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The Effect of Energy Security on Economic Growth in ASEAN During 2000–2020

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ABSTRACT

Energy is an important input for economic growth. The increase in non-renewable energy consumption has an impact on energy insecurity. This study aims to calculate energy security and analyze its effect on ASEAN economic growth during the 2000–2020 period. The method used in this study is the Principal Component Analysis to calculate energy security and the Feasible Generalized Least Square panel data regression to analyze its effect on economic growth. The authors use four dimensions to build an energy security index, namely availability, accessibility, acceptability, and efficiency. Several variables are included in the model, are capital, labor, trade, and world oil price. The results of this study indicate that the index and dimensions of energy security have a positive influence on ASEAN economic growth, except for the efficiency dimension. Capital. employment, trade, and oil prices have a positive influence on ASEAN economic growth. Regional Governments need to reduce the gap in the electrification ratio in several countries and build energy infrastructure. The government also needs to increase the application of energy diversification, increase renewable energy production and the need to pay more attention to environmental policies in economic activities.

Keywords: ASEAN, Energy Security, Economic Growth, Feasible Generalized Least Square, Principal Component Analysis
JEL Classifications: Q41, Q43

1. INTRODUCTION

Energy has a strategic role in an economy as a factor in supporting development and welfare. Energy has a role as an input in the production process to encourage economic growth (Christensen et al., 1973). Energy consumption is getting higher at the stage of economic development and industrialization especially in developing countries (Wei et al., 2011). Both on the demand and per capita energy supply side are important determinants in growth (Zhang et al., 2017; Le and Nguyen, 2019). Therefore, energy security is an important goal to achieve sustainable growth and development (Le and Nguyen, 2019).

Energy security relates to the ability of households, businesses, and governments to accommodate supply disruptions in the energy market (Liu et al., 2019). Energy reserves guarantee the amount of energy supply needed for people's lives, economic, social, and defense activities at an affordable price. For developed countries, energy security refers to resilient energy systems, the demand of which is always met at an affordable price, while developing countries define energy security as access to modern energy services (Kanchana and Unesaki, 2014).

Currently, ASEAN's energy needs are very high. According to the total of ASEAN energy consumption by sector, industry, residential, and transportation are the sectors that absorb the most energy. Since 1990 the increase in energy consumption has also shown an increasing trend. This is due to the massive growth of the industrial and transportation sectors using energy as an input for their production activities.

Although energy is an important input, the energy sector faces challenges in a sustainable context. The share of fossil fuels in the total primary energy supply is estimated to be around 80% by 2050

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(Sahid et al., 2019). A large part of the energy supply in ASEAN is based on fossil fuels while renewable energy still occupies a small propotion of its share. Currently ASEAN is the region with the fastest growth in coal demand in the world where Indonesia, Malaysia, Thailand, the Philippines, and Vietnam control more than 90% of the region's energy share (ACCEPT, 2020).

Massive exploration of fossil energy will have an impact on the depletion of these energy reserve sources which then have implications for energy prices (Sahid et al., 2019). Fluctuations in energy prices cause macroeconomic and fiscal instability not only for economies that rely heavily on energy imports but also for major energy exporting countries (Le and Nguyen, 2019). In a free-market economy where trade (export-import) is one of the determinants of growth, this volatile oil price will affect companies and consumers (Le and Nguyen, 2019). This has implications for increasing investment uncertainty and economic growth itself.

In the case of Indonesia, for example, the Ministry of Energy and Mineral Resources (2012) stated that Indonesia's crude oil reserves will run out within 23 years, gas 59 years and coal 82 years assuming no alternative energy is found as a source of fossil energy. This will certainly have an impact on the issue of the energy crisis, so that energy problems are a serious problem in all countries along with the increasing demand for energy (World Bank, 2022).

The increase in global energy demand may contribute to energy insecurity in some developing countries due to energy availability and energy affordability (Nepal and Paija, 2019). The increase in energy demand will pose a threat to energy security (Mahmood and Ayaz, 2018), due to the gap between energy demand and its supply (Nepal and Paija, 2019).

This growing demand is putting pressure on the energy system and encouraging policymakers to meet energy needs. The commitment of ASEAN governments in encouraging energy security is conceptualized under the ASEAN Action Plan for Energy Cooperation (APAEC) 2016-2025 with the main agenda of encouraging security, accesibility, affordability, and energy sustainability (acceptability).

The concept of energy security develops with renewable capacity and energy efficiency. The goal of energy security is to maintain energy independence by reducing the ratio of energy consumption to energy production (Liu et al., 2019). Le and Nguyen (2019) stated that energy supply security is formed from several aspects, namely the availability and accessibility of energy s number, energy affordability, and acceptability (environment). Access to energy is very important for economic development and social (ACCEPT, 2020) as stated in the 7th SDGs, clean and affordable energy. In the aspect of accessibility, the IEA (2020) shows that ASEAN countries have achieved a 100% electrification ratio, there are Brunei Darussalam, Malaysia, Singapore, Thailand, and Vietnam.

The management of energy supply and demand should be based on the importance of energy efficiency. Energy efficiency relates to the effective and efficient use of available energy resources and is one of the ways to improve energy security by lowering energy demand (Le and Nguyen, 2019). Energy efficiency can produce the same amount of output by using less energy (Mahmood and Ayaz, 2018). Ozturk and Acaravci (2013) assert that improving energy efficiency will save the country's foreign exchange, reduce dependence on energy imports, and contribute to promoting economic growth.

Another issue of concern to ASEAN governments is related to the effects of climate change and environmental impacts along with increasing energy consumption. APAEC Phase II seeks a 32% reduction in energy intensity as well as a program to achieve a 23% share of renewable energy to the total primary energy supply by 2025. Thus, total energy use is expected to reduce environmental impact, thereby increasing energy security and overall productivity (ACCEPT, 2019).

The important role of energy security and its association with economic growth has not been widely studied in the literature, especially with quantitative approaches. This is due to the fact that most studies of energy security are qualitative. Studies related to energy security in ASEAN have so far focused only on the level of energy consumption and energy supply nationally. Erahman et al. (2016) in his study assessed how the energy dimension performed in Indonesia in 2008-2017 and compared it with 70 other countries. Their findings show that the highest average dimension value is efficiency, while the lowest is affordability. However, the study of Erahman et al. (2016) did not not analyze how the performance of energy security affects the economy but only an assessment of performance.

Balitskiy et al. (2014) has conducted a study related to energy security and its effects on the economy with a case study in Europe. However, the energy security indicators used are only limited to gas energy consumption and do not use the dimensions of energy security based on efficiency, availability, acceptance, affordability and accesstibility. It shows that gas energy consumption has a significant positive impact on economic growth.

Another study using indicators from the energy security dimension, namely efficiency, availability, acceptance, and accessibility was conducted by Le and Nguyen (2019), to analyze how it affects economic growth in 74 countries. Its findings show that there is a positive impact of higher energy security on economic growth. However, Le and Nguyen (2019) did not analyze how the specific influence of dimensions of energy security on an economy.

The three gaps from the study are interesting to explore, authors use the panel data regression method. This study will attempt to analyze the influence of each dimension performance and energy security index on ASEAN's economic growth.

2. FUNDAMENTAL THEORY

2.1. Energy Security

According to the Asia Pacific Energy Research Center (APERC, 2007) energy security is defined as the ability of an economy to ensure the availability of a sustainable and timely supply of energy resources with energy prices being at a level that will not adversely affect the economic performance of the economy. Le and Nguyen (2019) stated that energy supply security is influenced by the availability (physical) and accessibility (geopolitical) of energy sources, energy affordability, and acceptability (environment). Meanwhile, Erahman et al. (2016) use 5 dimensions of energy security which will be adopted to this analysis as shown in the table 1.

In relation to economic growth, Balitskiy et al. (2014) states that energy security indicated with gas consumption has a negative impact on economic growth, increased consumption of natural gas increases GDP in the long run. This is supported by Le and Nguyen (2019) using 10 energy security indicators where there is a positive impact of higher energy security on economic growth. Furthermore, Lin and Raza (2020) use several energy security indicators as shown in the table 2.

2.2. Expansion of Cobb-Douglas Production Functions

The Cobb–Douglas production function is a certain functional form of production function widely used to represent the technological relationship between the sum of two or more inputs (specifically physical capital and labor) and the amount of output that can be produced by those inputs. The Cobb–Douglas form was developed and tested against statistical evidence by Charles Cobb and Paul Douglas between 1927–1947 (Nicholson and Snyder, 2008). The mathematical form of the Cobb–Douglas production function is formulated as follows:

$$Q = f\left(K, L\right) = AK^{a}L^{b} \quad (1)$$

Where, d, Y is the aggregate real output, K is the capital stock, L is the labor stock, and A describes the technology. The coefficient of the Cobb-Douglas production function of the equation above, namely (α and β) shows the amount of elasticity which is a change in output due to changes in inputs in the production process. In addition, the summation of the coefficients will indicate the scale of return (return to scale).

According to Odularu and Okonkwo (2009) energy is one of the important components of technology andenergy consumption determines technological change. Based on empirical studies and theoretical concepts related to the main topics of Le (2016) and Balitskiy et al. (2014) presents a broader form of the Cobb-Douglas production function by which energy can be adopted as part of technology. In its investigation of the effect of energy resistance on output is formulated as the following functions:

$$Y = AK^{a1}L^{a2}ES^{a3}e^{\mu} \quad (2)$$

Where Y represents the real domestic output of an economy, K indicates capital, L explains labor while ES is energy security. A is a technological factor, and e describes the assumed error N(i.i.d). $\alpha 1$ $\alpha 2$ $\alpha 3$ represents the elasticity of output to capital, labor, and energy security, respectively. For such models, an expanded Cobb-Douglas production function with a constant yield scale was used ($\alpha 1 + \alpha 2 + \alpha 3 = 1$).

Energy is an important input that can control economic activity. The energy component can be a complementary good on other factors of production (Zweifel et al., 2017). According to Shahbaz et al. (2016) the A technology in the Cobb-Douglas function is determined endogenously by the degree of openness of trade.

Shahbaz et al. (2013) stated that the role of trade in economic growth can be achieved through technology and innovation. His study states that trade openness can increase economic growth through increased domestic productivity. Trade openness creates economies of scale through specialization (Amable, 2000), competition and efficiency (Hadhek and Mrad, 2015). By implication trade has a positive influence on technological progress (Le and Nguyen, 2019). Le and Nguyen (2019) formulate the role of trade through technology based on derivatives of the Cobb-Douglas function as follows:

$$At = ðTO_t^{ø}FD_t^{ø} \quad (3)$$

Where A is technology, TO is the openness of trade, ø is the elasticity of technology and ð as constant time-variant.

2.3. Previous Research

Energy plays the role of a driver of economic activity, a source of state income, fuel, production inputs, and various other important roles. Kasman and Duman (2015) and Balitskiy et al. (2014) state that energy is an important input of economic growth. It is also inline with the study of Destek and Aslan (2017) in their study state that there is unidirectional causality from both non renewable and renewable energy consumption to economic growth. Increased human activity is related to energy determined by economic growth and vice versa (Chang et al., 2015). So that the nature of the relationship between energy consumption and economic growth is very important for the formulation of optimal energy policies (Mirza and Kanwal, 2017).

The increase in energy demand, especially in developing countries, has implications for the high economic activity of a country. Berndt and Wood (1975) in their research analyzed the relationship between energy consumption and economic growth in the United States. His findings show that energy demand is very responsive to the elasticity of energy prices themselves, where energy as an economic input is one of the factors of American economic growth.

According to Yusgiantoro (2000), the role of energy in the Indonesian economy is very large, where energy consumption affects national economic growth. The increasing use of energy is driving the process of industrialization. The demand for energy in the manufacturing industry to run machines is indeed very high. On the other hand, this is supported by the role of energy, especially in export revenues and government revenues as accumulated development capital. By realizing that energy consumption is very closely related to GDP, it can be estimated how much energy consumption increase is needed to obtain a certain level of output. The magnitude of the increase in energy consumption required to increase one unit of output can be known by calculating the elasticity of energy consumption to national output.

Empirical studies show that energy security has an influence on the economy. Le and Nguyen (2019) in their study of 74 countries in 2002–2013. Ten measures of energy security are used to measure five aspects of energy security including availability, accessibility, acceptance, affordability, and development capabilities. Using Panel-Corrected Standard Errors (PCSE) and Feasible Generalized Least Squares (FGLS) techniques, the results found that energy security increased economic growth for both the entire sample and subsamples of the country.

Another study was conducted by Shahbaz et al. (2016) with a case study in China in 1972-2017. Using ARDL and the granger causality test, this study aims to analyze the influence and relationship between energy consumption and China's GDP. The results of this study show that there is empirical evidence of long-term relationships between variables. The use of energy has a positive effect on economic growth. Empirical results related to the effect of energy security on GDP are also supported by the findings of Alshehry and Belloumi (2015); Caraiani et al. (2015); Le (2016) and Tang et al. (2016).

Shahbaz et al. (2016) also found the results of Granger's causality analysis revealed that causal relationships are unidirectional from energy use to economic growth. His research states adanya two-way causality relationship between energy consumption and economic growth is shown by other findings from Fang et al. (2018); Kahia et al. (2017); Mutascu (2016).

Ozturk and Acaravci (2013) in their study aimed at testing the causal relationship between financial development, trade, economic growth, energy consumption and carbon emissions in Turkey for the period 1960-2007. His research produces evidence of a long-term relationship between per capita carbon emissions, per capita energy consumption, real income per capita, per capita real income square, openness and financial development. Ahmad and Du (2017) in their research investigated the relationship between energy production, CO2 emissions and Ira n economic growth. The methods used were DOLS and FMOLS for the period 1971–2011 where the results showed that energy production had a positive effect on Iran's economic growth.

In addition, according to the expansion of Cobb-Douglas prduction functions, apart from energy, number of research use various methods to analyse several critical factors that influence economic growth, such as capital, labor, and trade. Authors summarize related previous research as follows in the table 3.

3. METHODOLOGY

3.1. Analytical Techniques

3.1.1. Principal Component Analysis (PCA)

In measuring the dimensions and index of energy security, this study uses the Principal Component Analysis (PCA) method or analysis of the main components. Primary component analysis (PCA) is a multivariate technique used to analyze the interrelationships between variables and to explain these variables in terms of their components (Erahman et al., 2016). The number of components depends on the eigenvalues that can be found by solving the following equation:

$$(R - \lambda I) = 0 \tag{4}$$

Where R is the correlation matrix (N x N), l is the eigenvalue, and I is the identity of the matrix. The first eigenvalue describes the maximum variance in all individual indicators, and the second eigenvalue describes the maximum number of remaining variances and so on (Narula et al., 2015). Each eigenvalue represents each component. Therefore, the number of components extracted without losing much information follows kaiser criteria as a rule of thumb (Prambudia et al., 2012). This criterion retains all components above the eigenvalue of 1. Furthermore, such eigenvalues represent the weight of the components.

Indicators should be normalized to ensure comparability. This study used the min-max normalization method (Erahman et al., 2016), where each indicator was transformed using the following equation:

$$I'qct = \frac{Iqct - \min(Iqt)}{\max(Iqt) - \min(Iqt)} \tag{5}$$

Where, if, $I_{qct} > Limit_{Up}$, then $I_{qct} = Limit_{Up}$, while if $I_{qct} < Limit_{Low}$, then $I_{qct} = Limit_{Low}$. I'qct is the indicator value after normalization, I_{qct} is the indicator value before normalization, $\min(I_{qt})$ is the minimum value of the indicator in a given year, $\max(I_{qt})$ is the maximum value of the indicator in a given year, q is the indicator type, c is the country and t is the year.

Before performing the PCA, the data were evaluated with the Barttlet test and the Keiser-Meyer-Olkin test to determine the feasibility of factor analysis. This test looks for a small p-value, which shows the correlation matrix differs significantly from the zero-correlation matrix (Beaumont, 2012). The Barttlet test equation is as follows:

$$\chi^2 = -(n - 1 - \left(\frac{2p+5}{6}\right) x \ln|R|) \tag{6}$$

where χ^2 is chi square, n is the number of observations, p is the number of variables, and R is the determinant of the correlation matrix. Bartlett's Test of Sphericity tests the null hypothesis that variables in the population correlation matrix are not correlated. The test was carried out with the following criteria:

Sig i > 0.05; H0 is accepted; sig: < 0.05 H0 is rejected.

In addition, it can also be by comparing with $\chi^2\chi^2{}_{(df,a),}$ where H0 is rejected, if > $\chi^2\chi^2{}_{(df,a).}$ In addition, the KMO test compares the magnitude of the observed correlation coefficient with the magnitude of the partial correlation coefficient. If the variable has a general factor, the partial correlation coefficient should be small relative to the total correlation coefficient. The maximum value of KMO is 1 and as a rule of thumb, KMO values above 0.5 imply that the data set is appropriate for PCA calculations. The PCA calculation is used to determine the weight.

The total variance described describes how much variability the data represented by the extracted components is, usually displayed as a percentage (%). The weight of the component can be calculated by dividing the described variance by the total variance described. Furthermore, factor loading is the correlation coefficient between the main component, C, and the variable, x. Weighting is shown in the following equation:

$$C_1 = a_{11}x_1 + a_{12}x_2 + ... + a_{1Q}\ x_Q$$

$$C_2 = a_{21}x_1 + a_{22}x_2 + ... + a_{2Q}\ x_Q$$

$$C_c = a_{ci}x_i + a_{cj}x_j + ... + a_{cQ}\ x_Q \qquad (7)$$

C is the component score; x is the variable and a is the correlation coefficient between the component and the variable. c is the number of components retained; Q is the number of variables. Total score component is calculated as follows:

$$C_T = \Sigma\ C_1W_1 + C_2W_2 + ... + C_iW_i \qquad (8)$$

Where, i = 1, 2, 3,... c, CT is equal to the dimension score. Therefore, this equation is used for aggregation and is calculated for each country.

3.1.2. Panel Regression

This study uses a quantitative approach based on the expansion of the Cobb-Douglas production function where the metode used is Feasible Generalized Least Square (FGLS). This method is used to accommodate heteroscedasticity and autocorrelation disorders that occur in residual (Gujarati, 2009) so that FGLS does not require such testing (Greene, 2012). As for model in the study, it is formulated as follows:

$$lnGDP_{it} = \beta_0 + \beta_1\ ES_{it} + \beta_2\ lnCAPITAL_{it} + \beta_3\ LABOR_{it} + \beta_4\ lnTRADE_{it} + \beta_5\ lnOP_{it} + \mu_{it} \qquad (9)$$

From the model, ES is energy security, where the model will be estimated twice with Model 1, ES as the energy security index while Model 2, ES as the dimension of energy security which includes availability (AVA), acceptability (ACP), accesiblity (ACS), and efficiency (EFF). GDP represents gross domestic product, CAPITAL is the formation of gross fixed capital (PMTB), LABOR describes labor, TRADE is net trade, OP is the world oil price. ln is a form of natural logarithm, i is the state, t is the year, β is the parameter while μ is the error term. The transformed model into a natural logarithm form is intended to reduce the variance of the data.

3.2. Data

The data used is secondary data in the form of panels from 10 ASEAN countries for the 2000-2020 period, namely Brunei Darussalam, Cambodia, Indonesia, Malaysia, Myanmar, Laos, the Philippines, Thailand, Singapore, and Vietnam. Data on GDP, capital, labor, and trade are obtained from the World Bank while oil prices and indicators of energy security are obtained from the Energy Information Administration (EIA) and the International Energy Agency (IEA). This study used energy security indicators

Table 1: Definitions of the dimensions of energy security

Dimensi	Definition
Availability	Have sufficient energy supply from domestic resources, encourage energy production, diversify energy supply, and have final energy adequacy
Affordability	Have the final energy at a low cost and affordable for the local economy
Accesibility	Have sufficient access to commercial energy to promote equality
Acceptability	Minimizing the impact of global warming
Efficiency	Have minimum energy consumption for the same service and minimize energy loss up to the end user

Source: Erahman et al. (2016)

Table 2: Energy security indicators

Indicators	Description
EI	Total primary energy needs per GDP
OI	Oil consumption per GDP
OUPC	Oil consumption per population
EUPC	Total primary energy supply per population
STS	Energy consumption in the transport sector per total end energy
Parts of the use of oil in transport: Sectors per total oil use (OCTS)	**Oil consumption in transport sector per total oil consumption in all sectors**
NEIR	Net energy imports per net summation of energy imports and domestic sector supplies. NEIR is used to estimate dependencies
VI	Expenditure on energy imports per GDP
NOID	Net oil import per primary energy needs of oil

Source: Lin and Raza (2020).
VI: Vulnerability index, NOID: Net oil import dependence, NEIR: Clean energy import ratio, STS: Transportation sector share, EUPC: Energy use per capita, OUPC: Per capita oil use, OI: Oil intensity, E, I: Energy intensity, GDP: Gross domestic product

Erahman et al. (2016), Shadman et al., (2022) and Le and Nguyen (2019) from IEA, World Bank and ASEAN Statistic. Each dimension of energy security indicators is formed from several calculated variables as shown in the table 4.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Before analyzing the results of the estimated effect of energy security on ASEAN economic growth, the authors reviewed the data descriptively with a total of 210 observations. The energy security index and its four dimensions are obtained using PCA. The average ASEAN energy security index during the period 2000-2020 was 0.459 or 45.9%. The average availability dimension (AVA) is 0.252; accessibility (ACS) 0.559; acceptability (ACP) 0.544; and efficiency (EFF) 0.365.

Standard deviation describes the magnitude of the variation of the data. Table 5 shows the standard deviation values of each variable that are lower than the calculated average value, this means low data drift.

4.2. Bartlett and KMO Test Output

PCA calculations are intended to condense the information contained in several original variables into a set of smaller

Table 3: Effect of control variables on economic growth

Author	Level/period	Method	Result
Shahbaz et al. (2013)	China, 1971–2011	ARDL	Capital (+); Trade (+)
Kahia et al. (2017)	11 MENA Net Oil Importing Countries (NOICs), 1980–2012	Granger causality ECM panel	Labor (+) Capital (+)
Fang and Chang (2016); Ahmad and Du (2017)	(16 Asia-Pacific, 1970–2011); (Iran, 1971–2011)	Cointegration test panel; ARDL	Labor (+); Capital (+)
Le and Nguyen (2019)	32 European countries, 1995–2014	Panel FEM	Capital (+); energy price (+) for upper-middle income, (−) lower-high income
Alshehry and Belloumi (2015)	Saudi Arabia, 1971–2010	Johansen multivariate cointegration and Granger causality	Energi price (−)
Nasreen and Anwar (2014)	15 Asian countries, 1980–2011	Cointegration panel	Energy prices (−); Trade (+)
Ozturk and Acaravci (2013)	Turkey, 1960–2007	ARDL	Trade (+)

Source: Processed

Table 4: Energy security indicators

Dimension	Description	Measurement
AVA	AVA 1: Per capita energy production	$\frac{TPEP}{POP}$
	AVA 2: Per capita energy consumption	$\frac{TPEC}{POP}$
	AVA 3: Ratio of oil reserves per oil production	$\frac{OR}{OP}$
	AVA 4: Production adequacy	$\frac{RO}{OPC}$
ACS	ACS 1: Access to electricity	$\frac{PL}{POP}$
	ACS 2: Ownership of motor vehicles	Total units
	ACS 3: Access clean technology	$\frac{TL}{POP}$
ACC	ACP 1: Emissions per energy consumption	$\frac{CO2}{TPEC}$
	ACP 2: Emission intensity	$\frac{CO2}{GDP}$
	ACP 3: Share NRE to primary energy production	$\frac{EBT}{TPEP}$
EFF	EFF 1: Energy intensity	$\frac{TPEC}{GDP}$
	EFF 2: Power distribution losses	$\frac{EDL}{EP}$

Description: TPEP: Total primary energy production (qbtu), TPEC: Total primary energy consumption (qbtu), OP: Oil production (qbtu), OPC: Consumption of petroleum products (qbtu), NRE: Renewable energy (qbtu), EDL: electricity distribution losses (%), POP: Population (soul), OR: Oil reserves (qbtu), OR: Oil reserves (qbtu), RO: Refinery output (qbtu), CO2: CO2 emissions (metric tons), EP: Electricity production (%), Electricity access: Percentage of the population with access to electricity (PL/POP, %), Motor vehicle ownership: Total units of motor vehicles (units), Access to clean technology: the proportion of the total population that uses clean fuel and technology (TL, joules) for cooking (TL/POP, %). AVA: Availability, ACS: Accessibility, ACC: Acceptability, EFF: Efficiency, NRE: non-renewable energy, TPEP: Total primary energy production, TPEC: Total primary energy consumption, OP: Oil production, OPC: Consumption of petroleum products, EDL: Electricity distribution losses, POP: Population, OR: Oil reserves, RO: Refinery output, EP: Electricity production

Table 5: Descriptive statistics

Variable	Average	SD	Minimum	Maximum
lnGDP	24.974	1.656	21.254	27.726
lnCAPITAL	23.738	1.546	20.504	26.613
lnLABOR	16.233	1.784	11.965	18.757
lnTRADE	8.93	2.14	0.693	12.127
lnOP	4.009	0.484	3.141	4.695
AVA	0.252	0.172	0.043	0.658
ACS	0.559	0.259	0	1
ACP	0.544	0.256	0	1
EFF	0.365	0.253	0	1
ES INDEX	0.459	0.267	0	1

Sumber: Processed. AVA: Availability, ACS: Accesiblity, ACP: Acceptability, EFF: Efficiency, SD: Standard deviation

Table 6: Bartlett and KMO Test Outputs

Dimensions - Index	Bartlett test of sphericity	Kaiser-Meyer-Olkin
Availability (AVA)	Chi-square 76,596 Degrees of freedom 6 p-value 0.000	KMO 0.501
Accessibilitas (Accessibility (ACS)	Chi-square 121.122 Degrees of freedom 3 p-value 0.000	KMO 0.536
Acceptability (ACP)	Chi-square 76,565 Degrees of freedom 3 p-value 0.000	KMO 0.503
Efficiency (EFF)	Chi-square 7,601 Degrees of freedom 1 p-value 0.006	KMO 0.501
Energy Security Index (ES INDEX)	Chi-square 329,514 Degrees of freedom 6 p-value 0.000	KMO 0.645

components with minimal information loss, thereby reducing many variables to a small number of components (Erahman et al., 2016). In this study, PCA is used to build an index and dimension of energy security in ASEAN. The indicators used to form indices and dimensions by using PCA must be correlated. Table 6 shows the results of the Barttlet and Keiser-Meyer-Olkin tests to determine the feasibility of factor analysis. Bartlett's Test of Sphericity P-value of all dimensions and the energy security index

Table 7: Principal component analysis output of availability dimensions

Components	Eigen value	Difference	Proportion	Cumulative
Comp 1	1.545	0.527	0.386	0.386
Comp 2	1.018	0.023	0.255	0.641
Comp 3	0.996	0.555	0.249	0.890
Comp 4	0.441		0.110	1.000
Principal components/ correlation		Number of obs		210
		Number of comp		4
		Trace		4
Rotation: Unrotated=Principal		Rho		1.0000

Source: Processed

Table 8: Value weighting and contribution of availability dimensions

Variables	Comp 1	Comp 2	Weight	Contribution
Normal_ava1	0.424	0.352	0.000965	0.150546
Normal_ava2	0.564	−0.388	0.001284	0.200255
Normal_ava3	0.017	0.848	0.00255	0.397816
Normal_ava4	0.708	0.079	0.001611	0.251383
Total	1.696	0.848	0.00641	1
Proportion	0.386	0.255		
Cumulative proportions	0.641			
Standard weights	0.602184	0.397816	1	

Source: Processed

is a significant value of 0.000 which illustrates that the variables are correlated. The overall KMO value of more than equal to 0.5 implies that the data set is appropriate for PCA calculations.

4.3. PCA Results

4.3.1. Availability dimensions

Table 7 shows the result of PCA output of availability dimensions, in which comp1 and comp2 are chosen since the components above the eigenvalue of 1. The contribution of each indicator that forms the dimension of availability, namely per capita energy production (normal_ava1) of 15%, per capita energy consumption (normal_ava2) of 20%, oil reserve ratio per oil production (normal_ava3) of 39.8% and production adequacy (normal_ava4) of 25.13% as shown in Table 8. The standard weight is then multiplied by each component to obtain the value of the availability dimension.

Figure 1 show the value of the ASEAN availability dimension which tends to decrease with an average value of the availability dimension of 25.2%. The countries with the largest availability dimension are Malaysia, Singapore reaching more than 50% and Thailand 37%. This is due to the dimensional forming factors themselves, namely AVA1, AVA2, AVA3 and AVA4 from the country. The AVA1 trend, which tends to decline, is due to the growth of annual energy production that has not been able to keep up with the population growth and ASEAN is still dependent on oil energy. The decline in AVA1 in 2007 was due to the beginning of the global crisis and the decline in oil prices. AVA2 shows an increasing trend

Table 9: Principal component analysis outputs of accessiblity dimension

Components	Eigen value	Difference	Proportion	Cumulative
Comp1	1.736	0.823	0.579	0.579
Comp2	0.913	0.561	0.304	0.883
Comp3	0.352		0.117	1.000
Principal components/ correlation		Number of obs		210
		Number of comp		3
		Trace		3
Rotation: Unrotated=Principal		Rho		1.0000

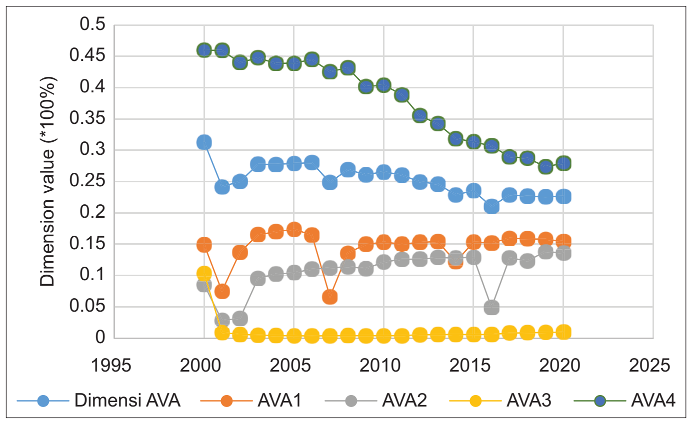
Source: Processed

Table 10: Weight values and contribution of accessibility

Variables	Comp 1	Weight	Contribution
Normal_acs1	0.671	0.00233619	0.403488
Normal_acs2	0.326	0.00113502	0.196031
Normal_acs3	0.666	0.00231879	0.400481
Total	1.663	0.00579	1
Proportion	0.579		
Cumulative proportions	0.579		
Standard weights	1		

Source: Processed

Figure 1: Dimension of availability of ASEAN



indicating an ever-increasing per capita energy consumption. The situation explains the ability of the community to meet energy needs. The decline in AVA2 in 2016 was due to economic slumps.

The small value of AVA3 is caused because some ASEAN countries such as Laos, Cambodia and Singapore do not have oil reserves. In addition, for the case of Thailand where its oil reserves are smaller compared to its production. So, the country has a high dependence on energy imports. The declining AVA4 trend is due to the decline in AVA1 along with the increase in AVA2. The biggest contribution from the final energy consumption still rests on fuel with production starting to be suppressed to switch to coal. Therefore, the decrease in AVA 4 was due to an increase in fuel consumption which was not followed by an increase in refinery production.

Figure 2: Dimension of accesibility of ASEAN

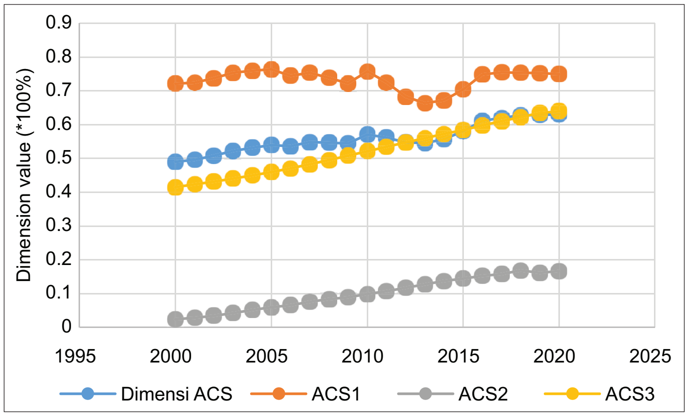
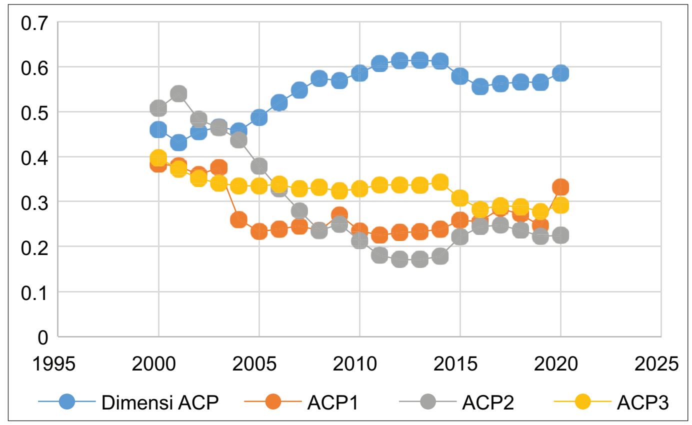


Figure 3: Dimension of acceptability of ASEAN



4.3.2. Accessiblity dimensions

Table 9 shows the result of PCA output of accesibility dimension, in which only comp1 is chosen since the component above the eigenvalue of 1. The contribution of each indicator that forms the accessibility dimension, namely the electrification ratio (normal_acs1) of 40.34%, motor vehicle ownership (normal_acs2) of 19.60%, and access to clean energy (normal_acs3) of 40.04% as shown in the tabel 10. The standard weight for component 1 is 100% which is then multiplied by the component to obtain accessibility dimensions.

Figure 2 shows the value of the ASEAN accessibility dimension which tends to increase with an average dimension value of 55.9%. The countries with the largest availability dimension values are Brunei, Malaysia, and Singapore with dimension values greater than 80%. This is due to the dimensional forming factors themselves, namely ACS1, ACS2 and ACS3. Even in Brunei, Malaysia and Singapore have an electrification ratio and access to clean technology reaching 100%. In addition, from a general basis in all ASEAN countries the three indicators of electrification ratio, motor vehicle ownership and access to clean technology have continued to increase since the year 2000.

4.3.3. Acceptability dimension

Some studies define the dimension acceptability as the dimension of sustainability and environment (Shadman et al., 2022).). Table 11 shows the result of PCA output of acceptability dimension, in which only comp1 is chosen since the component above the eigenvalue of 1. The contribution of each indicator that forms the dimension of acceptability, namely emissions per energy consumption (normal_acp1) of 19.89%, emission intensity (normal_acp2) of 38.70% and the share of NRE renewable energy production to total production primary energy (normal_acp3) of 41.40% as shown in the table 12.

Figure 3 shows the value of ASEAN's acceptability dimension which tends to increase with an average dimension value of 54.4%. The countries with the largest availability dimension values are Laos, Singapore, and Cambodia with values of 73%, 86% and 96%, respectively. The high value is because the three countries produce the least CO2 emissions when compared to other countries in ASEAN.

In general, the number of emissions per energy consumption and emission intensity in ASEAN tend to decrease. This is due to the commitment of both global and regional governments to include environmental aspects and climate change in development activities. The decline in ACP3 indicates a smaller growth in renewable energy production than the growth in total production of fossil-based primary energy. This is supported by the issue of the

Table 11: Principal component analysis output of acceptability dimension

Components	Eigen value	Difference	Proportion	Cumulative
Comp1	1.593	0.642	0.531	0.531
Comp2	0.951	0.495	0.317	0.848
Comp3	0.456		0.152	1.000
Principal components/ correlation		Number of obs		210
		Number of comp		3
		Trace		3
Rotation: Unrotated=Principal		Rho		1.0000

Table 12: Weight values and contribution of acceptability dimensions

Variables	Comp 1	Weight	Contribution
Normal_acp1	0.331	0.00105626	0.198918
Normal_acp2	0.644	0.00205507	0.387019
Normal_acp3	0.689	0.00219867	0.414063
Total	1.664	0.00531	1
Proportion	0.531		
Cumulative proportions	0.531		
Standard weights	1		

Source: Processed

Table 13: Principal component analysis output of efficiency dimensions

Components	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.190	0.379	0.595	0.595
Comp2	0.810		0.405	1.000
Principal components/ correlation		Number of obs		210
		Number of comp		2
		Trace		2
Rotation: Unrotated=Principal		Rho		1.0000

Source: Processed

EIA (2020) that renewable energy production has only experienced a small increase even in some countries tends to stagnate.

4.3.4. Efficiency dimension

Table 13 shows the result of PCA output of efficiency dimension, in which only comp1 is chosen since the component above the eigenvalue of 1. The contribution of each dimension-forming indicator, namely energy intensity (normal_eff1) and power distribution loss (normal_eff2) of 50% each as shown in the table 14. The standard weight for component 1 is 100% which is then used to obtain accessibility dimension values.

Table 14: Weight values and contribution of efficiency dimension

Variables	Comp 1	Weight	Contribution
Normal_eff1	0.707	0.002975	0.5
Normal_eff2	0.707	0.002975	0.5
Total	1.414	0.00595	1
Proportion	0.595		
Cumulative proportions	0.595		
Standard weights	1		

Source: Processed

Figure 4 shows the value of ASEAN efficiency dimensions that tend to stagnate throughout the 2000-2020 period with an average dimensional value of 36.5%. The countries with the largest availability dimension values are Malaysia, Thailand and Indonesia with each 63%; 63%; and 51%. The structure of such dimensional shapers EFF1 and EFF2 has an inverse relationship with the dimension value. EFF 1 has a downward trend due to the growth rate of energy consumption that is smaller than GDP growth. However, the trend of power distribution loss EFF 2 tends to fluctuate.

4.3.5. Energy security index

Table 15 shows the result of PCA output of energy security index, in which only comp1 is chosen since the component above the eigenvalue of 1. Table 16 shows the eigenvalues and the proposed values of the four dimensions used namely availability (AVA), accessibility (ACS), acceptability (ACP) and efficiency (EFF) obtained from previous PCA calculations. Table 16 shows the weight and contribution values of each dimension that make up the energy security index, namely AVA at 27.17%, ACS at 25.40%, ACP at 19.09% and EFF at 28.33%. The standard weight for component 1 is 100% which is then used to obtain the access dimension value ibility.

Table 15: Principal component analysis output of energy security index

Components	Eigenvalue	Difference	Proportion	Cumulative
Comp 1	2.441	1.471	0.610	0.610
Comp 2	0.971	0.652	0.243	0.853
Comp 3	0.319	0.051	0.080	0.933
Comp 4	0.269		0.067	1.000
Rotation: Unrotated=Principal		Rho		1.0000

Table 16: Weight value and contribution of energy security index

Variables	Comp 1	Weight	Contribution
AVA	0.538	0.00165747	0.271717
ACS	0.503	0.00154965	0.25404
ACP	0.378	0.00116455	0.190909
EFF	0.561	0.00172833	0.283333
Total	1.98	0.0061	1
Proportion	0.61		
Cumulative proportions	0.61		
Standard weights	1		

Source: Processed. AVA: Availability, ACS: Accessibility, ACP: Acceptability, EFF: Efficiency

Figure 5 shows the ASEAN energy security index formed by four dimensions with an average of 45.9%. The average value of the dimensions of availability, accessibility, acceptability, and efficiency was 25.2%, respectively; 55.9%; 54.4%; and 36.5%. The trend tends to stagnate during the period 2000-2020. The five countries with the highest energy security index value in ASEAN include Malaysia at 85%; Thailand 74%; Indonesia 62%; Singapore 61%; Brunei 54%. The value may differ according to the difference in the indicators used.

4.4. Panel Regression

Table 17 shows the regression results of the FGLS panels for index (Model 1) and dimensions (Model 2) of energy security on economic growth. The energy security index has a significant

Figure 4: ASEAN efficiency Dimension 2000-2020

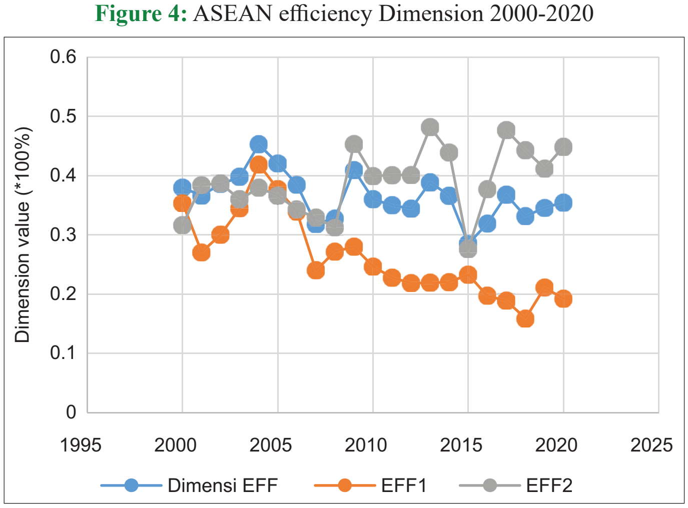
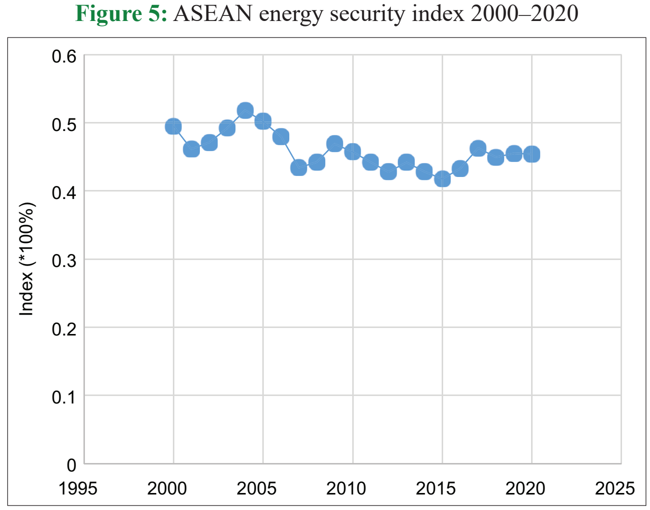


Figure 5: ASEAN energy security index 2000–2020



Source: Processed

positive influence on economic growth with a coefficient value of 0.538. This shows that a 1% increase in energy security increases economic growth by 0.538% assuming the average and other variables are considered constant.

The dimensions of availability (AVA), accessibility (ACS) and acceptability (ACP) have a positive influence on ASEAN economic growth (Model 1). The dimensions of AVA, ACS and ACP have coefficient values of 0.598; 0.723; and 0.538, respectively. This means that a 1% increase in availability, access to bility and acceptability increases economic growth by 0.598%; 0.723%; and 0.538% respectively with assumptions of averages and other variables is considered constant. The efficiency dimension has a positive coefficient value of insignificant effect on ASEAN economic growth.

Both model 1 and model 2 of capital (lnCAPITAL), labor (lnLABOR), trade (lnTRADE) and world oil prices (lnOP) have a significant positive influence on growth economy (lnGDP). Capital has coefficients of 0.943 (Model 1) and 0.738 (Model 2) which indicates that a 1% increase in capital will increase economic growth by 0.943% (Model 1) and 0.738% (Model 2) assuming other variables are constant.

Table 17: Feasible generalized least square estimation results

lnGDP	Coefficient (SE)	
	Model 1	Model 2
ES_INDEX	0.258* (0.146)	-
AVA	-	0.598*** (0.204)
ACS	-	0.723** (0.287)
ACP	-	0.538*** (0.185)
EFF	-	0.102 (0.132)
LnCAPITAL	0.943*** (0.033)	0.738*** (0.073)
LnLABOR	0.044** (0.019)	0.2*** (0.054)
LnTRADE	0.028** (0.012)	0.025** (0.012)
LnOP	0.199*** (0.053)	0.221*** (0.05)
Constant	0.783* (0.478)	2.331*** (0.65)
$P>\chi^2$	0.000	0.000
χ^2	3855.506	4548.900
AIC	17.191	4.055
Jarque-fallow test=0.8098, χ^2=0.667		

AIC: Akaike criterionm, AVA: Availability, ACS: Accessibility, ACC: Acceptability, EFF: Efficiency, SE: Standard deviation, lnGDP: influence on growth economy

Labor has coefficients of 0.044 (Model 1) and 0.2 (Model 2) indicating that a 1% increase in the workforce will increase economic growth by 0.044% (Model 1) and 0.2% (Model 2) assuming averages and other variables are considered constant.

Trade has coefficients of 0.028 (Model 1) and 0.025 (Model 2) indicating that a 1% increase in trade will increase economic growth by 0.0 28% (Model 1) and 0.025% (Model 2) assuming the average and other variables are considered constant. As for the world oil price, it has coefficients of 0.199 (Model 1) and 0.221 (Model 2) which indicates that an increase of 1% of the world oil price will increase economic growth by 0.1 99% (Model 1) and 0.221% (Model 2) assuming the average and other variables are considered constant.

Table 17 indicates the probability value for the JB normality test with a p-value higher than 0.05. This indicates that the distributed data is normal. A chi-2 probability value smaller than alpha 0.05. This indicates that, simultaneously, the independent variables used in Model 1 and Model 2 have a significant effect on economic growth.

The partial test t of each independent variable also has a significant value. The value of each P-value that is smaller than the 5% alpha significance level, except for the EFF is insignificant. This means that partially each independent variable affects economic growth in both Model 1 and Model 2. Table 18 shows the regression results of the PLS, REM and FEM panels for the robustness of the main FGLS models. The results show that in general the direction of the coefficient is equal to not much different values, except that the dimension values of EFF and ACS indicate the value of the

Table 18: Panel estimation results of PLS, REM, FEM

lnGDP	PLS		REM		FEM	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
ES_INDEX	0.258 (0.165)		0.258 (0.222)		1.013 (0.564)	
AVA		0.598*** (0.153)		0.598* (0.328)		0.130 (0.198)
ACS		0.723*** (0.252)		0.723 (0.554)		-0.869 (0.707)
ACP		0.538*** (0.189)		0.538 (0.334)		3.138*** (0.845)
EFF		0.102 (0.115)		0.102 (0.183)		-0.0501 (0.115)
lnCAPITAL	0.943*** (0.0383)	0.738*** (0.0738)	0.943*** (0.0462)	0.738*** (0.109)	0.561*** (0.0839)	0.317*** (0.0742)
lnLABOR	0.0436* (0.0237)	0.200*** (0.0531)	0.0436* (0.0231)	0.200** (0.0899)	0.498 (0.290)	0.869** (0.317)
lnTRADE	0.0279*** (0.00959)	0.0249*** (0.00920)	0.0279 (0.0218)	0.0249* (0.0149)	0.0881** (0.0268)	0.0484* (0.0253)
lnOP	0.199*** (0.0537)	0.221*** (0.0525)	0.199 (0.124)	0.221** (0.110)	0.290** (0.106)	0.0743 (0.0953)
_cons	0.783 (0.619)	2.331*** (0.785)	0.783 (0.815)	2.331** (1.094)	2.658 (5.532)	2.314 (3.627)
Mean depentenet variable	25.485	25.485	25.485	25.485	25.485	25.485
R^2	0.970	0.975			0.867	0.944
Overall R^2			0.970	0.975		
F-test	969.911	1150.777			61.009	
χ^2			3176.437	243725.314		
SD dependent var	1.435	1.435	1.435	1.435	1.435	1.435
P>F	0.000	0.000			0.000	
$P>\chi^2$			0.000	0.000		
Wald test Heteroskedasticity ($P>\chi^2$)			0.000			

Standard errors in parentheses *P<0.10, **P<0.05, ***P<0.01. AVA: Availability, ACS: Accessibility, ACC: Acceptability, EFF: Efficiency negative coefficient are insignificant on the model FEM. But the model has problems in the test of the classical assumption of heteroscedasticity.

4.5. Discussion

The results of this study show that the energy security index and dimension have a significant positive influence on ASEAN's economic growth, except for the efficiency dimension. This statement supports the findings of Le and Nguyen (2019) who state something similar. The availability dimension (AVA) describes how the condition of a country (in this case ASEAN) has sufficient energy supply from domestic resources, encourages energy production, diversifies energy supply and has final energy adequacy (Erahman et al., 2016). The availability dimension reflects supply with energy demand as well as national energy supply capacity and resource equalization, which implies the higher the value of that dimension the higher the level of energy security. The positive influence of the availability dimension on economic growth suggests that higher energy supply capacity to meet energy demand can drive economic growth.

The accessibility dimension has a significant positive influence on ASEAN's economic growth. Higher accesibility dimension score will positively contribute to economy growth. Erahman et al. (2016) defines the dimension of accessibility as the ability to have sufficient access to commercial energy. The dimension of accessibility in this research is related to access to electricity technology and infrastructure. In the production function of Cobb-Douglas explains how technology plays a role in driving output productivity. Technology creates cost and time efficiencies in producing output. Kyriakarakos et al. (2020) in the study stated that the existence of access to electricity increases output productivity In the Africa.

The dimension of acceptability in this study shows a positive influence on ASEAN economic growth. Higher acceptability dimension score will positively contribute to economy growth. The dimension of acceptability is related to the activities of minimizing the impact of global warming (Erahman et al., 2016). Dimension of acceptability describes the impact of energy production and utilization on economic and environmental aspects (Fang et al., 2018). The development of renewable energy in strengthening energy production supply capacity. The higher these dimensions indicate the lower the dependence on fossil energy for consumption. The reduction in carbon emissions from energy consumption measures the ability to develop energy security.

The positive influence of the acceptability dimension illustrates that renewable energy production provides a positive impetus to the economy. This is in accordance with the findings of Armeanu et al., (2017) and Inglesi-Lotz (2016) which state that non-fossil energy consumption has a positive impact on economic growth. Therefore, this finding supports the use of environmentally friendly energy resources. In addition, the use of environmentally friendly energy in economic activities reduces dependence on energy imports and vulnerability to oil and gas prices in the global market (Le and Nguyen, 2019).

Erahman et al. (2016) defines efficiency as the ability to have minimum energy consumption for the same service and minimize energy loss up to the end user. The decrease in energy intensity shows an increase in energy efficiency and has a good effect on energy security. Interestingly, the efficiency dimension in this study has not shown a significant influence on ASEAN economic growth, even though it has the largest contribution in shaping the energy securirty index. In addition, the efficiency dimension has the least coefficient when compared to other dimensions. This indicates that ASEAN's energy use is not yet efficient. The trend of power distribution losses continues to increase while the decreasing energy intensity may indicate wasteful energy use and suboptimal energy use so that a lot of power was wasted. This of course needs to be a concern for the government to optimize energy management from upstream to downstream to the community, especially related to distribution and energy transmission.

According to the result, the role of energy has the second largest contribution after capital. This supports the theory of the expansion of the Cobb-Douglas production function that energy is an important input to the economy and energy security has a positive impact on economic growth. This is indicated by the positive value of the energy security index to ASEAN economic growth. The higher the energy security of a country, the higher its influence in encouraging economic activity.

The results showed that capital contributes the most to its influence on ASEAN's economic growth. This supports the research of Le and Nguyen (2019); Fang and Chang (2016); Ahmad and Du (2017) who stated that capital has a positive influence on economic growth. These results are in accordance with the framework of the Cobb-Douglas function used where the embetuation of capital is an important input of economic production. The effect of capital on economic growth due to capital formation can increase the stock of capital goods. The increase in capital increases production capacity which has implications for economic growth (Le and Nguyen, 2019).

Labor has a positive influence on economic growth. This supports Fang and Chang's (2016) research; Fang and Wolski (2016) and Kahia et al. (2017). The study stated that an increase in the number of workers has an impact on increasing the economic growth of a country. A larger number of workers increases the amount of productive labor (Todaro, 2003). Lewis (2013) posited that the excess of workers of one sector would contribute to the growth of output and employment in another sector.

Trade significantly affects the economy of a country. The results of this study state that trade has a positive influence in increasing ASEAN's economic growth and has a positive impact on economic growth. This statement is supported by the results of the research of Shahbaz et al. (2013); Ozturk and Acaravci (2013); Nasreen and Anwar (2014). In addition, trade can have an impact on increasing state income, foreign exchange reserves, capital transactions and increasing employment opportunities.

Trade plays a role in creating domestic competition and innovation which ultimately has implications for efficiency and economic growth. Trade tends to increase economic growth by increasing domestic productivity through innovation and technological development (Shahbaz et al., 2013; Alam and Murad, 2021). Trade also creates economies of scale through specialization (Nguyen and Le, 2019).

This study shows that oil prices have a positive impact on ASEAN's economic growth. The influence of oil prices is not directly on economic growth. Le and Nguyen (2019) where his research states that the price of energy has a positive impact on economic growth in upper-middle-income countries, when demand-side oil prices are driven by economic expansion, so higher oil prices will have a positive effect on economic activity. This explanation is appropriate for the case of upper-middle-income countries due to strong economic growth over the past few decades. Plante and Traum (2012) state that rising world oil prices are likely to result in increased investment and real GDP through the motive of increased prudential savings.

This research has many limitations, one of which is due to the availability of data, so that the use of indicators in forming indices and dimensions of energy security is relatively a little bit. The dimensions used in this study are only 4 dimensions, not including other dimensions such as affordability and political stability.

This study uses the FGLS estimation method which captures the effect of energy security on ASEAN economic growth, not looking at its effect on each country. In addition, this study does not try to explore the reciprocal relationship between energy security and economic growth. Several studies such as Kahia et al., (2017), Fang and Chang (2016), Nasreen and Anwar (2014) in the study showed a mutually influencing relationship between energy and economic growth.

5. CONCLUSION

This study aims to calculate energy security and analyze its effect on ASEAN economic growth using the PCA method and FGLS panel regression. Overall, this study shows that the higher energy security index and dimension have a positive influence on ASEAN's economic growth, except for the efficiency dimension. The positive influence of the availability dimension on economic growth suggests that higher energy supply capacity to meet energy demand can drive economic growth. The accessibility dimension has a significant positive influence on ASEAN's economic growth. This relates to access to electricity technology and infrastructure in driving output productivity. The acceptability dimension in this study shows a positive influence on ASEAN's economic growth. The positive influence of the acceptability dimension illustrates that the production of environmentally friendly resources gives a positive impetus to the economy. However, the efficiency dimension in this study has not shown a significant influence on ASEAN's economic growth.

The results also show that capital and labor have a positive influence on ASEAN's economic growth. The increase in capital increases production capacity while the increase in the larger labor force increases the number of productive laborers. Trade has a positive influence in increasing ASEAN's economic growth has a positive impact on economic growth. Trade plays a role in creating domestic competition and innovation which ultimately has implications for efficiency and economic growth. This research also shows that world oil prices have a positive impact on ASEAN's economic growth. If demand-side oil prices are driven by economic expansion, higher oil prices will have a positive effect on economic activity.

Based on the results of research and discussion, here are some suggestions that can be used as consideration for policy making and subsequent research:

1. Increasing the dimension of availability can be done by the application of energy diversification, an increase in renewable energy in energy production. Regional governments need to reduce electrification ratio gaps in some countries and build energy infrastructure to improve accessibility. In increasing the dimension of acceptability, the government needs to pay attention to environmental policies in economic activities and the use of green energy technology to encourage efficiency.
2. The suggestion for further research is to increase the number of indicators and dimensions of energy security with a longer period. In addition, there needs to be further exploration of its influence inthe context of each country.

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