Nexus between Fuel Prices and Energy Consumption in ASEAN Region: Role of Coal, Gas and Oil Prices

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ABSTRACT

Energy consumption is considered as one of the most important sectors for revenue generation for the state. The revenue generation has tended to be limited for this consumption sector. For this purpose, this study investigates the problem by focusing on the factors like coal prices, gas prices and oil prices as they determine the energy demand's price elasticity. This effect and change in energy demand to the difference in prices can impact the revenue generation in the country. The data has been collected over a period of 30 years from 10 ASEAN countries including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. The independent variables are coal price, gas price and oil price and their effect are measured on the energy consumption. The control variables included are non-renewable energy consumption and population growth of these countries. For this purpose, we have used pooled mean group (PMG) and Augmented Dickey Fuller (ADF) technique along with unit root tests and the cointegration tests among the variables. The results indicate that gas price, oil price, and coal price significantly impact the fuel prices and the energy consumption in these countries.

Keywords: Energy Consumption, Coal Price, Gas Price, Oil Price, ASEAN Countries
JEL Classifications: K32, L95

1. INTRODUCTION

The globalization of markets of world has levelled the costs of customers for many products like prices of motor vehicle in ASEAN countries to an extreme that the ratio of price for vehicles now do not exceed above 50% between various countries. However, the costs of fuel are different on scale of around 500%. Therefore, the difference in relative cost is 10 times more than the price difference of motor vehicle. In accordance with Al-Mulali et al. (2015), the problem of appropriate pricing of energy within ASEAN countries require harmonization and clarification, not only from national economic point of view, but also from the perspective of environmental policy. The international problem of 'right' fuel price and energy consumption is more important in the context of basic subsidies of energy. In accordance with Apergis and Payne (2015), data used for the energy note of

ASEAN countries were taken, dependent on the cost of crude oil at US \$42/barrel.

In accordance with the outcomes of investigations of GTZ, the policies of fuel and energy policies of 11 ASEAN countries can be given one of the three categories. First category involves four countries that subsidize the cost of fuel, where the selling of fuel is done at cost below the preference price of the world like without the taxation of fuel. Within Myanmar, diesel costs start from 10 US cent/L, it approaches 18 US cents within Indonesia, 22 Cents within Malaysia and 19 cents in Brunei (Basnet and Upadhyaya, 2015). Second category involves three countries in the zone of slightly taxed gasoline and subsidized diesel. In Thailand, Philippines and Vietnam, the cost of diesel range to 37 cents from 32/L (Boontome et al., 2017). Third category involves four of the countries which

pursue the policy of high-cost and that is why it levy the tax on gasoline and diesel. The cost of diesel stand at 55 US cents in Singapore, it approaches 61 cents within Cambodia, 65 in Timor Leste and 63 cents in Laos (Creutzig et al., 2015). The cost of Gasoline Pipes start from US 65 liter and it approaches 71 Cents within Laos, 89 in Singapore and 79 in Cambodia. In Figure 1, time series of Retail Fuel prices in ASEAN countries is given (Dibenedetto, 2011).

The spot cost for barrel of crude oil of west Texas intermediate (WTI) from $11 at 1998's end to $140 in year 2008. It then got decremented to around $42 in year 2009, because of the International Financial Crisis (Dai et al., 2016). In year 2011, it got recovered to dollar 113, and then fell to dollar 33 in year 2016, and increased again to $80 in year 2018 (Dogan and Seker, 2016). However, the fall in cost of oil decreases the costs of firm. Driven through rapidly incrementing demand of electricity, the demand of coal in ASEAN countries has surged since year 2010 (Güneralp et al., 2017). The coal availability in ASEAN countries and its lower cost as compared to the other fuel has made coal to be more preferred choice to the demand of fuel. In past, there is none of the research which mainly refers to the relationship in between fuel prices and energy consumption. Moreover, the impact of oil, coal and gas on energy consumption have not been identified in detail. Therefore, there was a need of a research involving the in-depth analysis of the given factors. The objectives of the given research are as follows:
1. To determine the role of coal prices on energy consumption in ASEAN countries
2. To identify the role of oil prices on energy consumption in ASEAN countries
3. To check the role of gas prices on energy consumption in ASEAN countries.

Previously, there is no such research that has identified the relationship in between energy consumption and fuel prices (Mengistu et al., 2015). Moreover, the analysis of panel data has not been done in detail. This research will prove to be helpful in filling the gap that exists in literature. Moreover, it will help the government of ASEAN countries to consider the nexus between fuel prices and energy consumption (Mirzabaev et al., 2015). The first section of this research paper is introduction, second section is literature review, third one is methodology, forth one is discussion and fifth one is conclusion.

Figure 1: Oil consumption in ASEAN
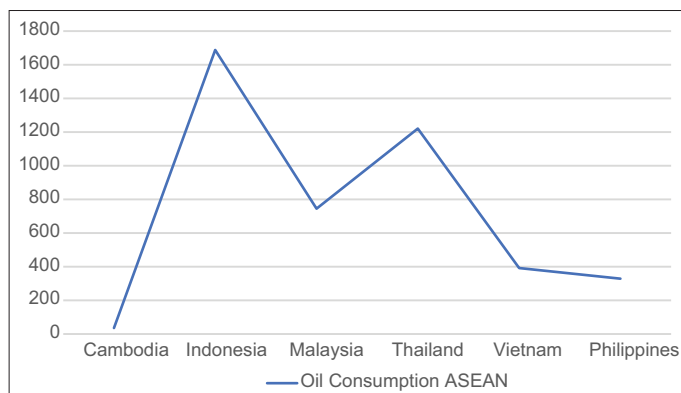
2. LITERATURE REVIEW

2.1. Oil Prices and Energy Consumption
Nowadays, the significance of crude oil being the major source of energy has waned somewhat, because of the appearance of different kinds of energy (like solar power, biomass, water and wind). Nonetheless, the significance of oil gets exceeded to the economic approaches and it influences the social life generally (Moriarty and Honnery, 2019). Therefore, the prevailing approach among economists is that oil prices and energy consumption have a stronger link. With the advancement in economy, improvements have been seen in information and industrialization. Therefore, it has resulted into a change in the patterns of energy consumption and speed of growth. Güneralp et al. (2017) analyzed the link in between consumption of energy and making improvement in productivity in manufacturing companies within Nigeria. In accordance with the outcomes of the research about ASEAN countries, change in industry structure, energy storage and composition of fuel utilized by industries, enhance efficiency within the manufacturing companies. The increment in costs cannot result into an increment in energy supply, but it can give more revenue to the government (Bakhtyar et al., 2017). Since, within shorter span, it is complicated to enhance the natural gas and electricity supply, it can be assumed that there is fixed supply (Patel et al., 2016). However, when referring to the long term investment made in the activities of exploration and expansion, an increment in supply can be seen (Labandeira et al, 2017). The increment in resources of government can make an improvement in the fiscal deficit and it give more of the funds for expanding the utilities of public. However, the influence on energy consumption can be the conservation of energy, which can be more costly and can even result into competitive disadvantage in shorter time period. In addition to this, in case when some of the improvements will be made in technology within the manufacturing industries, then changing costs of energy will outcome into some important outcomes (Magazzino, 2016). The outcomes show that industrial area of the country have the technology that is not much efficient in terms of energy. Along with it, in case when energy costs identify the real production costs, then the developers should not have the efficiency of energy consumption. On the other hand, the developers should choose the combination of such inputs that can incur the least cost of production. Generally, outcomes acquired through the researches show that costs of energy do not have any effective role on producing efficiency of energy consumption. Improvement in technology is identified as the most significant factor in enhancing the efficiency of energy consumption. Moreover, it plays the most important role when moving towards such industries that consume less-energy.

H_1: There is a significant impact of oil prices on energy consumption in ASEAN countries.

2.2. Gas Prices and Energy Consumption
In accordance with Mousavi et al. (2017), gas is basically a natural resource that is around us for million years. However, there are different kinds of gas. The use of natural gas is mainly for to provide cooking and heating facilities. It is found underground between hard rock. Basically, with the appearance of gas well,

the companies of energy first break through the surrounding of rock for releasing the gas, and then do the lining of hole with some of the special items for keeping the gas to be contained. Afterwards, electric charges are sent to the well, then are then given the pressurized solution. Both of these have an influence over the surrounding rocks and because of the reason that the solution tends to be higher as compared to the gas, therefore it gets to the top. Generally, the cost of gas gets influenced through demand and supply. With the passage of time, this balance can observe different alterations, which outcome into making bigger adjustments related to price for keeping the market to be stable. Major factors of supply that can have an influence over the cost involve alterations in the production of natural gas, amount of imported or exported natural gas and levels of storage. In case when supply gets overflowed, a decrement is seen in the cost. In case when supply gets scared, an increment is seen in the cost. Major factors of demand that can have an influence over the cost involve cost of competing fuels, weather and economy (Salahuddin et al., 2015). In case when the demand gets higher, an increment is seen in the cost. Same like this, when there is low demand, then there is lower cost (Hussain et al., 2017). In case when there are low prices of gas, the cost of production of electricity is reduced. While some other energy sources might not have similar rates. From the perspective of wholesale, a suit is followed to be competitive. The drop within market influences different individuals like power producers, utilities and customers. Consumers making use of gas for the purpose of cooking or heating, get significant benefits. The suppliers can be renegotiated or switched for taking benefit of better rates. Lower income groups or family are the kinds of consumers that decrease cost. In accordance with Tongsopit et al. (2016), for diversified utilities or for unregulated producers of power, a negative influence is seen. Wholesale rates of energy are seen connected to the rates of natural gas. In other words, it can be stated that falling rates result into further decrement in the rates of wholesale. As an outcome, it gets complicated for organization to make more profit. However, regulated utility organization get more advantages because of the lower rate. The government identifies that the profits are dependent on the model of cost-of-service. This implies that the ones have the power of offering consumers lower costs without even experiencing similar loss. It also implies more of the business, as consumers tend to make switch to gas heat.

H$_2$: There is a significant impact of gas prices on energy consumption in ASEAN countries.

2.3. Coal Prices and Energy Consumption
The classification of coal is done into four ranks: anthracite, bituminous, subbituminous and lignite, based on the kinds and amounts of carbon it has and the amount of total heat energy that can be produced through it. In accordance with Zhu et al. (2016), prices are seen as higher for coal having higher content of heat. Coal prices at surface mines are identified as having lesser costs as compared to the coal present at underground mines. In such locations, where there are near the surface and thick coal beds, the prices of coal are seen as lower as compared to that of locations where the beds are deeper and thinner, like in Appalachia. The coal's higher cost acquired through underground mines show more complicated conditions of mining and the requirement for more

of the miners. After the mining of coal, it should be moved to the customers. The costs of transportation are added to the delivered cost of coal. For instance, in some of the cases, the costs of transportation even get higher as compared to the coal price. This results into less energy consumption. The customers then avoid consuming such energy products, because of their higher costs.

H$_3$: There is significant impact of coal prices on energy consumption in ASEAN countries.

3. RESEARCH METHODOLOGY

The panel ARDL approach, also known as pooled mean group is used in the current study to fulfill the aim of the study. The relationship that exists between energy consumption (EC), CP, oil prices (OP), population growth (PG) and non-renewable energy consumption (NREC). The impacts that all of these variables cast on each other is focused in this study. The ARDL and cointegration approach shows that there exists a long-term relationship between all of these variables and all of the variables are seen to be impacting each other in a significant way. The data was acquired 8 ASEAN countries which was from Brunei, Laos, Myanmar (Burma), Cambodia, Vietnam, Indonesia, Malaysia and Singapore, data was collected from the World Bank website extending from 1995 to 2019 which was enough for the implementation of ARDL.

3.1. Model Specification and Method of Estimation
The ARDL approach and the cointegration is applied on this study in order to achieve the aims set by this study as this approach has its own advantages over the other approaches used for cointegration. ARDL approach has its advantages because it is applicable irrelevant of the stationarity present in the variables. The different natures of stationarity involve the level of [I(0)], level of [I(1)] and level of [I(2)]. The error correction mechanism takes in the different aspects of the long and the short-term equilibrium. The problems arising from the non-stationary data of time series can be nullified using the ARDL approach, both of the forms of the model are given below:

$$EC = f(CP, GP, OP, NREC) \qquad (1)$$

$$EC = \beta_0 + \beta_1 CP_t + \beta_2 GP_t + \beta_3 OP_t + \beta_4 NREC_t + \varepsilon_t \qquad (2)$$

In the equation above, *EC* refers to the energy consumption, *CP* refers to the coal prices, *OP* is referring to the oil prices and *NREC* is showing the non-renewable energy consumption. β_0 is a constant term whereas, β_1, β_2, β_3 and β_3 are showing the explanatory variables and e is showing to be the error term.

$$\Delta EC_t = \beta_0 + \sum\nolimits_{t-1}^{n} \beta_1 \Delta CP_{t-1} + \sum\nolimits_{t=0}^{n} \beta_2 \Delta GP_{t-1}$$
$$+ \sum\nolimits_{t=0}^{n} \beta_3 \Delta OP_{t-1} + \sum\nolimits_{t=0}^{n} \beta_4 \Delta NREC_{t-1} + \gamma ECM_{t-1} + \varepsilon_{t-1}$$
$$(3)$$

Where Δ is showing the operator changes and ECM_{t-1} is showing the error correction term. γ is the sign to denote the distance from short to long run. The ARDL model is given below:

$$\Delta EC_t = \beta_0 + \sum_{t=1}^{n} \beta_1 \Delta CP_{t-1} + \sum_{t=0}^{n} \beta_2 \Delta GP_{t-1} +$$

$$\sum_{t=0}^{n} \beta_3 \Delta OP_{t-1} + \sum_{t=0}^{n} \beta_4 \Delta NREC_{t-1} + \varepsilon_{t-1} \qquad (4)$$

Thus, it can be said that there is an expectation that, β_1, β_2 and β_4 < 0; β_3 > 0. It is expected that the variables will be significantly impacting each other.

$$H_0 : \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 \ (There\,is\,no\,long-term\,relationship)$$

$$H_1 : \beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \ (There\,is\,long-term\,relationship)$$

In ARDL approach there are three steps involved, first is devising and testing hypothesis, and the null hypothesis is stated as well. ECM is supposed to be equal to 0, ARDL co-integration involves advantages, it has all of the variables that are stationary at their nature, the variables need to be of the order 1[I(0)], 0[I(0)] because it will be the only way that ARDL will be applicable. It can also be seen that ARDL gives a closer and clearer view of the long-term model. The first assumption taken into account is that, the variables will be at a stationary condition at the first phase that is [I(1)], the second assumption that is made is that the variables will become stationary at [I(1)] at level 2. The data was acquired 8 ASEAN countries which was from Brunei, Laos, Myanmar (Burma), Cambodia, Vietnam, Indonesia, Malaysia and Singapore, data was collected from the world bank website extending from 1995 to 2019 which was enough for the implementation of ARDL.

3.2. Presentation and Discussion of the Results
The second section of this study will be providing the summary of the results and analytics, results will be stated regarding the impacts of EC and CP, GP, OP, NREC. The section will provide, mean, standard deviation, minimum and maximum points for all of the variables. The test of stationarity will be provided. Moreover, the results and details of ADF, Augmented Dickey Fuller (ADF) unit root test will be provided in this section of the study.

3.3. Unit Root Test for Stationarity
It has been witnessed that the variables in the time series study will be having unit root, and unit root is only present when the variables are not stationary and the unit root can be witnessed and seen after the stationarity test performance. The ground rule set for the being stationary is that the absolute critical value of the ADF should be greater than the critical value of the variables so that they can be called as stationary. To check on the integrating order of the involved variables, the unit root test for the stationarity was conducted. This step is important because it validates that all of the variables at least are differenced. So, the importance of the conduction of ARDL unit root test is that it will be made clear that none of the variable is integrated of order 2. Then the ADRL is presented both for long and short term, it can be clearly seen that whether long run relation exists or not.

4. EMPIRICAL RESULTS AND DISCUSSION

4.1. Unit Root Test Results
The null hypothesis of the ADF inidctaes that the variables are non-stationary. Looking at the results below we can conclude the results of ADF test and the LLC test at the level intercept and at the first differences of the variables. If the value of F-statistic turns out to be significant, then we reject the null hypothesis and conclude that the data and the variables are stationary and vice versa. The result of unit root test is described below with the significant values (Table 1):

The results above show the ADF as well as LLC unit root tests estimates. For the ADF test results at level, coal price, oil price, population growth, and energy consumption are significant at level 1% level of significance. Therefore, we reject the null hypothesis that states for the non-stationarity. Hence, conclude that these variables are stationary over the period of 30 years. However, gas price and non-renewable energy consumption have been non-stationary. At the first differences, all the constructs are significantly stationary. The LLC unit root test result at level indicate that coal price, oil price, non-renewable energy consumption, population growth, and energy consumption are significantly stationary. Therefore, we reject the null hypothesis that states for the non-stationarity. Hence, conclude that these variables are stationary over the period of 30 years. However, gas price has been non-stationary hence we do not reject the null hypothesis. At the first differences, all the constructs are significantly stationary.

4.2. Cointegration Test Results
After checking the stationarity, we have to see whether these variables have a stronger bond with one another or not. For that we see for the F-statistic values for rejecting or accepting the null hypothesis. If value of estimated F-statistic is more than upper bound null hypothesis is rejected and it is not rejected if it is beneath that value (Table 2). The results are as below:

The F-statistic value is 11.87 which is significant at 10% level of significance and indicates that it lies above the lower and upper bound critical values of the test, hence we reject the null hypothesis and conclude that there is cointegration among the variables. That coal price, gas price, oil price, non-renewable energy consumption, energy consumption has a stronger cointegration among each other.

4.3. Pooled Mean Group (PMG) or Panel Autoregressive Distributed Lag (ARDL) Model: Long Run and Short Run Results
The results for pooled ARDL shows the effect of coefficients in the long run and short run analysis. The results below show the impact of coal price, gas price, and oil price on the fuel prices of energy consumption in the long-run and short-run analysis (Table 3):

Looking at the results of short run analysis, we can see that coal price, gas price, oil price, population growth has significant impacts on the energy consumption of ASEAN countries. The impact of gas price on energy consumption as it effects about 39% increase in fuel price of energy consumption. Similarly, coal price increase and increase in oil price also affect about 20% and 28% increase in energy consumption respectively. However, non-renewable energy consumption has not been significantly impacting the energy consumption index. The adjusted R^2 value states the combined effects of all the independent variables on

Table 1: ADF and LLC unit root

Constructs	CP	GP	OP	PG	NREC	EC
ADF test						
Level	2.266*	2.276	4.376*	8.361*	2.271	3.231*
1ˢᵗ diff.	3.171***	2.776**	9.271**	3.183***	3.987***	2.476***
LLC test						
Level	−3.347*	−4.182	−2.917*	−5.237*	−3.371*	−3.378*
1ˢᵗ diff.	−5.277**	−7.272***	−5.216***	−5.266***	−8.376**	−6.277***

Table 2: Cointegration test

O.P.L. length (A.I.C)		(1,0,1,0,0,0)	
F-Stat. (Bound test)		11.8765***	
V.C	1%	5%	10%
L.B.C.V.	2.72	1.49	0.98
U.B.C.V.	4.23	2.76	1.78

Table 3: Pooled mean group long run and short run results

Variable	Short run results		Long run results	
	B	t-value	B	t-value
EC	-	-	1.281**	
EC (−1)	-	-	2.181	
EC (−2)	-	-	1.382***	
CP	0.176	2.061*	0.183	3.322**
GP	0.197	3.958**	0.293	2.531***
OP	0.253	2.865**	0.283	4.647***
PG	0.152	2.643**	0.145	1.246
NREC	0.013	1.846	0.205	3.875**
C	-	-	4.362	4.854***
R^2	0.714	7.864***	0.521	6.299***
Adj. R^2	0.682	5.857***	0.502	5.282***
D.W.	2.18		2.09	
Diagnostic test	-	-	-	-
X^2SC	2.731 (0.077)		3.829 (0.753)	
X^2W	3.498 (0.063)		4.283 (0.851)	
X^2AR	2.284 (0.836)		2.134 (0.098)	

the dependent one. In short-run analysis, the combined effects of coal price. The gas price, and oil price effect 68% of the energy consumption.

In the long run analysis, coal price, gas price, oil price, and non-renewable energy consumption have significant impacts on the energy consumption. The highest impact is of oil price as an increase in oil price will account for 46% increase in the fuel prices and energy consumption. The coal price effects an increase of 33% on the energy consumption. The gas price increase makes an increase of about 25% on the energy consumption. However, population growth has not been significantly impacting the energy consumption index. The adjusted R^2 value here is 50% which is less the impact than that in the short run analysis. Therefore, we conclude that the increase in the prices of coal, gas, oil can cause an effect in the differences in the fuel prices and energy.

5. DISCUSSION AND CONCLUSION

5.1. Discussion
The high cost of energy supplies and concern about the availability of fuel have remained great concerns on all the countries as energy have been a great demand (Demski et al., 2018). There is a strong

relationship between fuel prices and energy consumption in ASEAN countries as they place a great emphasis on energy demand management. Indonesia and Malaysia are known as an important exporter of oil and gas. However, recently, they have been looking for a curb domestic old demand in order to save energy costs so that they could make more oil available for export. The main objective of this research study is to understand the connection between the prices of fuel and energy consumption in ASEAN region. Furthermore, some scholars have also found out the relationship between energy consumption and fuel prices (Jewell et al., 2018). They indicated that when the population growth has increased, the demand for fuel is increased automatically which results in the high prices of fuel. The energy consumption in ASEAN countries has been increased in the past few decades when oil was the dominant energy source in the world energy market. This increase in energy needs was therefore, largely met by this energy source, but now it has become difficult to procure fuel due to high prices and high population growth (Han and Wu, 2018). The results and tables generated through the cointegration test and ARDL model indicates the significant and insignificant relationships between the control variables. The ARDL model is based on both short-run and long-run tests. It has been depicted from the short-run test that there is an insignificant impact of non-renewable energy on fuel prices and energy consumption. On the other hand, the long-run test has indicated that population growth has an insignificant impact on fuel prices and energy consumption (Ibrahiem, 2018). In this research, the ADF and LLC unit root test has also made it apparent that prices of fuel increase due to increase in energy consumption. In this case, coal, gas and oil prices play a great role as many industrialized ASEAN countries are using coal before the advent oil. It indicates that coal has been used in ASEAN countries prior to the penetration of oil and its consumption.

5.2. Conclusion
The main goal of this research study was to understand the relationship between fuel prices and energy consumption in ASEAN countries. The results are analyzed through ADF and LLC unit root test, cointegration test, and ARDL model. The tables and findings indicated that there is an insignificant impact of non-renewable energy and population growth on fuel prices, whereas the variables have a significant impact on fuel prices. The control variables, such as population growth and non-renewable energy, also significantly affect energy consumption and fuel prices.

5.3. Implications
For several decades, the ASEAN countries have taken steps to raise electricity production with the help of non-oil resources. Due to the reduction in the share of oil in electricity generation, the demand structure of petroleum products can be reduced which is an

important implication. This study can help the ASEAN countries to understand the role of prices between oil, coal and gas and how to use it to overcome the demand for energy. Most of the fuel in the ASEAN countries is obtained from organized energy supply industries such as petroleum, natural gas, and electricity. In this case, the non-commercial energy sources are not covered which results in the high prices of fuel.

5.4. Limitations
There are some limitations in this research and regarding the use of these resources to fulfill the demand of energy in ASEAN countries. The estimates in the research do no vary according to the specification of the equation but to the time period chosen in the estimation. It is recommended to the future researchers to take the non-commercial energy consumption into account during estimation. In addition, the sample size must be increased by the future researchers. They may also employ the tests for data analysis that have not been used by the researcher in this researcher. Another important aspect in this regard is that the future researchers may conduct the study in some other group of countries or some other region other than ASEAN countries.

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