THE CAUSAL RELATIONSHIP BETWEEN GDP, ENERGY CONSUMPTION, POPULATION, AND OIL PRICE: EVIDENCE FROM VIETNAM

Ngoc Thuy Ho¹, Wann Yih Wu², Adriana Amaya Rivas³, Phuoc Thien Nguyen⁴
¹Professor of Economics, Faculty of International Education, Foreign Trade University, Hanoi, Vietnam.
²Professor of Marketing, Program of International Business, Nanhua University, Dalin Township, Taiwan.
³PhD, Assistant Professor of Innovation and Entrepreneurship Escuela Superior Politécnica del Litoral, ESPOL, ESPAE Graduate School of Management, Guayaquil, Ecuador.
⁴Department of Business Administration, Nanhua University, Taiwan.
¹ngocht@ftu.edu.vn, ²wwanyi888@gmail.com, ³adriana.amaya@espol.edu.ec, ⁴nhuanduc08@gmail.com

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Abstract

Purpose of this study: This study aims to examine the relationship between energy consumption, gross domestic product, and population for the period of 1985-2015.

Methodology: The research questions for this study are as follows: (1) What is the association among energy consumption, GDP, population, and oil price? (2) Which suggestions can be provided on the basis of the research findings? Unit root test, co-integration test, VECM model, and Granger causality are employed to analyze the association among the aforementioned variables.

Main Findings: Firstly, the results show the existence of co-integration among the variables. By employing the Granger causality, the research findings demonstrate a unidirectional causality running from population to energy consumption, a unidirectional causality running from energy consumption to gross domestic product, and a unidirectional causality running from population to gross domestic product.

Implications: With these results, it is suggested that Vietnam should promote the growth of the population and the energy policies to generate economic growth.

Novelty: To the best of our knowledge, this study extends the scarce literature that provides empirical findings regarding this issue.

Keywords: Energy Consumption, Gross Domestic Product, Population, Oil Price, Granger Causality Test

INTRODUCTION

Energy is considered as an important force for the economic activity and production in any country. Therefore, it is expected that the availability of energy and resource would improve the economic growth. The hypothesis, which states that energy consumption is an important element in growth complementing capital and labor, is based on such growth (Mulugeta et al., 2010). The relationship between energy consumption and economic growth has been widely studied by employing different econometric methodologies (Ozturk, 2010; Mahadevan & Asafu-Adjaye, 2007; Chontanawat, Hunt, & Pierse, 2008; Lee & Chang, 2008). The necessity for launching policies to enhance the development of the economic growth does an imperious examination of the causality among energy consumption, GDP, oil price, and population (Narayan et al., 2010; Sadorsky, 2012). However, the exact directions of causation between energy consumption, GDP, oil price, and population still remain unclear (Tang, Tan & Ozturk, 2015).

Precisely, in developing economies as Vietnam, the current literature is scarce. Over the past years, Vietnam has become an important economy increasing its development towards industrialization and improving its position in the global economy (Tang et al., 2015). This can be explained due to Vietnam opening its economic production and exchange since 1989. On the other hand, according to the International Energy Agency Report (2012), the energy consumption in Vietnam has dramatically increased for more than 9 percent from 1990 to 2007 (Toan, Bao & Dieu, 2011). Since the industrial revolution, the development of the economies and commercial energy use has changed. Thus, the tendency of the global energy demand shows an important increase of the energy consumption worldwide (Ruhl et al., 2011). Vietnam’s energy consumption is foreseen to increase from 55.6 Mtoe to 146 Mtoe until 2025 (Do & Sharma, 2011). This fact is extremely interesting to policymakers for investigating its impact on the gross domestic product and to analyze the role of energy consumption in Vietnam’s economy. Some studies show that GDP is one of the most relevant...
drivers for defining energy consumption, but the findings do not show an unanimous conclusion (Ozturk, 2010; Lean & Smyth, 2010).

Vietnam’s economy is highly dependent on its export of crude oil. Exports of crude oil contribute to the gross domestic product by around 20 percent (Le & Vinh, 2011). Despite that, exports of crude provide significant earnings and Vietnam’s oil consumption depends on the import of refined products. Vietnam’s capacity for covering its domestic fuel demand lacks enough resources to satisfy it. Thus, many scholars state the importance of the influence of oil price shock to Vietnam’s economy (Le & Vinh, 2011). However, most of the studies examining the aforementioned influence have been employed to US or developed countries (Perron, 1989; Cunado & Garcia, 2005; Huang et al., 2005; Jin, 2008) leaving a room for further research. Finally, the population of any country influences its energy consumption (Islam, Shahbaz, & Alam, 2013).

To summarize, this study analyzes the association between gross domestic product (GDP), energy consumption (EC), oil price, and population for suggesting some energy policies that may improve the electricity supply, but at the same time to enhance a high level of economic growth. The data are collected for a yearly period from 1985 to 2015. Different time series techniques, such as unit root tests, Johansen’s co-integration test, vector error correction model (VECM), and Grange causality test, were employed. This study is organized as follows: (1) introduction; (2) literature review; (3) data and methodology; (4) presentation of the results; (5) discussions and suggestions.

LITERATURE REVIEW

Due to the importance of energy consumption and its implications on the development of economies, a vast literature has examined the causation between energy consumption and economic growth by employing different proxy variables of economic growth, such as gross domestic product (Chontanawat et al., 2008). Despite that, there are a vast literature that examines the association between energy consumption and economic growth. However, to the best of our knowledge, there are few studies that examine it in Vietnam. Precisely, Canh’s work (2011) examined the association between electricity consumption and economic growth in Vietnam during the period of 1975-2010. On the other hand, Loi (2012) employed Granger causality and investigated the association between energy consumption, trader, and GDP in Vietnam during the period of 1986-2006. Both researchers concluded that there is a co-integration relationship between GDP and electricity consumption, accompanied by a long-run causality association between GDP and electricity consumption in Vietnam.

Conversely, Chontanawat et al. (2008) analyzed the association between energy consumption and economic growth for more than 100 countries employing techniques, such as co-integration test and Granger causality test. Specifically, in the case of Vietnam, the findings show that both variables are not co-integrated; nevertheless, there is a causality running from energy consumption to economic growth. Supporting this finding, Binh’s (2011) work demonstrated that economic growth and energy consumption are not co-integrated, but there was a presence of causality running from economic growth to energy consumption in Vietnam’s case. In the case of Pakistan, Ageel and Batt (2001) demonstrated a significant association between GDP and economic growth. By examining the relationship and causality between energy consumption and GDP, Soytas and Sari (2003) found bidirectional causality in Argentina’s case. Based on these results, it can be concluded that many studies have employed Granger causality to examine the relationship between energy consumption and GDP; however, the findings are inconclusive and mixed (Tang et al., 2015).

Moreover, this study considers crude oil as one of the most important sources of energy due to the dependency of Vietnam’s economy. Thus, many scholars have intended to examine the influence of fluctuation of oil prices on GDP, energy consumption, FDI, and so on. For example, Bekhet and Yusop (2009) examined the association between oil price, energy consumption, and economic growth. The findings demonstrated that in the long-run, the variables commove together and at the same time they found a bidirectional causality running from economic employment to energy consumption. Despite the importance of population as an unlimited resource, the literature is scarce for Vietnam. For example, Tupe and Narayan (2007) employed a Granger causality test for India from 1971 until 2004. Their results show the presence of causation running from population to energy consumption. Furthermore, Islam et al. (2011) discovered the presence of a unidirectional causality coming from energy consumption to population in Malaysia.

This study aims to state the rationale of the relationship between energy consumption, GDP, oil price, and population for Vietnam by employing the Granger causality test in the frame of vector error correction model involving the aforementioned variables.
DATA AND METHODOLOGY

Unit Root Test

In order to test the stationarity of the variables, unit root test is firstly applied with the individual time series data of GDP, energy consumption, oil price, and population in this study. Precisely, this study employed Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) Unit Root test. Unit root test tests whether the null hypothesis can be rejected after performing the ADF and PP test. Unit root test assures that the time series do not cause any spurious problem and in order to do so, it is necessary to confirm the stationarity of the data. Both tests comprise to transform the variables into the first differences and then run a regression of the first differences having a dependent variable to the series lagged once.

Cointegration Test

Through the implementation of a cointegration test, this study examines whether or not a set of non-stationary time series is co-integrated, which means that in the long-run, there is equilibrium between the proposed time series. This study employed the Johansen and Juselius cointegration test, which provides two statistics called Trace and the maximum eigenvalue. Specifically, this test finds out the number of co-integration equations but only for I (1) series. In order to assure a long-term association, it should at least exist as one co-integrating equation. Precisely, the Johansen cointegration test will test two hypotheses as follows:

H0: There is no co-integration association between time series.
H1: There is co-integration association between time series.

Vector Autoregressive Model

The vector autoregressive model (VAR) is performed to depict the dynamic behavior of the proposed time series. VAR model provides better results for forecasting when compared to the uni-variate time series models. In order to apply VAR, it is necessary to prove that the variables present a different order of integration or that the cointegration test does not find equilibrium among the variables (Gujarati, 2004).

Lag Length Selection

The lag lengths of the VAR and VEC models are selected according to the Akaike or Schwartz criterion.

Vector Error Correction Model

The vector error correction model (VECM) has been introduced by Sargan (1964) and it was expanded by Engle and Granger (1987). VECM can be considered as a type of VAR in which variables are stationary in their first differences and cointegrate in the long-run. VECM can provide some insights regarding the adjustments that are undertaken towards the equilibrium state (Verbeek, 2008). In other words, the cointegration equation will frame the equilibrium conditions, and then VECM model will depict how the proposed model will adjust in each period of time to its long-term equilibrium. Due to the proposed time series being co-integrated, it is expected that dependent variables will react under short-run deviations and adjust their movements towards their equilibrium.

Granger Causality Test

Precisely, the Granger causality should be conducted in the context of VAR or VECM models’ dependencies on the results. Granger causality sheds lights on the direction of causality between the time series. This causality can be measured on the basis of conceptualization of prediction developed by Granger (1988). For example, a time series variable Y Granger causes a time series variable X, only if the previous values help to foresee the next values. In an essence, the Granger causality lays on the idea that the cause occurs before the consequence. According to Eagle and Granger (1987), under the condition that there is a co-integrating equation between variables, it is likely that either unidirectional or bidirectional Granger causality exists between these two time series variables.

EMPIRICAL RESULTS

The aim of this study is to examine the casual relationship among energy consumption, GDP, population, and oil price for Vietnam. The Granger causality test is employed in this current study by applying Eviews 8.0 statistical software. The annual data for the period from 1985 to 2015 are employed for the empirical analysis. All variables followed with L are represented in logarithm, e.g., LEC is the logarithm of energy consumption and so on. Table 1 shows the sources from where the research variables data were obtained.
Firstly, unit root test is performed with the time series data of energy consumption, GDP, oil price, and population to test the stationarity of the time series. Specifically, this study employed Augmented Dickey-Fuller (AD) and Phillips-Perron (PP) tests, which calculate their estimates at levels and first differences of the time series. On the frame of these two tests, there are three models, such as with an intercept, with an intercept, and trend or with none, which need to be tested. In order to evaluate the results, this study performed the ADF test at levels (with an intercept, with an intercept, and trend or none), which denoted that the variables were not stationary. Following the same procedure, PP test was performed at levels.

As shown in Table 2, the unit root results obtained from ADF unit root test and PP unit root test indicate a non-stationarity at level for the understudied variables. Then, ADF unit root test and PP unit root test examined the non-stationarity at the first difference. The first difference unit root results demonstrated that all variables were stationary at the first difference on the frame of an intercept and trend. Therefore, the results show that all variables possess the same order of integration I(1). Moreover, the results were significant at 5 percent. Therefore, these results demonstrate to be robust.

### Table 2: Augmented Dicky-Fuller Unit Root Test for Vietnam

| Variables | Test with Intercept | Test with Intercept and Trend | Test with no Intercept and Trend |
|-----------|---------------------|-------------------------------|----------------------------------|
| LNGDP     | 0.903               | 0.954                        | 0.999                            |
| LNEC      | 0.991               | 0.256                        | 1.000                            |
| LNOIL     | 0.692               | 0.472                        | 0.665                            |
| LNPOP     | 0.452               | 0.983                        | 0.758                            |

Notes: *, **, *** denote significance at 10%, 5% and 1% respectively.

After determining the order of integration of variables and whether they are non-stationary, it is necessary to analyze the optimum lag length of the variables. By doing this, this study employed Schwarz Bayesian Information criterion (SIC) and Akaike Information Criterion (AIC). It is critical to determine the optimum lag length to find the autoregressive time series and the residual process in the ADF and PP tests (Schwert, 1989). As shown in Table 3, the lowest value was selected and the selected lag was then employed in the further steps. The results show that the optimum lag length is lag 1 by employing the aforementioned criteria.

### Table 3: Optimal Lag Length for Vietnam

| Lag | LogL  | AIC       | SC        |
|-----|-------|-----------|-----------|
| 0   | 21.78251 | -1.111407 | -0.928190 |
| 1   | 209.2068 | -11.82543*| -10.90934*|
| 2   | 218.6553 | -11.41596 | -9.767003 |
| 3   | 230.1077 | -11.13173 | -8.749912 |
| 4   | 246.8538 | -11.17836 | -8.063675 |

Notes: LQ - Likelihood Ratio Test
AIC - Akaike Information Criterion
SC - Schwartz Bayesian Information Criterion

By employing the Johansen’s cointegration test, this study examined whether the four variables commove together toward a long-run equilibrium association. On the frame of Johansen’s cointegration test, trace and maximum eigenvalue statistics were checked to confirm that the variables are co-integrated. As shown in Table 4, based on the results, the null hypothesis of (at the most) two co-integrating equations is not rejected for either trace or maximum eigenvalue statistics. Thus, this study concludes that two co-integrating equations exist among GDP, energy consumption, oil price, and population.
Table 4: Johansen Co-Integration Test results

| Null: No. of CE(s) | Eigenvalue | Trace Statistic | Critical Value ( α=5% ) | Prob.** |
|-------------------|------------|-----------------|--------------------------|---------|
| None *            | 0.516172   | 61.72038        | 47.85613                 | 0.0015  |
| At most 1 *       | 0.469664   | 37.03551        | 29.79707                 | 0.0062  |
| At most 2 *       | 0.270226   | 15.47121        | 15.49471                 | 0.0504  |
| At most 3         | 0.130655   | 4.760502        | 3.841466                 | 0.0291  |

The Maximum Eigenvalue Test

| Null: No. of CE(s) | Eigenvalue | Max-Eigen Statistic | Critical Value ( α=5% ) | Prob.** |
|-------------------|------------|---------------------|--------------------------|---------|
| None *            | 0.516172   | 24.68487            | 27.58434                 | 0.1125  |
| At most 1 *       | 0.469664   | 21.56430            | 21.13162                 | 0.0435  |
| At most 2 *       | 0.270226   | 10.71071            | 14.26460                 | 0.1693  |
| At most 3         | 0.130655   | 4.760502            | 3.841466                 | 0.0291  |

* denotes rejection of the hypothesis at the 0.05 level

** The probability is computed using the method proposed by Mackinnon, Haug, and Michelis (1999).

According to the research findings, a VECM model was built up with two co-integration equations and at one lag-length to perform the Granger causality test. As evidenced in Table 5, the results show that population unidirectionally Granger caused energy consumption, whereas energy consumption unidirectionally Granger caused gross domestic product. In addition, a unidirectional causality is also found from population to gross domestic product. However, oil price seemed to not play an influential role among the variables.

Table 5: Results from the Granger Causality Test

| Panel A LnEnergy_Consum Granger caused by | Chi-square Statistic | Degree of Freedom | Probability |
|------------------------------------------|----------------------|------------------|-------------|
| LNPopulation                              | 3.931                | 1                | 0.047       |
| Panel B DLNGDP Granger caused by          |                      |                  |             |
| LNEnergy_Consum                           | 7.785                | 1                | 0.005       |
| LNPopol                                  | 5.696                | 1                | 0.017       |

Note: Those significant at the 1%, 5%, and 10% levels are reported.

CONCLUSION

The aims of this research are to examine the causal relationship between energy consumption, GDP, oil price, and population in Vietnam. Based on the results, it is important to remark that there is a uni-directional causality running from GDP to energy consumption and to population. This result is in line with the work of Tang et al. (2015), which only evaluated the causality from energy consumption to economic growth, while ignoring other important drivers of energy consumption.

Furthermore, there is a causality running from GDP to population. These findings have several implications. Firstly, the authors have identified the pivotal roles played by gross domestic product and energy consumption on Vietnam’s economy. Secondly, policymakers need to design policies to decrease global warming but in such a manner that does not affect the population growth. It is well known that one of the factors that have contributed to the development of Vietnam’s economy is its cheap labor force, which is appealing to investors for establishing factories. On the other hand, drawing from the findings, the authors suggest that policymakers may select appropriate policies that increase the gross domestic product. Instead of reducing the energy consumption, it is better to use other renewable energies that raise the level of production. Additionally, government should intend to expand energy supply to the population through the development of renewable energies.

As the renewable energies are in an incipient stage of its development, this could be an opportunity to innovate and generate jobs and may help Vietnam to be positioned in the region. Specifically, the Vietnamese government should launch policies that enhance the development of renewable energies and related technological sectors. By doing this, the government will promote the usage of new sources of energies. Therefore, the authors suggest that an awareness campaign is necessary for the population. Moreover, government should analyze which sector of the economy is consuming higher levels of energy and decide to support some strategic sectors that enhance the future policies. For example, government should implement some subsidies to promote the usage of renewable energies.
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