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How Energy Use, Financial Development and Economic Growth Affect Carbon Dioxide Emissions in Selected Association of South East Asian Nations?

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The relationship among economic growth, energy use, financial development, and carbon emissions (CO2) in the ASEAN nations is inspected in this study for the time period from 2000-2018. For examining aforementioned relationships, several econometric techniques are applied. The second-generation stationarity test is applied to investigate the integration order of the data series. This study uses these two CIPS and PESCADF unit root rest, and the results indicate that carbon emission is integrated at level I(0), and the rest of all are I(1). Further, the study employed panel cointegration test proposed by Kao and Johansen Fisher test and these tests validate the existence of cointegration among data series. The analysis revealed the existence of cointegration among data series. Moreover, to estimate the long and short-run relationships, Pooled Mean Group (PMG), Dynamic Ordinary Least Squares (DOLS), and Fully Modified Ordinary Least Squares (FMOLS) estimators are used. The impact of economic growth, energy consumption and financial development is found to be positive on CO2 emission. The outcomes suggest that economic growth, energy use and financial development increase CO2 emission in selected nine ASEAN economies.

Keywords: Energy use, economic growth, financial development, CO2, ASEAN countries.

INTRODUCTION

The growth in the economies causes higher usage of energy particularly electricity, which in turn, leads to augment the CO_2 emission. Besides, the increase in energy usage is also observed with the financial development of a country. However, the energy usage and CO_2 emissions vary with the levels of economic development in different countries. Over recent decades ASEAN nations have witnessed incredible economic development. The ASEAN region has now jointly categorized as the world's fifth leading economy with current collective Gross Domestic Product (GDP) equals US$ 2.8 trillion in 2017, while Asians are the third largest economy. Figure 1 reports the patterns of the total values of ASEAN GDP over time 2000-2017. It can be observed from the Figure that the GDP of ASEAN region has grown dramatically from 2000 to 2017. For the purpose of analysis, the current study used nine ASEAN economies to investigate the interrelationship among variables of interest. The countries are Thailand, Cambodia, Brunei Darussalam, Malaysia, Indonesia, Philippines, Myanmar, Vietnam, and Singapore.

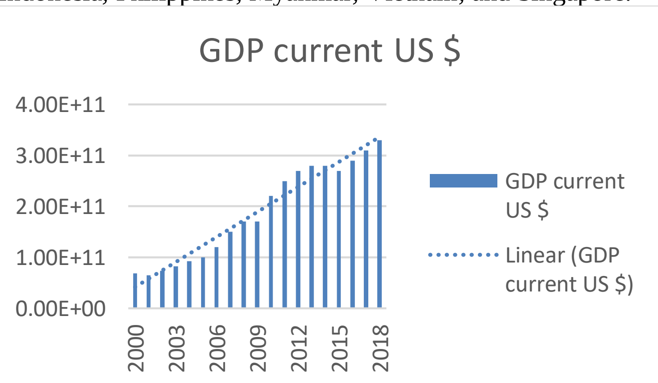

Figure 1: *ASEAN GDP total $US from 2000 to 2018*

A sharp economic growth continues from 2000 to 2008, which is hindered from the global financial crisis in 2009 where the GDP did not grow for one year. However, afterwards the growth continues its upward pattern. Moreover, from 2013 to 2015, a decline in economic growth is observed. Likewise, Figure 2 presents the GDP per capita of selected ASEAN countries. It is evident from Figure 2 that Brunei Darussalam and Singapore have the highest GDP per capita among all ASEAN economies throughout 2000 to 2018 and this gap with other ASEAN counties is increasing in every successive year.

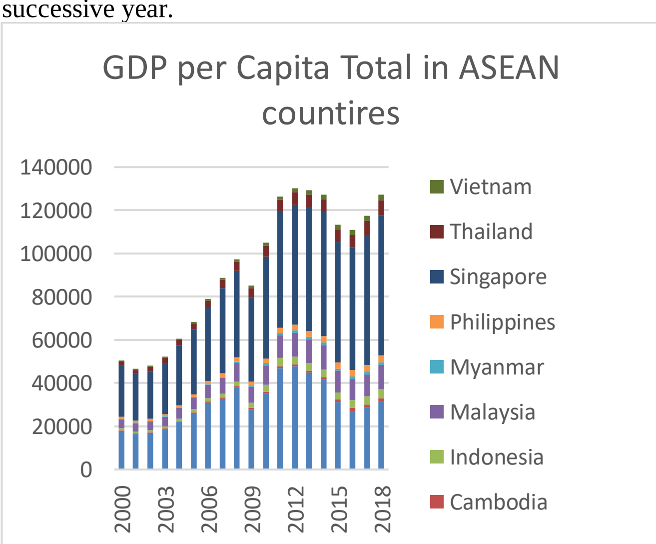

Figure 2: *GDP per capita $ US in selected 9 ASEAN countries*

The average GDP per capita measured in US dollars and the rank of selected ASEAN countries is presented in Table 1. It can be observed from Table 1 that highest per capita income in these ASEAN countries is Singapore while the lowest of them is Myanmar and the gap between these two countries despite being in the same region is huge (World Bank, 2020).

Table 1: ***GDP per capita in $US in ASEAN countries and ranking***

Countries	Average GDP per capita $ US	Rank
Singapore	42610.69	1st
Brunei Darussalam	30657.55	2nd
Malaysia	7910.032	3rd
Thailand	4424.491	4th
Indonesia	2420.32	5th
Philippines	1978.609	6th
Vietnam	1300.099	7th
Cambodia	785.5531	8th
Myanmar	729.4595	9th

The rapid growth of economic development in the ASEAN economies has given rise to increased energy use. The per capita energy use in these countries have exceeded the major advanced countries of other regions of the world (World Bank, 2020). The oil shocks of the 1970s impact on the energy demand and its composition in most of the countries around the globe. However, the impact of those shocks remained minimal in the context of ASEAN economies since their governments made use of their abundant and cheap energy sources to grow economies quickly. Since there is an evidence that domestic energy demand is rapidly increasing in ASEAN economies, therefore, there is a need to investigate the sustainable energy policies and the impact of energy use, economic growth (EG) and financial development (FD) on CO_2 emission in this region.

Therefore, this research investigates the long-run along with short-run associations amongst FD, EG, energy use, and CO_2 emission in selected nine ASEAN countries. Despite the research on CO_2 emissions is conducted in various countries and regions including ASEAN region, the findings of these studies are not consistent and ASEAN regions got limited attention in the literature. Therefore, the existing research attempts to fill the literature gap by employing recent techniques. Moreover, this research deals with policy discussion to regarding environmental impacts of energy use, FD and EG.

The remaining parts of the paper are as follows: the literature review is explained in the section two. Section 3 is devoted to the explanations of the estimation approaches applied. The fourth section, discussions of the findings are presented. The paper discusses policy suggestions and conclusions in the last section.

LITERATURE REVIEW

The current literature is dedicated to the link among environmental pollution, economic development, and consumption of energy. Numerous time series & panel data studies had been carried out on the correlation and cause and effect relationships among these variables. Saboori, Sapri, and bin Baba (2014) explored and assessed the long-run nexus amongst energy use, economic expansion, and CO_2 emission and for all OECD economies in the road transport sector. Employing the FMOLS technique, their findings revealed a two-way causality among CO_2 emission, energy use from transport and EG. Moreover, the researchers establish that most of the CO_2 emission is because of the effects of the use of energy. Additionally, the study emphasized on the need to move to further choices for energy, i.e., nuclear energy, renewable energy, biofuel energy and the significance of long-term strategies that purpose to increase the efficient use of energy.

Similarly, Hamdi, Sbia, and Shahbaz (2014) observed the association amid FDI, electricity use, economic growth, and capital in Bahrain. Their analysis of causality revealed a positive association between economic development and electricity use. Likewise, Cowan, Chang, Inglesi-Lotz, and Gupta (2014), using the sample of BRICS economies, establish the validity of the hypothesis of neutrality for china, India, and Brazil specifying that there is no nexus among consumption of electricity and economic development. Conversely, concerning the CO_2 emissions and GDP link, one-way causality was found between CO_2 emissions and GDP in Russia, while opposite causality was found for Brazil. Additionally, Sbia, Shahbaz, and Hamdi (2014) observed the empirical association among CO_2 emissions, economic development, trade openness and clean energy in UAE. They established that the demand for energy insignificantly related with carbon emissions, trade openness and FDI. The study by Alkhathlan and Javid (2013), in the context of Saudi Arabia, exposed a direct link between CO_2 emission and GDP growth. They also determined that as compare to other sources of energy, electricity makes less pollution.

Moreover, Ozcan (2013) verified the EKC hypothesis for twelve Middle-East economies from 1990 to 2008 using panel data. The study revealed an indication of U-shaped EKC for five countries and an inverse U-shaped EKC for three economies. However, for remaining four countries, this relationship was found to be insignificant. Moreover, Yii and Geetha (2017) checked the causation link among real output, consumption of energy, and CO2 emission GCC nations namely, Saudi Arabia, Kuwait, UAE, Bahrain, and Qatar for the time period 1980–2009. They also establish two way causation between energy use and CO_2 emission in the short-run.

Furthermore, Liao and Cao (2013), using a larger panel of 132 nation, found that economic environment, energy mix, population, trade, population density, and urbanization impact the CO_2 emissions. Likewise, Al-Mulali and Ozturk (2014) verified the pollution haven hypothesis (PHH) for the GCC economies. They studied the association of FDI with CO_2 emission. They found an inverse nexus among FDI and CO_2 emissions. Al-mulali, Sab, and Fereidouni (2012), employing the FMOLS, examined the relationship among CO_2 emissions, energy use, and urbanization and found a long-run nexus among said indicators for some countries.

In addition, Ziaei (2015) studied the impact of the FD on CO_2 emission and energy use. The outcomes unveiled a negative association between FD and CO_2 emission. Similarly, Boutabba (2014) inspected the long-run causality among trade openness, CO_2 emissions, FD, and energy use in India. The results showed a significant and positive long-run effect of financial development on CO_2 emission. Also, Chang (2015) observed the nonlinear association among income, FD and energy usage. The study analyzed the data for a panel 53 countries from 1999 to 2008. The results specify that financial expansion stimulates higher usage of energy. Likewise, Omri (2013) studied the causality among CO_2 emission, FD, and GDP growth in a panel of 54 economies. Their outcomes showed a uni-directional causality affiliation among CO_2 emissions and economic development in Sub Saharan, North African and Middle East nations and one-way causation among economic development and carbon emission for other regions and ASEAN nations (Nawaz, Azam, & Bhatti, 2019).

Furthermore, Ozturk and Acaravci (2013) investigated the effect of trade openness and financial development on per capital CO_2 emission. They found an insignificant association between FD and CO_2 emissions per capita for Turkey, which validate the EKC framework. Moreover, Shahbaz, Solarin, Mahmood, and Arouri (2013) applied ARDL in a time-series study of Malaysia to find out the cointegration among financial development and carbon emissions. Their results specify a significant and positive association among the variables. The outcomes suggest that more development of financial markets and economies tend to draw further investment and therefore increases industrialization, which augments energy usage and CO_2 emission. Moreover, Shahbaz, Hye, Tiwari, and Leitão (2013) investigated the association among CO_2 emissions, trade openness, usage of energy, financial development and GDP growth in Indonesia. Their finding showed a long-run association among the variables of interest. In a current panel study Al-Mulali and Ozturk (2014) maintained that energy usage upsurges due to financial development in GCC countries. Their findings showed a cointegration among financial development, total trade, urbanization and GDP. Additionally, Jalil and Feridun (2011) instituted that financial growth diminishes CO_2 emission, whereas Zhang and Cheng (2009) establish the reverse. Sadorsky (2011) inspected the outcome of financial expansion on the use of energy for 9 Eastern and Central European countries and revealed a positive association between these two variables. As observed in the literature, there are limited studies for the ASEAN nations on this problem and the findings reveal a mixed evidence. Thus, the objective of this research is to fill this gap in the literature.

METHODOLOGY AND DATA

The paper examined the environmental sustainability in the ASEAN countries, by estimating the influence of energy use, FD, and EG on carbon emission. So, the general form of the model will be as presented in Equation (1).

$$CE = f\,(EG, EU, FD) \quad \ldots \quad (1)$$

Where CE is carbon dioxide emissions, EG is economic growth, FD is the financial development and EU is the energy use in ASEAN countries. The econometrics model will be as presented in Equation (2).

$$CE_{it} = \alpha_o + \beta_1 EG_{it} + \beta_2 EU_{it} + \beta_3 FD_{it} + \epsilon_{it} \quad \ldots \quad (2)$$

Where α_o shows the coefficient of intercept and β_1, β_2 *and* β_3 shows the estimates for carbon dioxide emission from EG, energy use, and FD, respectively. To assess the model, following procedure is followed. Firstly, the test for cross-sectional dependency (CD) is conducted to confirm whether there is cross-dependency in the panel followed by an appropriate panel unit-root (CIPS) test. Secondly, Johansen-Fisher Panel and Kao-cointegration test were conducted, which confirms the long-term association between the variables. Lastly, DOLS, FMOLS and PMG estimators are employed to measure the long-term estimates.

The endogenous variable, CE is measured by CO_2 emission (kt). The exogenous variables are EG is measured in constant 2010 dollars, EU is measured by the kg of oil per capita and FD is measured by the domestic credit to private sector measured as percentage of GDP. Panel data of nine ASEAN economies from the 2000 to 2018 has been taken from the World Development Indicators (World Bank, 2020).

To avoid the multicollinearity, logarithm of all the indicators is taken following Shahbaz, Mahalik, Shah, and Sato (2016) and the equation will become as shown in Equation (3).

$$\log(C)_{it} = \alpha_o + \beta_1 \log(EG)_{it} + \beta_2 \log(EC)_{it} + \beta_3 \log(FD)_{it} + \epsilon_{it} \ldots (3)$$

Unit Root Test

It is argued that the long-term parameters of designed relationships appear to reflect a series of variables order of integrated I(1) (AlFarra & Abu-Hijleh, 2012; Hall & Asteriou, 2016). Thus, it is the order of priority in the estimation to test the stationarity of the data series. Secondly, the cross-sectional dependence among cross sections is examined. The inspection of contemporary correlation was achieved in each country through the implementation of a cross-dependency test (CD) proposed by Pesaran (2004), which describes CD statistics as shown in Equation (4).

$$CD = \left[\frac{TN(N-1)}{2}\right]^{\frac{1}{2}} \hat{\rho} \quad \ldots \quad (4)$$

Where ρ expresses the cross-sectional correlation in the residual pairs of the traditional ADF test. N and T are cross-sectional and time components, respectively. As the test of CD reflects the occurrence of a cross-sectional dependency on the panel, the CADF test is employed. The test equation is shown in Equation (5).

$$\Delta X_{it} = \beta_i + \gamma_i X_{it-1+}\delta_i T + \sum_{j=1}^{n} \varphi_{ij}\, \Delta X_{it-j} + \mu_{it} \ldots (5)$$

Where X_{it} signifies the explanatory variables, T for time trends, β_i is individual intercepts, Δ for the difference and μ_{it} for the error term.

Test of Cointegration

A number of methods are recommended by Pedroni (1999); (Pesaran, 2004) should be carried out if the outcomes of the CIPS test confirmed a cointegrated relationship in the data set. Seven-panel statistics are obtained for seven tests. Four are trials in the aspect, three of which focus on group statistics or between dimensions. The size and heterogeneity among countries are controlled by the Pedroni test, allowing multiple multipliers to differ from the dedicated vector in different parts of the panel (Pedroni, 1999).

Model Estimation

If a long-run association is originated amongst the indicators, the next step is to assess the long-run relationship among series. Given the presence of cointegrated constants, several competing econometric approaches are available. Among such methods are DOLS and FMOLS. Pedroni (2000, 2001) recommended the FMOLS estimators for panels that take care for heterogeneity and serial correlation problems. Moreover, FMOLS technique provides consistent estimations in case of small samples (Pedroni, 2001).

A common limitation with FMOLS and DOLS estimators is that they do not provide short-term coefficients (Murthy, 2007). Other approaches namely, MG, PMG, and dynamic fixed effect (DFE) are available to estimate the long run as well as short run coefficients at the same time. This study has employed PMG estimator for estimating the short-run and long run estimates.

RESULTS AND DISCUSSION

Before analyzing the relationship among EG, EU and FD with CE, we first check the summary statistics of the variables presented in Table 2, which include mean standard deviation, minimum and maximum values in the sample.

Table 2: ***Descriptive statistics***

Variables	CO_2	EC	FD	EG
Mean	10.883	7.059	3.835	25.399
Maximum	13.365	9.194	5.006	27.768
Minimum	7.700	5.527	1.138	22.452
Standard Deviation	1.596	1.144	0.955	1.408
Observations	162	162	162	162

Table 3 presents the outcomes of the CD tests. All tests indicate that there exits the cross-sectional dependence but Pesaran CD indicates that there does not exist a cross-section dependence.

Table 3: ***Cross-Sectional Dependence Test***

Variables	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
EG	0.000	0.000	0.000	0.000
CO2	0.000	0.000	0.000	0.144
FD	0.000	0.000	0.000	0.048
EC	0.000	0.000	0.000	0.324

Since overall outcomes indicate that there exists the cross-sections dependence in the variables. Thus, we cannot employ the first-generation unit root test; the outcomes of the second-generation unit root test are shown in Table 4.

Table 4: ***Unit root test***

Variables	CIPS				PESCADF			
	Level		First		level		First	
EG	-1.60	-2.33	-2.34	-2.33	-1.53	-2.34	-3.10	-2.34
CO_2	-2.81	-2.33			-2.83	-2.34		
FD	-1.76	-2.33	-3.26	-2.33	-2.07	-2.34	-2.83	-2.34
EC	-1.76	-2.33	-3.41	-2.33	-1.90	-2.34	-2.47	-2.34

Table 4 revealed the CIPS and PESCADF unit root tests results. Bot of the test indicates that there does not exit the unit root in carbon emissions at level and EG, EU and FD have a unit root. This means that CO_2 has an integration order of I(0) and others have I(1).

Table 5: ***Cointegration Test***

Kao Test		Johansen Fisher				
t-Stats	Prob.	No. of CE(s)	trace test	Prob.	max-Eigen test	Prob.
-3.255	0.00	None	162.900	0.00	114.200	0.00
		At most 1	77.240	0.00	63.110	0.00
		At most 2	31.480	0.01	28.270	0.02
		At most 3	23.430	0.10	23.430	0.10

The Kao and Johansen Fisher tests for cointegration are represented in Table 5. Kao test rejects the null hypothesis, which means there does exist the cointegration in the equation. However, the outcome of Johansen Fisher results otherwise.

Table 6: ***DOLS Results***

Variables	Coeff.	Std. Error	t-stats	Prob.
EC	0.641***	0.075	8.499	0.000
FD	0.589***	0.125	4.690	0.000
EG	0.542***	0.032	16.742	0.000
Model Diagnostics				
R-square				0.974
Adj. R-square				0.939

Note: ***,** and * show 1%, 5% and 10% level of significance respectively.

The DOLS estimates are illustrated in Table 6. It can be observed that CO_2 emissions are positively affected by energy use, economic growth, and financial development and these results are highly significant.

Table 7: ***FMOLS Results***

Explanatory Variables	Coefficients	Standard Error	t-stats	Prob.
EC	0.380***	0.076	-4.975	0.000
FD	0.226**	0.081	2.786	0.006
EG	1.123***	0.064	17.567	0.000
Model Diagnostics				
R-square				0.958
Adj. R-square				0.955

Note: ***,** and * show 1%, 5% and 10% level of significance respectively.

The findings of FMOLS estimation are presented in Table 7. It is evident from the findings of FMOLS that these estimates are consistent with DOLS estimates. A positive and highly significant relationship is found among energy use, FD, economic growth and CO_2 emissions.

Table 8: Pooled Mean Group Estimates

-+Long Run Outpu				
Explanatory Variables	**Coefficients**	**Standard Error**	**t-stats**	**Prob.**
EC	0.617***	0.102	6.051	0.000
FD	0.515***	0.093	-5.537	0.000
EG	0.365***	0.071	5.180	0.000
Short Run Output				
C	-0.032	0.207	-0.155	0.877
ECT	-0.282	0.171	-1.653	0.091
D(EC)	0.238	0.355	0.669	0.505
D(FD)	0.216*	0.123	1.750	0.083
D(EG)	1.153	1.392	0.828	0.409

Note: ***,** and * show 1%, 5% and 10% level of significance respectively.

The estimates of PMG are presented in Table 8, which show that, in the long-run, all three explanatory variables namely, energy use, FD and EG positively and significantly influence carbon emission in focus area. However, the effect of these variables remained insignificant in the short-run except financial development, which is significant at 10 percent. The error correction term (ECT) fulfills all three criteria, which means it is negative, significant and less than 1 in magnitude. The coefficient of ECT is – 0.282, which signifies the adjustment speed towards long-run equilibrium, which is 28%. Energy consumption has increased CO_2 emission in ASEAN economies, as also confirmed by Gbadebo and Okonkwo (2009). The outcome of the positive influence of EG on CO_2 emission is in line with the findings of Akpan and Akpan (2012). The increased energy use leads to increase CO_2 emission levels, which is in line with the study by Shahbaz, Solarin, et al. (2013). Moreover, the positive effect of FD on CO_2 emissions is also in line with the literature. Several studies in the literature has reported positive effect of FD on CO_2 emission in different contexts (Javid & Sharif, 2016)**.**

CONCLUSION

This paper attempted to study the influences of energy use, EG and FD on CO_2 emissions in selected nine ASEAN economies from 2000 to 2018. A mixed order of integration was found in various tests of stationarity. Also, the cointegration tests proposed by Kao and Johansen Fisher confirmed the existence of cointegration among variables of interest. In order to estimate the relationship between explanatory variables and carbon emissions, DOLS, FMOLS and PMG approached are employed. The findings of all three approaches illustrate similar results since a positive effect of all the explanatory variables on CO_2 emissions is found. This illustrate that increase financial development leads to increased energy use, which further augments the level of CO_2 emission in nine ASEAN countries.

The findings of the study have crucial political implications for ASEAN counties, not merely to be capable to effectively address the present climate challenges but also to predict their future post oil economic indicators. The sea level is already rising due to releases and disruption to coasts and marine life, causing in rising salinity intensities. This condition will result in a lack of fresh water. Already ASEAN nations run a huge number of desalination plants which are actual costly and are damaging the environment, as they require large volumes of energy to operate. Furthermore, over time as the supply of energy of these countries is expected to decrease, the cost of major government subsidizations to existing energy use is expected to be fiscally unjustifiable. While it may be difficult to forecast compensation amongst these political reality and opportunity costs of these nations, which is largely regulated by monarchies. Meanwhile these states are below probable danger because of their terrible emission levels and their responses to combat emissions appear to have been insufficient to date. To encourage the renewable sources of energy and efficient energy use, prompt actions are needed. On the other hand, they should do all conceivable actions to lessen their fuel-dependency. Also, modern technologies can be introduced to fulfill the energy demands while taking care of the environment.

In view of the outcomes of current study, it is recommended that ASEAN countries must decrease carbon emission through policy mix. There are other potential sources to generate electricity, which allow the countries to attain greater efficiency of energy levels. Lastly, the study recommends that ASEAN economies need to significantly increase investment for research into developing experience in energy and clean energy technologies. It will not only fulfil their present renewable energy targets and address the dominant climate challenges but also face more dares in the post-oil era.

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