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INVESTIGATING INDONESIA'S ENERGY TRADE EFFICIENCY: GRAVITY AND MALMQUIST INDEX APPROACH

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ABSTRACT

This study applies Gravity and Malmquist index approach to investigate energy trade efficiency between Indonesia and East Asia Countries (i.e. Japan, South Korea, and China). Gravity model is employed to identify the inputs that will be used in computing the energy trade efficiency; meanwhile, Malmquist index approach to identify the energy trade efficiency by taking data from 2000-2015. One of the findings shows that the considered inputs that will be utilised are the population of importer countries, Indonesian population, relative distance, and ratio of added value of industry sector towards GDP. In addition, the energy trade efficiency between Indonesia and East Asia countries from 2000 to 2015 was composed by technical change or technical/potential change. China averagely had the highest efficiency and showed improvement like South Korea did. Japan showed, on the other hand, deterioration.

Keywords: Energy, Malmquist index, Gravity model, Trade efficiency

JEL Classification: F18, Q43

INTRODUCTION

International trade is an economic activity that is able to connect one country to one or more countries through products and services they offer (Krugman et.al. 2012). A trade also can occur when there is a difference on resources, and that trade is called energy trade. According to Selinanova (2009), energy has an important role for economic activities and social development of a country. Yu et.al. (2015) and Abidin et.al. (2015), moreover, prove that the consumption of energy increases when economy grows. It is noted by World Bank (2016) that the increase of the consumption of energy from 1983 to 2013 was 37.9%. It can be caused by world population as well. The more world population grows, the more economic industrialization develops so that it needs more energy (World Bank, 2016; DeLong, 2015).

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Besides Indonesia is one of energy consumers in Southeast Asia, it is an energy producer (IEA, 2013; 2014). Based on Central Bureau of Statistics of Indonesia's Review (2014), Indonesia was in the fifth position of producers and exporters of Liquefied Natural Gas (LNG). That position was under Qatar, Malaysia, Australia, and Nigeria (EIA, 2015). Furthermore, Indonesia is either exporter or importer of crude oil in w orld oil commodity, and Indonesia has been a net-importer of world oil since 2004 because its domestic product is not able to fulfil its domestic need (EIA, 2015).

From 2000 to 2015, Indonesian trade flow considered East Asia countries as its prominent partners of energy commodity export. The following table presents the percentage of the energy trade flow between Indonesia and East Asia Countries from 2000 to 2015.

Table 1. Energy Trade Flow between Indonesia and East Asia Countries 2000-2015 (%)

Countries	2000-2005			2006-2010			2011-2015		
	Oil	Coal	LNG	Oil	Coal	LNG	Oil	Coal	LNG
Japan	31.75	27.16	78.27	28.94	18.39	58.84	36.89	14.26	46.27
South Korea	20.21	9.64	24.57	16.18	12.87	22.70	11.66	9.90	32.02
China	10.00	1.93	3.43	10.70	10.82	14.53	3.86	18.94	6.10

Source: UN comtrade, 2016, processed

Table 1 shows that the percentages of the energy trade flow between Indonesia and Japan were the biggest from 2000 to 2015. LNG commodity was the biggest percentage, which was followed by oil and finally coal. LNG commodity of Indonesia to South Korea had the biggest percentage as well. The smallest percentage of the energy trade of Indonesia, meanwhile, was with China with special characteristics. Table 1 explains that each period in trades between Indonesia and China had different commodity having the highest trade percentage. In the period of 2000-2005, oil commodity had the highest percentage. Meanwhile, LNG commodity had the highest percentage in the period of 2006-2010 and coal commodity did in the period of 2011-2015.

As a producer and consumer of energy products, Indonesia is required to fulfil its domestic needs as well as its partner countries' needs, especially for East Asia countries. Import activities in energy become so common in East Asia region since almost all countries in the area have a lack of energy resources (Tsukenawa, 2002). Due to the needs of energy increased as much as 20.44% from 2000 to 2014, Indonesia implements The National Energy Policy (*Kebijakan Energi Nasional*) to fulfil its domestic needs. The National Energy Policy explains that Indonesia gradually starts delimiting its energy export (Ministry of Energy and Mineral Resources, 2013). However, Ministry of Trade (2016) mentions that 11.39% of Indonesian trade balance was sustained by gas and oil sector until 2015; therefore, the limitation of energy export on each prominent partner country should be conducted gradually in order to maintain both its international relations with other countries and its trade balance.

Considering the above explanation, the energy trade efficiency between Indonesia and East Asia countries needs to be investigated deeply. Indonesia as an exporter should analyze its trade reduction implemented to each country in order to fulfil its domestic needs. This study finds out the highest energy trade efficiency of Indonesia averagely is with China although its trade flow with China is lower than the one with South Korea and Japan.

REVIEW OF RELATED LITERATURES

Efficiency is able to measure a performance of a company or a production activity (Fried et.al., 1993). Besides, it can be used to measure a performance of a trade by comparing an actual trade to potential trade conducted by a country (Drysdale et.al. 2000). There are two methods, according to Coelli et.al. (2000), to measure trade efficiency: Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). Meanwhile, Yu et.al. (2015) analyze efficiency and substitution of energy trade by utilizing the instrument of Malmquist-DEA and prove that trade efficiency has different composing factors on each category of state revenue of a country. A country with high state revenue, such as United State of America, creates its trade efficiency from its trade potential change, and so does China which is a country with middle state revenue. Indonesia as a country with low state revenue, on the other hand, has trade efficiency composed by technical efficiency change. The trade substitution of energy product is limited and makes the trade efficiency of energy product low.

In addition, Vicora (2014) benefits the instrument of SFA and Gravity Model to compare the trade efficiency of Romania's products with the ones of European countries. The study reveals the three efficiency bases: low, middle, and high. Netherlands, Germany, Austria, Sweden, and Denmark have high efficiency, but Slovakia, Malta, Latvia, and Romania have the lower one, and Romania even has the lowest efficiency. In line with Vicora (2014), Cruz and Deluna (2014) used the instrument of SFA and Gravity Model and found that trade efficiency is influenced by the integration of trade area. An export conducted by Philippines to some countries of North America Free Trade Agreement (NAFTA) members is a trade with the highest technical efficiency although the whole technical efficiency of Philippines is still low that is 38 to 40%. The trade potential of Philippines in the study can be identified as well. The highest trade potential is trades with China, United State of America, Japan, France, and Indonesia.

Another study conducted by Saputra (2014) compares the instrument of Stochastic Production Frontier (SPF) with Data Envelopment Analysis (DEA) and aims at investigating the technical efficiency and the export performance of the manufacture sector of Indonesia. Even though DEA shows a higher technical efficiency than SPF, but both DEA and SPF show that the technical efficiency of the manufacture sector of Indonesia averagely is still low. Some sectors like iron, steel, tobacco, transportation gear, food product, chemical industry, and electrical tools are good in technical efficiency. Moreover, the study reveals that all export determinant factors have significant influence in affecting the fluctuation of manufacture's export performance.

THE DATA AND METHODOLOGY

Gravity Model and Malmquist Index are utilized in this study. Gravity Model in the first stage is beneficial in identifying input and output used for efficiency analysis (Drysdale et.al, 2000). The variables of Operational Definition identified as input and output are presented in Table 2 below. The Gravity Model, furthermore, can predict and explain trade flow between countries by considering the measurement of economy and distance between the countries (Bergeijk and Brakman, 2010). The data gathered in this study are panel data, it needs to conduct a test to decide the best model (Common Effect, Fixed Effect, and Random Effect) in the first stage by observing trade flow between Indonesia and East Asia countries from 2000 to 2015 and utilizing Chow Test and Hausman Test. The Classical Assumption Test is conducted in order to find out the reliability and validity of the model used (Gujarati, 2009). Referring to Table 2, the model can be represented by the following equation.

$$Y = \alpha + b_0X_1 + b_1X_2 + b_2X_3 + b_3X_4 + b_4X_5 + e \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Next, in the second stage, trade efficiency is identified by utilizing Malmquist Index generally used to measure a productivity performance of a company, bank, or a country. Sten Malmquist stated that it is a quantity index explained by ratio of distance function (Coelli et.al, 2005; Nin Prat and Bingxin, 2008; Yu et.al, 2015). In this study, the efficiency can be identified through output orientation with an equation as follows:

$$m_o(q_{t+1}, x_{t+1}, q_t, x_t) = \frac{d_o^{t+1}(q_{t+1}, x_{t+1})}{d_o^t(q_t, x_t)} \left[\frac{d_o^t(q_{t+1}, x_{t+1})}{d_o^{t+1}(q_{t+1}, x_{t+1})} * \frac{d_o^t(q_t, x_t)}{d_o^{t+1}(q_t, x_t)} \right]^{½} \ldots\ldots\ldots (2)$$

Equation 2 shows that m_0 representing Malmquist Index is oriented output, and it mentions that d_0 is distance function or function showing change. In addition, output of trade is represented by q and input by x. t, furthermore, is period of time before observation, and period of time during observation is $t + 1$.

Table 2. The Variables of Operational Definition

Symbol	Variable	Indicator	Previous Study
Y	Trade Flow	Aggregate Energy Export (coal, oil, and LNG) based on USD	Yu *et.al.* (2015), Viorica (2015), Deluna (2013), Barnes and Bosworth (2014).
X1	Economy Mass	Importer Country's Population	Ridwan and Syafitri (2003), Bergijk and Brakman (2010), Yu *et.al.* (2015), Viorica (2015), Deluna Jr (2013), Barnes and Bosworth (2014).
X2	Economy Mass	Exporter/Indonesia Population	
X3	Control Variable of Economy Mass from Importer's side	Ratio of Added Value of Industry Sector towards GDP	Yu *et.al.* (2015)
X4	Trade Barrier	Economical Distance between Countries	Bergijk and Brakman (2010), Yu *et.al.* (2015), Viorica (2015), Deluna Jr (2013), Barnes and Bosworth (2014).
X5	Purchasing Power	Importer Country's Exchange Rate towards Rupiah	Ridwan and Syafitri (2003), Bergijk and Brakman (2010), Gul and Yasin (2011).

A previous study conducted by Yu et.al. (2015) stated that Malmquist Index can be utilized to measure actual trade efficiency towards potential as well as show the changes between periods of time and how the changes occur. Malmquist Index can be formed to be a technical change represented by Equation 3 and Equation 4.

$$\text{Technical Efficiency Change} = \frac{d_o^{t+1}(q_{t+1}, x_{t+1})}{d_o^t(q_t, x_t)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

And

$$\text{Technical Change} = \left[\frac{d_o^t(q_{t+1}, x_{t+1})}{d_0^{t+1}(q_{t+1}, x_{t+1})} * \frac{d_o^t(q_t, x_t)}{d_o^{t+1}(q_t, x_t)}\right]^{½} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

In Equation 3, Yu et.al. (2015) defines the technical efficiency change as a distance change between a trade before observation and the one during observation or between period t and t+1. Equation 4 presents the maximum trade potential change depending on demand and choice between two periods of time. Using logic of output oriented in Malmquist Index, Yu et.al. (2005) wrote Malmquist Index by using Linear Programming in Equation 5 as follows:

$$max_{\theta,\lambda}\theta_0$$

$$\text{s.t.}$$

$$\sum_{r=1}^{R} y_{rk}\,\lambda_t - y_{om} \geq 0 \qquad m = 1, \ldots, M$$

$$x_{0m}\theta_0 - \sum_{r=1}^{R} x_{rn}\lambda_r \geq 0 \; n = 1, \ldots, N$$

$$\lambda_i \geq 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

From the above equation, it can be known that *m* represents trade flow and *n* represents trade factor (Yu et.al. 2015). Trade efficiency ranges from 0 to 1, but Fare et.al. (1994) using Malmquist Index, explains that the increase of the trade efficiency show more than 1 and the decrease of the trade efficiency show less than 1.

According to Fare (1994) and Yu et.al. (2015), Malmquist Index is divided into five indexes. However, there are only three indexes that are utilized since the three indexes, which are Malmquist Index, technical efficiency change, and technical change, have explained the objective of the study. So, this study disregards the other two indexes (i.e perfect efficiency change and efficiency scale change index) in its analysis.

FINDING AND DISCUSSION

Energy Trade Flow of Indonesia

In the stage of model test used Chow Test and Hausman Test, but Fixed Effect Model is proven as the best model that can be benefitted. The model of this study passes the classical assumption test showing there are no problems on validity and reliability of the model. The regression result of Gravity Model is presented in the Table 3. The energy trade flow between Indonesia and East Asia countries is considered by some influential factors that are determined by some previous studies especially applied Gravity Model. The influential factors are divided into economy mass, economy barrier, and other factors describing the condition of exporters and importers.

The economy mass is determined by the population of importer and exporter. Population of importer in Gravity Model defines as a market existing in importer's country and showing purchasing power in the country of importer (Bergeijk, 2010; Krugman et.al, 2012); therefore, the bigger population of importer is, the faster trade flow is. Some studies reveal that population in East Asia countries (Japan, South Korea, and China) which are importers of Indonesia's products influences export activities of Indonesia. Regarding the population of exporter, production will be more conducted when economy grows (Krugman et.al, 2012). The production is conducted by serving other products or services in other sectors, and this condition requires more energy to support the production (Darmstadter, 2004; DeLong and Burger, 2015). Energy, in fact, is not renewable so that export activities should be limited in order to fulfil domestic needs as population grows.

Table 3. Energy Trade and its Independent Variables

Independent Variable	**Coefficient**
Importer Population	10.90283*
Exporter (Indonesia) Population	-7.061326*
Relative Distance	-2.624614*
Exchange Rate	0.122625
Ratio of Added Value of Industry Sector	0.106180*

Source: processed data
Note: * significant on the level of 5%; Dependent variable used is energy trade flow between Indonesia and East Asia countries

This study utilizes relative distance to describe economic activities between areas (Kimura, 2004; Antweiler, 2007), and it finds out that the increase of the relative distance will reduce Indonesia's energy trade towards its prominent partner countries. Bergstrand et.al. (2015) then prove that relative distance brings the same influence like geographic distance does, but it brings less influence if it is compared to geographic one. Unlike added distance, ratio of added value of industry sector towards GDP can increase energy export of Indonesia, and Yu et.al. (2015) have proven it. Particularly the study explains that industry sector in East Asia countries like Japan, South Korea, and China is developed and requires more energy. According to ADB (2013), industry sector of East Asia has consumed as much as 37.8%.

Some studies, even though currency exchange rate is an indicator that shows purchasing power of Japan, South Korea, and China on energy commodity exported by Indonesia, reveal that exchange rate of each importer countries in East Asia does not give significant influence towards energy export done by Indonesia. In other words, energy will still be requested whether or not currency exchange rate of East Asia countries increase towards Indonesian Rupiah. Phoumin and Kimura (2014) state that price of energy product is inelastic since there is no substitution from energy product used.

General Overview of Trade Efficiency between Indonesia and East Asia Countries

From 2000 to 2015, trade efficiency between Indonesia and East Asia countries averagely increased and reached 2.4%. It was influenced by the increase of the technical efficiency as much as 2% and technical/ potential as much as 2.2%. However, in general, trade potential change gives influence to the energy trade efficiency of Indonesia with East Asia countries, and it can be seen on the following table.

Table 4. Energy Trade Efficiency between Indonesia and East Asia Countries

Year	East Asia		
	Technical Efficiency Change	**Technical Change**	**Malmquist Index**
2001	**1.032****	1.697	1.752
2002	1.000	0.696	0.696
2003	1.000	0.843	0.843
2004	**0.969***	0.937	0.908
2005	1.016	1.174	1.194
2006	1.000	1.023	1.023
2007	0.985	1.328	1.309
2008	1.031	**1.843****	**1.899****
2009	1.000	0.892	0.892
2010	1.000	0.973	0.973
2011	1.000	0.923	0.923
2012	1.000	1.075	1.075
2013	1.000	0.753	0.753
2014	1.000	1.718	1.718
2015	1.000	**0.452***	**0.452***

Source: processed data
Note: *=showing the lowest number; **=showing the highest number

Table 4 mentions the highest energy trade efficiency in East Asia was in 2008 and the lowest in 2005, and this condition also happened to potential change since trade efficiency is composed by the trade potential change. The technical efficiency change reached the highest in 2001 and the lowest in 2004.

Energy Trade Efficiency between Indonesia and Japan

Energy trade efficiency between Indonesia and Japan averagely was 0.987 from 2000 to 2015 and showed that the number decreased. The decreasing number was not composed by technical efficiency change since the technical efficiency change that is 1.000 did not show any changes. The decrease of the efficiency trade energy actually was composed by the decrease of the potential change as much as 1.3%. From 2000 to 2015, moreover, Indonesia’s energy trade efficiency to Japan reached its highest number in 2007 and the lowest one in 2015 (See Appendix 1). The energy trade of Indonesia with Japan in 2007 increased better than the previous period since its input increased although input in the form of barrier decreased. The increasing energy trade flow of Indonesia to Japan was also caused by a trade agreement between two of them, namely Indonesian and Japan Economic Partnership Agreement (IJEP). The two countries agreed that the trade of energy and mineral resource is one of points of economy agreement. According to IJEPA (2007), Indonesia and Japan decided to reduce trade barrier, add investment from Japan to Indonesia particularly in industry sector, and guarantee stable energy supply.

Meanwhile, the lowest number of the energy trade efficiency of Indonesia with Japan occurring in 2015 was caused by the decrease of the aggregate energy trade as well as the increase of the input compared with the previous period. There was also the decrease of the energy export caused by National Energy Policy that was the revision of National Energy Policy in 2014 (Tharakan, 2015).

Energy Trade Efficiency between Indonesia and South Korea

Referring to data mention on Appendix 1, the average number of the energy trade efficiency of Indonesia with South Korea from 2000 to 2015 was 1.011 showing increasing number since it is more than 1. Indonesia's energy export to South Korea, however, had no technical efficiency change because its average trade efficiency was 1.000 and averagely was composed as much as 1.1% so that Indonesia's energy trade efficiency with South Korea was composed by technical/ potential change.

Indonesia had its highest trade efficiency with South Korea in 2005, and it had the lowest in 2013. South Korea in 2013 was the biggest oil consumer in the world (Rasounilezhad, 2016); accordingly, it increased its import of oil including importing from Indonesia as a follow up of an agreement between ASEAN countries and South Korea concerning energy trade signed in 2005. However, energy trade efficiency between Indonesia and South Korea did not show high number.

Energy Trade Efficiency between Indonesia and China

Having average number of energy trade efficiency as much as 1.079, Indonesia's energy trade efficiency to China increased 7.9% from 2000 to 2015. It was composed by 0.6% of technical efficiency change and 6.9% of potential change. Potential change, even though energy trade efficiency between Indonesia and China was composed by either technical efficiency or potential efficiency, had more contribution in creating trade efficiency.

In 2008, energy trade efficiency between Indonesia and China positioned the highest number and was composed by potential change; there was, in fact, economy crisis. China luckily did not face the crisis but developed its economy as well as had trade surplus. Thus, energy trade efficiency between Indonesia and China in 2008 increased twice compared to Japan and South Korea. On the other hand, positioned the lowest number in 2015 and was influenced by policies and decrees established by Indonesian Minister.

CONCLUSION

On average, energy trade efficiency between Indonesia and East Asia countries (Japan, South Korea, and China) is composed by technical change. Indonesia's trade efficiency to China averagely decreased from 2000 to 2015, and it was composed by technical/potential change, not technical efficiency one. The one with South Korea, on the other hand, averagely increased. It was also composed by technical/potential change like the one occurring in Japan. In addition, trade efficiency between Indonesia and China averagely showed the highest number. Unlike the ones with Japan and South Korea, the trade efficiency with China was composed by both the increase of the technical efficiency change and technical/potential change, but the potential one gave more contribution in composing trade efficiency. Finally, energy trade needs to be gradually delimited to a country in which the trade efficiency and trade potential are the lowest, and Japan is in this case.

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Appendix 1. The Summary of the Energy Trade Efficiency between Indonesia and East Asia Countries

	Index	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Japan	Technical Efficiency Change	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Technical Change	1.070	1.030	0.861	0.920	0.996	0.995	**2.031****	0.565	0.957	1.234	0.982	1.001	1.001	1.745	**0.408***
	Malmquist Index	1.070	1.030	0.861	0.920	0.996	0.995	**2.031****	0.565	0.957	1.234	0.982	1.001	1.001	1.745	**0.408***
South Korea	Technical Efficiency Change	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Technical Change	1.150	0.997	0.950	0.979	**1.588****	1.075	1.104	0.922	1.081	0.994	1.097	1.257	**0.457***	1.002	0.936
	Malmquist Index	1.150	0.997	0.950	0.979	**1.588****	1.075	1.104	0.922	1.081	0.994	1.097	1.257	**0.457***	1.002	0.936
China	Technical Efficiency Change	1.100	1.000	1.000	**0.909***	1.050	1.000	0.957	**1.095****	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	Technical Change	3.970	0.328	0.732	0.915	1.024	1.000	1.045	**12.019****	0.686	0.752	0.731	0.987	0.934	2.901	**0.242***
	Malmquist Index	4.367	0.328	0.732	0.832	1.075	1.000	1.000	**13.164****	0.686	0.752	0.731	0.987	0.934	2.901	**0.242***

Source: data processed
Note: *=showing the lowest number; **=showing the highest number