by the first and the second parenthesis.

The first parenthesis represents the difference between the stabilized price and the equilibrium price. Using equation (3.30) the first parenthesis may be shown to equal - αt which is always negative. The value of the second parenthesis depends on the demand and supply shift variables which is also negative from the parameter constraints so the gains in social welfare from a one way price stabilization are always positive.

In an extreme case where the prices of a given petroleum product are constant throughout a given period, the price variance is zero, and so the stabilized price equals the equilibrium price. In this case, σ_{pp} and the terms in the first parenthesis of equation (3.36) are zero so there are no gains in social welfare from a one way price stabilization.

In another case, it is possible to have price fluctuations in such a way that the equilibrium price in a given period equals the stabilized price so there is no oil fund collection. In this case, the terms in the first parenthesis is zero and the gains in social welfare depend on the degree of price fluctuations.

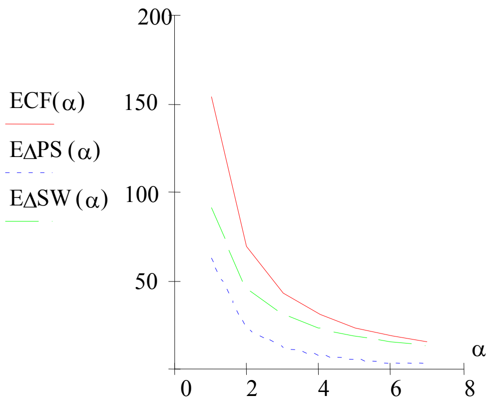

Figure 5 Supply Parameter and Social Welfare

The gains in social welfare also depend on the supply parameter α and the demand parameter β. The relationship between the gains in social welfare and the supply parameter are shown for given values of the remaining parameters in Figure 5. The absolute numbers have no significant meaning and the graph intends to illustrate only the relationship between the supply parameter and the gains in social welfare. The supply price elasticity increases with the value of α and it can be observed that the gains in social welfare decrease sharply as the supply of a given petroleum product becomes relatively more elastic, and approaches zero as the supply elasticity approaches infinity.

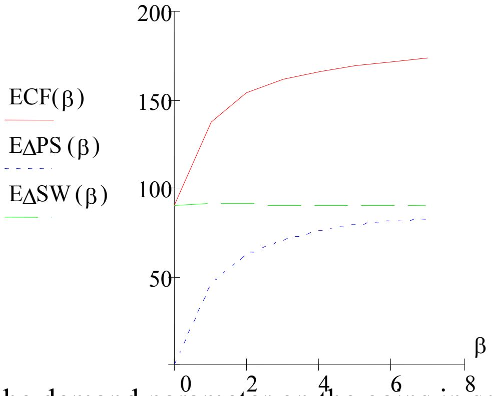

Figure 6 Demand Parameter and Social Welfare

The effects of the demand parameter on the gains in social welfare are shown in Figure 6. An increase in the va [illegible] relatively more elastic. In contrast to the supply case, the gains in social welfare increase sharply as the demand for a given petroleum product becomes relative more price elastic and approaches a steady level at some level of price elasticity.

4. A One Way Price Stabilization Option for Thailand

There are two issues to be considered in adopting a one way price stabilization option for Thailand. The first issue concerns the selection of the price components in the retail price structure for stabilization. The second issue concerns the selection of the petroleum products for a one way price stabilization.

4.1 Selection of Price Components and Petroleum Products for a One Way Price Stabilization

Since the government controls all of the transfer payment components in the retail price structure, there are no reasons to stabilize these components. The uncontrolled fluctuations in the retail price of a given petroleum product come from its costs or the sum of the ex-refinery price component and the marketing margin component. It is then reasonable to stabilize only these two components.

The analysis in the previous section shows that a one way price stabilization generates a maximum benefit for a petroleum product with a relatively inelastic supply and a relatively elastic demand. These constraints make gasoline and high speed diesel unsuitable candidates for a one way price stabilization. The supply of these two products are shown to be perfectly price elastic while their demand are shown to be relative price inelastic (Vikitset, 2012). A petroleum product that is suitable for a one way price stabilization needs to have a relatively elastic demand and, at least, a less than perfectly elastic supply. It will be argued below that gasohol and biodiesel are potential candidates for a one way price stabilization.

The production of gasohol requires a blending of gasoline with ethanol in a given proportion. Ethanol is produced locally in Thailand and its production costs depend on the investment costs of the ethanol plant, the feedstock costs, the operation and maintenance costs, and the sales of the by-products (Yoosin, 2007). For a given ethanol plant, the marginal costs of ethanol depend on the costs of the feedstock and the operation and maintenance costs.

The feedstock options for ethanol production in Thailand are cassava, corn, rice, sugarcane and molasses. The costs of a given feedstock depend on its ethanol yield and its prices. It was found that sugarcane and cassava are the two feed stocks that have the lowest costs for ethanol production. The marginal costs of gasohol production then depend on the marginal costs of ethanol produced from the sugarcane and cassava feedstock, the marginal costs of gasoline, and the proportion of ethanol and gasoline in the gasohol.

Biodiesel in Thailand is produced from the refined bleached deodorized palm oil palm stearin (RBD palm stearin); RBD; crude palm oil; and a small amount of used vegetable oil. The biodiesel is mixed with high speed diesel in a given proportion so the marginal costs of the mixture depend on the marginal costs of high speed diesel, the marginal biodiesel costs, and the proportion of biodiesel in the mixture.

On the demand side, it is suspected that the demand for gasohol is relatively price elastic due to its high substitutability with gasoline (Gorte and Just, 2009b). Similarly, the demand for biodiesel is expected to be price elastic due to its substitutability with high speed diesel. On the supply side, it can be shown that the supply of gasohol and biodiesel are less than perfectly elastic even though the supply of gasoline and high speed diesel are perfectly elastic.

The reason for a less than perfectly supply of gasohol or biodiesel is explained in Figure 7 for the case of gasohol which is assumed to be a perfect substitute of gasoline. The perfectly elastic supply S_g in Figure 5 represents the supply of gasoline, the supply S_e represents the marginal costs of ethanol, and the supply S_h is the marginal costs of gasohol which is determined by the equation

$$P_h = xP_e + (1-x)P_g$$

where x is the proportion of ethanol in gasohol.

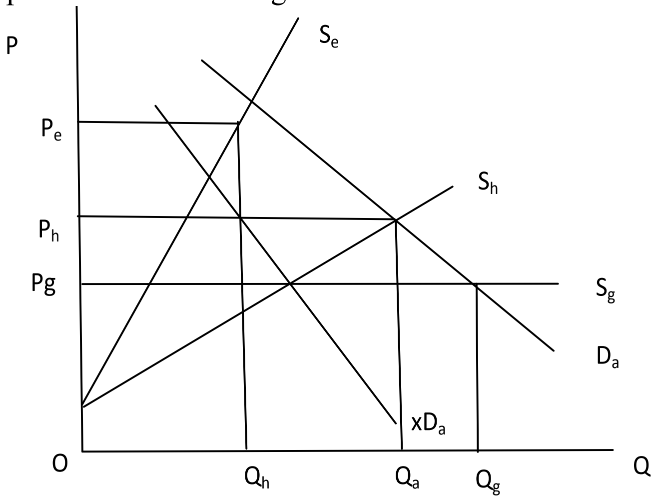

Figure 7 Demand and Supply of Gasohol

Before the emergence of gasohol, D_a is the demand for gasoline. The equilibrium price and consumption of gasoline are determined at P_g and Q_g respectively. When gasohol is introduced into the market its demand is reflected by the demand xD_a. The total consumption of gasoline and gasohol is now equal to Q_a which consists of Q_h units of gasohol consumption at the price P_h, and Q_a-Q_h units of gasoline consumption at the price P_g. By similar analysis, it can be shown that the supply of biodiesel is less than perfectly elastic.

4.2 Estimation of Demand and Supply Parameters of Gasohol and Biodiesel

The estimations of the demand and supply parameters for gasohol are presented in this section. The estimations are illustrated for the case of E10_91 for gasohol and B5 for biodiesel. Apart from the prices of the commodity, it is necessary to identify the relevant shift variables for demand and supply before they can be integrated into a single shift variable x and y in the model.

The demand/supply model is estimated from a monthly data from January 2007 to September 2012.

Table 8 Estimation Results of Demand and Supply of B5

Demand QB5	Coefficient	Std. Error	t-Statistic	Prob.
P_B5	-209.72	46.71	-4.49	0.00
P_HD	195.22	52.60	3.71	0.00
M1	0.00	0.00	1.63	0.11
C	-970.21	231.34	-4.19	0.00
P_BEN95	27.63	9.55	2.89	0.01
Adjusted R-squared	0.85			
Prob(F-statistic)	0.00			
DW	1.44			
Supply QB5				
P_B5	0.65	3.03	0.22	0.83
P_FBDBIOD	-4.22	2.38	-1.77	0.08
C	135.28	61.91	2.18	0.03
QB5(-1)	0.95	0.04	25.56	0.00
Adjusted R-squared	0.93			
DW	1.44			

P_B5 = retail price of B5; P_HD = retail price of high speed diesel; M1 = money supply M1; P_BEN95 = retail price of gasoline 95; P_FBDBIOD = price of biodiesel feedstock

Many past studies on the demand estimations of gasoline have been published. A survey of past demand studies (Espey,1988) on gasoline shows that, apart from income and price of substitutes, some measure of vehicle ownership is a variable that significantly explains the demand for gasoline. In the demand estimations for E10_91 an B5, the money supply M_1 is utilized as a proxy variable for income since the income variable or the GDP variable is not available on a monthly basis. It has been shown (Vikitset, 2012) that M_1 is a robust and suitable proxy variable for GDP.

After several trials of estimations, the two stage least squares method is selected as an estimation method for the demand and supply equations. The estimation results of the demand and supply of B5 are presented in Table 8. The coefficient of the number of vehicles in the B5 demand equation has an unexpected but not significant sign and it is not included in the equation.

Table 9 Estimation Results of Demand and Supply of E10_91

Demand E10_91	Coefficient	Std. Error	t-Statistic	Prob.
P_E10_91	-20.80	10.11	-2.06	0.04
P_BEN91	17.56	8.62	2.04	0.05
M1	0.00	0.00	9.85	0.00
C	-161.25	20.85	-7.73	0.00
Adjusted R-squared	0.77			
Prob(F-statistic)	0.00			
DW	0.45			
Supply E10_91				
P_E10_91	5.41	1.03	5.26	0.00
P_ETH	6.51	1.43	4.55	0.00
C	-187.90	33.41	-5.62	0.00

Adjusted R-squared	0.50
Prob(F-statistic)	0.00
DW	0.23

P_E10_91= retail price of E10_91; P_BEN91= retail price of gasoline 91; M1 = money supply M1; P_ETH = retail price of ethanol

The coefficient of M1 has an expected but not significant sign and is left in the equation. All the price variables have relatively large coefficients with the expected and significant signs. The coefficients in the supply equations have expected signs but the coefficient of the B5 price is not significant.

The estimation results of the demand and supply of E10_91 are presented in Table 9. As in the case of B5, the vehicle variable is not significant in the demand equation and is not included in the equation. The price variable in the supply equation has an expected and significant sign. The estimation results provide some indications that a one way price stabilization may be implemented for B5 and E10_91.

5. Application of a One Way Price Stabilization: An Illustration for B5 and E10_91

A similar one way price stabilization has been proposed for the United States (Merril and Schizer, 2010)**.** The major difference in that proposal is that the collected tax is reimbursed to the oil consumers rather than to the oil traders. In a one way price stabilization for Thailand, the arithmetic mean of the ex-refinery price in a given month is computed from its daily announcements and used as a reference price for the subsequent month. If the announced ex-refinery price on a given day in the subsequent month is less than its reference price an oil fund is collected to raise the ex-refinery price to the reference price. There is no oil fund collection if the announced ex-refinery price is greater than the reference price.

The same criterion is applied to the marketing margin. At the end of the month the oil fund collections for the stabilization of the ex-refinery price and for the stabilization of the marketing margin are reimbursed to the oil traders. The other transfer payment components are left unchanged and are added to the stabilized ex-refinery price and the stabilized marketing margin to determine the stabilized retail price by the formula

(4.1) $P_{ret\_s} = 1.07(P_{exr_s} + MM_s + ET + MT + CF)$

where P_{ret_s}= stabilized retail price; $P_{\_exrs}$ = stabilized ex-refinery price; MM_s= stabilized marketing margin; ET = excise tax; MT = municipal tax; CF = conservation fund

The effects on the costs and retail price of a given product from the stabilizing oil fund in a one way price stabilization are then compared to the effects on the costs and the retail price from an existing oil fund. The benefits from a one way price stabilization are then estimated by using the results of the parameter estimations and equation (3.36).

5.1 One Way Price Stabilization of B5

As an illustration, a one way price stabilization is applied to the month of April 2007 and the results are presented in Table 10. The references for the ex-refinery price and the marketing margin are based on their means in the previous month. It can be observed that there are relatively little fluctuations in the costs and the retail price of B5 in this month as their variances are less than 2 percent of their means.

Even though the actual oil fund and the stabilizing oil fund have approximately the same mean, they have different effects on the costs and the retail price of B5. The stabilized costs in column 5 have a lower mean than the actual costs with the oil fund in column 4 by about 6.6 percent. If the actual oil fund is replaced by the stabilizing oil fund, the stabilized costs in column 5 still have a lower mean than the actual costs in column 2 by about 5 percent.

The transfer payment components are added to the stabilized costs to obtain the stabilized retail price of B5 in the last column of Table 10. The stabilized retail price is approximately the same as the actual retail price with the oil fund but with slightly lower fluctuations. However, when the stabilizing oil fund of 0.31 baht/liter, on average, is reimbursed to the oil traders at the end of the month the 'effective' retail price to the oil traders is about 0.31 baht/liter or about 1.3 percent lower than the actual retail price.

Table 10 Illustration of a One Way Price stabilization for B5, April 2007

Date	P_exr+MM	OF_actual	P_exr+MM+OF	(P_exr+MM)_s	OF_s	P_ret	P_ret*	P_ret_s
2/4/2007	19.13	0.30	19.43	19.15	0.78	23.44	23.14	23.96
3/4/2007	19.13	0.30	19.43	19.20	0.81	23.44	23.14	23.99
4/4/2007	19.51	0.30	19.81	18.81	0.43	23.84	23.54	23.98
5/4/2007	19.51	0.30	19.81	18.71	0.38	23.84	23.54	23.92
9/4/2007	19.51	0.30	19.81	18.96	0.50	23.84	23.54	24.06
10/4/2007	19.51	0.30	19.81	18.78	0.41	23.84	23.54	23.96
11/4/2007	19.88	0.30	20.18	18.22	0.00	24.24	23.94	23.92
12/4/2007	19.88	0.30	20.18	18.52	0.10	24.24	23.94	24.02
18/4/2007	19.88	0.30	20.18	19.56	0.62	24.24	23.94	24.58
20/4/2007	19.88	0.30	20.18	18.17	0.00	24.24	23.94	23.92
23/4/2007	19.88	0.30	20.18	18.28	0.00	24.24	23.94	23.92
24/4/2007	19.88	0.30	20.18	18.61	0.14	24.24	23.94	24.07
25/4/2007	19.88	0.30	20.18	19.30	0.49	24.24	23.94	24.44
26/4/2007	20.25	0.30	20.55	18.90	0.10	24.64	24.34	24.43
27/4/2007	20.25	0.30	20.55	18.87	0.08	24.64	24.34	24.41
30/4/2007	20.25	0.30	20.55	19.05	0.18	24.64	24.34	24.51
mean	19.76	0.30	20.06	18.82	0.31	24.12	23.82	24.13
variance	0.13	0.00	0.13	0.16	0.08	0.14	0.14	0.06
variance/mean	0.01	0.00	0.01	0.01	0.24	0.01	0.01	0.00

P_exr = ex-refinery price; MM = marketing margin; OF_s = total stabilizing oil fund; P_ret = retail price; P_ret* = retail price without oil fund; P_ret_s = stabilized retail price
The stabilized costs are based on the mean ex-refinery price of 17.10 baht/liter and the mean marketing margin of 1.55 baht/liter in March 2007.

If the existing oil fund is replaced by the stabilizing oil fund, the mean of the stabilized retail price in the last column is greater than the mean of the retail price without the oil fund in column 8 by about 0.31 baht/liter. The two retail prices will be approximately equal with the reimbursement of the oil fund.

The results of the demand/supply model estimations in Table 8 may be used to quantify the benefits of a one way price stabilization for B5 in April 2007. Assuming that the price coefficient of B5 price is constant throughout the estimation period, the equilibrium price and quantity in a given period is determined by the shift variables in that period. The demand and supply equations of B5 for the month of April 2007 are specified by the equations

$$Q_{B5} = y - 209.72P\_B5$$

and

$$Q_{B5} = x + 13P\_B5$$

where y is the demand shift variable and x is the supply shift variable.

The consumption and the retail price of B5 in April 2007 are 32.17 million liters and 24.12 baht/liter respectively. The actual retail price and consumption are used to calibrate the demand and supply shift variables. Substituting the retail price and the consumption of B5 into the demand and supply equations give the shift variable x = -281.39 and y = 5,090.62. The first parenthesis in equation (3.36) can be shown to equal –t.α where t is the stabilizing oil fund collection which equals 0.31 baht/liter for April 2007. Substituting in the relevant value into equation (3.36) gives the gains in social welfare equal to 1,926.42 million baht.

5.2 One Way Price Stabilization of E10_91

Table 11 illustrates a one way price stabilization for E10_91 in the month of May 2007. As in the case of B5, there are relatively little fluctuations in the costs and the retail price of E10_91 in this month.

On average, the actual oil fund is more than 4 times the stabilizing oil fund which causes the stabilized costs in column 5 to be lower than the actual costs with the oil fund in column 4 by about 5.6 percent. If the actual oil fund is replaced by the stabilizing oil fund, the stabilized costs in column 5 are still lower than the actual costs in column 2 by about 2.9 percent. At the end of the period, the reimbursement of 0.17 baht/liter would make the effective costs of E10_91 lower than the actual costs by about 3.7 percent.

At the retail level, the stabilized retail price in the last column is lower than the existing retail price by about 2.3 percent. With the reimbursement of the stabilizing oil fund, the stabilized retail price would be lower than the existing retail price by about 3 percent. If the existing oil fund is replaced by the stabilizing oil fund the mean of the stabilized retail price in the last column is higher than the retail price without the oil fund in column 8 by 0.14 baht/liter. With the reimbursement of the stabilizing oil fund, the effective stabilized retail price would be lower than the existing retail price without the oil fund by about 0.03 baht/liter.

Table 11 Illustration of a One Way Price stabilization for E10_91, May 2007

Date	P_exr+MM	OF_actual	P_exr+MM+OF	(P_exr+MM)_s	OF_s	P_ret	P_ret*	P_ret_s
1/5/2007	19.95	1.00	20.95	19.52	0.21	26.39	25.39	25.55
2/5/2007	19.95	1.00	20.95	19.52	0.21	26.39	25.39	25.55
3/5/2007	19.95	1.00	20.95	19.53	0.22	26.39	25.39	25.56
4/5/2007	19.95	1.00	20.95	19.60	0.26	26.39	25.39	25.59
8/5/2007	19.95	1.00	20.95	19.35	0.13	26.39	25.39	25.46
9/5/2007	19.95	1.00	20.95	19.22	0.07	26.39	25.39	25.39
11/5/2007	19.95	1.00	20.95	19.60	0.26	26.39	25.39	25.59
14/5/2007	20.35	0.60	20.95	19.64	0.08	26.39	25.79	25.83
15/5/2007	20.35	0.60	20.95	20.11	0.31	26.39	25.79	26.08
16/5/2007	20.35	0.60	20.95	19.84	0.18	26.39	25.79	25.94
17/5/2007	20.35	0.60	20.95	20.05	0.28	26.39	25.79	26.05
18/5/2007	20.35	0.60	20.95	20.20	0.36	26.39	25.79	26.13
21/5/2007	20.73	0.60	21.33	20.43	0.29	26.79	26.19	26.45
22/5/2007	20.73	0.60	21.33	20.50	0.32	26.79	26.19	26.49
23/5/2007	20.73	0.60	21.33	20.47	0.30	26.79	26.19	26.47
24/5/2007	20.73	0.60	21.33	19.93	0.03	26.79	26.19	26.18
25/5/2007	20.73	0.60	21.33	19.67	0.00	26.79	26.19	26.15
28/5/2007	20.73	0.60	21.33	19.75	0.00	26.79	26.19	26.15
29/5/2007	20.73	0.60	21.33	19.56	0.00	26.79	26.19	26.15
30/5/2007	20.73	0.60	21.33	19.43	0.00	26.79	26.19	26.15
mean	20.36	0.74	21.10	19.80	0.17	26.55	25.81	25.95
variance	0.12	0.04	0.04	0.14	0.02	0.04	0.13	0.13
variance/mean	0.01	0.05	0.00	0.01	0.09	0.00	0.00	0.00

P_exr = ex-refinery price; MM = marketing margin; OF_s = total stabilizing oil fund; P_ret = retail price; P_ret* = retail price without oil fund; P_ret_s = stabilized retail price; cf = coefficient of variation

The stabilized costs are based on the mean ex-refinery price of 18.60 baht/liter and the mean marketing margin of 0.86 baht/liter in April 2007

In the evaluation of the benefits from a one way price stabilization, the demand and supply equations of E10_91 are specified as

$$Q_{E10\_91} = y - 20.8P\_E10\_91$$

$Q_{E10\_91} = x + 5.41P\_E10\_91$

The consumption and retail price of E10_91 in May 2007 are equal to 15.28 million liters and 26.59 baht/liter respectively. Substituting the retail price and consumption into the demand and supply equations the demand shift variable and setting the stabilizing oil fund equal to 0.17 baht/liter give the gains in social welfare from equation (3.36) equal to 116.4 million baht.

6. Summary and Conclusions

The oil fund has been utilized as a tax instrument for gasoline and high speed diesel, the two major petroleum products before the emergence of gasohol and biodiesel in 2007. The oil fund utilization has been found to increase the fluctuations in the costs and the retail prices of gasoline and high speed diesel during this period.

After the emergence of gasohol and biodiesel in 2007, the oil fund became a price stabilizing instrument which reduces the fluctuations in the costs and the retail prices of gasohol, biodiesel, gasoline, and high speed diesel. The utilization of the oil fund after 2007 also has a cross price subsidy feature where the gasoline 91 consumers are the major contributors to the oil fund and the E85 consumers are the major recipients of the subsidies. The oil fund account can be either in surplus or in deficit in a given period depending on the degree of the cross price subsidies.

A deficit in the oil fund account has been shown to decrease social welfare. In contrast, the oil fund account is always in surplus and reimbursed to the oil traders under a one way price stabilization which has been shown to increase social welfare. The existing price structure can accommodate the implementation of a one way price stabilization without any significant change in the price structure.

A one way price stabilization is effective for a petroleum product with relatively elastic demand and inelastic supply. The price elasticity constraints imply that there are no gains from a one way price stabilization for gasoline and high speed diesel whose supply have been shown to be perfectly elastic. A one way price stabilization is applicable for the petroleum products that have relatively more elastic demand and less than a perfectly elastic supply such as gasohol and biodiesel.

It is must be noted that the oil fund is a price stabilizing instrument in a one way price stabilization, and not a revenue generating component for the government. The remaining transfer payment components in the price structure are the components that generate revenue for the government. The conservation fund component has been earmarked to finance the government sponsored energy conservation projects. The excise tax is collected on a per unit basis and the rate varies among the petroleum products. The value added tax is collected at two levels, seven percent of the wholesale price, and seven percent of the marketing margin for all petroleum products.

It is well known that these revenue generating components create deadweight losses which decrease social welfare. A more 'efficient' option of the revenue generating component in the price structure is an issue that requires further investigations. Example of an alternative option is to have only one revenue generating component in the price structure that follows an inverse elasticity rule. The merit of this option for Thailand needs more researches that lie outside the scope of this report.

In contrast to the revenue generating components that cause welfare losses, the absence of a component in the existing price structure that reflects the externality costs of the petroleum products also causes welfare losses. These externality costs have been identified along with the type of instruments required for their corrections (Parry et al., 2007). A per unit tax that reflects the costs of global warming has been proposed for inclusion into the price structure (Vikitset, 2012). The components that correct the other type of externality costs and the feasibility of their inclusion into the price structure remain open for further investigations.

The price stabilizing oil fund, the revenue generating components, and the externality correction components lead to the ultimate objective of the ‘optimum’ price structure. The ‘optimum’ price structure that integrates the price stabilizing component with the revenue generating component(s), and the externality correction component(s) remain a challenging endeavor for future researches.

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