ENERGY CONSUMPTION, CO₂ EMISSION AND ECONOMIC GROWTH IN ASEAN COUNTRIESChairit Thongrawd^{1*}, Chayan Kerdpitak²¹College of Logistics and Supply Chain, Suan Sunandha Rajabhat University, Bangkok, Thailand²Graduate School, Suan Sunandha Rajabhat University, Bangkok, ThailandE-mails: chairit.th@ssru.ac.th (Corresponding author); chayan.ke@ssru.ac.th

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Abstract. The article analyzes the causal relationship among energy consumption, CO₂ emissions and economic growth in four ASEAN countries for the period 1980-2018. The results of the Vector Error Correction Model (VECM) indicate a positive significant relationship among energy consumption, CO₂ emissions and economic growth. The CO₂ emissions and GDP per capita growth form a nonlinear EKC relation in the long run. The granger causality test statistics reveal a unidirectional causal relation from energy consumption and CO₂ emissions to economic growth. While in short-run unidirectional Granger causality is found from CO₂ emissions to energy consumption.

Keywords: ASEAN; CO₂ emissions; energy consumption; economic growth

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JEL Classifications: O1, Q54

1. Introduction

The Global warming ever-rising risk and environmental changes have targeted concentration on the association of economic-growth and environment pollutant (Tetsman, Bazienè, Viselga, 2017; Haseeb, Kot, Hussain, Jermisittiparsert, 2019; Sriyana, 2019; Zamil, Furqan, Mahmood, 2019; Kormishkina, Kormishkin, Gorin, Koloskov, Koroleva, 2019; Eddelani, El Idrissi, Monni, 2019; Rezk, Radwan, Salem, Sakr, Tvaronavičienė, 2019; Moumen, El Idrissi, Tvaronavičienė, Lahrach, 2019; Energy Transformation towards Sustainability, 2020).

The Intergovernmental board on weather Changes declared that the worldwide-temperature average was evaluated to increase within 1.1°C to 6.4°C in the next hundred years in 2007 (Solomon, 2007). It is predictive that a meagre 2°C temperature rise will create a considerable transform to several expected eco-systems and raise in the level of the sea that will have a main effect on the life of semi populace of the world that breathes in coastal-zone (Lau, Tan, Lee, & Mohamed, 2009).

Unless comparatively in recent times there have been two comparable studies on the link among economic-growth and environment-pollutants. The earliest researches have concentrated on the economic growth and environment pollution relationship and have been directly associated to test the EKC hypothesis. The Environmental Kuznets Curve hypo-thesis stated that when income rise, CO₂ emissions rise as well unless several entrance income-level is achieved subsequent to CO₂ emissions initiate to turn down. Dinda (2004) and Stern (2004) critique and review on most of the environmental Kuznets curve studies. The environmental Kuznets curve hypothesis indicates CO₂ emission is a function of income, which expects uni-directional causal relation flows from income to CO₂emissions.

It is believable that causal relation can flow from CO₂ emissions to income thereby CO₂ emissions happen in the process of production and consequently income rises. Recognizing this position various researchers have analyzed the way of Granger-causality among economic-growth and environment pollutant (Akbostancı, Türlüt-Aşık, & Tunç, 2009; Coondoo & Dinda, 2002; Dinda & Coondoo, 2006; Lee & Lee, 2009). The Granger Causality does not involve that ‘independent variable cause’s dependent variable’ in the predictable logic. Alternatively, the same as Diebold (2004) place it, ‘independent variable cause’s dependent variable’ in the granger logic means that ‘independent variable includes helpful details for predicting dependent variable’. Although these studies are an exact enhancement on the ordinary Environmental Kuznets Curve literature in the logic that they mould the dynamics of time series, they remain could be experienced from the trouble of omitted variable biases.

A 2nd studies-set has targeted on the economic-growth and energy-consumption nexus on the association among economic-growth and environment pollutant since flaming fossil fuels are primarily generated pollution emissions. While the influential research via Kraft and Kraft (1978), an enormous Granger Causality literature has appeared investigating the relationship between economic growth and energy consumption. The restrictions of this literature, related to those Granger Causality findings that have measured the relationship among economic growth and environment-pollutions, are that a lot of findings investigate the link among economic growth and energy consumption in a bi-variate structure and therefore experience from omitted variable biases (Stern, 1993, 2000). The marital of these twin findings thereby the relationship among economic growth, energy consumption and CO₂ emissions are measured through a Granger Causality multi-variate structure is a comparatively fresh part of the study. Most present researches are for single countries. Here are researches for developing-economies, like China Zhang and Cheng (2009); Malaysia Ang (2008) and Turkey (Halicioglu, 2009; Soytas & Sari, 2009), developed countries, like France Ang (2007) and the United States (Soytas, Sari, & Ewing, 2007), similarly the OPEC oil-rich economies (Soytas & Sari, 2009). The findings are mixed in these researches. For instance, Soytas et al. (2007) and Soytas and Sari (2009) establish long-run uni-directional Granger Causality relation among energy-consumption and CO₂emissions, although Halicioglu (2009) establish short-run and long-run bidirectional granger causality relation among economic-growth and CO₂emissions. Zhang and Cheng (2009) establish long run uni-directional Granger Causality relation from economic-growth to energy consumption and energy consumption to CO₂emissions, although Ang (2007) establish long-run unidirectional granger causality relation as of economic-growth to energy consumption and CO₂emissions. Sari and Soytas (2009) came to contradictory findings for 5 oil-exporting economies like Venezuela, Nigeria, Indonesia, Algeria and Saudi Arabia.

This article expands this research to judge the relations among economic-growth, energy consumption and CO₂ emissions for four ASEAN’s over the period 1980 to 2018. This paper investigation concentrates on four ASEAN countries such as Singapore, Malaysia, Indonesia and Thailand. In 1967 these four economies were the unique beginning member of ASEAN’s Here are panel granger causality findings of the economic growth and environment pollutant link (Dinda & Coondoo, 2006; Lee & Lee, 2009) and the energy consumption and economic growth link for e.g. (Al-Iriani, 2006; S.-T. Chen, Kuo, & Chen, 2007; Joyeux & Ripple, 2007; Lee, 2005; Lee & Chang, 2008; Mahadevan & Asafu-Adjaye, 2007; Mehrara, 2007; Mishra, Smyth, & Sharma, 2009; Narayan & Smyth, 2008, 2009). Though, the one panel-data research of Central American countries to apply a multi-variate structure to study the relationships among economic growth, energy consumption and CO₂emissions (Apergis & Payne, 2009).

The probable cause for contradictory outcomes through one country research is that for several countries, we have yearly highest width data of just 40-45 years and frequently less. The influence of usual unit-root tests is a problem, namely the Augmented Dickey-Fuller test and usual co-integration test, namely the Johansen (1988) test, could be indistinct while the data width is little (Campbell & Perron, 1991). The only cause for using a panel cointegration

and granger causality technique is so as to it has the benefit more concentration on one nation that it offers additional useful data, additional volatility, an additional degree of freedom and therefore more competence in evaluation.

The 2nd cause for reviewing a panel-data set of ASEAN economies is that an aim of the ASEAN's image 2020, accepted in 1997, is to follow a reliable method to provincial development in the collection and optimizing competent consumption of sources. Through the energy cooperation plan of action for ASEAN's (2004-2009) coordinated policies exist at a level of practical, at the ASEAN level of regional (ASEAN, 2004). Leading with combined measures is the ASEAN grid of power and the ASEAN's trans Gas Pipeline road and rail network Projects (ATGP), which have been recognized to guarantee total provincial accessibility to gas stocks and better constancy and energy-protection provide inside ASEAN's. In the same way, a lot of the environment troubles suffered by ASEAN's have a Tran's frontier nature and such as, require a cooperative reaction. The flaming of tropical rain forests to generate gap for palm plants to construct bio-fuel and oil has been spewing an enormous pulsation of CO₂ that extends to neighboring economies resulting unfavorable consequences to wellbeing in Indonesia and Malaysia (Thavasi & Ramakrishna, 2009). The Secretariat (1994) acknowledges "the significance, if not necessity of maintaining the region's resources and defending its atmosphere", stated that "every radical and irretrievable decrease in the regions resources or deprivation of its environment will have broad implications for the regions bionetwork and worth of living". Therefore, it provides logic to study the relation among economic-growth, energy consumption and CO₂emissions for ASEAN's at an aggregate level.

1.1 The ASEAN's background

The selection of the four ASEAN's is considered through the reality that such economies have been amongst the maximum growth countries in the globe during the previous decade. The speedy increase in the economic growth of ASEAN countries has been related to energy consumption. The cement-production plant, oil-refinery plants, agricultural industries, power generation plants, chemical industries and forestry-based industries are major sources of CO₂ emissions. The primary commercial energy requirement of ASEAN countries about ninety per cent are satisfied through fossil fuels (gas-oil-coal) (Karki, Mann, & Salehfar, 2005). The quick rise of information and communication technologies (ICTs) using namely digital-videorecorders, personal computers and digital-melody-players that necessitate considerable contribution of electricity has positioned enlarged stress lying on the utilization of fossil fuels for energy production. The ASEAN economies fast industrialisation during the previous 3 years has also caused in the development of managerial processes and infrastructure that more use of electrical energy. The increase in electricity consumption in the future expected a worldwide shift towards a digital society. The estimation is that flanked by 2000-2010, the utilization of coal for electrical energy production will rises 235-per cent (Karki et al., 2005). In ASEAN economies energy-consumption is predictable to raise about 200 million ton of oil counterpart in 2000 to about 580 mtoe in 2020, according to ASEAN Energy-Centre, (Yoo, 2006).

Per-capita CO₂emissions in ASEAN's economies are never higher with the exclusion of Singapore, definitely relative to the United States, China and India. However, CO₂emissions are rising gradually in four ASEAN countries due to the rapid economic-growth and fossils fuel burning. additionally, the impact of weather vary are the commencement to be powerfully found in the ASEAN's economies with ASEAN's captivating a guide in conflict for a decrease in CO₂emissions universal during discussions on the post-Kyoto and in the Kyoto protocol discussions in Bali in 2008. This posture, into a spin, meaning that the ASEAN countries its selves should be observed to be set a paradigm. Worth of Air in Kuala Lumpur, Bangkok, Manila and Jakarta are among the poorer in the globe (Karki et al., 2005). The manifestations of weather vary is an increase in the ocean height, a rise in the regularity of steamy storms and a top frequency of respiratory and cardiovascular infection (G. Chen & Li, 2007). Some areas of south-east Asia are suffering a high prevalence of infections like malaria and dengue-fever related

through warmer temperatures. Indonesia is an island state, is predominantly susceptible to change in climate. Indonesia comprises of regarding 17,000 islands. The estimate is that 2000 of them will be underwater by 2030 due to increase in levels of sea, in case the latest trend of worldwide warming continues constantly (G. Chen & Li, 2007).

2. Model, data and estimation method

2.1 Model

For the Central American countries, the research enacts a similar method as that adopted through Ang (2007) for France and (Apergis & Payne, 2009). The long-run relationship among CO₂ emissions, electricity consumption and *GDP* is particular the same as follow:

$$CO_{2it} = a_{it} + \beta_{1i}GDP_{it} + \beta_{2i}GDP_{it}^2 + \beta_{3i}EC_{it} + \varepsilon_{it} \quad (1)$$

Here $i = 1, \dots, N$ denotes all countries in data set, $t = 1, \dots, T$ denotes the period of time. CO_2 is carbon dioxide emission (per capita metric-tons), EC is electricity-consumption (per capita millions-kWh), GDP is real *GDP* per-capita (measured in 2000 U.S dollars) and GDP_2 is *GDP* square. The real *GDP*, a square of real *GDP* and electricity consumption with respect to β_1 , β_2 and β_3 stand for the long-run estimate elasticity of CO₂emissions. The environmental kuznant curve hypothesis implies that we must expect $\beta_1 > 0$ and $\beta_2 < 0$. $\beta_1 > 0$ takes the primary raise in CO₂emissions when income raises although $\beta_2 < 0$ shows the U shape inverted outline, one-time income surpasses the doorsill. The hypothesis is $\beta_3 > 0$ as greater electricity consumption will consequence in additional CO₂emissions.

2.2 Data

The experiential research is established on four ASEAN economies (Thailand, Malaysia, Indonesia and Singapore) during the time interval of 1980-2018. The model is controlled to these four ASEAN for such data set on per capita electricity-consumption, per-capita real *GDP* and per-capita CO₂emissions is accessible during this time interval. The yearly dataset was collected from the Asian Development Bank on electricity consumption (per-capita million-kWh). Yearly dataset on per capita real-*GDP* was collected from the statistics department for those four countries. Annual data on CO₂emissions (per capita metric-tons) was sourced from the Energy-Information-Agency. Before conducting the analysis, the dataset was transformed in log forum.

3. Estimation Method

The experiential research has two aims. The 1st is to check CO₂emissions, Electricity Consumption and real *GDP* long-run relation. The 2nd is to check the variables dynamics causative relation. For the testing procedure, four stages are implied. The 1st stage is to apply panel unit-root tests and check which variable contains a unit root. When all variables have a unit-root then the 2nd stage is to check either here is a long-run co-integrating association among the variables. When a long-run association among the variables is established then the 3rd stage is using a suitable long run estimator to estimate Equation (1). When a long-run relationship among the variables is establishing then the last stage is an estimation of panel VECM (vector error correction model) and classifies to deduce the granger causality relationship among the variables.

3.1 Panel unit root tests

In this paper, we employ the Panel unit-root tests projected via (Breitung, 2001), Im, Pesaran, and Shin (2003) and Maddala and Wu (1999). (Im et al., 2003) develop t bar-test which supposes that all ASEAN economies congregate

over the rate of equilibrium at diverse speed through the alternative hypothesis. By developing the t bar test here are two steps. The 1st step is an estimation of the individual average A.D.F t-statistics for all ASEAN economies in the model. The 2nd step is to estimate the standard t'bar statics same as follow:

$$t - bar = \sqrt{N}(t_{\alpha} - k_t) / \sqrt{v_t} \quad (2)$$

here the panel size is denoted by N, the individual ADF-t-statics average for all ASEAN nations is denoted by t_{α} , without and with a trend, $k_t - v_t$ are correspondingly estimate the variance and mean for all $t_{\alpha i}$. Im et al. (2003) tabulate accurate critical values for a different combination of T and N provided k_t and v_t monte carlo simulations. A probable trouble in t-bar test is that the test is no longer applicable in the occurrence of cross section reliance in the instability. yet Im et al. (2003) indicated that in the occurrence of cross-section reliance, data could be modified through humiliating and that the standardize demean t'bar facts converge to the average usual in limits.

Maddala and Wu (1999) critiqued the Im et al. (2003) test on the origin that in various actual worlds application, annoyed co-relations are improbable to obtain the uncomplicated structure projected by Im et al. (2003) that could be successfully abolished through mortifying the data. Maddala and Wu (1999) projected an Augmented Dickey-Fuller Panel-unit-root test depend on (Fisher, 1932). The Fisher ADF test has basically merged the p-value of the test statics for unit-root in every residue cross-section units. The cross-section unit or country is denoted by N, where the test has a chi-square distribution which is non-parametric through 2N degrees of freedom. The chi-squared variable using the additive property, the subsequent test statistics could be derivative:

$$\lambda = -2 \sum_{i=1}^n \log_e \pi_i \quad (3)$$

Here, the test-static for component i is the p value of π_i . The Maddala and Wu (1999) test have the benefit across the Im et al. (2003) test in individual Augmented Dickey-Fuller regressions that it does not rely on various lag-lengths. Maddala and Wu (1999) conducted Monte Carlo simulation indicating that his test is better to that projected via Im et al. (2003).

The panel unit-root test by Breitung (2001) has the structure in the following:

$$y_{it} = \alpha_{it} + \sum_{k=1}^{p+1} \beta_{ik} x_{i,t-k} + \varepsilon_t \quad (4)$$

According to Equation.(4), the Breitung (2001) process is difference stationary when the test-statics checks the subsequent null hypothesis: the panel series is stationary according to alternative hypothesis assumes that; that is, for all i . Breitung (2001) construct the test statistic by using the following transformed vectors:

$$y_i^* = AY_i = [y_{i1}^*, y_{i2}^*, \dots, y_{iT}^*]$$

$$X_i^* = AX_i = [X_{i1}^*, X_{i2}^*, \dots, X_{iT}^*]$$

The test statistic leads as follows:

$$\lambda_B = \frac{\sum_{i=1}^N \sigma_1^{-2} y_i^{*'} X_i^{*'}}{\sqrt{\sum_{i=1}^N \sigma_1^{-2} X_i^{*'} A' A X_i^{*'}}} \quad (5)$$

a normal distribution is shown.

3.2 Panel cointegration

When all variables hold a unit root, we pursue to check either here is a long-run association among the variables through the panel cointegration Johansen-Fisher test projected via Maddala and Wu (1999). The panel co-integration Johansen Fisher test is a panel edition of the particular Johansen (1988) co-integration test. Depend on the similar principle foundation the Fisher Augmented Dickey-Fuller panel unit-root analysis stated beyond, the values of individuals maximize eigenvalue and trace value figures are panel co-integration test of Johansen Fisher

aggregates. Under the panel null hypothesis, if π_i is the p-value for cross-section i as of an individual co-integration test,

$$-2 \sum_{i=1}^N \log(\pi_i) \rightarrow \chi_{2N}^2 \quad (6)$$

3.3 Panel long-run estimation

When the long-run cointegrating association exist among the variables then we analysis equation.(1) by a panel edition of DOLS (Dynamic Ordinary Least Squares) projected via (Pedroni, 2001). Considered the model $y_{it} = \alpha_i + \beta_i X_{it} + \mu_{it}$ so that y_{it} is CO_2 and X shows the vector of EC , GDP and GDP^2 . For the control of endogenous feedback this analysis is augmented with lagged and lead differences:

$$y_{it} = \alpha_i + \beta_i X_{it} + \sum_{k=-k_j}^{k_i} \gamma_{ik} \Delta X_{it-k} + \mu_{it}^*$$

The group means panel-DOLS estimator could be developed from this analysis as,

$$\hat{\beta}_{GD}^* = \left[N^{-1} \sum_{i=1}^N \left(\sum_{t=1}^T Z_{it} Z_{it}' \right)^{-1} \left(\sum_{t=1}^T Z_{it} \tilde{s}_{it} \right) \right]$$

here Z_{it} is the $2(k+1) \times 1$ vector of the independent variable $Z_{it} = (X_{it} - \bar{X}_i, \Delta X_{it-k}, \dots, \Delta X_{it+k})$, $\tilde{s}_{it} = s_{it} - \bar{s}_i$. i is similar to the predictable panel *DOLS* estimator as the expression of the following summation, the estimator of panel-DOLS could be developed such as $\hat{\beta}_{GD}^* = N^{-1} \sum_{i=1}^N \hat{\beta}_{D,i}^*$, where $\hat{\beta}_{D,i}^*$ is the predictable penal- *DOLS* estimator, employed to the i^{th} the element of the panel. The same as an effect, the t'statics for the DOLS panel estimation could be developed as follow:

$$t_{\hat{\beta}_{GD}^*} = N^{-\frac{1}{2}} \sum_{i=1}^N t_{\hat{\beta}_{D,i}^*} \text{ where } t_{\hat{\beta}_{D,i}^*} = (\hat{\beta}_{D,i}^* - \beta_o) \left(\hat{\sigma}_i^{-2} \sum_{t=1}^T (X_{it} - \bar{X}_i) \right)^{\frac{1}{2}}$$

The panel-DOLS findings for Equation (1) are specified in Table (3). All the coefficients are statistically significant on the five-per-cent level or improved and the signs are predictable, for the panel of ASEAN's. The findings for the panel show that one per cent rise in per capita electricity-consumption is related to a rise in CO_2 emissions per capita of 0.401 per cent. This finding is inline by the finding of Ang (2007) and Apergis and Payne (2009) they discover that direct relation among per capita electricity consumption and per capita CO_2 emissions. The flexibility of per-capita CO_2 emissions as compared to per capita real GDP , in the long-run, is 2.104-0.404 GDP through the threshold earnings of 7.688 in the log. The EKC hypothesis is supporting this finding for the four ASEAN countries overall the level of CO_2 emissions first rise when income rise, then stabilize and decline according to the threshold earnings level. This finding is inline through the results of Ang (2007) and Apergis and Payne (2009) and usually inline through the findings of Grossman and Krueger (1995), Shafik and Bandyopadhyay (1992) and Selden and Song (1994) they also find a U shaped relations among per capita CO_2 emissions and per capita real GDP .

3.4 Panel Granger causality

The presence of a long run co-integrating relation among variables indicates the presence of Granger causality in one direction at least; although, it does not show the causality directions. when granger causality exists among the variables then we employ a dynamic-error-correction-model (DECM). The following regressions are based on Granger-Causality test:

$$\Delta CO2_{it} = \pi_{1i} + \sum_p \pi_{11ip} \Delta CO2_{it-p} + \sum_p \pi_{12ip} \Delta EC_{it-p} + \sum_p \pi_{13ip} \Delta GDP_{it-p} + \sum_p \pi_{14ip} \Delta GDP_{it-p}^2 + \Psi_{1i} ECT_{it-1} + \varepsilon_{1it} \quad (7a)$$

$$\Delta EC_{it} = \pi_{1i} + \sum_p \pi_{21ip} \Delta CO2_{it-p} + \sum_p \pi_{22ip} \Delta EC_{it-p} + \sum_p \pi_{23ip} \Delta GDP_{it-p} + \sum_p \pi_{24ip} \Delta GDP^2_{it-p} + \Psi_{2i} ECT_{it-1} + \varepsilon_{2it} \quad (7b)$$

$$\Delta GDP_{it} = \pi_{1i} + \sum_p \pi_{31ip} \Delta CO2_{it-p} + \sum_p \pi_{32ip} \Delta EC_{it-p} + \sum_p \pi_{33ip} \Delta GDP_{it-p} + \sum_p \pi_{34ip} \Delta GDP^2_{it-p} + \Psi_{3i} ECT_{it-1} + \varepsilon_{3it} \quad (7c)$$

$$\Delta GDP^2_{it} = \pi_{1i} + \sum_p \pi_{41ip} \Delta CO2_{it-p} + \sum_p \pi_{42ip} \Delta EC_{it-p} + \sum_p \pi_{43ip} \Delta GDP_{it-p} + \sum_p \pi_{44ip} \Delta GDP^2_{it-p} + \Psi_{4i} ECT_{it-1} + \varepsilon_{4it} \quad (7d)$$

The model of the ECT is as follows:

$$E\hat{C}T_{it} = CO2_{it} - \hat{\alpha}_i - \hat{\beta}_{1i} GDP_{it} - \hat{\beta}_{2i} GDP^2_{it} - \hat{\beta}_{3i} EC_{it}$$

Here, GDP , GDP^2 , CO_2 and EC are defined the same as above, the variable at first difference denoted by Δ , the Error Correction Term indicated by ECT , and the lag lengths indicate by p . By employing the Schwarz information criteria, the best possible lags were selected automatically.

There is a Causality relation from ΔGDP and ΔGDP^2 to ΔCO_2 (ΔEC) in case the joint null-hypothesis $\pi_{13ip} = \pi_{14ip} = 0 \forall ip$ ($\pi_{23ip} = \pi_{24ip} = 0 \forall ip$) is rejected using a Wald-test. By applying a likelihood-ratio test the existence of 2 variables measured real output-growth same as ΔGDP and ΔGDP^2 , in the structure needed cross equations limitation to conclude the causality from any ΔCO_2 or ΔEC to real output-growth. The causality from ΔCO_2 (ΔEC) to is ΔGDP and ΔGDP^2 assisted in case the null-hypothesis $\pi_{31ip} = 0 \forall ip$ and $\pi_{41ip} = 0 \forall ip$ ($\pi_{32ip} = 0 \forall ip$ and $\pi_{42ip} = 0 \forall ip$) is rejected. For the causality in long-run, in case, the null-hypothesis $\psi_{3i} = \psi_{4i} = 0 \forall i$ is discarded, then ΔGDP and ΔGDP^2 reacts equally to long-run equilibrium deviations.

4. Results and discussion

Table 1. Panel unit-root tests

Unitroot-test	GDP	GDP^2	CO^2	EC
		Level		
I-P-S test	0.271	0.233	1.808	2.140
ADF Fisher test	7.086	7.035	7.305	6.580
Breitung-test	-1.257	-1.357	1.575	2.036
		1 st -difference		
I-P-S test	-2.755	-2.735	-2.621	-6.382
ADF Fisher test	26.455	26.135	23.570	51.528
Breitung-test	-4.106	-3.861	-1.686	-2.008

Notes: the unit-root-tests were conducted according to trend and intercept of individual series. By applying Schwarz information criteria, the selection of best possible lags was automatically. For all the tests the unit-root is a null hypothesis. * (**) (***) indicates 10% (5%) (1%) level of significance.

The Table.(1) shows unit-root panel tests results. Breitung (2001).test employed to GDP and GDP^2 , such are statistically-significant just on the ten percent-level with the exclusion of the test statics in regards logarithm-levels of CO_2 , EC , GDP and GDP^2 are in-significant statistically. The findings of log-levels recommend that three variables are non-stationary as a whole. For the 1st difference of the four variables we can employ the panel tests of

unit-root, at one per cent level the entire 3 test rejects the joint null hypothesis for these four variables. Therefore, we can conclude through all the tests, all of the variables contain a panel unit-root.

Table 2. Panel cointegration Johannes Fisher test

Hypothesis No of CEs	Fisher-statics	Fisher-statics		
	Trace test	Prob	Max Eigen Test	Prob
None.	42.10	0.000	29.19	0.001
At most-1	22.23	0.003	21.5 1	0.011
At most-2	9.99	0.255	9.02	0.328
At most-3	7.107	0.507	7.107	0.507

* By applying the asymptotical Chi-square distributions probabilities are computed.

The chi-square statics value depends on the MacKinnon, Haug, and Michelis (1999) p-value for Johansen (1988) co-integration trace-test and maximize Eigen value-test. The results are identified too heavily based on the vector autoregressive system order lag in the type of Johansen cointegration-test. The findings, such are stated in Table. (2), shows that a single co-integrating vector exists and use one lag. If two lags are employed, then the findings are the identical.

Table 3. DOLS Panel long-run estimation. The Dependent Variable is CO₂

Country	<i>EC</i>	<i>GDP</i>	<i>GDP²</i>
Malaysia	0.632*** (3.287)	-0.451 (-0.105)	0.021 (0.102)
Singapore	0.312*** (2.231)	0.641 (0.581)	-0.011 (-0.257)
Indonesia	0.275*** (7.112)	4.212* (1.765)	-0.236 (-1.612)
Thailand	0.616*** (8.170)	3.142 (1.227)	-0.212 (-1.201)
Panel	0.401*** (12.252)	2.104** (2.053)	-0.102** (-1.518)

The values in parenthesis show t-statistics. *** (**) (*) denotes 1% (5%) (10%) level of significance.

According to the findings of one country, in all cases, a rise in per capita electricity consumption is related to a rise in per capita CO₂ emissions. The findings show that a one per cent rise in per capita electricity consumption is related to rise in CO₂ emissions per-capita of 0.275 per-cent in Indonesia at the bottom and 0.632 per cent in Malaysia on the top. The findings with respect to the relation between income and CO₂ emissions are varied. CO₂ emissions in Indonesia are monotonically rising with levels of income. The findings for Indonesia are inline consistent with existing results by Holtz-Eakin and Selden (1995), Shafik (1994). Here the relation between income and CO₂ emissions in Thailand, Singapore and Malaysia does not exist.

Table 4. Panel Granger Causality Results

$\Delta GDP, \Delta GDP^2$	ΔEC	ΔCO_2	ECT	
$\Delta GDP, \Delta GDP^2$ (0.212)	- (0.273)	3.155 (0.201)	1.644	9.530
ΔEC (0.025)	1.170 (0.171) (0.136)	-	0.117**	0.024
CO_2 (0.266)	0.645 (0.361)	0.064 (0.665)		0.006

The parenthesis shows the p-value. *** (**) indicates 1% (5%) level of significance.

The Table (4) shows panel granger causality findings in short-run and long-run. The Table (4) results show that here is panel granger causality in short run operating from CO₂emissions to electricity consumption. Here is uni-directional Granger Causality operating as of electricity consumption and CO₂emissions to real *GDP* in long-run.

5. Discussion and policies

The findings of the model *DOLS* (dynamic ordinary least square) show that for the four ASEAN's economies here is a non-linear and significant relation among CO₂emissions and income and a direct relation among CO₂emissions and electricity consumption. The long-run estimation, though; does not show the causality direction among the variables. In the long run, the granger causality test findings propose that here is unidirectional Granger causality operating as of electricity consumption and CO₂emissions to *GDP*.

In the long-run, the uni-directional Granger Causality operating as of electricity-consumption to *GDP* suggests that these four economies are dependent on energy. The rise in electricity consumption leads to a rise in *GDP* since, moreover to the direct impact of electricity addicted for business work that produced the rising rate of economic growth, rising energy consumption leads to raising in energy production, it has the negative impact on employment-generating and road and rail network in electricity services.

The conclusion is that four ASEAN countries have a significant amount of economic growth which nurtures through the growth of the industry, which implies concentrated utilize of energy because these four ASEAN economies are energy-dependent economies. The value-added of industry as in *GDP* proportion was 39 per cent in Malaysia, 39 per cent in Indonesia and 35 per cent in Thailand in 2018 (Bank, 2009). Amusingly, the findings recommend that greater electricity consumption and economic growth does not granger causes CO₂emissions. In ASEAN these findings may replicate the reality that even as CO₂emissions have been gradually rising with economic growth, through the exclusion of Singapore, they are at rest quite low down. Although ASEAN's is blessed with recoverable resources of energy, improvement over-utilizing them beneath the Global Alliance for Building and Construction has been sluggish and sustainable source of energy in the county continue under-utilized (Lidula, Mithulanathan, Ongsakul, Widjaya, & Henson, 2007).

Somewhat, the findings in this research decrease the importance for policymakers of ASEAN's to discover and use recoverable resources of energy, due to the apparent effect of electricity consumption and economic growth on gas emission of green house. This believed that economic growth is a product of growth in inputs or extra active utilize of in-puts. Consequently, policies for four ASEAN countries is that continuous swift economic growth needs high and most resourceful utilization of energy. The results recommend that these four ASEAN countries must accept the multi-pronged approach of rising investments in electricity road and rail network to enlarge electricity inputs, and rigid transformation of electricity road and rail network and placing in position electricity preservation policies to recover deliverance effectiveness. A number of ASEAN countries have earlier taken actions to reinforce electricity inputs and enhance efficiency in energy, in accumulation to regional actions to make sure energy protection, like TAGP and the ASEAN Power-Grid. Singapore has taken actions to enhance efficiency in energy, for instance in the vend markets of electricity Singapore has liberalized its gas and electricity market to allow complete rivalry. In Singapore, the average effectiveness of plants of oil-fired is similar to OECD economies. In general, the efficiency of generation in Singapore improved as of 38 per cent to 44 per cent during 2000 to 2006, by the acceptance of joint-cycle using and steam-turbines and gas, and around sixteen per cent decrease in CO₂emissions (Thavasi & Ramakrishna, 2009).

The results of this article also show that Granger-causality exists between environmental-degradation and economic growth in the long run. This result is reliable with CO₂emissions generating in the procedure of production and reflects the experiences of various industrialized economies. Thus, obviously, is nor to declare that Environment-Degradation is a suitable path to encourage economic growth. At a certain stage, policymakers suggest that the focal point of government policy must be on societal well-beings rather than per capita income and here is want to be heedful literature on sustain-ability (J. Gowdy, 2005; J. M. Gowdy, 2004). Here are a rising integer of findings that recommend Environmental-degradation, counting noise and air pollutions, lower living contentment (Di Tella & MacCulloch, 2008; Ferrer-i-Carbonell & Gowdy, 2007; Rehman & Maddison, 2008; Smyth, Mishra, & Qian, 2008; Van Praag & Baarsma, 2005; Welsch, 2002, 2006). At the second stage, in the long-run, a constant reduction in quality of environment might create negative externalities in favour of the country throughout decreasing productivity and health human capital (Ang, 2008).

In 2018, a hundred per cent populations live in urban areas in Singapore. The parallel number was 76 per cent in Malaysia, 55 per cent in Indonesia and 50 per cent in Thailand (Bank, 2009). Fifty per cent or extra of the populace in urban areas have an unfavourable impact on the healthiness of peoples, according to the environmental situation of Asian countries (Thavasi & Ramakrishna, 2009). In many Asian countries, it is alerted that indoor pollutant from catering, illumination and warming is a reason for the loss of sight, diseases of the heart, lung cancer, and tuberculous. Bio-Mass stove-top cooking is stated to escape six to twenty per-cent of the CO₂ as pollution and consequently causes constant bad impact on health on intake (Padma, 2007). In many Asian countries outdoor-pollution created through automobile CO₂emissions is a main feature of causative to respiratory-disease. Deduction in the traffic volume could recover outdoor pollution. For instance, Singapore has introduced mass rapid transport structure in organizing to control CO₂ emissions.

Conclusion

The first limit of this research is that the investigation is at an aggregate level. The intensities of energy differ in differing industries. At this position, here are a few types of research that observe the relation among electricity consumption much commonly, and real *GDP* on a level of disaggregated and never equivalent to the panel-data researches. In a panel of ASEAN's, it could be complex to get disaggregate data on electricity consumption; nevertheless, if a single country data would be collected, such as Thailand, a similar plan could be a valuable area for upcoming study. The other one is this research use CO₂emissions like a substitute for environmental degradation and electricity consumption like a substitute for energy consumption. Upcoming researches which employ another proxy for energy consumption and Environmental Degradation can give more approaching concerning the relation among energy consumption, environmental-degradation and GDP.

The 3rd way for upcoming studies could be to check the causative relation among GDP, CO₂emissions and additional possible related variables like urbanization, automobile-use and health expenditures. Here is a high confirmation that the enlarged occurrence of an automobile in various Asian countries, which has accompanied rising urbanization and increasing incomes, has compounded CO₂emissions. Mishra et al. (2009) and Zhang and Cheng (2009) contain a variable such as urbanization, as investigating the energy-consumption and economic-growth relation, other than the role of automobile ownership neither consider in research. In the same way, huge studies occur which finds the long run relation among health-expenditures and economic growth, although Narayan and Narayan (2008) investigate the effect of CO₂emissions and *GDP* on health-expenditures. This would be expanded to address multi-variate Granger Causality setup among economic growth, health-expenditure and different types of CO₂emissions.

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