



## Significance of Economic Activities in Environmental Protection: Evidence from a Panel of 4-ASEAN Economies

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### ABSTRACT

Environmental degradation is increasing gradually due to economic activities by the Association of Southeast Asian Nations (ASEAN). ASEAN energy center estimated 4.4% increase in the consumption of final energy among ASEAN nations in 2030 which is greater than the average growth rate of 1.44%. The current study empirically analyzes the impact of economic activities on environmental protection across four largest ASEAN economies (Indonesia, Thailand, Singapore and Malaysia) over a period of 1998-2018. In order to achieve this objective, the study employs several panel econometric tests; ADF, panel cross-sectional dependence, Johansen-Fisher panel cointegration, FMOLS and country specific long run output method. The study finds significant positive impact of non-renewable energy consumption (NRNC), GDP and labor force on CO<sub>2</sub> emission. Renewable energy consumption (RNC) has negative impact on CO<sub>2</sub> emission. As RNC causes reducing CO<sub>2</sub> emission in the sample ASEAN economies, the study suggests the policy makers to inductee effective policies to encourage the generation of renewable energy and its uses across ASEAN economies. While the generation of non-renewable energy should be discouraged as it promotes CO<sub>2</sub> emission.

**Keywords:** Economic Activities, Energy Consumption, GDP, ASEAN, FMOLS

**JEL Classifications:** R11, K32

### 1. INTRODUCTION

Many researchers in the current era consider environment as a main area of interest in ASEAN economies. Degradation of environment is one of the main hazards of these nations. It is a process of environment deterioration through depletion and extraction of natural resources like soil, air and water, habitats destruction, ecosystem's devastation and pollution etc. Environmental degradation changes the climate, due to which global temperature rises (Ito, 2017). Some of the main factors that damage the environment are renewable energy consumption: RNC, non-renewable energy consumption: NRNC, market price of gross domestic product: MGDP, gross fixed capital formation: GFCF, labor force: LBR and remittances received: RR.

Energy consumption (EC) is increasing gradually due to economic activities (RNC, NRNC, MGDP, GFCF, LBR and RR) by Association of Southeast Asian Nations (ASEAN). ASEAN energy center estimated 4.4% increase in the consumption of final energy among ASEAN nations in 2030 which is greater than the average growth rate of 1.44%. However, the current level of CO<sub>2</sub> omission (COE) in ASEAN nations are relatively small as compare to US and China, but in 50 years ahead, ASEAN state is foreseen to be most pretentious by the increment of COE. Consequently, this might be suitable for the government of the ASEAN nations to generate electricity through most appropriate and beneficial sources that have less contributions in increasing COE as different apparatuses and machines that are used in the EC process, are omitting CO<sub>2</sub> that adversely affects environmental quality. Global warming and the changes

in climate become the biggest hazard for the people of ASEAN nations in 21<sup>st</sup> century.

Economic growth (EG) is an increase in per head level of production of services and goods over a particular period of time. It is measured as a percentage increase in gross domestic product (GDP). EG rate is an annual growth rate in GDP between current and prior year. GDP increases with the rise in the production of services and goods. A nation's economy utilizes labor, energy, raw material and capital in the production of services and goods. In this process of production, raw material such as minerals, trees, water and metals are mined from environment which causes environment degradation (Alper and Oguz, 2016).

In the light of above debate the current study empirically analyzes the impact of economic activities “(renewable energy consumption: RNC, non-renewable energy consumption: NRNC, market price of gross domestic product: MGDP, gross fixed capital formation: GFCF, labor force: LBR and remittances received: RR)” on “environmental protection (EP) across four largest ASEAN economies over a period of 1998-2018. In order to achieve this objective, the study employs several panel econometric tests; Johansen-Fisher panel cointegration test for long run association among variables and FMOLS (fully modified least square) method.”

Some of the recent studies by Jebli (2016), Dogan and Seker (2016b) and Mbarek et al. (2016) and various other studies have prolonged the work on RNC and COE in different contexts. The findings of these researches in this specific aspect of debate are questionable yet. Most of these researches have considered real GDP or GDP within their work. The current research considers market price of GDP (MGDP) LBR, RNC, NRNC, GFCF, and RR as explanatory variables for COE. In this context, the current study crumbles casual effects of RNC and NRNC on COE. Additionally, this study brings a new dimension by taking into consideration the top four ASEAN economies. Therefore, the current study fills the existing gap in the debate of ASEAN economies.

The remaining work is structured as follows: Section 2 comprises of brief review of literature; this section also has outlined the hypotheses. Section 3 is about the data and methodology, section 4 presents the empirical findings, and lastly section 5 presents the conclusions along with policy implications.

## 2. LITERATURE REVIEW

Salahuddin and Khan (2013) disclosed that energy consumption (EC) had a direct impact on CO<sub>2</sub> emissions (COE) in Australia. They used the data from 1965 to 2007 and forecasted the relationship between energy consumption and COE. They concluded that coming 10 years might be beneficial for the creation of future energy policy for Australia. Haruna and Mahmood (2018) examined the impact of EC on COE and found that EC caused environment pollution in short as well as in long term. Hasnisah et al. (2019) explored the affiliation between EC and environment quality (COE) using the data of 13 developing countries in Asia for a period of 1980-2014. They found that EC was inversely

related with the quality of environment as higher EC reduced the quality of environment by increasing COE. Halicioglu (2009) utilized the data from Turkey for examining the influence of EC on the quality of environment and found that EC adversely affected the environment quality. Ito (2017) studied the causal relation between EC and COE using the data of 28 provinces of China from 1995-2007 and observed that the quality of environment and EC moved in opposite direction. Alper and Oguz (2016) reported the association between bio-mass energy consumption and COE in Africa from the period of 1980-2010 and found that increase in mass EC reduced the quality of environment. Mass energy consumption increased the COE which in turn increased the environment pollution that ultimately reduced the quality of environment. Shahbaz et al. (2018) also showed a direct relationship between energy consumption and COE. Similarly, Alvarado and Toledo (2017) and Ang (2007) also found a positive association between EC and COE.

Holladay (2016), by using the Chinese provincial data, found the presence of direct linkage between GDP and COE. Alper and Oguz (2016) used the data of eight European member nations to examine the impact of economic progress (GDP) on COE and found significant connection between COE and GDP. Aremu et al. (2014) also analyzed the association between COE and GDP and found a long run association between GDP and COE. Kahuthu (2006) said that there was inverted U-shape interaction between GDP and COE. He confirmed the EKC (environment-Kuznet curve) in global context. Vaaler (2011) examined the influence of remittances received (RR) on COE. For this purpose, the study utilized the data of 12 developing nations over the period of 2002-2007 and showed direct effect of RR (a positive shock tends to increase COE, while a negative shock tends to reduce COE) on COE. Ahmad et al. (2019) also concluded a direct relationship between RR and COE by applying NARDL model. The study was conducted in China by using the data over the period of 1980-2014. Findings also revealed that as compare to a negative shock in RR, the effect of positive shock has more significant contributions in increasing COE. Fragiadakis et al. (2019) investigated the impact of human labor on COE and revealed that there was a positive relationship between human labor and COE. The study suggested that human labors were degrading the environment in the form of traveling and deterioration. Rahman and Ahmed (2019) worked on the relationship between gross fixed capital formation (GFCF) and COE. Using the data of Pakistan over the period of 1980-2018. The study revealed a non-linear relationship between GFCF and COE. Stupnikova and Sukhodolets (2019) found a positive influence of GFCF on COE by using the data of Russia over the period of 2000-2016.

Huang et al. (2019) considered the effect of FDI on the productivity of environment; known as “green total factor productivity (GTFP).” The findings of their study showed positive effect of FDI on GTFP. Li et al. (2019) explored the role of FDI on environmental performance (EP). The authors concluded that FDI had insignificant contribution in EP. Zheng and Sheng (2017) tested the pollution harbor hypothesis and found a positive contribution of FDI in increasing the COE. Cole et al. (2017) explored the association between FDI and ED and concluded a

direct interaction between FDI and ED. Perkins and Neumayer (2012) conducted their research for examining the influence of FDI on ED. For this purpose, they utilized the data of 77 countries and observed a positive impact of FDI on ED and concluded that FDI directly contributed in increasing the COE. This effect was most obvious in the host countries. Awan and Shahzad (2018) studied the association between COE and poverty (PV) in Pakistan over the period of 1974-2016 and found a direct relationship between COE and PV. They considered environment as a basis for the survival of poor people that became suspected when the environment was deteriorated. The authors found that rural poor were depended on the natural environment for almost everything like nutrition, beverage, medication, petroleum, and building material, in doing these things, the environment was devastated. Panayotou (2016) used the data of Bangladesh for examining the relationship between COE and PV and found a positive link between COE and PV. Similarly, Aggrey (2010) used the data of Katanga basin and found a positive impact of COE on PV reduction and suggested that a flourishing environment was a main index for sustainable progress and the toxic environment condition executed adverse effects on the residents. Ravnborg (2003) also showed a positive link between COE and PV in Nicaraguan Hillside and suggested that the government should make such policies that reduce PV. Aremu et al. (2014) quantified the association between (population) PP and COE, in the case of India and found a positive linkage between PP and COE. Their findings concluded that increase in PP contributed to the deterioration of land that ultimately increased COE. Sherbinin et al. (2007) studied the connection between size of PP and COE and concluded that there was a positive link between size of PP and COE. Shi (2003) investigated the impact of PP on COE using the panel data of 93 nations for the period of 1975-1996 and found a positive interaction between PP and COE. This relation was found to be more obvious in developing countries.

Hypotheses:

- H<sub>1</sub>: There is an impact of RNC and NRNC on COE.  
 H<sub>2</sub>: "There is significant relationship between MGDG and COE.  
 H<sub>3</sub>: There is significant positive relationship between RR and COE.  
 H<sub>4</sub>: "There is significant positive relationship between GFCF and COE.  
 H<sub>5</sub>: LBR has positive impact on COE.

### 3. DESIGN OF RESEARCH AND METHODOLOGY

This section presents the data, sample, data source, data period, variables and their measurements and analytical techniques used in the study.

#### 3.1. Data and Sample

The study considers four ASEAN economies that are believed to be at the top of the list of ASEAN countries. The study constructs the set of panel data using a time period of 1998-2018, each cross section consists of 21 observations. The countries considered for the study are following: Indonesia, Thailand, Singapore and

Malaysia. The data of COE and NRNC are obtained from global and trading economy and MGDG, CP, LBR, RNC, RR, PV, PP and FDI are gathered from WDI (World Bank data base).

#### 3.2. Variables and their Measurements

Environmental protection (EP) is used as dependent variable and is measured as the total CO<sub>2</sub> emission (COE) due to energy consumption. Economic activities (ECAC) are measured as explanatory variables. ECACs are market price of gross domestic product (MGDP), renewable energy consumption (RNC) and non-renewable energy consumption (NRNC), gross fixed capital formation (GFCF), labor force (LBR) and remittances received (RR). MGDG is measured as the market price of GDP in current USD. RNC is the sum of solar, wind, traditional & modern biomass, waste, hydro, geothermal, biogas, biofuels and marine sources in TJ (terajoule). NRNC is the sum of petroleum, gas and coal in qBtu (quadrillion Btu). GFCF is measured as gross fixed capital formation in current USD. LBR represents total working population with aged 15 and more. RR consists of personal compensations and transfers of employees. "Personal transfers include current transfers in cash (or in kind of cash) received or made by resident households to or from nonresident households." RR is measured in current USD. The study also uses poverty (PV), population (PP) and foreign direct investment (FDI) as control variables. Poverty (PV) is defined as the "state of being extremely poor." It is a situation of not having enough possession of material or sufficient income to fulfill basic needs. It is a multilayered concept which includes political, social and economic elements. It is measured as headcount ratio at national lines as a percentage of total population. This headcount ratio is a percentage of people living below the poverty line. FDI is defined as "an investment of another country in a business." The study measures FDI as percentage of GDP. PP refers to "the collection of humans." It consists of the number of people living in a specific region, town, city, country or world. It is determined through a particular process known as census. It is measured as a total number of people (in millions) in a country. All the measurements of the study variables are in different units. Therefore, before analysis, the study converts all the variables into single or uniform unit. As guided by prior researchers (e.g., Bhattacharya et al., 2016), the study converts all the variables into logarithm natural to avoid the problems of distributive properties of series of data.

#### 3.3. Analytical Techniques

The study uses following analytical techniques to analyze the data: panel correlation matrix, panel unit root test, Johansen-Fisher panel cointegration test, FMOLS (panel fully modified ordinary least square) method and country-specific long-run output elasticities. The study empirically examines the impact of ECACs on EP in selected ASEAN economies, for this purpose, the study uses following model:

$$COE_{it} = f(MGDG_{it}, RNC_{it}, NRNC_{it}, GFCF_{it}, LBR_{it}, RR_{it}, PV_{it}, FDI_{it}, PP_{it}, v_t)$$

Where; "COE: CO<sub>2</sub> emission, MGDG: MARKET price of gross domestic product, RNC: Renewable energy consumption, NRNC: Non-renewable energy consumption, GFCF: Gross fixed capital formation, LBR: Labor, RR: Remittances received,

PV: Poverty, FDI: Foreign direct investment, PP: Population: v: Individual fixed country effects. *i* and *t* denote time and country, respectively.”

As discussed above, as all the variables are in different units, the study converts all the variables into logarithm natural and develops following model:

$$LCOE_{it} = \alpha_0 + a_1LMGDP_{it} + a_2LRNC_{it} + a_3LNRNC_{it} + a_4LGFCF_{it} + a_5LLBR_{it} + a_6LRR_{it} + a_7LPV_{it} + a_8LFDI_{it} + a_9LPP_{it} + v_i$$

Where; “LCOE: log of CO<sub>2</sub> emission, LMGDP: Log of market price of gross domestic product, LRNC: Log of renewable

energy consumption, LNRNC: Log of non-renewable energy consumption, LGFCF: Log of gross fixed capital formation, LLBR: Log of labor, LRR: Log of remittances received, LPV: Log of poverty, LFDI: Log of foreign direct investment, LPP: Log of population: v: Individual fixed country effects. *i* and *t* denote time and country, respectively.”

### 4. RESULTS

The Table 1 shows the multicollinearity (Panel A) and cross-sectional dependence test (Panel B). The correlation among the study variables is shown is Panel A of Table 1. The outputs show that COE is positively correlated with MGDGP and NRNC

**Table 1: Multicollinearity and cross-sectional dependence tests**

Variables	Panel A: Panel correlation matrix										Panel B: Cross-sectional dependence	
	COE	MGDP	RNC	NRNC	GFCF	LBR	RR	PV	FDI	PP	P-value	Lag length
COE	1										0.821	3
MGDP	0.36	1									0.148	1
RNC	-0.43	-0.51	1								0.892	2
NRNC	0.41	0.37	0.49	1							0.214	1
GFCF	0.28	0.21	0.37	0.32	1						0.297	1
LBR	-0.08	-0.50	0.24	0.54	-0.23	1					0.391	4
RR	0.19	0.36	0.09	0.61	0.17	0.45	1				0.341	1
PV	0.17	0.26	0.16	0.32	0.28	0.33	0.21	1			0.426	1
FDI	0.31	0.43	0.12	0.07	0.39	0.27	0.35	0.11	1		0.278	2
PP	-0.29	-0.18	0.08	0.33	-0.47	0.05	0.44	0.21	0.23	1	0.793	1

**Table 2: Augmented Dickey-Fuller unit root test**

Variable	At level		First difference	
	ADF statistics	Critical value	ADF statistics	Critical value
COE	-1.93482 (0.48325)	1%Level	-6.98214*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
MGDP	-1.98324 (0.39625)	1%Level	-9.37151*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
RNC	-2.84212 (0.12745)	1%Level	-13.68545*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
NRNC	-0.28541 (0.24853)	1%Level	-7.38541*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
GFCF	-4.38532*** (0.00000)	1%Level	-5.39325*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
LBR	1.63251 (0.63214)	1%Level	-4.68314*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
RR	0.93251 (0.83214)	1%Level	-6.14287*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
PV	-4.63587 (0.00254)***	1%Level	-11.93218*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
FDI	1.47853 (0.48321)	1%Level	-4.68743*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level
PP	0.93512 (0.58742)	1%Level	-3.45852*** (0.00000)	1%Level
		5%Level		5%Level
		10%Level		10%Level

“The (\*\*\*) indicates the rejection of null hypothesis at 1% of level of significance.”

while inversely correlated with RNC. However, the highest coefficient is 0.54 stating that the data are free from the problem of multicollinearity. The study also applies Pesaran (2004) test to analyze the cross-sectional dependence in data. For this test, the null hypothesis is set as “the cross-sections are independent”. The outputs of this test are provided in the Panel B of Table 1. The outputs show that the null hypothesis is accepted, implying that the panels’ cross-sections are independent. Therefore, it forces the study to conduct a panel unit root test.

The variables’ order of integration is analyzed through ADF test. The outputs of this test are shown in Table 2. This test has the null hypothesis (unit roots: non-stationary) against an alternative hypothesis (no unit roots: stationary). The results of ADF test accept the null hypothesis at level for all the variables (except PV and GFCF). Although, when the test is used to first difference of the data series, the null hypothesis is rejected at 1% level for all the variables, indicating that all the study variables are having same order of integration; I(1). The outputs of ADF report that there may exist a long run association among the variables.

**Table 3: Johansen-Fisher Cointegration and panel FMOLS tests**

Panel A: Johansen-Fisher Cointegration test				
CE(s)	Trace stat.	P-value	Max. Eigen value	P-value
None	328.24	0.0000***	293.275	0.0000***
At most 1	283.674	0.0000***	104.64	0.0000***
At most 2	191.342	0.0000***	93.241	0.0000***
At most 3	89.345	0.0000***	68.371	0.0000***
At most 4	31.242	0.3481***	31.242	0.3481***

\*\*\* indicates rejection of no cointegration at 1%”

Panel B: Panel FMOLS test				
Variables	Coefficient	t-stat.	Std. Error	P-value
MGDP	0.0357	3.4921	0.0253	0.0000***
RNC	-0.0597	-4.3932	0.3421	0.0000***
NRNC	0.0831	3.4852	0.4621	0.0000***
GFCF	-0.0196	-0.2831	0.0932	0.4485
LBR	0.1175	5.3941	0.0496	0.0000***
RR	0.6314	0.4831	0.8214	0.6321
PV	0.4361	0.0597	0.6821	0.8321
FDI	0.4124	2.9721	0.4381	0.0024***
PP	-0.0932	-6.4972	0.0042	0.0000***

\*\*\*shows level of significance at 1%”

**Table 4: Country specific long-run outputs**

Variables	Indonesia		Thailand		Singapore		Malaysia	
	Coef.	P-value	Coef.	P-value	Coef.	P-value	Coef.	P-value
C	0.2541	0.0000***	1.2411	0.0000***	0.3714	0.0000***	0.5421	0.0000***
MGDP	0.1542	0.0000***	0.1441	0.0004***	0.1765	0.0051***	0.1258	0.0000***
RNC	-0.0921	0.0000***	-0.0693	0.0000***	-0.0842	0.0000***	-0.1145	0.0164***
NRNC	0.0512	0.0000***	0.0701	0.0496**	0.0354	0.0000***	0.0642	0.0000***
GFCF	0.5321	0.2641	0.6324	0.6341	0.3842	0.4975	0.3412	0.8321
LBR	0.0124	0.0212**	0.0434	0.0536**	0.0493	0.0284**	0.0284	0.0351**
RR	0.1287	0.3741	0.1423	0.5493	0.5412	0.1975	0.4632	0.5712
PV	0.6821	0.6421	0.8324	0.6712	0.0493	0.3541	0.3412	0.2831
FDI	0.0392	0.0176***	0.0901	0.0374**	0.0712	0.0154***	0.0482	0.0463**
PP	0.0214	0.0000***	0.0371	0.0000***	0.0248	0.0245**	0.0348	0.0000***
R <sup>2</sup>	0.7821		0.7124		0.6932		0.6154	

\*\*\* and \*\* shows level of significance at 1% and 5%, respectively”

As the panel unit root test confirms that the study variables have the integration order at the same level i.e., first difference, allowing the study to conduct Johansen-Fisher panel cointegration test to identify the long run association among variables. The outputs are presented in Panel A of Table 3. The findings show that there exists a significant long run association among COE, MGDP, RNC, NRNC, GFCF, LBR, RR, PV, FDI and PP in a panel of four ASEAN nations. The result reports that the study variables as a whole may reach at a point of equilibrium in long-run. The Johansen-Fisher test only confirms the long-run relationships but it does not indicate whether there is a positive or negative impact of explanatory variables on COE. Therefore, the study applies FMOLS test to analyze the impact. The outcomes of FMOLS are presented in Panel B of Table 3. The study finds significant positive impact ( $\alpha = 0.0357$ ,  $P < 0.01$ ) of MGDP on COE, reporting that one unit increase in MGDP causes to enhance COE in the environment by approximately 0.04 units, accepting  $H_2$ . NRNC has positive impact ( $\alpha = 0.0831$ ,  $P < 0.01$ ) on COE. The coefficient implies that a single unit increase in NRNC leads 0.08 units rise in COE. LBR also signifies a positive ( $\alpha = 0.1175$ ,  $P < 0.01$ ) role in increasing COE in the environment. It reports that one-point rise in LBR cause 0.12 units inclination in COE.  $H_3$  is supported. The RNC shows negative impact ( $\alpha = -0.0597$ ,  $P < 0.01$ ) on COE. The negative coefficient of RNC reports that one unit increase in RNC leads to decline the COE in the environment.  $H_1$  is also accepted. FDI (PP) has positive (negative) impact on COE. Moreover, the study could not find any significant impact of GFCG, RR and PV on COE.

The study further analyzes the country-specific long-run associations among the variables across the selected countries. The findings for individual countries are shown in Table 4. The findings report that RNC has significant negative effect on COE in all the sample countries. It causes to decrease COE by 0.0921 units in Indonesia, 0.0693 units in Thailand, 0.0842 units in Singapore and 0.1145 units in Malaysia. While NRNC causes to enhance COE in the sample countries as it has positive impact on COE. NRNC leads to increase 0.1542 units, 0.1441 units, 0.1765 units and 0.1258 units in Indonesia, Thailand, Singapore and Malaysia, respectively. MGDP also shows significant association with COE in all the sample countries. It leads to increase COE by 0.1542 units, 0.1441 units, 0.1765 units and 0.1258 units in Indonesia, Thailand, Singapore and Malaysia, respectively. For the sample countries, LBR also shows positive contribution in increasing the

COE in the environment, it causes to increase COE by 0.0124 to 0.0493 units. Moreover, the study does not find any significant contributions of GFCF, RR and PV in increasing COE. While the other control variables FDI and PP shows significant associations with COE.

## 5. CONCLUSIONS AND POLICY SUGGESTIONS

Environment degradation is increasing gradually due to economic activities (RNC, NRNC, MGDG, GFCF, LBR and RR) by Association of Southeast Asian Nations (ASEAN). ASEAN energy center estimated 4.4% increase in the consumption of final energy among ASEAN nations in 2030 which is greater than the average growth rate of 1.44%. The current study empirically analyzes the impact of economic activities “(RNC, NRNC, MGDG, GFCF, LBR and RR)” on “environmental protection (EP) across four largest ASEAN economies over a period of 1998-2018. In order to achieve this objective, the study employs several panel econometric tests; ADF, panel cross-sectional dependence, Johansen-Fisher panel cointegration, FMOLS and country specific long run output method.” Some of the recent studies by Jebli (2016), Dogan and Seker (2016b) and Mbarek et al. (2016) and various other studies have prolonged the work on RNC and COE in different contexts. The findings of these researches in this specific aspect of debate are questionable yet. Most of these researches have considered real GDP or GDP within their work. The current research considers market price of GDP (MGDP) LBR, RNC, NRNC, GFCF, and RR as explanatory variables for COE. In this context, the current study crumbles casual effects of RNC and NRNC on COE. Additionally, this study brings a new dimension by taking into consideration the top four ASEAN economies. Therefore, the current study fills the existing gap in the debate of ASEAN economies.

The findings of Johansen-Fisher test show that there exists a significant long run association among COE, MGDG, RNC, NRNC, GFCF, LBR, RR, PV, FDI and PP in a panel of four ASEAN nations. The result reports that the study variables as a whole may reach at a point of equilibrium in long-run. But Johansen-Fisher test only confirms the long-run relationships but it does not indicate whether there is a positive or negative impact of explanatory variables on COE. Therefore, the study also applies FMOLS test.

The findings of FMOLS report a significant positive impact of MGDG on COE, reporting that one unit increase in MGDG causes to enhance COE in the environment by approximately 0.04 units. NRNC has positive impact on COE. A single unit increase in NRNC leads 0.08 units rise in COE. LBR also signifies a positive role in increasing COE in the environment. It reports that one-point rise in LBR cause 0.12 units inclination in COE. The RNC shows negative impact on COE. The negative coefficient of RNC reports that one unit increase in RNC leads to decline the COE by 0.06 units. The study also analyzes the country-specific long-run associations among the variables across the selected countries. The findings report that RNC has significant negative effect on COE in all the sample countries. While NRNC causes to enhance COE in the sample countries as it has positive impact on COE. MGDG also

shows significant association with COE in all the sample countries. For the sample countries, LBR also shows positive contribution in increasing the COE.

Given the findings above, RNC causes reducing CO<sub>2</sub> emission in the sample ASEAN economies. The study therefore suggests the policy makers to inductee effective policies to encourage the generation of renewable energy and its uses across ASEAN economies. On the opposite, NRNC promotes CO<sub>2</sub> emission in the environment; the study implies that the generation of non-renewable energy should be discouraged, at least in the selected countries.

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