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Investigating the Causal Linkage among Economic Growth, Energy Consumption, Urbanization and Environmental Quality in ASEAN-5 Countries

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ABSTRACT

The present study aims to explore the causal relationship among economic growth energy consumption and urbanization and environmental quality in ASEAN-5 countries. The current study conduct time series analysis in ASEAN-5 countries using the granger casualty model consisting data set from 1980 to 2018. The outcomes of the present study reveals that the energy consumption urban population granger cause to CO_2 emission in ASEAN-5 countries. The study suggested that ASEAN-5 should reduce the utilization of fossil fuel based energy and induct robust policies towards augmenting the adeptness of renewable energy and energy-usage programs to condense redundant energy waste.

Keywords: Economic Growth, Energy Consumption, Environmental Quality, CO_2 Emission, Environmental Sustainability, ASEAN-5
JEL Classifications: F64, N75, O13

1. INTRODUCTION

In recent years, the rapid change in climate and the increase in global warming is noticed. The natural life of this planet is adversely affected by climate change. Climate change is a result of vast human activities that increased anthropogenic greenhouse gases and carbon dioxide emissions. By considering the impact of the environment on human beings, it is needed to form environmentally friendly policies to reduce the damaging effects of CO_2 emissions (Haider and Akram, 2019). From the last few decades, although the global economies are growing remarkably at the cost of serious environmental issues (Liu et al., 2018).

Human activities play an important role to assess environmental quality. it is a fair fact that none of any human activity is performed without the help of energy consumption. it's even a harsh fact that most of the energy consumption is generated with the help of fossil fuel and this harms the environment the most. The variations in environmental quality result in the form of climate changes as melting glaciers, rising air and ocean temperatures, increasing sea levels, decreased agricultural output, destroyed wildlife, and deteriorating productivity of the workforce (Wang, 2019; Xu et al., 2018).

Thus, it is a dire need to focus and address the main issue which causes of environmental degradation. Hence, of environmentalists and policymakers also have to detect the problem regarding climate change and the rising risks associated with environmental quality. the present study fills the gap of literature by incorporating economic growth, energy consumption, and urbanization of environmental quality on ASEAN-5 countries.

As ASEN-5 are considered the primary members and most prominent region among other ASEAN countries along with higher economic growth. The growing economy utilized higher energy, also the ASEAN-5 countries are based in a tropical region. The utilization of energy is very high due to hot weather as hot weather increases the consumption of air conditioners in offices, malls, and domestic use as well. Furthermore, the growing population massively utilized automobiles on road in the ASEAN-5 region which increases the CO_2 emissions and degrade the environmental quality. Hence, keeping environmental sustainability as the main agenda, economists and policymakers are focusing on determinants that create a negative impact on environmental quality. All efforts are made to shift the paradigms of policymakers and researchers from the only increase in economic growth to worry about sustainable economic growth (Alam et al., 2016).

2. LITERATURE REVIEW

Previous studies examined the environmental Kuznets curve by using economic growth and CO_2 emissions. Grossman and Krueger (1995) were the pioneers, who first introduce the EKC hypothesis to examine the relationship between per capita income and environmental variables. The inverted u-shape or the EKC shows the relationship between environmental quality measured by CO_2 emission and economic growth, which is measured by GDP per capita (Dinda, 2004). According to Panayotou (2016), in the beginning, as the economy grows the income of the people also grows so people purchase more, as a result, the economic activity comes on a fast track which is the sign of development. At this stage, the pollution is increased because the main focus is on increasing economic growth and the environment is secondary at this stage. Although the environmental Kuznets curve is criticized in different perspectives the validity of the EKC hypothesis is tested in many studies by different researchers (Dinda, 2004; Perman and Stern, 2003; Sinha et al., 2019; Stern, 1998). Among these studies, very few found valid support towards an inverted u-shape pattern (Boubellouta and Kusch-Brandt, 2020; Gorus and Aslan, 2019).

Many studies established the relationship between CO_2 emission, economic growth, and energy consumption. According to Gökmenoğlu and Taspinar (2016) explore the relationship between FDI inflows, growth, energy use, and CO_2 emissions from 1974 to 2010 in turkey. The researcher uses the Toda-Yamamoto causality technique and the results show two-way causality between CO_2 emissions and energy consumption also between CO_2 emissions and FDI inflows. Additionally, real growth and FDI inflows, and between energy use and real growth, there is one-way causality exists. Based on the results study in Sri Lanka from 1971 to 2006 Uddin et al. (2016) use VECM causality that shows one-way causality between CO_2 emissions and GDP growth in the long-run and there is unidirectional causality found between energy consumption and economic growth. there is research by Dogan and Turkekul (2016) that reveals that in the USA there is a feedback causality causal relationship between CO_2 emissions, energy consumption, real output, the square of real output, trade openness, urbanization, and financial development. Saboori and Sulaiman (2013) analyzed that in ASEAN-5 countries, there is cointegration and causal relationship exists between economic growth, CO_2 emissions, and energy consumption. Munir et al., 2020 use data from 1980 to 2016 to investigate feedback causality between CO_2 emissions and the economy in Malaysia, the Philippines, Singapore, and Thailand. the results also show one-way causality running from growth to energy in Indonesia, Malaysia, and Thailand.

A big portion of energy consumption is non-renewable resources like coal, petrol, gas in ASEAN-5 countries, this leads to the problem of higher carbon concentration in the atmosphere and the accumulation of non-recallable waste. is destroying the environment to address this issue production mode must be shifted to renewable resources like solar energy, hydropower, biomass energy needs to be introduced to generate the energy in emerging countries (Destek and Sinha, 2020). Similarly, the effect of energy consumption on environmental quality indicated that the high energy consumption regime makes the environment more polluted, increasing economic activity and increase in population size, whiles the increase in industrialization also causes emissions as a result of industrial processes. Electricity is the main driver of energy and at the same time is the main source of carbon emission through the burning of hydrocarbon as well.

3. DATA DESCRIPTION AND METHODOLOGY

This study used a time series dataset for ASEAN countries for the period 1980–2018. The sample is considerably larger (in terms of both the number of nations and the length of the period addressed). The present research focuses on five ASEAN countries (i.e., Indonesia, Malaysia, the Philippines, Singapore, and Thailand) from 1980 to 2018. The sample period is subject to data availability. The data was collected from the World Development Indicators (WDI, 2018). Urban population is taken in number, Real GDP per capita measured as constant 2010 US$ and CO_2 emissions use as (metric tonnes per capita). Total energy consumption (Quadrillion Btu) was rooted out from the International Energy Agency (IEA, 2017). Firstly data converted into natural logs then used for analysis.

The prime objective of the study to test the relationship between CO_2 emission and economic growth, energy consumption, and urbanization that whether economic growth, energy consumption and urbanization lead to increase CO_2 emission. Energy is the main factor to boosted the economic growth as well as used massively with the rapid increase in urban population. Human life is dependent on energy as without energy none of the functions of life perform. The important factor to discuss is that the major source of energy production is a fossil fuel. Hence it is important to examine the environmental quality subject to economic growth, energy consumption, and urbanization.

The present study is consists of a small sample of 39 observations i.e. 1980– 2018 and critical values created by Pesaran et al. (2001) are included. Hence the current study used lower and upper critical bounds generated by Narayan (2004). For larger data set Pesaran et al. (2001) bond value used. It is confirmed that cointegration exists between CO_2 emission, economic growth, energy consumption, and urbanization. After confirming the cointegration results we should move to explore the causal relationship between the series throughout 1980–2018. Granger (1969) said that if the variables are integrated at I(1) then the vector error correction method (VECM) is a suitable approach to test the direction of causal rapport between the variables. On the other hand, the VECM is a restricted form of unrestricted VAR (vector autoregressive) and the restriction is levied on the presence of a long-run relationship between the series. The VECM in five variable cases can be written as follows.

To satisfy the condition of stationary at I(1) and cointegrated as well among the variables, the vector error correction model (VECM) is the most appropriate model to apply. Besides, the VECM is a theoretically-driven approach for estimating both short- and long-term elasticities of one-time series with a large sample size. Thus, the granger causality relationship and VEC Model for CO_2 emission with economic growth determinants are expressed in Equation 1.1 and 1.4 respectively, and the granger causality relationship and VEC Model for CO_2 emissions with economic growth determinants are expressed

$$\Delta lnCO2_t == \beta_0 + \sum_{S=1}^{n} \beta_1 \Delta lCO2_{t-s} + \sum_{S=0}^{n} \beta_2 \Delta ln_{GDP-0} + \sum_{S=0}^{n} \beta_3 \Delta l_{east-0} + \sum_{S=0}^{n} \beta_4 \Delta lnURB_{t-0} + \gamma_i ECT_{t-1} + v_t \quad (4.1)$$

$$\Delta lnGDP_t = \beta_0 + \sum_{S=1}^{n} \beta_1 \Delta lGDP_{t-s} + \sum_{S=0}^{n} \beta_2 \Delta lnCO2_{t-0} + \sum_{S=0}^{n} \beta_3 \Delta lnEC_{t-0} + \sum_{S=0}^{n} \beta_4 \Delta lnURB_{t-0} + \gamma_i ECT_{t-1} + v_t \quad (4.2)$$

$$\Delta lnEC_t = \beta_0 + \sum_{S=1}^{n} \beta_1 \Delta lEC_{t-s} + \sum_{S=0}^{n} \beta_2 \Delta lnCO2_{t-0} + \sum_{S=0}^{n} \beta_3 \Delta lnGDP_{t-0} + \sum_{S=0}^{n} \beta_4 \Delta lnURB_{t-0} + \gamma_i ECT_{t-1} + v_t \quad (4.3)$$

$$\Delta lnURB_t = \beta_0 + \sum_{S=1}^{n} \beta_1 \Delta lURB_{t-s} + \sum_{S=0}^{n} \beta_2 \Delta lnCO2_{t-0} + \sum_{S=0}^{n} \beta_3 \Delta lnGDP_{t-0} + \sum_{S=0}^{n} \beta_4 \Delta lnEC_{t-0} + \gamma_i ECT_{t-1} + v_t \quad (4.4)$$

Where β_0 is the constant value, and n is the maximum number of lags. The βis (i = 1, 2, 3, and 4) are short-run elasticities among the variables used in this study. The ECT_{t-1} is the error correction term, which is a residual term obtained by running long-term cointegration. Meanwhile, γi is the long-run elasticity of the ECT_{t-1} and is used to confirm the existence of long-run relationships among the variables(Brini et al., 2017). The value of γi should be negative and the existence of long-run dynamic relationships (F-statistics) among the analyzed variables suggested that there is a granger causality in one direction. Thus, this study proceeds to employ the vector error correction model (VECM) model for determining the direction of causality.

Using the VEC model is applicable if a set of variables is cointegrated. The model is then augmented by the lagged error correction term. The VEC model reintroduces the information lost due to the differencing of the series. This step helps examine the long-run equilibrium and short-run dynamics. Thus, the VEC model allows capturing both the short- and long-run Granger causality. Hence, it can be developed in matrix form, as in Equation (1.5).

$$\begin{bmatrix} lnCO2 \\ lnGDP \\ lnGDP2 \\ lnEC \\ lnGEA \\ lnURB \end{bmatrix} = \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix} + \sum_{s=1}^{m} \Delta \begin{bmatrix} a_{11} a_{12} a_{13} a_{14} a_{15} a_{16} a_{17} \\ a_{21} a_{22} a_{23} a_{24} a_{25} a_{26} a_{27} \\ a_{31} a_{32} a_{33} a_{34} a_{35} a_{36} a_{37} \\ a_{41} a_{42} a_{43} a_{44} a_{45} a_{46} a_{7} \\ a_{51} a_{52} a_{53} a_{54} a_{55} a_{56} a_{57} \\ a_{61} a_{62} a_{63} a_{64} a_{65} a_{66} a_{67} \\ a_{71} a_{72} a_{73} a_{74} a_{75} a_{76} a_{77} \end{bmatrix}_s \begin{bmatrix} lnCO2 \\ lnBC \\ lnGDP \\ lnGDP2 \\ lnFD \\ lnEC \\ lnGEA \\ lnURB \end{bmatrix}_{t-s} \begin{bmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \\ \gamma_5 \\ \gamma_6 \\ \gamma_7 \end{bmatrix} \left[ECT_{t-1}\right] + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \end{bmatrix} \quad (4.5)$$

Where Δ is the first difference operator, εits are the serially uncorrelated random error terms, and ECT_{t-1} is the one period lagged error-correction term derived from the cointegrating equation. The short-run Granger causality can be obtained using the F-statistic of the lagged explanatory variables (Bélaïd and Youssef, 2017; Rafindadi and Olanrewaju, 2016; Shahbaz et al., 2016). Thus, the possible presence of this causality is investigated by testing the null and alternative hypotheses as follows. H0: bis = 0 (no short-run causality exists) and H_1: bis ≠ 0 (there is a short-run causality). If the estimated value bis are significantly less than zero, there is a short-run Granger causality between the variables. In other words, if the value of the F-statistic is less than the critical value, the null hypothesis may be rejected. Otherwise, the variables detect no short-term Granger causality if the estimated value bis are equal to zero or the value of the F-statistic is more than the critical value. So, the null hypothesis is rejected.

4. RESULTS

The present study performs descriptive statistics to know some basic characteristics of the variables. This section provides a comprehensive descriptive analysis of the growth and environmental indicator of ASEAN-5 countries. The summary consists of mean, standard deviations, minimum and maximum values of environmental quality determinants of the overall sample. Based on Table 1, provides a descriptive summary of Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The analyses have been examined separately for each country sample. Table 1 exhibits focus on ASEAN-5 countries (i.e. Indonesia, Malaysia, the Philippines, Singapore, and Thailand) from the year 1980 to 2018. The sample period is dictated by data availability. All data are transformed into natural logs.

The descriptive statistics of each variable for each country are reported in Table 1. The mean of CO_2 emissions is reported highest in Singapore (1.03), followed by Malaysia (0.68), Thailand (0.40), Indonesia (0.30), and the Philippines (0.07). Moreover, variation in CO_2 emission is measured by standard deviation as reported in Table 1. It is observed that the maximum deviation in CO_2 emission is reported in Indonesia (0.73) followed by Malaysia (0.68), Thailand (0.40), Singapore (0.12), and Philippines (0.11). As far as GDP is concerned the GDP is reported highest in Singapore (4.48), followed by Thailand (3.51), Malaysia (3.83), Indonesia (3.34), and the Philippines (3.25). Moreover, variation in GDP is measured by standard deviation as reported in Table 1. It is observed that the maximum deviation in GDP is reported in Thailand (0.20) followed by Singapore (0.19), Malaysia (0.17), Indonesia (0.15), and the Philippines (0.07).

Likewise, the mean value of energy consumption per capita is reported highest in Indonesia (2.85), followed by Thailand (2.09), Malaysia (1.78), Philippines (1.76), and Singapore (2.66). Moreover, variation in energy consumption per capita is measured by standard deviation as reported in Table 1. Similarly, the mean value of urbanization is reported highest in Indonesia (7.89), followed by the Philippines (7.52) Thailand (7.31), Malaysia (7.10), and Singapore (0.96). Moreover, variation in urbanization is measured by standard deviation as reported in Table 1. It is observed that maximum deviation in urbanization is reported in both countries Malaysia and Indonesia is reported the same value that is (0.19) followed Thailand (0.13), Philippines (0.12), and Singapore (0.11).

A unit root test is applied to examine the stationary properties of the data series used in this study. It is employed to avoid spurious regression result analysis. Thus, this study employed unit root tests such as Augmented Dicky-Fuller (ADF) and Phillips-Perron test (PP) and In the present study Table 2, presents the results of stationary properties for each variable (CO_2 emission, GDP, energy consumption, and urbanization) for Indonesia, Malaysia, Philippines, Singapore).

Based on results Table 2 empirical evidence of the current study demonstrate the unit roots and co-integration has chosen to use a probability value of 0.10, which is an appropriate level of significance to be used with small sample sizes such as that used here. Table 2 reported that the results of the unit root tests for series at a level I(0) are not significant at 10% level of significance for and energy consumption(Thailand). However, the first differences I(1) confirm the stationarity at 10% level of significance for all models. These results are in line with the existing literature (Grubler et al., 2018; Ozturk et al., 2016; Rafindadi and Olanrewaju, 2019).

Table 1: Descriptive summary ASEAN-5

Country	Statistics	*ln* CO_2	*l*GDP	*l*EC	*l*URBAN
Indonesia	Mean	0.30	3.34	2.85	7.89
	Median	0.10	3.34	2.83	7.92
	Maximum	2.47	3.63	2.97	8.17
	Minimum	-0.19	3.09	2.57	7.51
	Std. Dev.	0.73	0.15	0.53	0.19
Malaysia	Mean	0.68	3.80	1.78	7.10
	Median	0.75	3.83	1.81	7.13
	Maximum	0.91	4.08	2.87	7.37
	Minimum	0.30	3.52	1.63	6.76
	Std. Dev.	0.20	0.17	2.23	0.19
Philippines	Mean	0.07	3.25	1.76	7.52
	Median	0.06	3.22	0.58	7.54
	Maximum	0.21	3.48	1.53	7.69
	Minimum	0.28	3.14	0.31	7.24
	Std. Dev.	0.11	0.09	0.32	0.12
Singapore	Mean	0.13	4.48	0.96	6.58
	Median	1.06	4.50	1.69	6.59
	Maximum	1.25	4.76	2.86	6.75
	Minimum	0.63	4.13	1.29	6.38
	Std. Dev.	0.12	0.19	0.96	0.11
Thailand	Mean	0.40	3.51	2.09	7.31
	Median	0.47	3.54	1.56	7.28
	Maximum	0.97	3.80	3.50	7.54
	Minimum	0.11	3.14	2.61	7.10
	Std. Dev.	0.30	0.20	1.40	0.13

Table 2: Unit root testing for ASEAN-5

Country	Variable	Augmented Dicky-Fuller test		Phillips-Perron test	
		I (0)	I (1)	I (0)	I (1)
Indonesia	*l* CO_2	1.602*	–0.18**	0.56	–6.08*
	*l*GDP	0.16*	–4.66*	0.164	–4.65*
	lGDP^2	0.35*	–4.60**	0.45	–4.62*
	*l*EC	–3.57*	–6.23**	–1.55**	–6.23*
	*l*URBAN	–2.79*	–6.10**	–12.05	–6.11*
Malaysia	*l* CO_2	–1.58	–6.70*	–1.61	–6.67*
	*l*GDP	–0.48*	–5.14**	–0.48	–5.14*
	lGDP^2	0.23*	–5.23*	–0.25	–5.23*
	*l*EC	1.29*	–4.14**	1.39**	–4.23*
	*l*URBAN	–2.73*	–4.61**	–3.94	–4.60**
Philippines	*l* CO_2	0.43*	–5.69**	0.35**	–5.69*
	*l*GDP	1.49*	–5.75**	2.85**	–10.69**
	lGDP^2	1.59*	–5.70**	3.07	–10.85**
	*l*EC	–2.54*	8.38**	–1.51	–6.95*
	*l*URBAN	–1.08*	–4.67**	–6.12*	–4.67**
Singapore	*l* CO_2	–2.30	–6.36**	–2.31	–7.63*
	*l*GDP	–2.19*	–5.51**	–2.33	–5.60*
	lGDP^2	–1.86*	–5.71**	–1.92	–5.75*
	*l*EC	–1.54*	–6.68**	–1.54*	–6.69*
	*l*URBAN	–0.14*	–2.89**	–1.22	–6.12**
Thailand	*l* CO_2	–2.79*	–6.90*	0.07	–6.91*
	*l*GDP	–1.43	–7.33**	–1.51**	–8.84**
	lGDP^2	–1.24**	–749**	–1.27*	–9.80**
	*l*EC	1.51	–7.12**	–2.90**	–7.13**
	*l*URBAN	0.58**	–4.45**	0.03	–4.46*

The existence of cointegration among these variables is analyzed using the bayer and hanck cointegration test, which is performed due to it having many advantages compared to the other conventional methods. However, this test is sensitive to lag selection and can be detected using LR, FPE, AIC, SBC, and HQ and HJ criteria. These criteria are useful in choosing a suitable lag length. Besides, it is capable of capturing the long-term dynamic relationships to select the best time-series model for environmental quality estimations. However, the AIC is the best test to select an appropriate maximum lag order due to the small sample size and minimizes the loss of freedom as well. Thus, the maximum lag length is found to be 2 for applying the Granger causality (Table 3).

The results of the Bayer and Hanck cointegration test for the long-term dynamic relationships among the variables are shown in Table 4 presents the results of the cointegration between CO_2 emission, economic growth, energy consumption, and urbanization in the ASEAN-5 region by applying Bayer and Hanck cointegration. The results found a significant dynamic relationship between economic growth determinants and environmental quality in each ASEAN-5 countries. It suggests that a long-run cointegrating relationship exists among variables in the ASEAN-5 region. The results are consistent with the findings of (Chandran and Tang, 2013) and (Majid et al., 2009). In the ASEAN-5 region, several researchers confirm the existence of a long-run relationship between economic growth determinants and environmental quality. Saboori et al. (2012) identified that GDP impact on CO_2 emission in Malaysia, whereas, Salman et al. (2019) confirms the long-run relationship in Thailand.

The results of the long- and short-term Granger causality tests are documented in Tables 5-9, which reported the results of the long- and short-run VECM granger-causality for ASEAN-5 countries to analyze the causal relationship among economic growth determents and environmental quality (CO_2 emission). Based on the results in Table 5, there are bidirectional and unidirectional short-run and the long-run relationship between the variables in Indonesia. the results reveal the evidence of the long-term error

Table 3: Lag length criteria

		Indonesia		
Models	**AIC**	**SBC**	**HQC**	**HJC**
Indonesia				
Model-1	–37.226 (2)*	–33.354 (2)	–35.623 (2)	34.668 (3)
Model-2	–32.226 (2)*	–31.354 (2)	–31.623 (2)	34.668 (2)
Malaysia				
Model-1	–36.9072 (2)*	–33.6595 (2)	–35.1912 (2)	–33.3740 (3)
Model-2	–33.4638 (2)*	–28.6127 (2)	–31.1433 (2)	–29.3163 (3)
Philippines				
Model-1	–39.580 (2)*	–36.147 (3)	–38.977 (4)	–37.281 (3)
Model-2	–42.090 (2)*	–34.147 (3)	–37.977 (4)	–30.281 (3)
Singapore				
Model-1	–33.4638 (2)*	–29.6117 (2)	–31.1433 (2)	–29.3163 (3)
Model-2	–33.4638 (2)*	–29.6117 (2)	–31.1433 (2)	–29.3163 (3)
Thailand				
Model-1	–41.189 (2)*	–37.233 (2)	–39.586 (4)	–35.184 (3)
Model-2	–33.4638 (2)*	–29.6117 (2)	–31.1433 (2)	–29.3163 (3)

***,** and *denotes statistically significance at 1%, 5% and 10% level, respectively. This table presents the lag length criteria which describes the appropriate lag to measure the VECM model

Table 4: Bayer and Hanck cointegration

Country	**Estimated models for ASEAN-5**	**EG-JOH**	**EG-OH-BOBDM**	**Conclusion**
Model-1				
Indonesia	$lnCO2_t = f\begin{pmatrix} lnGDP_t, lnGDP2_t, \\ lnEC_t, lnURB_t \end{pmatrix}$	55.72	166.24	Cointegration
Malaysia	$lnCO2_t = f\begin{pmatrix} lnGDP_t, lnGDP2_t, \\ lnEC_t, lnURB_t \end{pmatrix}$	10.81	28.79	Cointegration
Philippines	$lnCO2_t = f\begin{pmatrix} lnGDP_t, lnGDP2_t, \\ lnEC_t, lnURB_t \end{pmatrix}$	55.72	166.24	Cointegration
Singapore	$lnCO2_t = f\begin{pmatrix} lnGDP_t, lnGDP2_t, \\ lnEC_t, lnURB_t \end{pmatrix}$	6.63	10.60	Cointegration
Thailand	$lnCO2_t = f\begin{pmatrix} lnGDP_t, lnGDP2_t, \\ lnEC_t, lnURB_t \end{pmatrix}$	73.68	145.17	Cointegration
Significance level		**Critical value**	**Critical value**	
1% level		15.31	29.03	
5% level		10.29	19.68	
10% level		8.16	15.73	

Table 5: Long-run and short-run causal relationships for Indonesia

Variables	Short-run					Long run
	ΔL CO_2t	ΔLGDPt	ΔLGDP2t	ΔLECAt	ΔLURBt	ECT_{t-1} (t-statistic)
ΔL CO_2t	-	1.0000 (1.0000)	0.0002 (0.9885)	0.0241 (0.8764)	0.0821 (0.7744)	–0.3589* (–2.6507)
ΔLGDPt	0.4734 (0.4914)	-	0.0766 (0.7819)	0.5289 (0.4671)	1.6856 (0.1942)	–0.194581* (–2.068479)
ΔLGDP2t	0.4679 (0.4939)	0.0756 (0.7833)	-	0.5185 (0.4715)	1.3842 (0.2394)	–25.9812* (–4.4460)
ΔLECAt	0.5130* (0.0738)	0.1023 (0.7491)	0.0961 (0.7565)	-	10.3619** (0.0013)	–17.8203* (–8.0065)
ΔLUrbant	0.3685 (0.5438)	0.0713 (0.7893)	0.0744 (0.7849)	0.0003 (0.9843)	-	–13592.14* (–14.8035)

***, ** and *denotes statistically significance at 1%, 5% and 10% level, respectively

Table 6: Long-run and short-run causal relationships for Malaysia

Variables	Short-run					Long run
	ΔL CO_2t	ΔLGDPt	ΔLGDP2t	ΔLECAt	ΔLUrbant	ECT_{t-1} (t-statistic)
ΔL CO_2t	-	1.728175 (0.9232)	0.0039 (0.9496)	8.8718*** (0.0029)	1.0438 (0.3069)	–7.692* (–5.432)
ΔLGDPt	0.3604 (0.5483)	-	0.7481 (0.3871)	1.6709 (0.1961)	1.1448 (0.2846)	3.2408* (–5.820)
ΔLGDP2t	0.3846 (0.5351)	0.0005 (0.3607)	-	1.8177 (0.1776)	1.0478 (0.3060)	3.2408 (5.023)
ΔLECAt	2.74854* (0.0973)	0.0241 (0.2440)	1.3888 (0.2386)	-	3.2668* (0.0707)	–0.4862* (–2.757)
ΔLUrbant	1.1064 (0.2929)	1.7281 (0.7383)	0.0618 (0.8036)	1.9119 (0.1667)	-	4.0166 (5.629)

***, ** and * denotes statistically significance at 1%, 5% and 10% level, respectively

Table 7: Long-run and short-run causal relationships for the Philippines

Variable	Short-run					Long run
	ΔL CO_2t	ΔLGDPt	ΔLGDP2t	ΔLECAt	ΔLUrbant	ECT_{t-1} (t-statistic)
ΔL CO_2t	-	0.7273 (0.3937)	0.6763 (0.4108)	0.2011 (0.6538)	0.0132 (0.9082)	11.13280* (–5.07391)
ΔLGDPt	4.8363** (0.0279)	-	1.9266 (0.1651)	3.1767* (0.0747)	0.2211 (0.6382)	–186.7232* (–5.38254)
ΔLGDP2t	4.9781** (0.0257)	1.8303 (0.1761)	-	3.2924* (0.0696)	0.2466 (0.6194)	29.31683 (5.48404)
ΔLECAt	0.0280 (0.8669)	0.0375 (0.8463)	0.0622 (0.8030)	-	0.0113 (0.9152)	–1.613289 (–1.01835)
ΔLUrbant	1.8675 (0.1718)	1.7788 (0.1823)	1.5845 (0.2081)	0.4032 (0.5254)	-	–4.765767* (–5.94539)

***, ** and * denotes statistically significance at 1%, 5% and 10% level, respectively

Table 8: Long-run and short-run causal relationships (CO_2) for Singapore

Variables	Short-run					Long run
	ΔL CO_2t	ΔLGDPt	ΔLGDP2t	ΔLECAt	ΔLUrbant	ECT_{t-1} (t-statistic)
ΔL CO_2t	-	3.2281* (0.0724)	3.3556* (0.0670)	1.2656 (0.2606)	0.9719 (0.3242)	–6.129216* (–4.37895)
ΔLGDPt	0.9072 (0.3408)	-	1.3923 (0.2380)	3.0199* (0.0822)	0.1674 (0.6824)	–9.175852 (–0.42520)
ΔLGDP2t	0.7921 (0.3734)	1.7223 (0.1894)	-	3.7112* (0.0540)	0.3502 (0.5539)	2.574258 (1.07516)
ΔLECAt	0.5886 (0.4429)	3.4019* (0.0651)	3.4767* (0.0622)	-	0.4075 (0.5232)	–3.901359* (–7.65383)
ΔLUrbant	1.9656 (0.1609)	0.9410 (0.3320)	0.9189 (0.3377)	10.4509** (0.0012)	-	–3.599475 (–1.70214)

***, ** and * denotes statistically significance at 1%, 5% and 10% level, respectively

Table 9: Long-run and short-run causal relationships for Thailand

Variable	Short-run					Long run
	ΔL CO_2t	ΔLGDPt	ΔLGDP2t	ΔLECAt	ΔLUrbant	ECT_{t-1} (t-statistic)
ΔL CO_2t	-	0.4755 (0.4905)	0.4110 (0.5214)	0.0546 (0.7993)	4.3783** (0.0364)	9.897* (–6.060)
ΔLGDPt	0.1171 (0.7322)	-	8.2058*** (0.0042)	0.3671 (0.7531)	0.3722 (0.5418)	–4.8132* (–3.0035)
ΔLGDP2t	0.0052 (0.9421)	9.1136*** (0.0025)	-	0.0035 (0.9522)	0.7144 (0.3980)	0.330653 (1.39384)
ΔLECt	17.815*** (0.0000)	0.2055 (0.6502)	0.2151 (0.6652)	-	0.1211 (0.7278)	0.260376 (5.57555)
ΔLUrbant	4.2498** (0.0393)	0.4498 (0.5002)	0.4684 (0.4952)	0.0336 (0.8544)	-	1.775069 (8.51485)

***, ** and * denotes statistically significance at 1%, 5% and 10% level, respectively

correction mechanism for the GDP, GDP2, energy consumption, and urbanization. Furthermore, the validity of the long-run causal relationship confirms due to the coefficients of t-statistics ECT_{t-1} are significantly different from zero.

In the long run in Indonesia, reported as CO_2 emission specification there is only one bi-directional causal relationship reported between CO_2 emission and urbanization. Table 5 report short-run causal relationship in Indonesia, while there is a unidirectional causality running from CO_2 emission and energy consumption, and energy consumption, the results also provide evidence of unidirectional causality running from energy consumption towards CO_2 emissions, from energy consumption to economic growth.

Table 6 reported the long-run and short-run causality among variables in Malaysia, the findings are traced when the test indicates the significance of the coefficient for error correction term (ECT_{t-1}) using the t-statistics. Thus, the results found that the long-run models are indicating the interaction between CO_2 emissions and its determinants. Hence, the P-values of ECTs in CO_2 emissions, biocapacity, GDP, GDP^2, energy consumption, and urbanization equations are demonstrated significant. Table 6 reported that in the long run for Malaysia, as CO_2 emission unidirectionally granger cause energy consumption. Finally, energy consumption unidirectionally causes CO_2 emission and urbanization. Table 6 reported that in the short-run empirical directions of granger shows energy consumption granger cause CO_2 emission, while, urbanization granger cause to energy consumption.

Likewise, Table 7 reported the long-run VCM granger causality results for the Philippines. Moreover, GDP ganger causes CO_2 emission and energy consumption. The short-run VCM granger causality results for the Philippines. Besides, there is a unidirectional causal relationship between CO_2 emission and GDP and GDP^2. Energy consumption also granger cause to GDP and GDP^2 unidirectionally.

Table 8 confirms the ganger causality results for the short run and long run in the case of Singapore. In long-run causality, the findings are traced when the test indicates the significance of the coefficient for error correction term (ECT_{t-1}) using the t-statistics. Table 8 documented that the short-run result supports the unidirectional causal relationship for VECM Granger causality for Singapore demonstrated that GDP^2 unidirectionally cause CO_2 emissions, energy consumption. Energy consumption also unidirectionally granger cause urbanization.

Table 9 provides the long run and short run casual relationships for Thailand. In the long-run causality, the findings are traced when the test indicates the significance of the coefficient for error correction term (ECT_{t-1}) using the t-statistics. Thus, the results found that the long-run models are indicating the interaction between CO_2 emissions and economic growth determinants in Thailand. There is evidence of a bidirectional causal relationship between CO_2 emission and biocapacity and CO_2 emission and GDP in the case of Thailand. Table 9 provides the short tum causal relationship, there is a unidirectional causal relationship between CO_2 emissions with energy consumption.

5. DISCUSSION

The cointegration results imply the existence of causality of at least one direction. However, it does not provide any definite indications concerning direction. Hence, the present study has performed the Granger causality test by using VECM. The results have shown the existence of Granger causality between the CO_2 emission, economic growth energy consumption, and urbanization in the long run and short run in ASEAN-5 countries.

Based on results reports of Granger causality tests for ASEAN-5 economies, summarizes the direction of causality. In the long run, the present study found evidence of bi-directional causality between CO_2 and economic growth emission in Indonesia and Thailand. While, the unidirectional relationship between the Philippines, Singapore, and Thailand in the short run. The results indicate that these two countries recutting the growth activities which are a cause of pollution. Furthermore, the utilization of these products also creates environmental issues. Hence, the increase in GDP per capita income causes an increase in pollution. This situation indicates that Malaysian spend more on products that increase pollution levels in the country in the long run. Furthermore, a robust relationship was witnessed between economic growth and energy consumption. As a development grantee to transform from the agriculture sector to the industrial sector. There is an increase in GDP per capita income, so people purchase more energy consumable products. On one hand, the increase in economic growth increase energy consumption. On the other hand, due to an increase in energy consumption economic activities are increased as well. In both situations, environmental quality is negatively affected. As fossil fuel-based energy is the base of economic growth in Malaysia in the long run. The findings are in line with the previous studies (das Neves Almeida et al., 2017; Demetriades and Hussein, 1996; Shahbaz et al., 2016; Ziaei, 2015).

Moreover, short-run unidirectional Granger causality exists between GDP and CO_2 emissions. There is not any evidence of short-run causality from GDP to CO_2 emissions in the cases of Indonesia and Malaysia. It suggests that GDP is not the only variable to decrease the intensity of CO_2 emissions in the short-run in Indonesia and Malaysia. CO_2 emission of Malaysia and Singapore bi-directionally Granger causes energy consumption. This indicates that a rise in energy consumption may degrade the environment by increasing CO_2 emissions. In the long run, unidirectional causal relation running from GDP to energy consumption in the case of Indonesia, Malaysia, and Thailand. Therefore, energy conservation is unlikely to have much impact on economic growth. The results of the present study advocate that governments could reduce energy-related expenditures in the case of Indonesia, Malaysia, and Thailand. Consequently, allowing huge spending in other sectors could benefit growth in the long run, such as health and education. These results in line with previous literature (Akram et al., 2020; Munir et al., 2020; Rajbhandari and Zhang, 2018).

6. CONCLUSION AND POLICY IMPLICATIONS

The outcomes of the current research study have many implications for economists, researchers, and policymakers. Since structural changes entail a social transformation from traditional to industrial societies, it is important to look at the environmental changes. Modern technologies innovate societies and broad social change. Hence, ASEAN-5 countries witnessed dramatic variations in environmental quality through the socially, industrially, and economically changes (Kardooni et al., 2018; Behrouzi et al., 2016; Tang and Tan, 2013). Hence, the environmental quality of ASEAN-5 consider the most prominent issue to discuss and it's the prime responsibility of key policymakers to make every effort to enhance environmental quality and reduce depleting the natural resources. Keeping in view, the study highlighted the impact of economic growth determinants on environmental quality. The outcome of the study identified that the following policy implications must be followed to recuperate environmental quality in ASEAN-5 countries.

Firstly, ASEAN-5 countries should attempt to access the environmental impact of economic growth on CO_2 emission to rely on fossil fuel-based energy because increased utilization of fossil fuel-based energy increase the level of CO_2 emission. Secondly, this research study suggests that energy consumption cause a decline in environmental quality due to greater energy is produced by fossil fuel and most human activities required energy during their daily life and also essential for the industrial sector. It suggests that energy consumption increases due to an increase in human activities and causes of environmental degradation. The ASEAN-5 legislators should support and invest more in the expansion of renewable energy consumption and vigilant utilization of natural resources and make prudent policies to sustain the resources. On the other hand, the relevant authorities should increase the investment to improve the infrastructure by replacing fossil fuel-based energy with renewable energy. Effective policies must be formed to address this issue as it is poorly understood and neglected previously. Finally, the most important implication of the present study is that uniform carbon emissions control policies are improbable to ensure improvement in environmental quality equally across countries with different carbon emissions and ecological footprints levels. Hence, policymakers should make environmental policies and implement laws to prevent environmental quality in ASEAN-5 countries.

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