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Causality Relationship between Electric Power Consumption and Economic Growth in Malaysia and Thailand: Autoregressive Distributed Lag Bound Testing Approach

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ABSTRACT

This paper examined the causal relationships between per capita electric power consumption and economic growth per capita in Malaysia and Thailand. The data used in this study was the yearly data from 1971 to 2014. The ARDL and Granger causality approaches were employed. Overall, the empirical results showed that it had established a long-run relationship between electric power consumption and economic growth. Moreover, the Granger causality approach recognized a one-way causal direction flowing from economic growth to electric power consumption in Malaysia. However, for Thailand, empirical results had no long-run relationship between electric power consumption and economic growth. Therefore, the Granger causality approach had recognized no way of causal direction flowing from electric power consumption to economic growth. Finally, the empirical results of this study provided policymakers a better understanding of energy consumption and economic growth nexus to formulate energy policy in Malaysia and Thailand. In addition, the government of Malaysia should consider the economic situation when implementing the relevant energy policies.

Keywords: Electric Power Consumption, Economic Growth, Autoregressive Distributed Lag, Granger Causality Approaches
JEL Classifications: C13, C20

1. INTRODUCTION

Energy consumption and economic growth have become important research topics in recent years. International Energy Agency (IEA) has predicted that energy consumption will increase 53% by 2030, and 70% of the growth will happen in developing countries such as ASEAN countries (International EnergyAgency, 2013). Therefore, In this study, we will focus on ASEAN countries such as Malaysia and Thailand.

In recent years, energy consumption in Malaysia has seen a 20.7% contribution from the residential sector (National Energy Balance, 2017). The average electricity consumption for residential was 345 kWh per month based on the survey of 348 samples in Malaysia (Ahmed et al., 2017). The electricity consumption for residential in Malaysia is expected to rise due to increasing appliance ownership, economic improvement, and changing lifestyles (Green Technology, 2017).

For Thailand, the residential sector consumed the electricity about 23.01% of the total electricity consumption of Thailand in 2017 (DEDE, 2017). It increases continuously due to the growth of the economy. The electricity demand growth rate was 5.20% per year, rising from 32,799.46 GWh in 2011 to 44,373.96 GWh in 2017 (EPPO, 2017).

Since both countries have energy consumption at the top rank in ASEAN and we want to know the relationship between electric power consumption and economic growth. Therefore, policymakers must take action in the future for electrical power management, which is becoming more and more critical every day and impacts the economy.

The study detailed here is pursuing the following objectives:

1. To examine the existence and direction of the causal relationships between per capita electric power consumption and per capita economic growth in Malaysia and Thailand.
2. To suggest policymakers regarding the formulation of electricity in Malaysia and Thailand.

2. REVIEW OF LITERATURE

For this section, there are four types of causal relationships between electric power consumption and economic growth that various authors have revealed:

1) unidirectional causality runs from electric power consumption to economic growth
(2) unidirectional causality runs from economic growth to electric power consumption
(3) bi-directional causality exists between electric power consumption to economic growth
(4) no causality exists between electric power consumption to economic growth

Tables 1-3 summarizes the literature on the various hypotheses or relationships established between electric power consumption and economic growth in the present study. The authors have used several methodologies such as Cointegration, Vector Error Correction (VECM), Vector Autoregressive (VAR), the ARDL approach, and Granger causality.

Table 1 offers a sequential view of an empirical study that declares a causal route from electric power consumption to economic growth. Table 2 summarizes literature that proved way causal route from electric power consumption to economic growth. Finally, Table 3 presents the bi-directional causality between electric power consumption to economic growth.

3. RATIONALE AND SCOPE OF THE STUDY

Since 1971, there has been a growing demand for electricity in every sector in Malaysia and Thailand (as shown in Figures 1 and 2). An increase in electricity consumption indicates an expansion of production activities and improvement in the living standard of citizens, which may reflect the advancement of an economy. However, it is not clear that the growth in electricity consumption is the crucial factor for economic development in Malaysia and Thailand. The former paper has not been studied enough to testify the causality among these two variables in the evidence of Malaysia and Thailand. Therefore, this study explores the existence and route of the causal relationship between electric power consumption and economic growth in Malaysia and Thailand. Identification of the existence and direction of the causal relation between electric power consumption and economic growth may support policymakers in determining the steps to be taken towards the beginning and implementation of various electricity policies in Malaysia and Thailand.

4. DATA AND RESEARCH METHODOLOGY

4.1. Data Collection and Variables

We have used yearly data of ELE and GDP of two ASEAN countries from 1971 to 2014, such as Malaysia and Thailand. The data are graphically represented in Figures 1 and 2. The World Bank Indicator has been the source of data for both study variables. Data on the gross domestic product (GDP) per capita is measured in the current U.S. dollar, and electricity consumption per capita is measured in kWh. Thus, GDP has been used as a variable of economic growth, and ELE has been used as a variable of electric power consumption.

Table 1: Empirical literature that declares one-way causal route from electric power consumption to economic growth

Countries	Authors	Methodology
Fuji Island (1971-2002)	Narayan and Singh (2007)	Cointegration, Granger causality approach
Malaysia (1972-2003)	Tang (2008)	ARDL bound test
Ghana (1971-2008)	Adam (2010)	Granger causality test and ARDL approach
Russia (1990-2017)	Bass (2018)	Cointegration, VECM, and Granger causality test
Indonesia and Thailand (1971-2014)	Bunnag (2020)	Cointegration and VECM

Table 2: Empirical literature that declares one-way causal route from economic growth to electric power consumption

Countries	Authors	Methodology
Nepal (1980-2006)	Duungel (2009)	Cointegration and Granger causality approach
Turkey (1945-2006)	Pempetzoglou (2011)	VAR and Granger causality approach
India (1974-2014)	Kumari and Sharma (2016)	Cointegration and Granger causality approach

Table 3: Empirical literature that declares bi-directional causality among electric power consumption to economic growth

Countries	Authors	Methodology
Portugal (1971-2009)	Shahbaz *et al*. (2011)	VECM and ARDL bound test
Mauritius (1970-2009)	Sultan (2012)	ARDL approach and VECM
Portugal (1970-2005)	Tang *et al*. (2013)	VECM and cointegration
Nigeria (1970-2012)	Osigwe and Damilola (2015)	ECM approach
South Africa (1983-2016)	Nyon and Phiri (2018)	Cointegration and Granger causality test

Figure 1: Relationship between per capita electric power consumption and per capita GDP of Malaysia

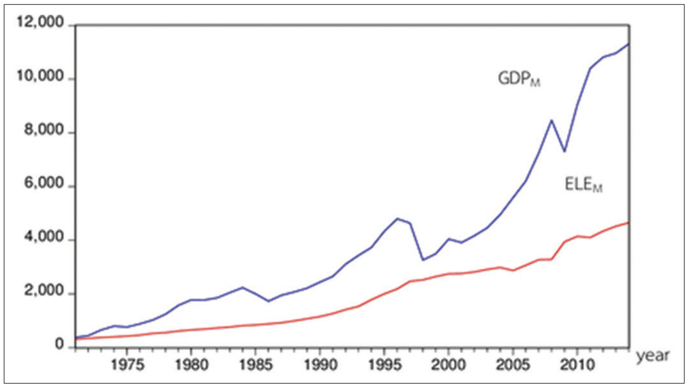
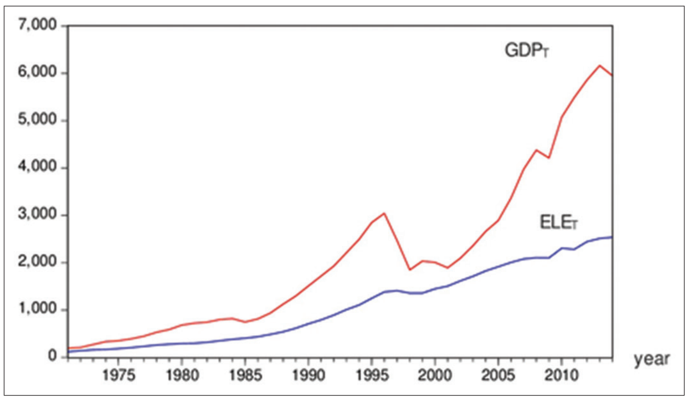


Figure 2: Relationship between per capita electricity consumption and per capita GDP of Thailand



4.2. Research Methodology

4.2.1. Model specification

For testing whether economic growth causes electric power consumption or not, the following simple model was used:

$$Yt=\alpha+\beta X+\mu t$$

However, in this study, we rely upon two ASEAN countries such as Malaysia and Thailand. So we can write this model again as follows:

$$GDPM=\alpha M+\beta ELEM+\mu tM \quad (1)$$

$$GDPT=\alpha T+\beta ELET+\mu tY \quad (2)$$

Where GDPM= GDP per capita (Current US$) of Malaysia
ELEM=Per capita electric power consumption (kWh) of Malaysia
GDPT=GDP per capita (Current US$) of Thailand
ELET=Per capita electric power consumption (kWh) of Thailand
α_M and α_T = constant
μ_{tM} and μ_{tT} = error term
t = time trend

We assume that electric power consumption and economic growth have a relationship and cause to each other. The long-run and causal relationships between the electric power consumption per capita and GDP per capita will be performed in two steps. Firstly, we will test the long-run relationships among the variables by using the ARDL bounds testing approach of cointegration. Secondly, we will try causal relationships by using the error-correction-based causality models.

4.2.2. Autoregressive distributed lag (ARDL) cointegration analysis

The ARDL approach to cointegration is developed by Pesaran and Shin (1998) and Pesaran et al. (2001). The ARDL cointegration approach has more advantages in comparison with cointegration methods such as Johansen and Juselius (1990) and Johansen (1991) procedures:

1. The ARDL approach can be applied whether the regressors are I(1) or I(0), while Johansen cointegration techniques require that all the variables be of equal order of integration. This means that the ARDL can be applied, and no need for unit root testing.
2. While the Johansen cointegration techniques require large data samples for validity, the ARDL approach is a statistically more significant approach to determine the cointegration relation in small samples.
3. The ARDL approach allows the variables to have different optimal lags, while it is impossible with cointegration approaches.
4. The ARDL approach employs only a single reduction from the equation, while the cointegration approaches estimate the long-run relationships within system equations.

The ARDL model for log-linear functional specification of a long-run relationship between per capita electric power consumption and GDP per capita may follow as:

$$\Delta \log GDP_t = \alpha + \sum_{i=1}^{k} \varnothing_i \Delta \log GDP_{t-i} + \sum_{j=0}^{t} \beta_j \Delta \log ELE_{t-j} + \delta_1 \log GDP_{t-1} + \delta_2 \log ELE_{t-1} + \vartheta_t \quad (3)$$

Where ϑt and Δ are the white noise term and the first difference operator, respectively. An appropriate lag selection is based on a criterion such as the Akaike information criterion (AIC). The bounds testing procedure based on the joint F-statistic that is tested the null of no cointegration,

H0: $\delta r=0$
H1: $\delta r\neq 0$, r=1, 2,….

Two sets of critical values are generated; the upper bound critical values refer to the I(1) series and the lower bound critical values to the I(0) series. If the calculated F-statistic lies above the upper level of the band, the null hypothesis is rejected, indicating there are long-run relationships that exist (cointegration). On the other hand, if the calculated F-statistic is below the critical value, we cannot reject the null hypothesis of no cointegration, indicating no long-run relationships exist.

If there is cointegration between the variables, Equation 4 presents the long-run models, and Equation 5 shows the short-run models:

$$\log GDP_t = \alpha + \sum_{i=1}^{m} \varnothing_i \log GDP_{t-i} + \sum_{j=0}^{n} \beta_j \log ELE_{t-j} + \mu_t \quad (4)$$

$$\Delta \log GDP_t = \alpha + \sum_{i=1}^{k} \varnothing_i \Delta \log GDP_{t-i} + \sum_{j=0}^{t} \beta_j \Delta \log ELE_{t-j} + \sigma ECT_{t-1} + \varepsilon_t \quad (5)$$

Where σ is the coefficient of error correction term, it shows how quickly variables coverage to equilibrium, and it should have a statistically significant coefficient with a negative sign.

4.2.3. Causality analysis

ARDL cointegration method tests whether the existence or absence of a long-run relationship between the electric power consumption per capita and GDP per capita. It does not indicate the direction of causality. Once the estimating the long-run model in Equation 4 to obtain the estimated residuals, the next step is to estimate a Vector Error Correction Model (VECM), with the variables in first differences and including the long-run relationships as error correction term in the system. Therefore, the following VECM is estimated to investigate the Granger causality between the variables:

$$\Delta \log GDP_t = \alpha_1 + \sum_{i=1}^{k} \varnothing_i \Delta \log GDP_{t-i} + \sum_{j=0}^{t} \beta_j \Delta \log ELE_{t-j} + \sigma_1 ECT_{t-1} + \varepsilon_{1t} \quad (6)$$

$$\Delta \log ELE_t = \alpha_2 + \sum_{i=1}^{k} \gamma_i \Delta \log GDP_{t-i} + \sum_{j=0}^{t} \delta_j \Delta \log ELE_{t-j} + \sigma_2 ECT_{t-1} + \varepsilon_{2t} \quad (7)$$

Residual terms, ε1t and ε2t are independently and normally distributed with zero mean and constant variance. An appropriate lag is based on a criterion such as AIC. Rejecting the null hypotheses indicates that logELE does Granger cause logGDP and logGDP does Granger cause logELE, respectively.

Using Equation 6 and 7, Granger causality can be examined in two ways:

(1) Short-run Granger causalities are detected by testing H0: βj=0 and H_0: γj=0 for all j in Equation 6 and 7, respectively.

(2) Another possible source of causation is the ECT's in equations. The coefficients on the ECT's represent how fast deviations from the long-run equilibrium are eliminated following changes in each variable. Therefore, long-run causalities are examined by testing H_0: σ1=0 and H0: σ2=0 for Equation 6 and 7, respectively.

5. EMPIRICAL ANALYSIS AND RESULTS

This study investigates the long-run and causal relationships between per capita electric power consumption and GDP per capita in Malaysia and Thailand from 1971 to 2014 by employing electric power consumption per capita and GDP per capita variables. To examine this linkage, we use the two-step procedure from the Engle and Granger model:

(1) We explore the long-run relationships between the variables using the recently developed ARDL bounds testing cointegration approach.
(2) We employ the VECM to test causal relationships between variables.

According to Pesaran and Shin, the study used the AIC to select an appropriate lag for the ARDL model. Table 4 presents the estimated ARDL model that has passed several diagnostic tests that indicate no serial correlation and heteroscedasticity.

In addition, due to the structural changes in the economies of these countries, macroeconomic series may likely be subject to one or multiple structural breaks. For this purpose, the stability of the short-run and long-run coefficients is checked through the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) test proposed by Brown et al. (1975). Figures 3 and 4 present the plot of

Figure 3: Stability tests for Malaysia

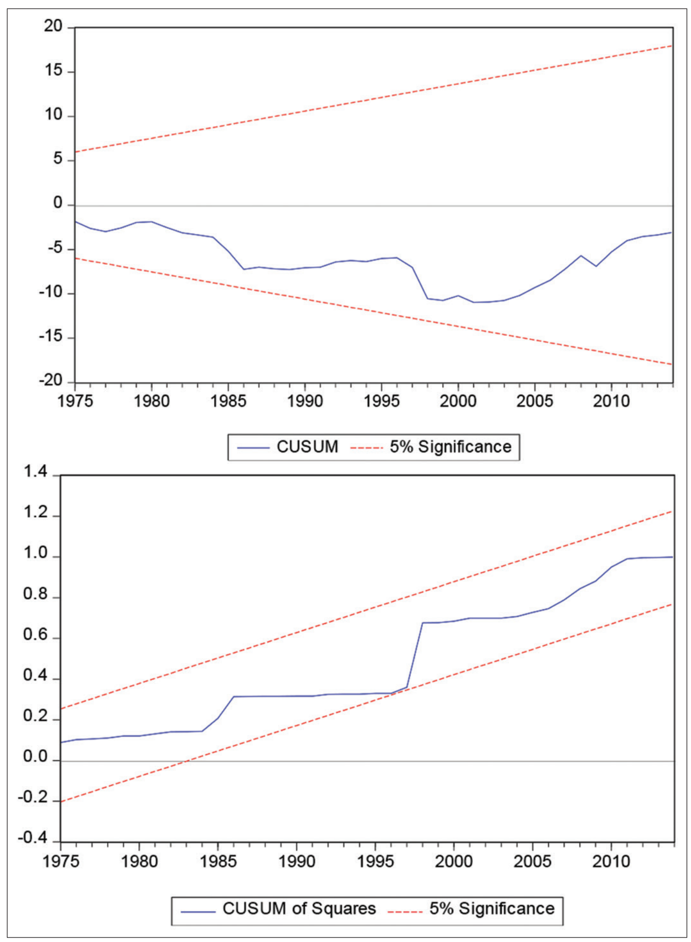


Table 3: Empirical literature that declares bi-directional causality among electric power consumption to economic growth

Countries	Authors	Methodology
Portugal (1971-2009)	Shahbaz *et al*. (2011)	VECM and ARDL bound test
Mauritius (1970-2009)	Sultan (2012)	ARDL approach and VECM
Portugal (1970-2005)	Tang *et al*. (2013)	VECM and cointegration
Nigeria (1970-2012)	Osigwe and Damilola (2015)	ECM approach
South Africa (1983-2016)	Nyon and Phiri (2018)	Cointegration and Granger causality test

Table 4: Estimated ARDL models and bound F-test for cointegration

Countries	Models	F	LM	HT
Malaysia	ARDL (1,0)	9.7460	1.3050 (0.2511)	0.0998 (0.8987)
Thailand	ARDL (4,2)	2.1309	1.0237 (0.2786)	1.7625 (0.1330)
Critical values		**I (0)**		**I (1)**
Critical values at 1%		4.94		5.58
Critical values at 2.5%		4.18		4.79
Critical values at 5%		3.62		4.16
Critical values at 10%		3.02		3.51

F is the ARDL cointegration test. The critical values for the lower I (0) and upper I (1) bounds are taken from Narayan (2005). L.M. is the Lagrange multiplier test for serial correlation with a χ^2 distribution with two degrees of freedom. H.T. is the Heteroskedasticity test with a χ^2 distribution

Table 5: Granger causality tests for Malaysia

The null hypotheses	Chi-square (P-value)
Short-run Granger causality	
$\Delta\log ELE_M \rightarrow \Delta\log GDP_M$	0.4766 (0.4900)
$\Delta\log GDP_M \rightarrow \Delta\log ELE_M$	2.2644 (0.1324)
Long-run Granger causality	
$\log ELE_M \rightarrow \log GDP_M$	1.6584 (0.1978)
$\log GDP_M \rightarrow \log ELE_M$	2.9984 (0.0833)*

* is significant at 10% level

Table 6: Granger causality tests for Thailand

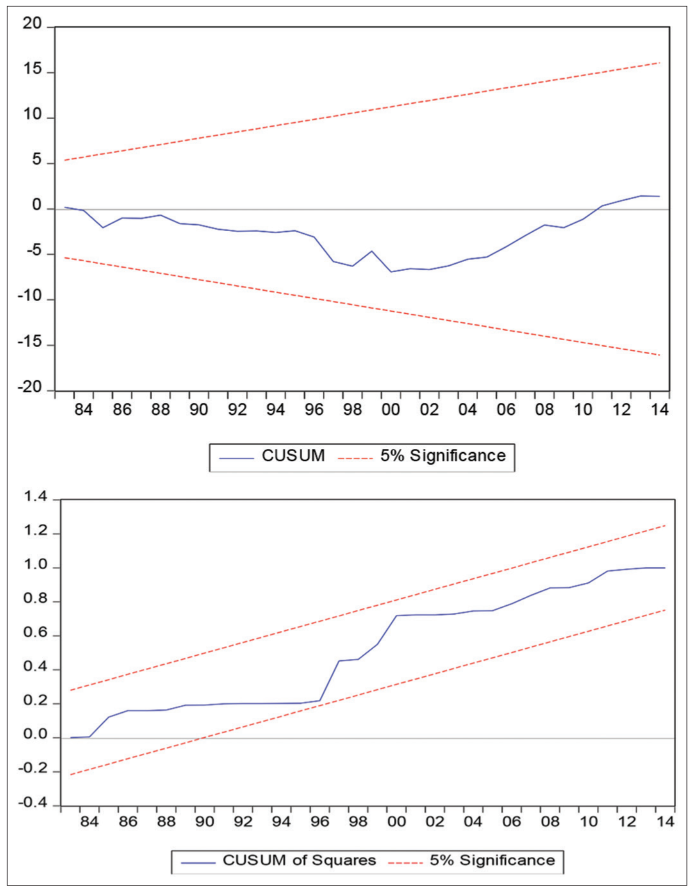
The null hypotheses	Chi-square (P-value)
Short-run Granger causality	
$\Delta\log EL_{ET} \rightarrow \Delta\log GD_{PT}$	0.1522 (0.9267)
$\Delta\log GD_{PT} \rightarrow \Delta\log EL_{ET}$	0.4289 (0.8070)
Long-run Granger causality	
$\log EL_{ET} \rightarrow \log GD_{PT}$	0.1348 (0.9348)
$\log GD_{PT} \rightarrow \log EL_{ET}$	3.6909 (0.1580)

CUSUM and CUSUMSQ test statistics for Malaysia and Thailand that fall inside the critical bounds of 5% significance. This implies that the estimated parameters are stable throughout 1971-2014.

The ARDL bound test results show a unique long-run relationship between electric power consumption per capita and GDP per capita in Malaysia at a 10% significance level. In other words, there is cointegration between electric power consumption per capita and GDP per capita in Malaysia. On the other hand, there is no unique long-run relationship between electric power consumption per capita and GDP per capita in Thailand at a 10% significance level. In other words, there is no cointegration between electric power consumption per capita and GDP per capita in Thailand (Table 4). Therefore, the econometric analysis suggests that any causal relationships within VECM for Malaysia can be estimated.

The existence of a cointegration relationship among electric power consumption per capita and GDP per capita in Malaysia suggests that there must be Granger causality in at least one direction. This study found evidence of a one-way (unidirectional) long-run Granger causality between GDP per capita and electric power consumption per capita only in Malaysia (Table 5). However, there is no short-run Granger causality in Malaysia. Moreover, for Thailand (Table 6), we found no short-run and long-run Granger causality between these variables.

Figure 4: Stability tests for Thailand



6. CONCLUSIONS

The paper investigates the nexus between electric power consumption and economic growth for Malaysia and Thailand from 1971-2014. To examine this linkage, we use the two-step procedure from the Engle and Granger model: Firstly, we explore the long-run relationship between two variables by using the ARDL bounds testing approach of cointegration. Secondly, we employ VECM to test the causal relationships between the variables.

All results suggest that there is long-run Granger causality between electricity power consumption and economic growth:

(1) There is a long-run relationship (cointegration) between economic growth and electric power consumption. However, evidence of one-way (unidirectional) long-run Granger causality between these variables is found only in Malaysia.

(2) There is no unique long-run relationship between electric power consumption and economic growth in Thailand.

(3) Any causal relationships within VECM for Thailand cannot be estimated.

The empirical results of this study provide policymakers a better understanding of energy consumption and economic growth nexus to formulate energy policy in Malaysia and Thailand. In addition, the government of Malaysia should consider the economic situation when implementing the relevant energy policies.

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