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Article

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Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Chonmapat Torasa/Witthaya Mekhum (2020). Analyzing the impact of energy imports, fuel substitution and technological change on real GDP : a panel data study of ASEAN countries. In: International Journal of Energy Economics and Policy 10 (6), S. 559 - 565. https://www.econjournals.com/index.php/ijeep/article/download/10453/5508. doi:10.32479/ijeep.10453.

This Version is available at:
http://hdl.handle.net/11159/8065

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2020, 10(6), 559-565.

Analyzing the Impact of Energy Imports, Fuel Substitution and Technological Change on Real GDP: A Panel Data Study of ASEAN Countries

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Received: 10 July 2020 **Accepted:** 27 September 2020 **DOI:** https://doi.org/10.32479/ijeep.10453

ABSTRACT

The determinants of real GDP growth have been enticed the researchers and policy makers since the last century. This study aims to empirically analyze the role of efficient energy consumption in real GDP growth of ASEAN countries. For this purpose, study used energy import, fuel substitution, and technological change as independent variables to explain their impact on dependent variable such as real GDP growth. The panel data of eight ASEAN countries including Indonesia, Malaysia, Thailand, Singapore, Philippine, Vietnam, Cambodia, and Laos for the period of 1990-2016 are used in the study. In addition, two control variables, population growth and Nonrenewable energy consumption, are also incorporated in the model to check the robustness of results. In order to estimate the empirical model, panel cointegration technique is employed to check the long run relationship between variables. The findings of the study indicate that energy imports, fuel substitution, and technology change have positive contribution in the real GDP growth. From the findings it is anticipated that the study will provide useful policy guidelines to researchers and policy makers for planning and taking decision on future policies regarding energy consumption to further bolster the potential of real GDP of ASEAN countries.

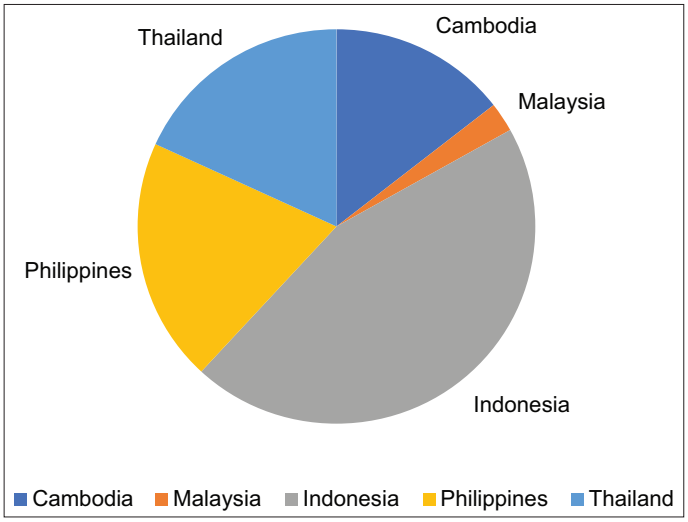
Keywords: Energy Import, Fuel Substitution, Technological Change, Real GDP Growth
JEL Classifications: P18, O141

1. INTRODUCTION

In year 2018, the estimated net GDP of all of the ASEAN countries was around 2.92 trillion U.S. dollars, which is a major raise from past years (Blazquez et al., 2017). In fact, GDP of ASEAN countries has been rising steeply for some years, showing the economy of the region. In Figure 1, the real GDP of ASEAN countries is given (Bel and Joseph, 2018). Since year 1973, the cost of energy concerns and supplies about the presence of oil have exerted a pressure over all of the countries to re-analyze the policies of national energy. A better interpretation of national patterns of consumption of energy will help formulating policy related to the conservation and use of energy. It will permit more assumptions to be made related to the forecasting of energy demand. In accordance with (Cai and Arora, 2015), Malaysia and Indonesia are net gas and oil exporters. In current years, these have been looking forward to the ways for curbing the requirement for domestic oil. Along with the savings in costs of energy, these can make more of the oil to get available for the purpose of export. Singapore does not have any conventional resources of energy of any type. It is the country that is more deficient in terms of energy in the region.

As in different other countries having deficiency of energy, its basic strategy is to do promotion of efficient and rational usage of energy without impeding the development of economy (Dargahi and Khameneh, 2019). There are limited reserves of conventional sources of energy, particularly oil in Thailand and

Figure 1: Energy imports in ASEAN countries



Philippines. The bulk of the requirements of energy have been fulfilled through imports. Increasing costs of import have made more of the claims over the earning over previous decade, making the conservation and substitution of oil to be the major domestic concern. Major disparity is also seen in between ASEAN countries when referring to production structure, development stages, urbanization, income and population. The given diversities along with uneven distribution of energy resource, make contribution to the inhomogeneity in the demand patterns of energy (Dargahi and Khameneh, 2019). While ASEAN region is the major region of natural energy within world. Some of the countries within ASEAN perform poor when referring to resources of energy. Middle Eastern and Asian organizations are making expansion of their presence within Southeast Asian gas and oil industry. These are looking forward to make replacement of majors of Big Oil that have been shrinking exposure towards the region since year 2014 when the cost of oil collapsed (Dissanayake et al., 2018).

In previous 4 years, global oil organizations have sold around 800 million of oil barrels equivalent in assets of ASEAN countries (Dargahi and Khameneh, 2019). It has been identified that global oil players shun the locations of higher-risk like ASEAN countries, targeting on the new priorities: faster return projects and low-cost in US shale patch. Technology has a major impact on various aspects of a country such as economy, GDP growth and development as it involves different types of machinery and equipment that can be used in order to introduce innovative and advanced practices. This will have an ultimate impact on increase in the economic activity and thus GDP growth will be positively influenced.

In the past, there are very few researches that have considered the aspects such as technology, fuel substitution and energy imports along with their impacts on Real GDP. Moreover, panel data study of ASEAN countries has not been done in detail. Therefore, the purpose of this research is to analyses the given issue in detail. The research objectives are as follows:

1. To analyses the impact of energy import on real GDP of ASEAN countries
2. To check the impact of fuel substitution on real GDP of ASEAN countries
3. To determine the influence of technological change on real GDP.

This research will help ASEAN countries to analyze the impact of energy import, fuel substitution and technological change on real GDP. Based on this, ASEAN countries will get enough able to analyses that which of these have positive influence and which one have negative influences on real GDP.

The division of the given research has been done into Introduction, then Literature Survey, Research Methodology, Discussion and Conclusion.

2. LITERATURE REVIEW

2.1. Energy Import and Real GDP

The link of energy import and real GDP has been discussed in the research of ABC. The energy import is promoted based on its comparative benefit to the enhanced GDP growth and economic welfare. The outcomes support the export related policies of growth as causality was seen from exports to GDP development for Singapore and Thailand and more causality for other countries. There is no long-term link between real GDP and imports for Thailand and Singapore. On the other hand, causality of short term was seen in Malaysia after making control of imports, but no long-term links were found for Thailand and Singapore. In accordance with the research of Kamidelivand et al. (2018), outcomes were in support of development caused by import, as there was bidirectional or unidirectional causality to GDP growth from imports for the chosen countries. Kat et al. (2018) recommended that there is co-integrating link in between GDP growth and exports, when GDP is considered as some dependent variable. However, the converse is not considered to be true, therefore it can be stated that hypothesis of export resulted by through growth is supported. The causality test of Kilinc-Ata (2016) is identified as being sensitive to the limit of some deterministic component. Li et al. (2017) revealed a feedback link in between GDP and imports and unidirectional causality of long term to GDP from exports by implying the strategy of co-integration.

H_1: There is significant impact of energy import on real GDP in ASEAN countries.

2.2. Fuel Substitution and GDP

Nature abhors some vacuum; other organizations take their place with more tolerance to risk, like Japanese Mitsubishi and JXTG Nippon, the Kuwait Foreign Petroleum Exploration Organization, Saka Energy and Microinertia. These organizations with other regional or local players have bought more than 600 million reserves through supermajors. ASEAN countries may not still be attractive as these used to be for global oil organization, but its requirement for oil is growing and production peaked at 5.9 million in year 2010 (Lin and Raza, 2019). Oil crises of 1970s have made different changes to the market of oil. One of the major changes was seen in the patterns of demand of energy resources. The demand of oil got reduced to 37.6% from 47.3% (Miskinis et al., 2019). Use of alternate sources, exploitation and production

were developed and sought. The major development was seen in developing natural gas. The major growth was seen in developing natural gas. Requirement for natural gas got incremented to 1.68 billion from 1.07 billion (Nong and Siriwardana, 2018). The trend of production of natural gas and its usage in ASEAN is not different as compared to the international trend. The natural gas share in total consumption of energy has got incremented in all ASEAN countries except within Singapore. The demand of domestics is even diverse and higher. ASEAN is rich when referring to various resources of natural gas – Malaysia, Indonesia and Brunei are all basic exporters and producers. These three countries mainly account for over two-thirds of LNG exports of the world. The production and reserves of Thailand are more substantial. There is an increment in domestic demand in mostly ASEAN countries. The experts of energy are seen optimistic related to the given view to play a broader role in energy scene and economy in ASEAN. Substantial additions made to the reserves of natural gas were seen around the world between year 1983 and year 1988. The reserves of ASEAN countries got incremented to 4369 billion cubic meters from around 2,897 billion cubic meters. It resulted into an incremented of over 50% as opposed to the world-wide reserve. The ranking of Indonesia was done at first; Malaysia was ranked at third after Australia and Indonesia in terms of reserves of gas. In accordance with Othman (2017), Brunei that is the country of around 230,000 individuals accounts for over 3% of the gas reserves of far east. ASEAN countries did the production of around 57.6 million toe natural gas in year 1987, which is compared to 118.3 million two of production of Far east. The reserve gas life of ASEAN is around 67 years at the current production level. The average production of Indonesia got developed by around 19.2% during year 1979 to year 1986. Malaysia registered the higher development among the ASEAN countries that produce gas (Sheng et al., 2018). It resulted into an overall increment of real GDP of ASEAN countries.

H_2: There is a significant impact of Fuel Substitution on real GDP in ASEAN countries.

2.3. Technological Change and Real GDP

However, the economic development and real GDP has been discussed mainly in current years, the growth of technology and science has not yet got more attention and its impact over real GDP has not been analyzed, except in Singapore. However, with the increment in costs of labor, foreign relations started showing issues within China. The management technique of Chine plus One has got developed mainly within ASEAN countries over the initiative of Japanese organizations. As an outcome, the organizations of Japan made expansion of its business not only in Indonesia, Vietnam and Thailand, but also had closer link with Japan, and in Cambodia, Laos and Myanmar. It has made a major contribution to the real GDP in the given countries (Wang et al., 2018). As done by different countries in the world, when the real GDP of a country approaches a particular level, the promotion of technological changes is done and these are empowered for maintenance and development of growth. Most of the countries than for Singapore, which depicted better performance as developed as Japan and other Western countries, targeted on making technological changings. It is quite early for ASEAN countries to make technological changes in the front lines. Thailand and Malaysia are considered to be at higher levels after Singapore. In accordance with Wang and Li (2016), the given two countries and Singapore can build good link of cooperation with South Korean, Chinese and Japanese researcher for increasing real GDP. The following countries are Philippines, Indonesia and Vietnam. These countries tend to have higher population and can gain great influence when the ones see more economic development within future. Out of other four countries of ASEAN, Myanmar, Laos and Cambodia are busy in referring to the infrastructure development and national building. Moreover, in order to make an increment in real GDP, these are also required to make implementation of technological changes on full scale. There is no such link of technological changing to the real GDP. On the other hand, more changes in technology has significant influence on real GDP.

H_3: There is significant impact of technological change on Real GDP in ASEAN countries.

3. METHODOLOGY

3.1. Data Collection

The effectiveness of any empirically research is highly dependent on the quality and authenticity of data. In order to empirically examine the effect of our explanatory variables on the explained variable which is Real GDP growth, the study used the secondary data of all the variables from World Bank and Global Economy data sources. The scope of the study is limited to ASEAN countries, therefore the data of eight ASEAN countries including Indonesia, Malaysia, Singapore, Thailand, Cambodia, and Vietnam, Philippines, and Laos are taken for the period of 27 years from 1990-2016. In addition, two control variables such as population growth and nonrenewable consumption are also including as an independent variable to check the robustness of our results. The purpose of incorporating population growth and nonrenewable energy as our control variable is to circumvent the biasness in results due to omitted variables which may significantly impact the dependent variable energy import.

3.2. Model Specification

In our empirical model three categories of variables are included: Dependent, Independent, and Controlled variables. The dependent variables are those variables which are explained/measured by our explanatory variables. Moreover, the measurement unit of all the variables incorporated in the study has been specified by the author. The major goal of this study is to empirically explain the impact of Energy Imports, Fuel Substitution and Technological Change on the real GDP growth of eight aforementioned ASEAN countries. For this purpose, the dependent variable, which is real GDP growth, is measured as the growth of real GDP at constant US$ symbolized by the RGDP in the model. Moreover, the independent variable energy import, which is denoted by EI in model, is measured by the net import of energy in percentage of total energy used in the country. Fuel substitution is also the independent variable which is measured by the proxy of the cross and own price elasticity fuel, denote by FS in the model. In the same way, another independent variable technological change is measured by the total R&D (Research and Development

Expenditure) percentage share in GDP. The data of technological change symbolized by TC in model is taken from the World Development Indicator. Besides, these, two independent control variables are also discussed to check the robustness in empirical findings. First, population growth is incorporated because of its significant implications on real GDP growth to control the variability in findings. The data of population growth for ASEAN countries are taken from World Bank's databases and denoted by PG in our model. Second, another control variable of the study is renewable energy consumption which is measured by the share in percentage of nonrenewable energy in total energy consumption denoted by NREC in the model. The author incorporates the dependent and control variables in the model to explained real GDP growth after going through massive literature on energy and real output growth. The following empirical model is specified, to empirically measure the impact of energy import, technological change, and fuel substitution on real GDP growth:

$$RGDP_{it} = \alpha + \beta_1 EI_{it} + \beta_2 FS_{it} + \beta_3 TC_{it} + \beta_4 PG_{it} + \beta_5 NREC_{it} + \varepsilon_{it} \quad (1)$$

In above stated equation 1, EI represents energy import, FS represents fuel substitution, TC represents technological change, PG denotes population growth, and NR

4. EMPIRICAL ESTIMATION

4.1. Unit Root Tests

Prior to formally estimate the above-mentioned econometric equation, it is pre-requiting to check the stationarity of the all the variables used in the model. In the short panel data, when number of cross sections is less than number of time period then usually panel cointegration models are employed to investigate the long run and short run linkages among the variables. For this purpose, it is important to pre check the presence of unit root in panel data, which also alternatively the test of stationarity of data. The presence of unit root at level means the data of the variables incorporated in the model is not stationery (no same variance and mean reverting). Moreover, all the variables' data may not stationary at level, so in order to find the order of integration it is required to study the stochastic properties of data. For this model, Im, Pesaran and Shin (IPS), which follows the Dickey fuller process and most efficient for long data, are employed in the study. This panel unit root test takes into account the both time wise and cross section wise dimension of data and also measure the normal distribution of data to present the efficient results. The test based on two hypotheses: null hypothesis denotes the presence of unit root or non-stationary data; Alternative hypothesis denotes no unit root or stationary data. Based on the p values of results the inference about the stationary data is made. The IPS data stationary test employed in this study has following equation based on ADF regression with individual effects and no trend in time.

$$\Delta y_{i,t} = a_i + \rho y_{i,t} - 1 + \sum_{J=1}^{pi} a_J \Delta y_{i,t-J} + \varepsilon_{i,t} \quad (2)$$

Where i stands for cross section, i = 1, 2, …8 (ASEAN countries)

Where t stands for time series, t = 1, 2,… 27 (number of years)

Here $\Delta y_{i,t}$ is the difference that $\Delta y_{i,t}$ shows for i^{th} country for the specific time period of t.

4.2. Panel Cointegration Test

In order to formally estimate the model, the study employed the Pedroni panel cointegration test. The test investigates the short run and long run linkages between the variables of interest. This cointegration test is comprised on two hypotheses: Null hypothesis of panel cointegration test denotes no cointegration or long run association between variables; Alternative hypothesis denotes cointegration or long run relationship between variables. The equation employed to test the Pedroni cointegration in the model based on following equation:

$$y_{i,t} = \alpha_i + \delta_{i,t} + \beta_1 X_{1,i,t} + \beta_2 X_{2,i,t} + \ldots + \beta_n X_{n,i,t} + \varepsilon_{i,t} \quad (3)$$

Where t stands for time period, "i" stands for cross section and n stands for regressors.

4.3. Fully Modified Ordinary Least Square Estimation (FMOLS)

The study aims to attain the efficient and unbiased findings on the basis of empirical model. For this purpose the FMOLS model (purposed by Pedroni) is employed which tackle the possible endogeneity, biasness, auto or serial correlation in the model. Moreover, FMOLS model allows the unbiased estimation of cointegration vectors by addressing the issues of unit root and simultaneity biasness in variables. Moreover, it is also efficient to deal with equation of cointegration with combination of integration I (1). The FMOLS model also employs the "Kernal estimators" to deal with nasty parameters which impact the asymptotic OLS distribution. Moreover, the coefficient value in FMOLS model represents the value of independent variables by which the Real GDP will be affected. The following equation of FMOLS model is employed in the study.

$$\hat{\alpha}_{FM} = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} (x_{i,t} - \overline{x}_i)^2 \right)^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \left(x_{i,t} - \overline{x}_i \right) RGDP_{i,t} - T\hat{\delta}_{\varepsilon u} \right) \quad (4)$$

In aforementioned equation, $RGDP_{i,t}$ is the altered variable of real GDP growth after endogeneity correction, while $\hat{\delta}_{\varepsilon u}$ denotes the serial correlation rectification by FMOLS.

4.4. Empirical Findings

4.4.1. Findings of panel unit root test

As discussed in previous section, the study employed IPS test to examine the stationarity in data and as well as the stochastic trend and order of integration in data. Table 1, depicts the finding of IPS unit root test. It can be seen that first two columns of Table 1 presents the findings of unit root test with level and with level and trend. Whereas third and fourth columns of table present the IPS unit root test with level and with level and trend. The results indicate that presence of unit root in all variables except

Table 1: Panel unit root test – Im, Pesaran and Shin

Variable	Level		1st difference	
	Intercept	Intercept+Trend	Intercept	Intercept+Trend
EI	−2.2820	−3.6719	−6.6877**	−6.6929***
FS	−1.8341	−5.8570	−4.0708*	−10.54997**
TC	−0.0295*	−7.4769**	−7.5845*	−9.4593**
PG	−3.3840*	−8.4299**	−8.5081**	−11.0358***
NREC	−1.4872	−4.6988*	−7.9848*	−10.4821**
RGDP	−4.7444	−9.3431**	−9.8711*	−12.9310**

*Null rejected at 10% significance level, **Null rejected at 5% significance level, ***Null rejected at 1% significance level

technological change and population growth. It denotes that all the variable except mentioned, are not mean reverting and same variance. Whereas according to third and fourth columns indicate that variables become stationary at first difference so it's integrated with first order I (1). In addition, the star sign denotes that null hypothesis of unit root or non-stationary data at different significance level such as 1%, 5% and 10%.

4.4.2. Findings of panel cointegration test

After conducting the pre cointegration test of unit root, author has employed the Pedroni cointegration test to analyze the short term and long run relationship between variables. Table 2 depicts the findings of Pedroni's cointegration test of panel data of ASEAN countries. The purpose of panel cointegration test in time wise panel data is to explore the short run and as well as long run association of independent variables with dependent variable that is real GDP growth. Moreover, the panel cointegration tests are more efficient than ordinary cointegration test to check the steady state relationship between variables in time series data of various cross section countries. The Pedroni test employed two techniques: within dimension and between dimension. Table 2 indicates that all two techniques of between dimensions reject the null hypothesis of no cointegration between variables, and two techniques of with dimension also reject the null hypothesis of no cointegration or long run association between variables. The four out of seven techniques indicate the presence of long run association between variables at different significance level. Therefore, in this context it can be inferred that there is good chances of cointegration between the variables.

Table 2: Cointegration test - pedroni panel

Test	Statistics	P-values
(Within dimension) panel V-statistic	−0.0948	−4.4787
Panel ρ-Statistic	−0.3892	−5.4871
Panel t-statistic: (non-parametric)	−2.6409***	−6.7634*
Panel t-statistic (adf): (parametric)	−3.1284**	−4.4523**
(Between dimension) Group ρ–statistic	−5.9421**	−12.9756**
Group t-statistic: (non-parametric)	−0.0372	−10.2654*
Group t-statistic (adf): (parametric)	−5.4587*	−12.4877*

*Null rejected at 10% significance level, **Null rejected at 5% significance level, ***Null rejected at 1% significance level

Table 3: FMOLS estimation

Estimator	Coefficient	Standard error	Probability
EI	0.121*	0.317	0.041
FS	0.284**	0.638	0.037
TC	0.201**	0.811	0.061
PG	0.091	0.983	0.047
NREC	0.276**	0.796	0.005
Adj. R square	0.732	0.992	0.000
F-value	57.180	-	-
D.W. Stat	2.58	-	-

4.4.3. Results of fully modified ordinary least square model

As discussed earlier that, FMOLS model is the most efficient model to deal with biasness in the model emanated by the presence of endogeneity, simultaneous equation, and serial correlation among panel data variables. Furthermore, FMOLS is meant to presents most efficient and unbiased results. Table 3 depicts the empirical findings of the FMOLS model, which investigates the impact of energy import, fuel substitution and technological change on real GDP growth. Table 3 comprises on three columns, first column presents the coefficients of independent variables, second column presents the standard error of variable, and third column presents the P-value of variables. According to first column of Table 3, energy import has positive impact on the real GDP growth of ASEAN countries. The coefficient of energy import is significant at 10% confidence interval, which illustrates that 1% increase in energy import will cause 0.12% increase in real GDP growth. Similarly, the coefficient of fuel substitution is also significant at 5% significance level (also depicts by p-values or probability in column three) which indicates that fuel substitution has long run relationship between real GDP growth and 1% increase in fuel substitution will cause 0.3% increase in real GDP growth. Furthermore, the coefficient of the third independent variable, technological change, also denotes that presence of long run positive relationship of technological change with real GDP growth. The value of coefficient denotes that 1% increase in technological change in ASEAN countries will bring 0.2% increase in real GDP growth. Finally the coefficients of our control variables such as population growth and Nonrenewable energy consumption indicates that population growth has not significant impact on real GDP growth of ASEAN countries. Whereas nonrenewable energy consumption is positively impact the real GDP growth in long run.

The adjusted R2 value indicates that overall 73% variation in real GDP is explained by the empirical model of the study. F stats value which is significantly higher than 10 also illustrates that overall model is strong to explain the dependent variable. The Durbin Watson value indicates the absence of serial correlation in variables.

Table 4 depicts the empirical findings of multicollinearity test of variance inflating factors. The values of variance inflating factors in Table 3 indicate that there is no multicollinearity among the variables because all the values are <10.

Table 4: Multicollinearity test

	VIF	TOL
EI	1.037	0.592
FS	1.371	0.391
TC	2.696	0.668
PG	1.498	0.448
NREC	2.477	0.583
RGDP	4.571	0.683
Mean VIF	1.477	-

5. DISCUSSION AND CONCLUSION

5.1. Discussion

Basically, renewable energy plays a great role in ASEAN countries; therefore it is necessary to examine the impact of energy imports and GDP on energy consumption. The non-renewable energy is being consumed to a great extent in the ASEAN countries, and in this case population growth plays a great role (Fan and Hao, 2020). The basic purpose of the following research is to analyze the impact of GDP on non-renewable energy consumption in ASEAN countries. The results and the findings of the study indicate that population growth has an insignificant impact on the consumption of energy. However, the impact of population growth on fuel substitution and technological change is significant. This is depicted with the help of results presented in the panel unit root test table. Some of the researchers have also focused on the impact of population growth with the help of FMOLS model. According to them, the policies of the ASEAN countries highly influence the afforestation and are crucial to reducing the carbon dioxide emissions in host countries (Wang and Ma, 2018). Meanwhile, some scholars indicate that energy consumption is not limited when population growth is high as people do not consider technological change as an issue. The results and tables indicate the significant and insignificant relationships between the dependent and independent variables. There is a strong relationship between energy consumption, fuel substitution, technological change and GDP growth. Basically, energy use and GDP are positively correlated; however energy has a little bit intensity as it has been declined over time in the ASEAN countries (Bakirtas and Akpolat, 2018). There are numerous factors that affect the possibilities for energy efficiency improvements to reduce energy intensity. It has been suggested by natural science that energy is fundamental to economic production, but mainstream economic growth theory almost ignores the role of energy. This study has induced that hat non-renewable energy has been a principal driver of growth.

Furthermore, the population growth and non-renewable energy consumption act as a control variable in the research. The control variables insignificantly impact non-renewable energy. It has been indicated that the population growth influences the non-renewable energy consumption. The higher the population growth, the more will be energy consumption, fuel constitution, and technological change (Chester and Elliot, 2019). Therefore, population growth is directly connected with the non-renewable energy consumption, fuel substitution and technological change especially in the ASEAN countries where population growth is high then the other developing countries.

5.2. Conclusion

In order to summarize the information, it can be depicted that population growth has an insignificant impact on the consumption of energy. The primary purpose of this research is to understand the impact of energy imports, technological change and fuel substitution on real GDP. The panel unit root test, cointegration test-Pedroni panel, and FMOLS have been performed in this study. Moreover, the multicollinearity test has also been performed to specify the results. Population growth and non-renewable energy have been taken as control variables which have an insignificant impact on energy consumption.

5.3. Implications

This study can help the economy of ASEAN countries in understanding the consumption of non-renewable energy and technological change. The results and tables explained that there is an insignificant impact of population growth on energy consumption and is a significant impact on the fuel constitution and technological change. It can help the ASEAN economy to control its population growth in order to reduce energy consumption or focus on energy consumption instead of technological change and fuel constitution.

5.4. Limitations

This empirical study provides different insights into the relationship between control variables. There are several limitations in the research that is necessary to mention, for example, this study have only focused on population growth and its impact on other variables which is one of the biggest limitation. It is recommended that the future studies should essentially focuses on other aspects to get the reliable output and results. Future researchers can use other variables in order to conduct this study. Moreover, the studies may focuses on other factors.

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