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Abstract
The main objective of this paper is to examine the relationship between energy use, exports, and imports in Thailand. The annual data from 1979 to 2012 are employed. The results from bounds testing for cointegration reveal that energy use is the main determinant of exports and imports. The results from short-run dynamics indicate that there is long-run causality running from energy use to exports and imports. Policy implication based upon the results of this study is that energy policy should be designed so as to generate sufficient energy for production in the exported and energy-intensive imported goods.
Keywords: Energy use, exports, imports, cointegration, causality
JEL Classification: Q43, C22

1. Introduction

Empirical studies emphasized the dynamic relations between macroeconomic variables have considered energy consumption (or energy use) as an important factor that interacts with output and trade. A substantial number of studies have concentrated on the relationship between energy and growth.[1] However, few studies have focused on energy use-trade nexus. Energy is used in almost all production process of an economy. The impact of energy use on exports can be positive, i.e., an increase in energy demand raises the production capacity of tradable goods and thus exports, and vice versa. On the import side, the lack of energy supply can reduce the usefulness of machinery and equipment, which are energy-dependent imported goods for many countries. An increase in energy-dependent import demand can lead to more energy use (see Sadorsky, 2012).

Kahrl and Roland-Holst (2008) examine the linkages between exports and domestic energy consumption in China. They find that exports are the largest source of energy demand growth. Narayan and Smyth (2009) use a panel data set of six Middle Eastern countries to examine the relationship between electricity consumption, real GDP and exports. They find that there exists a short-run causation running from electricity consumption to real GDP and from real GDP to exports. Furthermore, there exists an evidence of a long-run causation running from exports and electricity consumption to real GDP and from exports and real GDP to electricity consumption. Lean and Smyth (2010) use annual data of Malaysia from 1971 to 2006 to investigate the causal relationship between output, electricity consumption exports, labor and capital in a multivariate framework. One of their main findings is that there exists a causation running from electricity consumption to exports. Sadorsky (2011) finds a unidirectional causality running from exports to energy consumption as well as a bidirectional causality between energy consumption and imports. The role of energy consumption on imports is indicated by Sardosky (2012) who finds that more imports of energy-intensive goods, such as imported equipment, lead to more energy use. Dedeoglu and Kaya (2013) use panel data of 25 OECD countries to test for long-run relationship between energy use, exports, imports and real GDP and find that the pairs of enegy use-GDP, energy-use-exports and energy use-imports are

[1] See Ozturk (2010) for a survey on energy-growth nexus.

cointegrated. Turan Katircioglu (2013) finds the existence of cointegration between energy consumption and imports in Singapore. In addition, there are long- and short-run unidirectional causation running from energy growth to import growth.

Thailand is a non-oil exporting country that has adopted the export-promotion strategy since 1972. The country experienced high economic growth for few years before the Asian crisis in July 1997. Like other developing economies, energy as an important factor in Thailand's production process, especially tradable goods and imported capital goods that are energy-dependent. The main types of energy produced in Thailand are thermal gas turbine, hydro power and diesel. In 1980, the fraction of purchased energy accounted for only 5.1 percent of total energy use. However, this fraction increased to 29.6 percent in 2001, and substantially increased to more than 50 percent in 2012. Therefore, the country can be considered as an energy-dependent economy.

The present study employs annual data pertaining to energy use (or energy consumption), exports, imports and real GDP from 1979 to 2012 to investigate energy use-exports and energy use-imports nexus. The autoregressive distributed lag (ARDL) procedure or the bounds testing for level relationship proposed by Pesaran et al. (2001) is employed. The results of contegration test show that energy use is the main determinant of exports and imports in Thailand. The long-run causations between exports, energy use and GDP, and imports, energy use and GDP are also observed.

The rest of this paper is as follows: Section 2 describes the data and estimation methods. Section 3 presents the findings, and the last section concludes.

2. Methodology

2.1 Data

Annual data pertaining to energy use, exports, imports and real GDP are used in this study. The data set covers the period from 1979 to 2012 is obtained from various sources. Nominal exports, imports, the US dollar exchange rate (baht/US dollar) and consumer price index (CPI) are retrieved from the Bank of Thailand website. Since annual imports and exports are expressed in terms of US dollar, they are converted to the baht (domestic currency) value by the exchange rate. The lack of yearly data for export and import unit value leads to a use of CPI to deflate nominal exports and imports to obtain their real values. Energy consumption (energy use) series measured in billion kilowatt hours is obtained from the Electricity Generating Authority of Thailand, which is available up to 2012 and thus limits the sample size to 34 observations.[2] The real GDP series expressed in terms of US dollar with the 2010 base year is obtained from World Bank (World development indicator). This series is converted to the baht value by the US dollar exchange rate. Real exports, real imports and real GDP are specified in billion baht. The correlation coefficients between each pair of the series are reported in Table 1 while the time series properties of all variables are reported in Table 2.

Table 1 Correlation coefficients

	Exports	Imports	Energy use	Real GDP
Exports	1.000			
Imports	0.991	1.000		
Energy use	0.993	0.985	1.000	
Real GDP	0.986	0.996	0.990	1.000

Note: All variables are in their logarithmic series.

[2] Gross energy generation plus energy purchase are assumed to be domestically consumed by various sectors in the Thai economy.

The correlation coefficients of each pair of variables are high and positive. The high values of correlations are noteworthy because they will affect the results of long-run regressions.

Table 2 Unit root tests

Variable	ADF test with constant	ADF test with constant and trend	PP test with constant	PP test with constant and trend
Level				
LRX (exports)	-3.713*** (6)	-0.637 (6)	-0.875 (4)	-1.278 (4)
LRM (imports)	-0.506 (0)	-1.969 (0)	-0.504 (3)	-2.111(1)
LEC (energy)	-3.028**(0)	-0.197(0)	-2.995(3)	-2.255(3)
LY (real GDP)	-3.901** (0)	-0.917 (0)	-2.829* (3)	-0.870 (2)
First difference				
ΔLRX	-2.115(2)	-4.307**(8)	-5.039***(4)	-5.406***(3)
ΔLRM	-5.079***(0)	-4.997***(0)	-5.409***(4)	-4.957***(4)
ΔLEC	-1.744(1)	-3.945**(0)	-3.161**(3)	-3.872**(3)
ΔLY	-1.339(2)	-2.388(2)	-3.953***(3)	-5.274***(2)

Note: The number in parenthesis is the optimal lag or bandwidth. The optimal lag length of ADF tests is determined by Akaike information criterion (AIC), and the optimal bandwidth of PP tests is determined by Bartlett kernel. ***, **, and * denotes significance at the 1%, 5% and 10%, respectively.

Using Augmented Dickey-Fuller (ADF) a of Dickey and Fuller (1981) and Phillips-Perron (PP) tests of Phillips and Perron (1988) and allowing for intercept only and intercept and time trend, the results show mixed between intergration of order 0, I(0), and integration of order one, I(1), series. Only real exports (LRM) is I(1) series. Therefore, using the bounds testing for cointegration seems to be suitable for the data set.

2.2 Estimations

The autoregressive distributed lag (ARDL) approach or the so-called 'bounds test for cointegration proposed by Pesaran et al. (2001) is employed to examine the log-run relationship and any possible long-run causality between trade and energy use. The test for cointegration is performed in a multivariate framework with the real GDP variable as a control variable. This procedure allows for testing for long-run relationship as well as short-run dynamics. In addition, the significance of the coefficient of the error correction term will show the existence of a long-run causality.[3]

According to the cointegration technique of Pesaran et al. (2001), the long-run regressions can be expressed as:

$$LRX_t = a_{10} + a_{11}LEC_t + a_{12}LY_t + e_{1t} \quad (1)$$

$$LRM_t = a_{20} + a_{21}LEC_t + a_{22}LY_t + e_{2t} \quad (2)$$

$$LEC_t = a_{30} + a_{31}LRX_t + a_{32}LY_t + e_{3t} \quad (3)$$

and

[3] The representation theorem of Engle and Granger (1987) states that cointegrated series can be represented in the form of a dynamic error correction model. Thus the present study utilizes this concept.

$$LEC_t = a_{40} + a_{41}LRM_t + a_2 LY_t + e_{4t} \qquad (4)$$

where LRX is the log of real exports, LRM is the log of real imports, LEC is the log of energy consumption (or energy use), LY is the log of real GDP and e is the error term. Equations (1) and (2) are used to test for the impact of energy use on real exports and imports while equations (3) and (4) are used to test for the impacts of real exports and imports on energy use.

The dynamics error correction models can be expressed as:

$$\Delta LRX_t = \alpha_{10} + \sum_{i=0}^{p1} \beta_{1i} \Delta LRX_{t-i} + \sum_{j=0}^{q1} \gamma_{1j} \Delta LEC_{t-j} + \sum_{k=0}^{r1} \delta_{1k} \Delta LY_{t-k} + \lambda e_{1t-1} + u_{1t} \qquad (5)$$

$$\Delta LRM_t = \alpha_{20} + \sum_{i=0}^{p2} \beta_{2i} \Delta LRM_{t-i} + \sum_{j=0}^{q2} \gamma_{2j} \Delta LEC_{t-j} + \sum_{k=0}^{r2} \delta_{2k} \Delta LY_{t-k} + \lambda e_{2t-1} + u_{2t} \qquad (6)$$

$$\Delta LEC_t = \alpha_{30} + \sum_{i=0}^{p3} \beta_{3i} \Delta LEC_{t-i} + \sum_{j=0}^{q3} \gamma_{3j} \Delta LRX_{t-j} + \sum_{k=0}^{r3} \delta_{3k} \Delta LY_{t-k} + \lambda e_{3t-1} + u_{3t} \qquad (7)$$

and

$$\Delta LEC_t = \alpha_{40} + \sum_{i=0}^{p4} \beta_{4i} \Delta LEC_{t-1} + \sum_{j=0}^{q4} \gamma_{4j} \Delta LRM_{t-j} + \sum_{k=0}^{r4} \delta_{4k} \Delta LY_{t-k} + \lambda e_{4t-1} + u_{4t} \qquad (8)$$

where Δ denotes first difference of each series and the one-period lag of e_1, e_2, e_3 and e_4 is the error correction term obtained from equations (1)-(4). The significant coefficient of the error correction term shows how far the variables from the equilibrium are and how fast the adjustment toward equilibrium is.

Without the error correction term in equations (5)-(8), each equation is the ARDL(p,q,r) model. Each ARDL(p,q,r) model should be parsimonious and free of serial correlation. This model is tested against the model with one-period lag of level of all variables. The computed F-statistic resulted from the test will be compared with the upper bound and lower bound critical F-statistics provided by Pesaran et al. (2001). If the computed F-statistic is above the upper bound critical value, the null of no cointegration is rejected. If the computed F-statistic is below the lower bound critical value, the null of no cointegration is accepted. The computed F-statistic that takes the value between the lower bound and upper bound critical values leads to an inconclusive result.

3. Results

One of the advantage of bounds testing for cointegration is that re-parameterization of the model into the equivalent vector error correction model is not required. The results of cointegration test are reported in Table 3.

The results in Table 3 show that there are two cointegrating equations, i.e., equations (1) and (2) because the null of no cointegration is rejected (the computed F-statistics are above the critical bound F-statistic). Equation (3) show no cointegration since the computed F-statistic is below the lower bound critical value. For equation (4), the computed F-statistic is between the lower bound and upper

Table 3 Cointegration between energy use, trade and GDP

Equation	Computed F-statistic	$\chi^2_{(2)}$
(1) Exports, energy use and GDP	5.138[r]	2.201 (p-value=0.333)
(2) Imports, energy use and GDP	8.003[r]	0.664 (p-value=0.717)
(3) Energy use, exports and GDP	1.891	2.427 (p-value=0.297)
(4) Energy use, imports and GDP	4.068	3.411 (p-value=0.182)
Critical value of F-statistic at the 5% level of significance	Upper bound critical value 4.35	Lower bound critical value 3.23

Note: The parsimonious ARDL(1,1,1) model is used in testing for cointegration. [r] indicates rejection of the null of no cointegration. $\chi^2_{(2)}$ is the Chi-square statistic which test the null of no serial correlation in the residual. P-value is the probability of accepting the null. The critical values are from Table CI (iii) in Pesaran et al. (2001).

bound critical values and, thus the result is inconclusive. Therefore, it can be concluded that energy use is the determinant of exports and imports while exports and imports are not the determinant of energy use. The results of long-run relationship are reported in Table 4.

Table 4 Long-run relationship between exports, imports and energy use

	Exports, energy use and GDP	Imports, energy use and GDP
Dependent variable	LRX (exports)	LRM (imports)
Intercept	1.611 (1.802)	5.420***(5.173)
LEC (energy use)	1.018***(5.647)	1.466***(6.936)
LY (real GDP)	0.216 (1.074)	-0.483**(-2.049)
R^2	0.986	0.974
F	1,081.577	580.652

Note: The number in parenthesis is t-statistic. ***, ** denote significance at the 1% and 5%, respectively.

Estimations of log linear equations allow for interpreting the results in terms of elasticity. The elasticity of real exports with respect to energy use is significantly positive with the value of 1.018 while the elasticity of real imports with respect to energy use is also significantly positive with the value of 1.446. These coefficients are elastic, and thus a 1% increase in energy use causes more than 1% increases in real exports and imports. The impact of real GDP on real exports is insignificantly positive, which implies that real GDP is not the important determinant of real exports. Theoretically, real exports are affected by real exchange rate and foreign real income. Interestingly, the impact of real GDP on real imports is significantly positive, i.e., a 1% increase in real GDP causes real imports to decrease by 0.483 %. The rationale behind this result might be because of the role substituted imports, but not because of the role of imported equipment or machinery. The results of short-run dynamics are reported in Table 5.

The results in Table 5 indicate that the coefficients of the error correction terms in both exports and imports equations are significantly negative and less than one in absolute value. The results suggest that there exits long-run causality from energy use and real GDP to both real exports and imports, but not the other way around. Furthermore, any deviation from the long-run equilibrium will be corrected

Table 5 Short-run dynamics

Exports (LRX), energy use (LEC) and LY (GDP)		Imports (LRM), energy use (LEC) and LY (GDP)	
ΔLRX_t		ΔLRM_t	
Intercept	0.042 (1.451)	Intercept	0.011 (0.346)
ΔLRX_{t-1}	0.207 (1.250)	ΔLRM_{t-1}	0.357**(2.315)
ΔLEC_t	0.612*(1.739)	ΔLEC_t	2.308***(5.504)
ΔLEC_{t-1}	-0.001 (-0.003)	ΔLEC_{t-1}	-0.769 (-1.488)
ΔLY_t	0.164 (0.653)	ΔLY_t	-0.792** (-2.589)
ΔLY_{t-1}	-0.549**(-2.149)	ΔLY_{t-1}	-0.529 (-1.686)
e_{1t-1}	-0.495***(-3.729)	e_{2t-1}	-0.564***(-4.355)
R^2	0.508	R^2	0.692
F	4.295	F	9.344

Note: The number in parenthesis is t-statistic. ***, **, * denote significance at the 1%, 5% and 10%, respectively.

fast enough. The significance of the coefficient of the error correction term also suggests that the estimated long-run equations are stable. The results of stability tests using CUSUM and CUSUM of squares reveal that they are stable as shown in Figures 1 and 2.

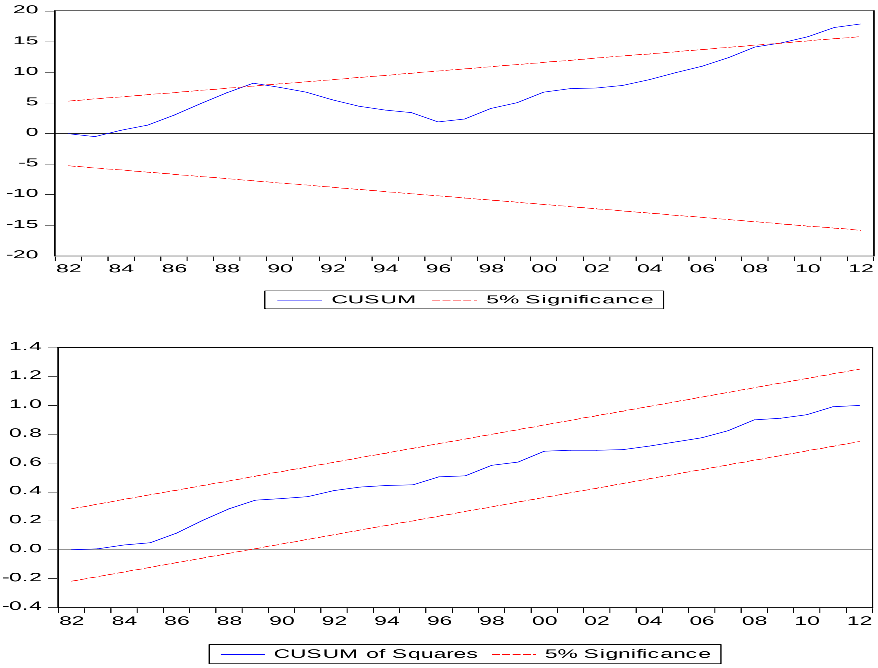

Figure 1 Stability of the long-run relationship between exports, energy use and real GDP

There seem to be no structural breaks in both long-run equations because the line is in the band in CUSUM and CUSUM of squares tests.

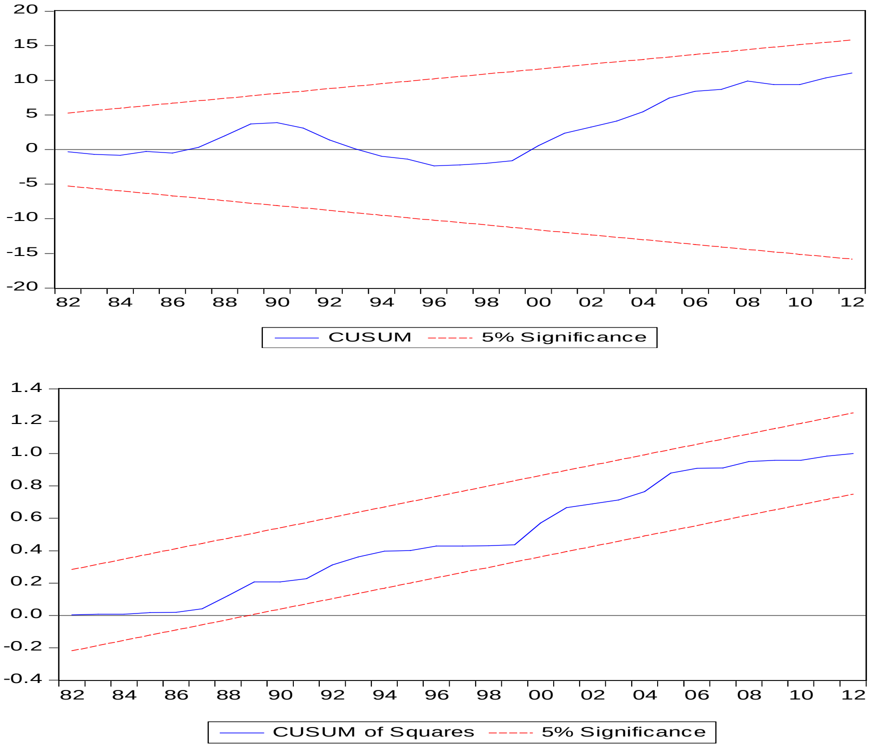

Figure 2 Stability of the long-run relationship between imports, energy use and real GDP

Based upon the results from this study, policy implications for Thailand, a non-oil exporting country, are: investing more in energy infrastructure to facilitate energy generation, and implementing energy conservation measures to prevent a reduction in energy supply. Otherwise, future expansion of exports and demand for imported equipment could not be fulfilled, which can harm the economy.

4. Conclusion

In this study, the relationships between exports, energy use and GDP, and imports, energy use and GDP are examined. The results show strong evidence that there exists stable long-run relationship of two groups of variables. In addition, the results of this study indicate a unidirectional long-run causation running from energy use and real GDP to real exports and to real imports. However, there is no causation running from real exports and real GDP to energy use or from real imports and real GDP to energy use. These findings support the notion that energy use is the main determinant of real exports and real imports. Therefore, policy measures that can maintain sufficient energy supply seem to be necessary. This will also reduce the burden from imported energy.

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