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Do Steel Consumption and Production Cause Economic Growth?: A Case Study of Six Southeast Asian Countries

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This study aims to determine the factors of sector gains and labor shifts on poverty of Vietnam, and examine how far the effects of these two factors on poverty reduction have changed over time. The empirical analysis utilizes data from the Vietnam Household Living Standards Survey in 1998 and 2002. As a result, agricultural sector has been central to the strong poverty reduction experienced by Vietnam over the last decade. Around 60% of the aggregate decline in poverty indicators originated from improvement in income of farmers. Lower poverty incidence of all the remaining sectors jointly accounted for around 30% and 20% of the national fall in poverty indices in 1993-1998 and 1998-2002 respectively. In contrast, as a result of quicker movements from low productivity sectors to higher productivity ones, labor shifts evolved as a more important contributing factor to poverty reduction in the same period. The highest concentration and severity of the two farmer groups, and their impressive participation in the reduction of aggregate poverty as pointed out in this study convey a strong message to policy makers, which implies that policies to reduce poverty in Vietnam must continue to reach farmers if a considerably further reduction in poverty is to be achieved.

JEL Codes: C12, C32, O53

Keywords: Steel production, Steel demand, Economic growth, Granger causality, Cointegration, Southeast Asian countries

1. INTRODUCTION

The steel industry is regarded as a strategic industry for the national economy, playing a crucial role in the economic development by providing the basic materials for construction, automobiles, electronics, shipbuilding, and so on.[1] However, Southeast Asian countries have been experiencing a lack of domestic steel supply because the capacity for steel production is very limited. Figure 1 shows the trend for the total consumption and production of crude steel by six Southeast Asian countries — Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam — for the period 1972-2006. Steel consumption increased to 48.1 million tons in 2006 from 22.4 million tons in 1998. On the other hand, the total production of crude steel by the countries increased by only 9.0 million tons from 8.1 million tons in 1998. The gap between consumption and production has increased from 14.4 million tons in 1998 to 33.0 million tons in 2006.[2] Also, the six Southeast Asian countries imported a total

[1] Usually, an input-output analysis is used to examine the impact of the steel industry on the economy (Kim *et al*., 1998; Choi, 2007). Also, Ghosh (2006) examined the relationship between steel consumption and economic growth for India.

[2] The numbers are calculated from the IISI (International Iron and Steel Institute) Steel statistical yearbook.

of 33.0 million tons of steel products, while the total export for the year was 9.8 million tons, a difference of 23.2 million tons in 2006.[3]

The governments of these Southeast Asian countries are planning to increase the capacity of the steel mills to the level of the demand for steel. The Southeast Asian steel-makers have already launched huge expansion plans for the short and medium terms. For example, the Indonesian government is planning to increase the country's total steel production to 10 million tons by 2010, up from 6 million tons in 2006, and Malaysia's Ann Joo Resources Bhd is aiming to start constructing its 0.5 million tonnes mini blast furnace plant.[4] If these plans are realized, the steel industry of Southeast Asia could meet the strong domestic demand as well as compete in the international market to supply to other regions. Furthermore, the steel sector of these Southeast Asian countries could enjoy the advantages of the domestic availability of raw materials and cheap labor, because the input costs for steel production rises rapidly with a rapid increase in global demand (mainly from China, India, Latin America, and other Asian countries) as well as the limited availability of iron ore and coking coal. By utilizing these advantages, expanding the steel production or/and steel capacity would lead the region to have a more solid foundation for economic development.

The objective of this study is to examine the relationship between the steel industry and the economic growth of these six Southeast Asian countries by Granger causality between steel consumption and economic growth, and steel production and economic growth in a vector autoregression (VAR) framework.[5] Our empirical results could provide meaningful implications for policy formulation regarding the steel industry. If, for example, there is unidirectional Granger causality from steel production to economic growth, increasing domestic steel production could lead to a rise in national income. On the other hand, no causality in either direction would indicate that steel production would not affect economic growth and vice versa.

In the next section, we explain the concept and method of the Granger causality between steel consumption and economic growth, and steel consumption and economic growth for the six countries. Also we examine data for the tests. Section 3 presents the empirical results from the estimations. Finally, section 4 summarizes the main findings and draws conclusions.

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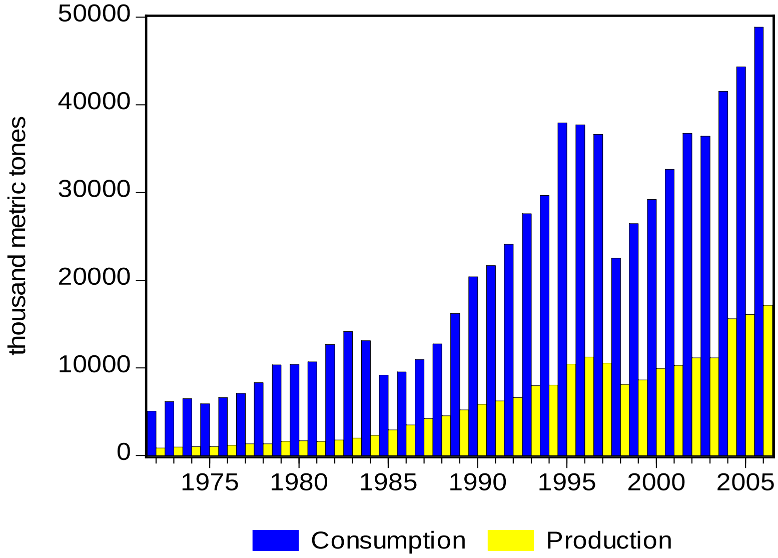
[3] SEAISI (South East Asia Iron and Steel Institute) Newsletter, July 2007.

[4] SEAISI (South East Asia Iron and Steel Institute) Newsletter, July 2007.

[5] We acknowledge that, in theoretical terms, analysis on economic growth theory and steel demand function may be needed to examine the relationship between steel consumption (production) and economic growth. Also, we acknowledge that an input-output analysis can be used to examine the impact of the steel industry on the economy using forward and backward linkage impacts. However, for the large scope of analysis which is beyond this paper and the lack of the industrial data for the countries, we leave this analysis for the future study. Instead, the Granger causality may be used as an alternative way to examine the relationship between the steel industry and economy. The Granger causality is a statistical concept of causality that is based on prediction. According to the Granger causality, if a variable X_1 'Granger-causes' (or 'G-causes') a variable X_2, then past values of X_1 should contain information that helps predict X_2 above and beyond the information contained in past values of X_2 alone. Its mathematical formulation is based on linear regression modeling of stochastic processes (Granger, 1969 and 1980). See section 2 for more discussion.

Figure 1. Steel Consumption and Production of Southeast Asia (1972-2006)



2. METHODOLOGY AND DATA

2.1. Concept and implication of the causality test

Engle and Granger (1987) showed that if the series *X* and *Y* are individually I(1) (i.e., integrated of order one) and cointegrated, then there would be a causal relationship at least in one direction. However, the direction of causality can be detected through the vector error correction model of long-run cointegrating vectors. Furthermore, Granger's representation theorem demonstrates how to model a cointegrated I(1) series in a VAR format. VAR can be constructed either in terms of the level of the data or in terms of their first differences, i.e., I(0) variables, with the addition of an error correction term to capture the short-run dynamics. If the series are I(1) but not cointegrated, the causality test may give misleading results unless the data are transformed to induce stationarity.

A three-stage procedure has been employed to test the existence of causality. As the first step, we test for the order of integration of the natural logarithm of the variables by using augmented Dickey and Fuller (ADF) (1981) statistics. Conditional upon the outcome of the tests, the second stage involves investigating the cointegration relationship among the variables using the VAR approach of Johansen (1988, 1991) and Johansen and Juselius (1990). The third stage (or second, if a bivariate cointegration is rejected) involves constructing standard Granger-type causality tests, augmented where appropriate with a lagged error correction term.[6]

[6] We acknowledge that the Granger causality tests should be used with care, because it will be often be hard to find any clear conclusions unless the data can be described by a simple '2-dimensional'

Regarding the economic implications of the Granger causality, the existence of the Granger causality from economic growth to steel consumption reveals that a growth in income is responsible for the increasing steel consumption. This is quite obvious as, with economic growth, the demands for consumer durables, automobiles, construction, and infrastructure have been increased where steel is used as one of the basic materials. The Granger causality running from economic growth to steel production may reflect the increase in steel capacity or steel production induced by the economic growth to meet the steel demand.

On the other hand, the existence of the Granger causality running from steel consumption to economic growth or from steel production to economic growth may reflect the increase in economic outcome which is realized through steel consumption and production. For example, the increase in steel consumption in the automobile industry would mean an increase in the production of automobiles, leading to a rise in GDP. Also, the increase in steel production would mean a rise in GDP.

2.2. Stationarity and cointegration tests

For the Granger causality test, we need to perform a unit root test and determine whether the variables are integrated or not. In this study, an ADF test is conducted for the stationary test and Johansen's method is adopted for the cointegration test, following the common way. In the first stage, the order of integration of the variables is investigated. We conduct ADF unit root tests on the natural logarithms of the levels and the first differences of the variables. On the basis of the ADF statistics, we decide to reject the null hypothesis of a unit root. The stationarity test is performed by running a similar test on the first difference of the variables. Then, in the second stage, the Johansen maximum likelihood procedure is used to detect cointegration.

2.3. Granger causality test

Finally, based on the results of the cointegration tests, we perform the Granger causality test to identify the causality between steel consumption and economic growth, and steel production and economic growth.[7]

If the series, X and Y are individually I(1) and cointegrated, then the Granger causality tests may use I(1) data because of the superconsistency properties of estimation:

Method I

$$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-i} + \sum_{j=1}^{n} \gamma_i Y_{t-j} + u_t \quad (1)$$

$$Y_t = a + \sum_{i=1}^{q} b_i Y_{t-i} + \sum_{j=1}^{r} c_j X_{t-j} + v_t \quad (2)$$

system, and another potentially serious problem may be the choice of sampling period, for example, a long sampling period may hide the causality (Toda and Phillips, 1994).

[7] We adopt the method suggested by Ghosh (2006) for the Granger causality test.

where u_t and v_t are zero-mean, serially uncorrelated, random disturbances.

Secondly, Granger causality tests with cointegrated variables may utilize the I(0) data with an error correction term (*ECT*), i.e.,

Method II

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \sum_{j=1}^{n} \gamma_i \Delta Y_{t-j} + \delta ECT_{t-1} + u_t \quad (3)$$

$$\Delta Y_t = a + \sum_{i=1}^{q} b_i \Delta Y_{t-i} + \sum_{j=1}^{r} c_j \Delta X_{t-j} + dECT_{t-1} + v_t \quad (4)$$

Thirdly, if the data are I(1) but not cointegrated, valid Granger-type tests require transformation to make them I(0). So, in this case the equations become:

Method III

$$\Delta X_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta X_{t-i} + \sum_{j=1}^{n} \gamma_i \Delta Y_{t-j} + u_t \quad (5)$$

$$\Delta Y_t = a + \sum_{i=1}^{q} b_i \Delta Y_{t-i} + \sum_{j=1}^{r} c_j \Delta X_{t-j} + v_t \quad (6)$$

The optimum lag lengths *m, n, q,* and *r* are determined on the basis of Akaike's (AIC) and/or Schwarz's (SIC) and/or log-likelihood ratio (LR) test criterion.

For equations (1) and (2), Y Granger causes (GC) X if

H0 : $\gamma_1 = \gamma_2 = ... = \gamma_n = 0$ is rejected, against HA : at least one $\gamma_j \neq 0, j = 1,..., n$.

X Granger causes Y if

H0 : $c_1 = c_2 = ... = c_n = 0$ is rejected, against HA : at least one $c_j \neq 0, j = 1,..., r$.

For equations (3) and (4), ΔY, Granger causes ΔX if

H0 : $\gamma_1 = \gamma_2 = ... = \gamma_n = 0$ is rejected, against HA : at least one $c_j \neq 0, j = 1,..., n$ or $\delta \neq 0$.

ΔX Granger causes ΔY if

H0 : $c_1 = c_2 = ... = c_n = 0$ is rejected, against HA : at least one $r_j \neq 0, j = 1,..., r$ or $d \neq 0$.

For equations (5) and (6), ΔY, Granger causes ΔX if

H0 : $\gamma_1 = \gamma_2 = ... = \gamma_n = 0$ is rejected, against HA : at least one $\gamma_j \neq 0, j = 1,..., n$.

ΔX Granger causes ΔY if

H0 : $c_1 = c_2 = ... = c_n = 0$ is rejected, against HA : at least one $c_j \neq 0, j = 1,..., r$.

2.4. Data

The tests are conducted on the annual data for the six Southeast Asian countries covering the period 1972-2006. For the lack of data in the case of Vietnam, we conducted the tests for the period 1985-2006.[8] Data on the gross domestic product (GDP) at 2000 prices, as a proxy to economic growth, have been collected from International Financial Statistics (IFS) provided by the International Monetary Fund (IMF). The annual consumption and production of crude steel for the same time period is taken from the Steel Statistical Yearbook, published by the International Iron and Steel Institute (IISI). $\log Steel_C$, $\log Steel_P$, and logGDP represent the consumption of crude steel, the production of crude steel, and GDP, respectively, after their logarithmic transformation following the conventional way to measure the steel demand function.

3. EMPIRICAL RESULTS

3.1. Stationarity test

In the first stage, the order of integration of the variables is investigated. The results of the ADF unit root tests on the natural logarithms of the levels and the first differences of the variables are summarized in Tables 1-2.[9]

Except for the logGDP of Indonesia (we may accept the unit root because it is rejected at the 10 percent level), the unit root tests do not reject the unit root in level for all cases. However, we reject the unit root in the differenced data at the 1 percent significance level, except for $\log Steel_p$ and logGDP of Vietnam. The unit root test on the differenced data of $\log Steel_p$ of Vietnam is rejected at the 10 percent significance level, and the differenced data of the logGDP of Vietnam is rejected at the 15 percent significance level. For Vietnam, the statistics may not be accurate because of the small sample size (22 observations). The series of Vietnam may be regarded as being stationary in the differenced data to perform the

Table 1. The Augmented Dickey-Fuller Unit Root Tests on the Variables

Variables	Indonesia		Malaysia		Philippines	
	Level	First difference	Level	First difference	Level	First difference
$\log Steel_C$	-1.857	-4.109^{***}	-2.703	-5.914^{***}	-2.686	-5.569^{***}
$\log Steel_P$	-1.943	-7.115^{***}	-1.488	-5.712^{***}	-0.912	-2.620^{*}
log GDP	-2.716^{*}	-4.409^{***}	-2.241	-5.194^{***}	-2.621	-5.655^{***}
Time period	1972-2006		1972-2006		1972-2006	

Notes: Significance levels are 10% *, 5% **, and 1% ***. We selected the augmentation lags for each Dickey-Fuller regression in order to minimize the Schwarz Information Criterion (SIC). Each regression contains an intercept but no time trend.

[8] We acknowledge that our sample size may not be big enough to estimate the long-run relationship between steel consumption (production) and economic growth. Also, we acknowledge that there are other omitted variables to explain steel consumption, such as steel price, and price of a substitute or complement material. We leave these issues of omitted variables for the future study.

[9] The Phillip-Perron unit root test is an alternative method for the Augmented Dickey-Fuller test that controls for serial correlation when testing for a unit root. The results are not reported here, because the results are not much different from those of the ADF test.

Table 2. The Augmented Dickey-Fuller Unit Root Tests on the Variables

Variables	Singapore		Thailand		Vietnam	
	Level	First difference	Level	First difference	Level	First difference
log $Steel_C$	-2.236	-4.155***	-2.240	-5.249***	-0.976	-4.828***
log $Steel_P$	-2.391	-5.600***	0.857	-5.054***	-1.124	-2.697*
log GDP	-2.150	-3.806***	-1.818	-5.396***	-0.065	-1.915†
Time period	1972-2006		1972-2006		1985-2006	

Notes: Significance levels are 10% *, 5% **, and 1% ***. We selected the augmentation lags for each Dickey-Fuller regression in order to minimize the Schwarz Information Criterion (SIC). Each regression contains an intercept but no time trend. † denotes 15 percent significance level.

Granger causality test. Thus, we may believe that all the variables have an I(1) process, which means the data are non-stationary in levels.

3.2. Cointegration test

Based on the previous ADF unit root tests, in the second stage, the Johansen maximum likelihood procedure is used to detect cointegration. This provides a unified framework for estimation and testing of cointegrating relations in the context of a VAR error correction model. The cointegration rank, r, of the time series is tested using two test statistics. Denoting the number of cointegrating vectors by r_0, the maximum eigenvalue (λ_{max}) test is calculated under the null hypothesis that $r_0 = r$, against the alternative of $r_0 > r$. The trace test is calculated under the null hypothesis that $r_0 \leq r$, against $r_0 > r$.

Tables 3~8 summarize the statistics of the Johansen cointegration test for each country. Regarding the cointegration between log$Steel_C$ and logGDP for Malaysia, the Philippines, and Vietnam, the eigenvalue test and the trace test reveal that the null hypothesis $r = 0$ between log$Steel_C$ and logGDP can be rejected against the alternative $r \leq 1$ at the 5 percent significance level. These imply the existence of only one cointegration relationship between log$Steel_C$ and logGDP. Thus, we may use the bivariate system log$Steel_C$ and logGDP, which can be modeled using Method I or II. On the basis of SIC and adjusted LR test criteria, the optimal lag order of the VAR is chosen as two. The absence of residual serial correlation of the individual equations has also confirmed the correct order of the VAR selection. For the other countries — Indonesia, Singapore, Thailand — the eigenvalue test and the trace test reveal that the null hypothesis $r = 0$ between logGDP and log$Steel_C$ cannot be rejected, meaning the absence of cointegration between log$Steel_C$ and logGDP. Thus, we can use the bivariate system ΔlogGDP and Δlog$Steel_C$, where 'Δ' is the first difference operator and hence defines the growth of the respective variable, which can be modeled as an unrestricted VAR (Method III). On the basis of SIC and adjusted LR test criteria, the optimal lag order of the VAR is chosen as the appropriate order (two, one, and three lags, repectively). The absence of residual serial correlation of the individual equations has also confirmed the correct order of VAR selection.

Also, regarding the cointegration between log$Steel_P$ and logGDP for Indonesia, Singapore, and Vietnam, the eigenvalue test and the trace test reveal that the null hypothesis $r = 0$ between log$Steel_P$ and logGDP can be rejected against the alternative $r \leq 1$ at the 5 percent significance level. These imply the existence of only one cointegration between $logSteel_P$ and logGDP. Thus, we can use the bivariate system $logSteel_P$ and logGDP, which can be modeled using Methods I or II. For the other countries — Malaysia, the Philippines, and Thailand — the eigenvalue test and the trace test reveal that the null hypothesis $r = 0$ between logGDP and $logSteel_C$ cannot be rejected, meaning the absence of cointegration between $logSteel_P$ and logGDP. We can use the bivariate system ΔlogGDP and $\Delta logSteel_C$ in this case (Method III).

Table 3. The Johansen Tests for Cointegration (Indonesia)

Variables	Hypothesized Number of Cointegrating Vectors	Eigenvalues	Trace Statistics	Maximum Eigenvalue Statistic
log $Steel_C$ & log GDP	0	0.228	9.165 (15.495)	8.011 (14.265)
	≤ 1	0.037	1.154 (3.841)	1.154 (3.841)
log $Steel_P$ & log GDP	0	0.158	23.649^{**} (15.495)	22.620^{**} (14.265)
	≤ 1	0.033	1.029 (3.841)	1.029 (3.841)

Notes: Significance levels are 5% * and 1% **. The number in parentheses is a critical value at the 0.05 level. Both specifications include two lags, assuming a trend in the series but not in the cointegrating relationships.

Table 4. The Johansen Tests for Cointegration (Malaysia)

Variables	Hypothesized Number of Cointegrating Vectors	Eigenvalues	Trace Statistics	Maximum Eigenvalue Statistic
log $Steel_C$ & log GDP	0	0.499	22.213^{**} (15.495)	20.747^{**} (14.265)
	≤ 1	0.048	1.467 (3.841)	1.467 (3.841)
log $Steel_P$ & log GDP	0	0.211	10.803 (15.495)	7.595 (14.265)
	≤ 1	0.095	3.208 (3.841)	3.208 (3.841)

Notes: Significance levels are 5% * and 1% **. The number in parentheses is a critical value at the 0.05 level. Both specifications include two lags, assuming a trend in the series but not in the cointegrating relationships.

Table 5. The Johansen Tests for Cointegration (Philippines)

Variables	Hypothesized Number of Cointegrating Vectors	Eigenvalues	Trace Statistics	Maximum Eigenvalue Statistic
log $Steel_C$ & log GDP	0	0.412	20.025** (15.495)	16.448** (14.265)
	≤ 1	0.048	3.577 (3.841)	3.577 (3.841)
log $Steel_P$ & log GDP	0	0.367	13.279 (15.495)	10.634 (14.265)
	≤ 1	0.162	5.645** (3.841)	5.645** (3.841)

Notes: Significance levels are 5% * and 1% **. The number in parentheses is a critical value at the 0.05 level. Both specifications include two lags, assuming a trend in the series but not in the cointegrating relationships.

Table 6. The Johansen Tests for Cointegration (Singapore)

Variables	Hypothesized Number of Cointegrating Vectors	Eigenvalues	Trace Statistics	Maximum Eigenvalue Statistic
log $Steel_C$ & log GDP	0	0.267	14.908 (15.495)	9.636 (14.265)
	≤ 1	0.183	6.272** (3.841)	6.272** (3.841)
log $Steel_P$ & log GDP	0	0.598	28.627** (15.495)	26.424** (14.265)
	≤ 1	0.073	2.203 (3.841)	2.203 (3.841)

Notes: Significance levels are 5% * and 1% **. The number in parentheses is a critical value at the 0.05 level. Both specifications include two lags, assuming a trend in the series but not in the cointegrating relationships.

Table 7. The Johansen Tests for Cointegration (Thailand)

Variables	Hypothesized Number of Cointegrating Vectors	Eigenvalues	Trace Statistics	Maximum Eigenvalue Statistic
log $Steel_C$ & log GDP	0	0.277	15.361 (15.495)	10.399 (14.265)
	≤ 1	0.144	4.963** (3.841)	4.963** (3.841)
log $Steel_P$ & log GDP	0	0.223	10.807 (15.495)	8.808 (14.265)
	≤ 1	0.144	2.272 (3.841)	2.272 (3.841)

Notes: Significance levels are 5% * and 1% **. The number in parentheses is a critical value at the 0.05 level. Both specifications include two lags, assuming a trend in the series but not in the cointegrating relationships.

Table 8. The Johansen Tests for Cointegration (Vietnam)

Variables	Hypothesized Number of Cointegrating Vectors	Eigenvalues	Trace Statistics	Maximum Eigenvalue Statistic
log $Steel_C$ & log GDP	0	0.706	17.061^{**} (15.495)	15.912^{**} (14.265)
	≤ 1	0.085	1.149 (3.841)	1.149 (3.841)
log $Steel_P$ & log GDP	0	0.839	24.814^{**} (15.495)	23.745^{**} (14.265)
	≤ 1	0.079	1.069 (3.841)	0.079 (3.841)

Notes: Significance levels are 5% * and 1% **. The number in parentheses is a critical value at the 0.05 level. Both specifications include two lags, assuming a trend in the series but not in the cointegrating relationships.

3.3. Granger causality test

Based on the previous cointegrating test, Table 9 summarizes the existence or absence of cointegration between the variables and the method for the Granger causality test. Also, the Granger causality tests are conducted following the methods in section 2. Tables 10-15 represent the results of the Granger causality tests for each country. First, regarding the test for causality from steel consumption to economic growth, the null hypothesis of non-causality from $logSteel_C$ to logGDP or from $\Delta logSteel_C$ to ΔlogGDP, which is asymptotically distributed as a χ^2 variate, can be rejected in the case of Malaysia (at the 1 percent significance level for Method I and at the 10 percent significance level for Method II), the Philippines (at the 10 percent significance level for Method I and at the 5 percent significance level for Method II), and Thailand (at the 5 percent significance level for Method III). These imply the presence of unidirectional causality running from steel consumption to economic growth without any feedback effect. While testing the causality running from economic growth to steel consumption, the null hypothesis of non-causality from logGDP to $logSteel_C$ or from ΔlogGDP to $\Delta logSteel_C$ can be rejected in the case of Malaysia (at the 10 percent significance level for Methods I and II), the Philippines (at the 1 percent significance level for Method III), Singapore (at the 5 percent significance level for Method III), and Vietnam (at the 1 percent significance level for Method I). These imply the presence of unidirectional causality running from economic growth to steel consumption.

Also, regarding the test for causality running from steel production to economic growth, the null hypothesis of non-causality from $logSteel_P$ to logGDP or from $\Delta logSteel_P$ to ΔlogGDP can be rejected in the case of Malaysia (at the 10 percent significance level for Method III), the Philippines (at the 5 percent significance level for Methods III), Singapore (at the 5 percent significance level for Methods I and II), Thailand (at the 10 percent significance level for Method III), and Vietnam (at the 10 percent significance level for Method I). These imply the presence of unidirectional causality running from steel production to economic growth. Finally, testing the causality from economic growth to steel production, the null hypothesis of non-causality from logGDP to $logSteel_P$ or from logGDP to $logSteel_P$ can be rejected in the case of Indonesia, (at the 10 percent significance level for Method II) and Singapore (at the 10 percent significance level for Method I and at the 1 percent significance level for Method II). These imply the presence of unidirectional causality running from economic growth to steel production.

Table 9. Cointegration and Causality Tests

	Cointegration between log $Steel_C$ & log GDP	Method for Causality test	Cointegration between log $Steel_P$ & log GDP	Method for Causality test
Indonesia	No	III	Yes	I, II
Malaysia	Yes	I, II	No	III
Philippines	Yes	I, II	No	III
Singapore	No	III	Yes	I, II
Thailand	No	III	No	III
Vietnam	Yes	I, II	Yes	I, II

Table 10. Granger Causality Tests (Indonesia)

Null Hypothesis: Non-causality	Method	χ^2	P-value	Accept Causality?
△$Steel_C$ >> △log GDP	III	3.353	0.187	No
△log GDP >> △$Steel_C$	III	0.519	0.772	No
log $Steel_P$ >> log GDP	I	1.009	0.064	No
log GDP >> log $Steel_P$	I	2.933	0.231	No
△log $Steel_P$ >>△log GDP	II	3.159	0.206	No
△log GDP >>△log $Steel_P$	II	5.784	0.056	Yes

Table 11. Granger Causality Tests (Malaysia)

Null Hypothesis: Non-causality	Method	χ^2	P-value	Accept Causality?
log $Steel_C$ >> log GDP	I	16.195	0.003	Yes
log GDP >> log $Steel_C$	I	8.725	0.068	Yes
△log $Steel_C$ >> △log GDP	II	7.780	0.051	Yes
△log GDP >>△log $Steel_C$	II	6.501	0.089	Yes
△log $Steel_P$ >>△log GDP	III	4.109	0.043	Yes
△log GDP >>△log $Steel_P$	III	0.007	0.934	No

Table 12. Granger Causality Tests (Philippines)

Null Hypothesis: Non-causality	Method	χ^2	P-value	Accept Causality?
log $Steel_C$ >> log GDP	I	6.791	0.079	Yes
log GDP >> log $Steel_C$	I	26.427	0.000	Yes
△log $Steel_C$ >> △log GDP	II	8.052	0.018	Yes
△log GDP >>△log $Steel_C$	II	26.610	0.000	Yes
△log $Steel_P$ >>△log GDP	III	4.907	0.086	Yes
△log GDP >>△log $Steel_P$	III	0.133	0.936	No

Table 13. Granger Causality Tests (Singapore)

Null Hypothesis: Non-causality	Method	χ^2	P-value	Accept Causality?
△log $Steel_C$ >> △log GDP	III	4.211	0.520	No
△log GDP >>△log $Steel_C$	III	10.289	0.067	Yes
log $Steel_P$ >> log GDP	I	8.482	0.014	Yes
log GDP >> log $Steel_P$	I	5.303	0.071	Yes
△log $Steel_P$ >>△log GDP	II	13.165	0.011	Yes
△log GDP >>△log $Steel_P$	II	13.896	0.008	Yes

Table 14. Granger Causality Tests (Thailand)

Null Hypothesis: Non-causality	Method	χ^2	P-value	Accept Causality?
△log $Steel_C$ >> △log GDP	III	4.403	0.036	Yes
△log GDP >>△log $Steel_C$	III	0.087	0.769	No
△log $Steel_P$ >>△log GDP	III	28.142	0.002	Yes
△log GDP >>△log $Steel_P$	III	11.892	0.292	No

Table 15. Granger Causality Tests (Vietnam)

Null Hypothesis: Non-causality	Method	χ^2	P-value	Accept Causality?
log $Steel_C$ >> log GDP	I	1.197	0.754	No
log GDP >> log $Steel_C$	I	11.839	0.008	Yes
△log $Steel_C$ >> △log GDP	II	0.644	0.725	No
△log GDP >>△log $Steel_C$	II	3.791	0.150	No
log $Steel_P$ >> log GDP	I	7.362	0.061	Yes
log GDP >> log $Steel_P$	I	5.410	0.142	No
△log $Steel_P$ >>△log GDP	II	3.969	0.137	No
△log GDP >>△log $Steel_P$	II	1.566	0.457	No

3.4. Implication

Based on the previous Granger causality test, we identify the presence of the Granger causality between steel consumption and economic growth, and steel production and economic growth. The Granger causalities both running from steel consumption to economic growth and steel production to economic growth are identified in four countries: Malaysia, the Philippines, Singapore, and Thailand. Also we can see the Granger causalities running from economic growth to steel consumption in Malaysia, the Philippines, and Vietnam. For Singapore, the Granger causalities running from economic growth to steel production is detected as well. For Indonesia, only the Granger causality running from economic growth to steel production is detected. For Vietnam, the causality is not identified either in the relationship between steel consumption and economic growth, and steel production and economic growth.

As mentioned in section 1, the steel demand in Southeast Asia is expected to continue to grow by around 5 percent, driven by the continuing economic development and the strong demand in steel consuming sectors. However, the steel production in the area cannot meet the demand. Our empirical results seems to imply that an increase in steel production, i.e., an increase in steel capacity, may result not only in providing enough steel to the demand sectors, but also in economic growth for Malaysia, the Philippines, Singapore, and Thailand.

There is no causality in the case of Vietnam and only one for Indonesia (from economic growth to steel production) due to the lack of data or/and the fact that the steel industry is not big enough to influence the economy. In terms of the industrial structures, Indonesia and Vietnam have been more dependent on the non-manufacturing industry, i.e., agricultural sector (ADB, 2007). For example, for the manufacturing output to GDP ratio, Vietnam recorded just 21.3 percent in 2006, which is much lower than those of the other four countries (29.8 percent for Malaysia, 22.9 percent for the Philippines, 33.0 percent for Singapore, and 35.1 percent for Thailand). Further, in terms of the labor force, the ratio of labor force in agricultural sector to total labor force in Indonesia and Vietnam marked 44.5 percent and 52.2 percent in 2006, respectively, which are much higher compared with those of the other four countries (14.6 percent for Malaysia, 35.8 percent for the Philippines, 0.16 percent for Singapore, and 38.6 percent for Thailand). Thus, the difference of the industrial structure among the countries may be one reason for the different results from our Granger causality test.

4. CONCLUSION

This study examines the relationship between steel consumption and economic growth, and steel production and economic growth in six Southeast Asian countries by Granger causality test based on the existence of a long-run equilibrium relationship. For instance, from the test results, we identify the Granger causalities both running from steel consumption to economic growth and from steel consumption to economic growth, are identified in four countries: Malaysia, the Philippines, Singapore, and Thailand.

Further, our empirical results may provide policy implication that the increase in steel production, i.e., increase in steel capacity, may result in not only the providing enough steel to demand sectors, but also the economic growth in the case of Malaysia, the Philippines, Singapore, and Thailand. The expansion of the steel production capacity may contribute to the economic growth according to our results.

As mentioned in section 2, our Granger causality test may have drawbacks because it depends on the right choice of the conditioning set and right choice of sampling period. However, we may believe that our test is still useful because it is known that if the data are reasonably well described by a 2-dimensional (vectors) system, the Granger causality concept is most straightforward to think about and also to test.

Briefly, the development of the steel industry of Southeast Asia may contribute not only to meeting the demand but also to economic growth. However, the development of the steel industry would depend on the government's role and capability to accomplish these prerequisites in the near future. In order to make the domestic steel industry grow, the government needs to provide adequate infrastructure for the steel facilities. For instance, electric power, roads, rail road, and ports are essential prerequisites. Especially, to induce foreign investment in the steel industry, these prerequisites should be prepared as soon as possible. The other major deciding factor is the availability of raw materials. For the integrated steel plant, iron ore and coking coal are needed to be provided adequately. Also, the government needs to look at both the mineral policy and the coal policy. It would include the development of suitable policies for the exploitation of new mines, environmental issues, tariff rates, trading, and the export or import of iron ore and coking coals for the development of the steel industry.

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