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Johansen cointegration analysis of cross price elasticity of electricity demand in Thailand: An implication of government subsidy on diesel price

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ABSTRACT

Diesel oil is one of the energy sources for electricity generation in Thailand. This paper investigates the cross price elasticity of electricity consumption subjected to subsidized diesel oil price. It uses time series data applied with Johansen co-integration test and vector error correction model. It employs the data of electricity and diesel oil price from 1984 to 2014. The paper examines whether the generated electricity will be increased or not while the government subsidizes the diesel oil price. The result indicates that the cross price elasticity of electricity is inelastic to the diesel oil price. This means that the demand for diesel oil to generate electricity does not change much regarding to the lower price after the subsidy. Moreover, the result shows that the own price elasticity of electricity demand is also inelastic which means that the changes in electricity price does not affect big changes in electricity consumption.

***Keywords**:* Elasticity, Co-integration, Error correction model, Subsidies and Energy

1. Introduction

Thailand is one of the countries where the government tries to control the economically price for energy consumption such as fuel and electricity in order to pursue an affordable to their people and reduce the impact of fluctuation of energy price in the world (IISD, 2013). The main purposes of the fuel and electricity subsidies are to push economic growth, poverty reduction and safeness of energy supply (World Bank, 2010) and to established a stability of energy price in this country although there is a fluctuation from the world energy market. Consumer subsidies to energy consumption in Thailand are including liquefies petroleum gas (LPG), natural gas for vehicles (NGV), diesel, electricity and biofuel blends (IISD, 2013). For the case of diesel subsidies, Thai government has reduced the excise tax of diesel from 5.30 Thai Baht per liter to 0.005 Thai Baht per liter in 2011 with the imitation THB 0.40 per liter of VAT (IISD, 2013). This policy has reduced the consumers' expenditure on diesel oil price and so called as a subsidy. For electricity, there are two kinds of subsidies. First is the electricity tariff reduction that gave free electricity for low income family which used less than 90 kilowatt hours per month. Pusayanawin (2012) mentioned that this approval has been done by The Energy Regulatory Commission (ERC). However, these subsidies were reduced from 90 kilowatt hours to 50 kilowatt hours in the later 2012 (Ruangrong, 2012). The second type of subsidies is the lowering of tariff rate which set the price of electricity to be different for all people depend on their amount of consumption.

Figure 1 is the government budget for the energy subsidies in Thailand by 2012. According to this figure, diesel stands on number one in term of subsidy expenditure. It was followed by LPG and electricity. As of 2012, Thai government have spent almost 125 billion Thai baht for electricity and diesel. According to Thailand Ministry of Energy in 2014, petroleum and electricity shared almost 70% of the total energy in the coutnries and this ratio of the total petroleum consumption, diesel share 50% (IISD, 2013). The main problem for these subsidies is the contribution of benefits to the people. Does these subsidies really benefit to all people or just a small group of people? According to the report of International Institute for Sustainable Development in 2013, the subsidies in electricity and diesel oil price only benefit only 5 percent to 6 percent of the total 20 percent of the poor in this country. However, the government continues to maintain this policy because at least the low income people can afford to the energy consumption. The diesel subsidies which lower the price of diesel can benefit direct and indirect to the people. These benefits are including the lower cost of transportation and consuming economic sectors such as fishery, agriculture and industry (IISD, 2013). However, electricity subsidies are more important than diesel subsidies. The subsidies in electricity price allow all people in the country to have possibility to access to the electricity whether they are poorest consumers or those people in the rural area. Moreover, this policy is also the most desirable policy for those small and medium enterprises that use the electricity as their product input.

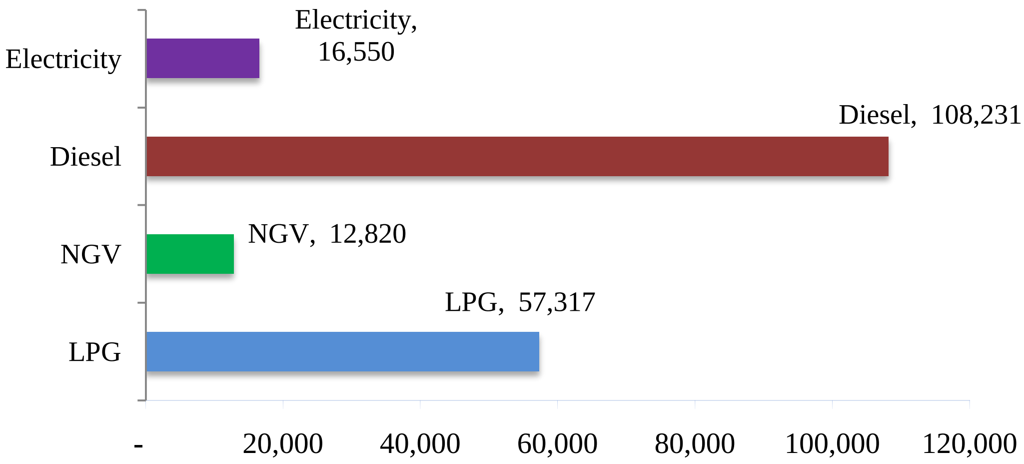

Figure 1: Estimated subsidies for energy in Thailand as of 2012 (Million BTH)
Source: International Institute for Sustainable Development, 2013

These are the main reasons that are going to be our assumptions in this paper. This research wants to investigate how sensitive people will react with the change in price of diesel and electricity. Even though electricity and diesel are used in different purpose but diesel is remain one of sources to generate electricity with the ratio of 1.32% of the total electricity generation in this country as of 2011. Since there is a subsidy policy for the diesel oil price to be lower than 30 baht per lite, this should be affect to the diesel oil consumption and increase the ratio to the share of electricity generation as well. Therefore, this paper will investigate the price, cross price and income elasticity of electricity consumption in associate to the substitute commodity namely diesel oil.

2. Econometric model and methodology

In this paper, the demand for electricity consumption is perform as a function of Gross National Income per capita and the subsidized commodity price which used the price of diesel oil to proxy. The form of the equation is given as below:

$$EC_t = f\left(I_t, P_t, DP_t\right) \quad (1)$$

where EC_t is denote as an electricity demand consumption of at time t, I_t is the gross national income per capita corresponding with the period t, P_t is the price of diesel oil at time t and P_t is the price of electricity per unit of kilowatt per an hours. The equation (1) will be deriving as follow:

$$EC_t = \alpha_0 + \alpha_1 I_t + \alpha_2 P_t + \alpha_3 DP_t + \varepsilon_t \quad (2)$$

The first step of the model is to test for the unit root test for all variables to see at which level that the data is stationary. At this stage, this paper employed the Augmented Dickey-Fuller (ADF) tests to check for unit root test in our time series data. ADF test is the augmented version of the Dickey–Fuller test. The general equation of the ADF test is:

$$\Delta y_t = \alpha + \beta t + \lambda y_{t-1} + \sum_{i=1}^{p-1} \lambda_i y_{t-i} + \varepsilon_t$$

where α is the constant tern and denoted as an intercept in the model. β is a coefficient of the time trend in the model. When modeling the testing for the unit root test, researchers have to set the $\alpha = 0$ and $\beta = 0$ to represent the data without constant and trend or set $\beta = 0$ is just to for the data with trend only. However, what this purpose of this research's paper is to see in the model is the coefficient of y_{t-1} and y_{t-i} namely λ_i which is the determinants to determine the stationary of the model. In ADF test, the coefficient of λ is set to be zero ($\lambda = 0$) as a null hypothesis of the test which mean the data has unit root test implied that our data is non-stationary. If $\lambda >$ MacKinnon statistic implied the significant of the p-value and leads to reject the null hypothesis. Therefore, the data is stationary. However, if $\lambda <$ MacKinnon statistic implied that the p-value is not significant and rather accepts the null hypothesis. This means that our data is not stationary or our data have unit root.

The second step is to apply the Johansen approach to test for the co-integration in the model due to our data is all stationary at first level_I(0). There might be a question why this research's paper chose Johansen to test for co-integration in the case that the data all are stationary at level one since there is also possible to use the Engle-Granger approach. The answer is about the order of co-integration. Engle granger will co-integrate variables depend on the one and only equation that you key in when you estimate your equation. However, Johansen approach will generate the co-integration test based on the number of variables that we have and we just choose the co-integration equation based on our desired model (Johansen, 1988). Johansen test start with the general concept of vector autoregression model (VAR) in the form of:

$$\Delta EC_t = \alpha + \sum_{i=1}^{p} (\mathrm{A}_i - \mathrm{I})(EC_{t-1} + P_{t-1} + I_{t-1} + DP_{t-1}) + \sum_{i=1}^{p-1} \sum_{j=i+1}^{p} (-A_j)(EC_{t-i} + P_{t-i} + I_{t-i} + DP_{t-i}) + \varepsilon_t \tag{3}$$

where denoted the term $\sum_{i=1}^{p} (\mathrm{A}_i - \mathrm{I}) = \Pi$ with the rank of $r < n$ which is denoted as a co-integration number of the element in the model. For a given value of r , the maximum likelihood estimator of Π will generated the r largest canonical correlation between Δy_t and y_{t-1} corresponding to the corrected number of lag (Rennhack, 2007). To verify the significant of these correlations and the number of co-integration r, the test need to be followed by trace test and maximum eigenvalue test which is proposed by Johansen. At this stage, this paper is going to employ the long run elasticity coefficient of the model which is depend on the significant value of the test. The general concept of Johansen test is to conduct the co-integration coefficients of the co-integration equation by using the maximum likelihood estimation method.

After the Johansen co-integration test, this research's paper utilized an error correction model (ECM) to estimate our model to get short run coefficients or so called short run elasticity. Bentzen & Engsted (2001) have risen up some of the benefit of using the ECM model such as ECM will generate simultaneously the number of equation or so called a system equation which is equal to the number of variables as mention previously. Another benefit of ECM model is the confirmation of the long run coefficients that were include in the ECM equation of short run estimation. ECM estimation will adjust the coefficient of the co-integration equation so that it is possible to make a conclusion whether the model have long run relationship or not. Moreover, ECM model is really popular for analysis of elasticity's research because it has ability to analyst the electricity demand and consumptions and its determinant factors in the form of simultaneously dynamic analysis (Jamil & Ahmad, 2011). The ECM equation model will be the same as below:

$$\Delta EC_t = \sigma + \theta\left(EC_{t-1} + aP_{t-1} + bI_{t-1} + cDP_{t-1}\right) + \varphi_i \sum_{i=1}^{k} D(EC_{t-i}) + \eta_i \sum_{i=1}^{k} D(P_{t-i}) + \rho_i \sum_{i=1}^{k} D(I_{t-i}) + \psi_i \sum_{i=1}^{k} D(DP_{t-i}) + \varepsilon_t \quad (4)$$

where k is denoted as a length of the lag in the model and θ is the speed of adjustment of the model in the long run relationship of the model. The coefficients of a, b and c are the co-integration coefficients that were generated from the Johansen test. φ_i, η_i, ρ_i and ψ_i are the short run coefficient in the model.

In this case, the coefficients of a, b and c that were generated from Johansen test just the long run coefficients that need to be adjusted so that they will be converge to the long run equilibrium. This convergent require the adjustment coefficient θ to be significant and negative. If so, it will provide the long run coefficients of price, cross price and income elasticity of electricity demand for our model. The OLS estimation will be conducted with the form of equation (3) to check for the significant and sign of adjustment coefficient. For the short run coefficients, φ_i, η_i, ρ_i and ψ_i, this study will employ Wald Test with restriction coefficients to check whether those coefficients are significant or not.

The data in this paper research is including the per capita of Kilowatt hour electricity consumption in Thailand (EC_t) which is generated from the U.S. Energy Information Administration (EIA). The price of electricity in a unit of baht per kilowatt hour (P_t), the Gross National Income per capita in local currency of Thai Baht (I_t) and the price of diesel oil calculated as Thai Baht per lite (DP_t). These data is generated from World Bank, International Monetary Fund and the Ministry of Energy.

3. Empirical Result

The empirical result of our paper started with the unit root test's result and then the co-integration result of the Johansen test which will generate the long run elasticity of electricity consumption. However, at this point, there is not enough evident to conclude for the significant of the long run elasticity value. Therefore, this paper will estimate the ECM model so that it will provide enough information criteria to conclude for the significant condition for both long run and short run elasticity value. The last process is the confirmation for serial correlation, normality and hecteroscedasticity of the model.

Table 1 is the result of the unit root test. The test was conducted by Augmented Dickey-Fuller (ADF) test. All variables are stationary at the first level of differential with probability less than 5%. This might be a great desirable result that might allow conducting the co-integration test which is based on Johansen test. Johansen co-integration test will perform better in the case which all variables are integrated of order one with respects to the significant probability level of less than 5%.

Table 1: the result of unit root test

Variable	Level		1st Difference		Stationary
	ADF-statistic	P-value	ADF-statistic	P-value	
EC_t	-0.498864	0.9779	-3.614314*	0.0460	I(1)
P_t	-2.307312	0.4171	-3.719437*	0.0370	I(1)
I_t	-2.359338	0.3914	-3.923131**	0.0239	I(1)
DP_t	-2.496412	0.3274	-5.538832***	0.0005	I(1)

*Note: *, ** and *** denoted the level of significant at 5%, 2% and 1% level respectively.*

Table 2 is the result of co-integration test based on the Johansen approach. The result indicates the number of co-integration of 4 and 1 for both test of trace test and Maximum eigenvalue test respectively. The coefficients of co-integration vector are the long run elasticity of electricity demand estimation which showed in equation (4). The co-integration coefficient of P_t is the long run own price elasticity of electricity demand and it equals to -0.486517 which is less than one. This indicated that in long run, people are not sensitive to the change of the price of electricity and they still consume the electricity in the amount that satisfies their utility. However, the long run income elasticity of electricity is greater than one with a negative sign. This indicated that in long run, income which is the economic indicator is an important determinant of Thailand electricity demand. The last value that is the most import for this paper is the gross price elasticity of electricity in long run. Its value was so small with negative sigh. The smallest and negative value of gross price elasticity of electricity regarding to the change in diesel oil price due to the subsidy indicated that both electricity and diesel are complement goods.

The result of our estimation is consistence to the previous research paper which claimed that the value of income elasticity is greater than the price elasticity in the long run (Amarawickrama & Hunt, 2008).

Table 2: the result of Johansen co-integration test

# of CE	Trace Test		Max-Eigen Test		Co-integration vector			
	Trace Sta	P-value	Eigen Sta	P-value	EC_t	P_t	I_t	DP_t
None	0.693** [47.86]	0.0001	33.15** [27.58]	0.0087	1	-0.49 (0.032)	-1.22 (0.024)	-0.017 (0.016)
At most 1	0.49** [29.80]	0.0031	18.71 [21.13]	0.1056				
At most 2	0.37** [15.50]	0.0081	12.74* [14.26]	0.0859				
At most 3	0.24** [3.84]	0.0054	7.74** [3.84]	0.0054				

*Note: the value in [.] is the MacKinnon 5% critical value which proposed by MacKinnon, Haug, & Michelis (1998). *, ** and *** denoted the level of significant at 5%, 2% and 1% level respectively.*

Table 3 is the short run estimation of the equation (4). In this table the result employ only short run coefficient for electricity of elasticity demand in Thailand. In here, the study's paper started to look at the speed of adjustment which is the main and only one indicator to confirm for the equilibrium of the model in long run. As mentioned previously, the speed of adjustment in the ECM model of equation (4) need to be significant and negative. However, our result does not fulfill the requirement because the speed of adjustment is significant but not negative. This indicated that the long run adjustment did not adjust toward the equilibrium.

Table 3: the result for short run estimation by ECM model

Equation	Speed of adjust	Cons	ΔEC_{t-1}	ΔP_{t-1}	ΔI_{t-1}	ΔDP_{t-1}	R^2	F-sta
Total EC	1.649*** 0.392	0.045* (0.021)	-1.096* (0.465)	0.213 (0.159)	2.012*** (0.487)	-0.143** (0.075)	0.68	4.29***
Wald Test								
F-statistic	-	-	-	3.21	8.98***	5.17**	-	-
Chi-square	-	-	-	6.41	17.97**	10.34***	-	-

*Note: *, ** and *** denoted the level of significant at 5%, 2% and 1% level respectively.*

The short run estimation by ECM model indicated that the cross price of electricity which substituted by the price of diesel is a small negative number which declared as a cross price inelasticity of electricity demand in substitute by diesel oil price. In general, the negative sign of gross price elasticity of electricity demand in substitute to the diesel oil price indicated the opposite direction of electricity consumption and price of diesel oil. This seems to be while Thailand government gave subsidies to lower the price of diesel oil caused the electricity consumption to increase. This is just the explanation which depends on the theory of inelasticity demand. This inelasticity indicated that people is not sensitive with the change of diesel price to their electricity consumption. This means that the amount of electricity consumption for every household do not depend on the price of diesel because in the case of Thailand, diesel contributes a small ratio share of the total resources which generate the electricity to supply in the countries. As of 2012, diesel contributed less than 1% of the total energy and electricity generation (Electricity Generating Authority of Thailand). Therefore, the increasing demand of Thailand diesel oil determined a small part of the increasing of electricity consumption in this country because most of the resource that contributed to the electricity generation in Thailand is from hydro power and thermal gas turbine (Electricity Generating Authority of Thailand). Moreover, this cross price inelasticity indicated that diesel is not a best substitute commodity for electricity. The reason is that most of the benefits from the diesel subsidies are not go to the poor (IISD, 2013). These subsidies benefit only 19% to the lower income people in this country (Fernquest, 2011).

The price and income elasticity of electricity consumption in Thailand is 0.213 and 2.012 respectively. This indicated that price elasticity of electricity consumption in Thailand is inelastic. This means that people are not sensitive to the change of electricity price. At this point, governor of the Electricity Generating Authority of Thailand (EGAT), Soonchai Kumnoonsate said that the electricity consumption in Thailand hit 27 139 megawatts as of

April 21 which rose from 27 054 megawatts on April 7, 2015 (Bangkok Post, 2015). The result also indicated that income elasticity of electric consumption is elastic. This is the same result (Dergiades & Tsoulfi dis, 2008; Jamil & Ahmad, 2011; Ziramba, 2008) . This is easy to understand the elastic of income elasticity of demand because people will concern when their income is decreasing.

Table 4 is the test for serial correlation, hecteroscedasticity and normality test. All the tests are insignificant which conclude to the rejection of null hypothesis. The insignificant of serial correlation implied that our model did not have serial correlation. Similarly to serial correlation test, our model did not have hecteroscedasicity which implied our variance is stable along the period of our study. All the data are distributed with normal distribution which ensure by the insignificant of Jarque-Bera test.

Table 4: Result for Serial correlation and Hecteroscedasticity test

Test	Serial Correlation	Hecteroscedasticity	Normality
F-statistic	0.531884	1.377879	0.5458
R-square	1.745540	14.68127	
F-Probability	0.5975	0.2752	0.7611

4. Conclusion

The result of this paper research provided a description of two main resources which contribute the most to energy generation in Thailand namely diesel and electricity. The own price elasticity and income elasticity of electricity are inelastic and perfectly elastic respectively. This empirical result indicates that income, proxy by GDP per capita, is the most important factor which determines the sensitivity of people regarding to their electricity consumption rather than the electricity price. The cross price elasticity of electricity demand is inelastic regarding to the change in diesel oil price. According to this result, the change in diesel oil price is not the main determinant to determine the people sensitivity even though diesel is one of the resources that used to generate electricity. This indicates that people concern about the price of electricity associate with their income rather than the price of electricity input, diesel. Honestly, we cannot ignore the benefits of diesel's price subsidies for Thailand economy even though it directly or indirectly benefits to low income people. However, government should pay more attention to this policy while it also provides disadvantages to Thailand which cause by illegal sale of diesel that happens in Thailand border with its neighboring countries (IISD, 2013). Electricity subsidies provide more benefits to all people in this country especially the target people, low income people, rather than the subsidies in diesel oil price.

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