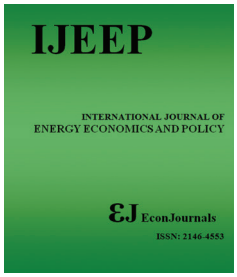

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Causal Link between Financial Globalisation Uncertainty, Economic Growth, Environmental Degradation and Energy Consumption in ASEAN+3 Countries

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ABSTRACT

This paper examines the causal relationship between financial globalisation uncertainty, environmental degradation, economic growth and energy consumption for ASEAN+3 countries using the second-generation approach for the period from 1970 to 2019. The results of second-generation unit root test revealed that economic growth and financial globalisation uncertainty were stationary at level, while energy consumption and environmental degradation were stationary at first difference. In addition, the Larson cointegration test showed that long-run cointegration exists between the variables. Similarly, we found that economic growth and environmental degradation have significant positive influence on energy consumption. However, financial globalisation uncertainty has insignificant influence on energy consumption. The results of causal relationship indicated a bidirectional causal relationship between financial globalisation uncertainty and energy consumption; environmental degradation and energy consumption; and economic growth and energy consumption.

Keywords: Environmental Degradation, Economic Growth, Energy Consumption, Second-Generation Approach
JEL Classifications: R11, O47, P18, P34, B23

1. INTRODUCTION

Throughout the past two centuries several researchers have studied the issue of causal link between variables in energy consumption and macroeconomics. The causal link among energy consumption and other independent variables which including economic growth, trade openness and financial development has been investigated in various studies. Energy is regarded the life-line of an economy, a very essential measure for socio-economic development, and is viewed as among the most major policy financial instruments (Bekhet et al., 2017). Energy is not only vital to the economy but also uncertain in its supply (Gorus and Aydin, 2019; Atiku et al., 2021). This is a critical force that both affects the results of conflicts, drives and restrains economic growth and contaminates, and cleans the environment. In the context of globalization, an increasingly rising market for energy and countries' reliance on energy means that energy will be one of the world's greatest challenges in the next century. That needs alternative, renewable energy sources. Theoretical models of growth concentrate mostly on capital and labour as major production factors and neglect the role of energy in the growth process (Munir et al., 2020). The issue of causal relation between energy consumption, environment and economic growth has already been studied in the literature of economics. Various studies aimed at different countries, proxy

variables, time periods, and the various econometric strategies used for the relation between energy consumption, environment and growth. The empirical research findings were diverse and, at times, contradictory. The findings on causality and long-term, versus short-term, effects on energy policy tend to be different. A successful research field was the relation among CO_2 emissions, economic growth and energy (Paul and Bhattacharya, 2004; Sadorsky, 2010; Antonakakis et al., 2017; Mirza and Kanwal, 2017; Bekun et al., 2019; Munir et al., 2020; Zhu and Shan, 2020). The purpose of this study is to examine the influence of financial globalization uncertainty, environmental degradation and economic growth on energy consumption for the period between 1970 and 2019 for ASEAN+3 countries. For this purpose, we used second generation approach, following the spirit of the traditional growth model paradigm.

2. METHODOLOGY AND DATA

2.1. Data

The study investigates a sample of ASEAN+3 countries for the period 1970-2019 using data from the World Bank Development Indicators. Many energy researchers, such as (Feng et al., 2009; Balcilar et al., 2010; Sadorsky, 2010; Shahbaz and Lean, 2012; Jaforullah and King, 2017; Mirza and Kanwal, 2017; Shahbaz et al., 2019; Zhu et al., 2019; Gorus and Aydin, 2019) among others, enclosed CO_2 emissions, economic growth, capital stock, financial development, labour force, trade openness, and foreign direct investment variables. These variables were typically considered relevant and have a statistically significant effect on economic growth. Consequently, our proposed model, that seems to be consistent with previous studies on the energy consumption determinants mentioned above, considers the following from:

$$EC_{it}=f(FGU_{it}, EG_{it}, CO_{2it}) \quad (1)$$

We start with slope homogeneity and cross section dependence test. Essentially, in data analysis the first concern for the panel is whether the slope parameters are heterogeneous or not. A robust null hypothesis is causal to cause by imposing a mutual constraint on the whole panel (Dumitrescu and Hurlin, 2012). In addition, the cross-section dependence test is the second step before assessing the integration order of the series; the primary issue is to step for cross-sectional dependence of the series. The panel unit root test has different techniques when testing for the presence of a unit root. This analysis selects root unit tests including the CIPS test, and CADF tests for second generation. This process measures the p-values paired which can be stated as follows:

$$Y_{i,t} = (1-\varphi_i)\,\alpha_i + \varphi_i\, y_{i,t-1} + \pi_{i,t}\ i = 1,2,3,\ldots\ldots\ldots,N \text{ and } t = 1,2,3,\ldots\ldots\ldots,T \quad (2)$$

$$\pi_{it} = \gamma_i f_t + \mu_{it} \quad (3)$$

Here f_t displays unobservable prevalent influence of each country, μ_{it} Reveals the error of individual-specific. Equation (1) and (2), as well as unit root hypothesis, can be given as follows:

$$\Delta y_{it} = \delta_i + \beta y_{i,t-1} + \tau_i f_i + \mu_{it}\ i = 1,2,3,\ldots\ldots,N \text{ and } t = 1,2,3,\ldots\ldots,T \quad (4)$$

H_0: $\beta_i = 0$ upon all i non-stationarity

H_1: $\beta_i < 0\ i = 1,2,3,\ldots,N_1\ \beta_i = o\ i = N_1 + 1, N_1 + 2\ldots\ldots\ldots,N$. The series is stationary

This statistic correlates to a typical normal distribution within the cross-sectional independence framework (Atiku et al., 2022, Kamalu et al., 2022). While, the Larsson et al. (2001) technique is comparable to the analysis of cointegration within the framework of a panel error correction model. It also has some great benefits over residual-based cointegration test. The Larsson et al. (2001) feature enables for more than one cointegration vector. This study used the revised version of (Driscoll and Kraay, 1998), which allows for {it} to be cross-sectionally dependent, heteroscedastic and autocorrelated. Depending on this assertion, empty set can be suitable for this role by OLS regression which will result in:

$$\check{L}_T = \check{\partial}_0 + \sum_{j=1}^{m(T)} w(j,m)\left[\check{\partial}_j + \check{\partial}_j'\right] \quad (5)$$

where matrix $\check{\partial}_j$ is:

$$\check{\partial}_j = \sum_{t=j+1}^{T} \check{h}_t(\delta)\,\check{h}_{t-j}(\delta)\ with \check{h}_t(\delta) = \sum_{i=1}^{N(t)} h_{it}(\widehat{\delta}) \quad (6)$$

It is, of course, exceptionally likely in various economic issues that if a causal relation occurs for a nation or an individual, it also occurs for some different country or country. Within that specific instance, the causality with NT observations can be evaluated all the more accurately in a panel context. Contrarily, the use of cross-sectional data requires recognition of the variation in the definition of the causal link across various countries (Dumitrescu and Hurlin, 2012). Estimates of the DH heterogeneous Granger causality test are:

$$\Delta LEC_{i,t} = \beta_i + \sum_{\aleph=1}^{\aleph} \sigma_i^{(\aleph)} LFGU_{i,t-\aleph} + \sum_{\aleph=1}^{\aleph} \tau_i^{(\aleph)} \Delta LEG_{i,t-\aleph} + \sum_{\aleph=1}^{\aleph} \pi_i^{(\aleph)} \Delta LCO_{2i,t-\aleph} + \varepsilon_{i,t} \quad (7)$$

$$\Delta LFGU_{i,t} = \beta_i + \sum_{\aleph=1}^{\aleph} \sigma_i^{(\aleph)} LEC_{i,t-\aleph} + \sum_{\aleph=1}^{\aleph} \tau_i^{(\aleph)} \Delta LEG_{i,t-\aleph} + \sum_{\aleph=1}^{\aleph} \pi_i^{(\aleph)} \Delta LCO_{2i,t-\aleph} + \varepsilon_{i,t} \quad (8)$$

$$\Delta LEG_{i,t} = \beta_i + \sum_{\aleph=1}^{\aleph} \sigma_i^{(\aleph)} LFGU_{i,t-\aleph} + \sum_{\aleph=1}^{\aleph} \tau_i^{(\aleph)} \Delta LEC_{i,t-\aleph} + \sum_{\aleph=1}^{\aleph} \pi_i^{(\aleph)} \Delta LCO_{2i,t-\aleph} + \varepsilon_{i,t} \quad (9)$$

Table 1: Summary of descriptive statistics

Variable	LEC_{it}	LCO_{2it}	LEG_{it}	$LFGU_{it}$
Mean	6.996	10.637	−2.186	0.001
SD	1.053	2.504	1.567	1.302
Sk	0.340	−0.279	0.471	−2.973
Kur	1.817	2.757	4.582	26.494
SF-test	0.932* (0.000)	0.989* (0.000)	0.953* (0.000)	0.734* (0.000)
SW-test	0.930* (0.000)	0.988* (0.000)	0.954* (0.000)	0.740* (0.000)

SD: Standard deviation

$$\Delta LCO_{2i,t} = \beta_i + \sum_{\aleph=1}^{\aleph} \sigma_i^{(\aleph)} LEG_{i,t-\aleph} + \sum_{\aleph=1}^{\aleph} \tau_i^{(\aleph)} \Delta LFGU_{i,t-\aleph} \quad (10)$$

$$+ \sum_{\aleph=1}^{\aleph} \pi_i^{(\aleph)} \Delta LEC_{i,t-\aleph} + \varepsilon_{i,t}$$

3. EMPIRICAL RESULTS

Table 1 display statistics comparable of ASEAN+3 countries. The Kurtosis and Skewness values indicate a lack of symmetry in the distribution. In general, if the Kurtosis and Skewness values are 0 and 3 respectively, it is assumed that the observed distribution is normally distributed. Jarque-Bera Variables coefficients of statistics show that the distributions of frequencies are not normal. Moreover, the results of Shapiro-Francia test and Shapiro-Wilk test were all significant at 1% level. This indicated that the variables are not normally distributed.

Furthermore, Table 2 below revealed the correlation analysis. The correlation between CO_2 emission, financial globalisation uncertainty and energy consumption is positive. Financial globalisation uncertainty is positively related to CO_2 emission. The relation between economic growth and energy consumption is negative. A negative correlation exists between CO_2 emission, financial globalisation uncertainty and economic growth.

Moreover, we used homogeneity and three cross-sectional dependence tests proposed by Pesaran, Friedman, and Frees to decide whether the panel time series are homogeneous and cross-sectional independent. Based on these correlations, the results of the CD tests in Table 3 and showed that LEC_{it}, $LFGU_{it}$, LEG_{it} and LCO_{2it} are homogeneous and highly dependent on countries. The probability values in parentheses demonstrate that the null hypothesis of independence is strongly rejected at the level of 1 percent, so that cross-sectional dependence must also be taken into consideration when calculating the panel's statistical data if deceptive inferences are to be eliminated and the panel's data set is statistically significant.

Additionally, the findings of panel unit root check are summarized in Table 5. The results of the CIPS and CADF unit root test revealed that the unit root hypothesis had been rejected. Table 4 demonstrates the results of the unit root analysis of the variables of the LEG, and LFGU at the level of 1%, respectively, was found to be stationary at I(0). LEC_{it} and $LCO2_{it}$ were thus non-stationary and not integrated in the same order, although it was found to be integrated and stationary at significance level of 1 percent at first difference. Therefore, the LEC_{it} and LCO_{2it} were stationary and integrated in the same order, i.e. I(1).

Table 2: Correlation analysis

Variable	LEC_{it}	LCO_{2it}	$LFGU_{it}$	LEG_{it}
LEC_{it}	1.000			
$LCO2_{it}$	0.125	1.000		
$LFGU_{it}$	0.042	0.111	1.000	
LEG_{it}	−0.526	−0.156	−0.037	1.000

Table 3: Test for slope homogeneity

Model	Delta
Adj	29.333 (0.000)
	30.919 (0.000)

Table 4: Cross-sectional dependency test

Variable	Pearson's test	AT	ρ	abs ρ
LEC_{it}	−14.723 (0.000)	50.00	0.24	0.59
$LCO2_{it}$	−33.347 (0.000)	50.00	0.53	0.56
LEG_{it}	−22.079 (0.000)	50.00	0.35	0.42
$LFGU_{it}$	−16.932 (0.000)	50.00	0.27	0.29
Friedman's test				
47.154 (0.000)	0.542	-	-	
Frees	4.645 (0.000)	0.542		

Table 5: Panel unit root tests

Variable	LEC_{it}	$LCO2_{it}$	LEG_{it}	$LFGU_{it}$
At level				
CIPS	−1.054	−0.754	−3.324*	−6.180*
CADF	−1.135	−2.260	−3.065*	−6.402*
At first difference				
CIPS	−5.794*	−5.467*	−5.655*	−6.190*
CADF	−4.678*	−4.790*	−6.073*	−9.313*

Larsson et al. (2001) suggested a probability check co-integrating rank in heterogeneous panels. Also, under null hypothesis, so every group on the panel has interrelationships which co-integrate as much as possible. After attaining the average of individual Johansen trace statistics, the research extracted a standardized LR-bar statistic that would be used as the basis for the panel cointegration rank test. Standardized asymptotic distribution of the LR-bar is by default natural. Table 6 presents the results of a cointegration test by Larsson et al. (2001) for emerging economies. As standard, the test follows normal distribution. The research results evidently indicated one co-integrating vector among LEC_{it}, $LFGU_{it}$, LEG_{it} and LCO_{2it} for the emerging economies.

In Table 7, we found that uncertainty over financial globalization has a negligible positive influence on energy consumption at both 1% and 5% level. An increase of 1% in financial uncertainty is expected to increase the demand for energy by 0.013%. Likewise,

Table 6: Cointegration results

Countries	r=0	P	r=1	P	r=2	P	r=3	P
Brunei	42.592	0.143	19.051	0.489	3.905	0.911	0.032	0.858
Cambodia	74.393*	0.000	30.696**	0.039	8.910	0.373	0.415	0.519
Indonesia	69.082*	0.000	33.485**	0.018	10.190	0.266	1.124	0.289
Lao	44.732	0.095	13.002	0.8915	2.226	0.991	0.004	0.949
Malaysia	68.517*	0.000	31.562**	0.031	10.184	0.267	1.364	0.243
Myanmar	49.025**	0.038	19.266	0.474	9.472	0.324	3.415	0.065
Philippines	59.208*	0.003	14.883	0.788	6.161	0.677	0.925	0.336
Singapore	75.425*	0.000	29.779	0.050	11.038	0.209	0.107	0.743
Thailand	70.957*	0.000	34.668**	0.012	15.024	0.059	5.436**	0.019
Viet Nam	74.535*	0.000	34.66**	0.013	16.704**	0.032	3.116	0.078
China	57.526*	0.004	26.105	0.126	9.235	0.344	0.035	0.852
Japan	91.159*	0.000	38.994*	0.003	16.202**	0.039	3.068	0.079
R/Korea	69.416*	0.000	38.025*	0.005	11.554	0.179	3.269	0.070
LR_NT	65.120*							
LR_TEST	20.03876							
E (Z_k)	27.729							
Var (Z_k)	45.264							
n	13.000							

Table 7: Driscoll and Kraay's estimate

Dependent variable: LEC_{it}			
Variables	**Coefficients**	**SE**	**P-value**
Long-run estimates			
$LFGU_{it}$	0.013 (1.59)	0.009	0.119
LEG_{it}	0.098** (2.98)	0.033	0.005
$LCO2_{it}$	0.144* (4.95)	0.029	0.000
HT	0.07		0.995
Mean value-VIF	1.03		

SE: Standard error

Table 8: Dumitrescu-Hurlin panel causality tests

Causality direction	W-statistics	Z-statistics	Decision
ΔLEC ←/– ΔLFGU	2.508** (0.001)	3.446	Bidirectional
ΔLEC ←/– ΔLFGU	3.550* (0.000)	5.900	
ΔLEC ←/– ΔLCO_2	18.318* (0.000)	40.693	Bidirectional
ΔLEC ←/– ΔLCO_2	12.880* (0.000)	27.882	
ΔLEC ←/– ΔLEG	9.581* (0.000)	20.110	Bidirectional
ΔLEC ←/– ΔLEG	4.929* (0.000)	9.151	

at a point of 1%, CO_2 emissions have a positive and statistically meaningful impact on energy consumption. It is expected that a 1% increase in CO_2 emissions will increase energy consumption by 0.098%. Economic growth also has a significant and positive impact on energy consumption at a significant 1% level. The economic growth coefficient is 0.144, meaning that for ASEAN+3 countries a 1% increase in the GDP growth rate raises energy demand by 0.144%. The findings here are consistent with those of a recent study by (Balcilar et al., 2010; Antonakakis et al., 2017; Bekun et al., 2019; Jaforullah and King, 2017). Uncertainty regarding financial globalization fosters innovation, which is increasing energy demand because of economic growth. Fast access to credit encourages customers to purchase long-lasting luxury goods on big tickets, and the use of consumer items directly raises the demand for energy.

In addition, the causality of DH IN Table 8 showed bidirectional causal link between LEC_{it} and $LFGU_{it}$; LEC_{it} and $LCO2_{it}$; LEC_{it} and $LEGP_{it}$.

4. CONCLUSION

Even though research on energy consumption, financial globalization uncertainty, CO_2 emissions, and economic growth has increased over the past few years, there is no research exploring the influence of financial globalization uncertainty, CO_2 emissions, and economic growth on energy consumption using a growth paradigm and second-generation approach. The results are based on a panel of time data from 1970 through 2019. We analysed this effect on the countries ASEAN+3. Our findings indicate positive and statistically significant effects of economic growth and CO_2 emissions on energy consumption. But the outcome revealed that uncertainty about financial globalization has a positive and statistically insignificant effect on energy use. That means complementary emissions of CO_2, economic growth, and energy use.

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