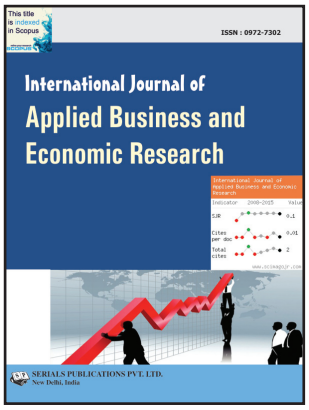

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International Energy Network Policies and Exonomic Growth in Korea

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ABSTRACT

This paper analyzes dynamic causality between international energy network policies in the petroleum industry and economic growth in Korea. We first employ unit root tests, cointegration ARDL bounds test. We then use a vector error correction model (VECM) causality tests to determine this econometric relationship using data for the period 1980–2003. The ARDL bounds test reveals the existence of a cointegrating relationship between international energy network policies and economic growth in Korea. The findings of the causality test employed using a VECM indicates short-run causality does not exist between them, but there is a unidirectional long-run causality from the network to the economic growth variable. Overall, the results suggest that international energy network policy implementation would be desirable for long-run economic growth in Korea.

Keywords: Network structure, Economic growth, causality and ARDL bounds test.

1. INTRODUCTION

While there is a growing literature identifying social networks as a significant factor in national growth (Atrostic and Nguyen, 2005; Edward, 2000; Knack and Keefer, 1997; Kraybill and Weber, 1995; Malecki, 2000; Montgomery, 1991; Narayan and Pritchett, 1996; North, 1990), networks derived from international trade pattern are rarely considered in the context of economic growth. However, international networks could be thought to generate a trade institutional environment that cultivates economic growth. As interactions between trading partners give rise to more exchanges, if trade networks persist as externalities, the network shapes domestic economic environment. Consequently, this study examines the effects of the international energy network structure derived from trade patterns in the petroleum industry on economic growth in Korea.

The network structures are used to estimate the international network index of Korean petroleum refineries. An important natural resource is petroleum refineries because most industries and households use petroleum to maintain a modern lifestyle. One feature of petroleum is that mining sites are distant from processing and refining sites, where petroleum is turned into products such as gasoline, heating oil, and petroleum naphtha. A large percentage of the world's energy consumption is accounted for by petroleum refineries, ranging from 51% for OECD in Europe, America, and Asia, to 43% for developing countries (see World Oil Outlook, 2012). In this respect, the international energy network index derived from Korean petroleum refineries shows its effect on economic growth in Korea.

Traditional international economics explains that international trade is driven by the productivity and endowment differences across countries. However, these differences may be less important in concentrated networks, as argued in Baskaran and Brück (2005) and Baskaran et. al., (2011). Especially in the petroleum industry, the number of countries exporting crude oil is limited, but those importing crude oil are numerous. Therefore, many countries importing crude oil are connected to the few crude oil-producing countries. Similarly, in the petroleum refinery industry, a few well-known countries export to most countries. Therefore, international network policies in the petroleum refinery industry play an important role in international trade and economic growth.

This study aim to analyze dynamic causality in the international network of the petroleum refinery industry and economic growth by (ARDL) cointegration test of Pesaran et. al., (2001) and the causality tests of Toda and Yamamoto (1995) for the period 1980–2003 in Korea. The remainder of this paper is organized as follows. First section introduces the theoretical network model for the empirical analysis and the analysis methods. In the next section, we present the empirical results. In Final section, Conclusion with policy implications follows in the next section.

2. MATERIALS AND METHODS

Data

A model of a long run dynamic between international network policies in the petroleum refinery industry and economic growth is considered. We explain the role of international network policy in the economic growth of Korea and, thus, test the hypothesis that gross domestic product (GDP) and international network policies have a long-run steady-state relationship:

$$lg_t = \beta_0 + \beta_1 r_t + \varepsilon_t \quad (1)$$

where prefix *l* represents the natural logarithm, *g* is the real GDP and *r* is the international network index. Data on real GDP for this study is from Bank of Korea's Economic Statistics System.

The network index is derived by the CEPII. The data used for the international network index cover 110 countries and Korea from 1980 to 2003. The international network index of petroleum refineries is constructed by considering the power-law distribution. Petroleum refineries are assumed to trade in network structures, in which countries are considered nodes. Based on the probability of the data's likelihood, the network index is derived by maximizing the likelihood function.

Test Methods

We first consider the derivation of the international network index by using the power law distribution (Albert & Barabási, 2002; Barabási & Albert, 1999; Cho et. al., 2015):

$$d(x) = n^{-r}\left(\sum_{n=1}^{\infty} n^{-r}\right)^{-1} \tag{2}$$

where, *d*, *r* and *n* denote a power law, network number, and connections per node, respectively. Petroleum refinery industry is assumed to be part of international network structures under the power-law distribution. Let countries be nodes, then the likelihood function of the international network is

$$\mathrm{L} = \prod_{i=1}^{k} n_i^{-r}(\varsigma(r))^{-1} \tag{3}$$

The logarithmic transformation of the likelihood function is

$$\log \mathrm{L} = \sum_{i=1}^{k}[-r\log(n_i) - \log(\varsigma(r)] \tag{4}$$

Maximization of the function by *r* yields

$$-\sum_{i=1}^{k}[\log(n_i)] - k\frac{1}{\varsigma(r)}\frac{d\varsigma(r)}{dr} = 0 \tag{5}$$

Rearranging Equation (5), we obtain the following equation:

$$d\ln\varsigma(r) = \frac{1}{k}\sum_{i=1}^{k}\ln(n_i) \tag{6}$$

A numerical algorithm of the Newton iteration method is implemented to derive the variable r in the Equation (6) by using mathematical software in which numerical algorithms such as the Newton iteration method are used.

The more countries take part in refining petroleum, the larger the number of countries importing from Korea is. Descriptive statistics are provided in Table 2.1. Mean and standard deviation for the network variable *r* are 1.347 and 0.004, respectively, and its values trend with fluctuations data for 1980–2003. For example, the values of the network continued to increase from 1.35 in 1980 to 1.37 in 1989 and subsequently declined to 1.31 in 2003. As more countries open over time, trade between countries increases and, thus, the network index fluctuates over time. This phenomenon also applies to petroleum refineries. During the same period, the mean of the log value of real GDP in Korea is 8.383 and its standard deviation is 0.114, respectively.

Table 2.1
Basic Statistics

Variable	*Mean*	*Standard deviation*
Log real-GDP	8.383	0.114
The number of networks	1.347	0.004

Based on the derived international energy network index, this study first examines the stability of the dynamic causality. We use the ADF and PP tests. Additionally, we consider the Elliott-Rothenberg-Stock test (ERS) (Elliott et. al., 1996).

Subsequently, the cointegration test of the ARDL bounds test is employed (Pesaran et. al., 2001). The Johansen's cointegration test may result in biases given the small sample size, as Cheung and Lai (1993) indicate, and, for small sample sizes, the ARDL estimators of the long-run coefficients are super-consistent (Pesaran and Shin, 1998). Previous studies have used ARDL bounds test (Fatai et. al., 2003; Narayan and Singh, 2007 Narayan and Smyth, 2005; Wolde-Rufael, 2006). The procedure for the ARDL bound tests is

$$\Delta \lg_t = \rho_0 + \beta_0 \lg_{t-1} + \beta_r r_{t-1} + \sum_{i=1}^{p} \varphi_{0i} \Delta \lg_{t-i} + \sum_{i=0}^{p} \varphi_i \Delta r_{t-i} + \varepsilon_i \quad (7)$$

where, lg denotes real GDP (log value) and *r* denotes the calculated international energy network index.

Subsequently, we test causality by using VECM, following the existence of cointegration relationship between the variables, which can be expressed as

$$\Delta \lg_t = \delta_g + \theta_g \text{ect}_{gt-1} + \sum_{j=1}^{p-1} \alpha_{ggj} \Delta \lg_{t-j} + \sum_{j-1}^{p-1} \alpha_{grj} \Delta r_{t-j} + \varepsilon_{gt} ,$$

$$\Delta r_t = \delta_r + \theta_r \text{ect}_{rt-1} + \sum_{j=1}^{p-1} \alpha_{rgj} \Delta \lg_{t-j} + \sum_{j-1}^{p-1} \alpha_{rrj} \Delta r_{t-j} + \varepsilon_{rt} , \quad (8)$$

where, $\text{ect}_{\text{it}-1}$ is the error correction term. The short-run causality test on whether an international energy network causes economic growth is the null hypothesis of H_0: $\alpha_{grj} = 0$, for all *j*. If the null hypothesis is rejected, international energy network policies do cause short-run economic growth. Similarly, short-run causality test on whether economic growth forms international network is null hypothesis of H_0: $\alpha_{rgj} = 0$, for all *j*. If the null hypothesis is rejected, economic growth does cause international energy network policies in the short run.

3. RESULTS

Unit-root

We employ the ADF, PP, and ERS tests and all series are considered as integrated of order 1.

Table 2.2
Tests for Unit-Root

		lg	*r*
Augmented DF	Level	–2.407	–0.671
	First difference	–3.947***	–4.776***
PP	Level	–4.675***	–0.491
	First difference	–3.947***	–10.10***
ERS	Level	–0.345	–0.799
	First difference	–3.980***	–4.308***

Notes: ***, **, and * indicate significance level at the 1%, 5%, and 10% levels of, respectively.

Cointegration Test

The results for unit-root test show that the real GDP and international network index of the petroleum refinery industry are I(1). We now test cointegration relationship by employing the ARDL bounds test

introduced by Pesaran et. al., (2001). Table 2.3 shows the results, according to which the null is rejected at 1% level, based on the F-statistic provided by Pesaran et. al., (2001) and Narayan and Smyth (2005). We can conclude from the ARDL bounds test with this small sample size that there exists a cointegration relationship between the variables.

Table 2.3
ARDL Bounds Test Results

Calculated F-statistic	*6.035****			
	1%		*5%*	
Critical bounds: Unrestricted intercept and no trend	I(0)	I(1)	I(0)	I(1)
Pesaran et. al., (2001)	4.29	5.61	3.23	4.35
Narayan (2005), N = 30	5.33	7.06	3.71	5.02

Notes: The SIC selection criteria is utilized to select lag length. The optimal lag length was found to be ARDL (2.1). The critical values provided by Narayan [2005] are based on small samples. The sample size of the present study is N = 23. *** indicates the 1% levels of significance

Causality Test Results

Next, we test the short-run causality using a VECM, since we confirmed the existence of a cointegration relationship between the international network policy variable and the economic growth variable from the ARDL bounds test.

The cointegrating equation extracted from the VECM for the two-variable system, where lg_{t-1} is the normalized variable, is as follows:

$$lg_{t-1} = -26.25 + 25.69r_t, \ (1.49) \qquad (9)$$

where values in parentheses denote *t*-statistics. The international network index of the petroleum refinery industry shows affirmative effect on economic growth. To test whether there is autocorrelation at lag order we performed the Lagrange multiplier test that the null hypothesis has no autocorrelation at lag order. The statistic for the test shows that $\chi^2_{serial}(1) = 3.34$, with a *p*-value of 0.59, indicating first serial correlation does not exist in the model.

Table 2.4 shows causality test results for the VECM with a two-variable system. There is no short-run causality between the variables. Statistically significant and negative coefficients of the ect variable in the cointegrating equations suggest that variables restore the long-run equilibrium from a deviation caused by the dynamic interactions of the variables. The estimated ect variable coefficients for real GDP equation are highly significant with negative coefficients. The result suggests a long-run causality from international network policies in petroleum refinery industry to economic growth. However, the ect variable of the network index equation indicates that there is no long-run causality from real GDP to international network policies. Therefore, the ect variable suggests unidirectional long-run causality from international network policies to economic growth. The long-run causality from the network to economic growth implies that the international network plays an important role in long-run economic growth, and, thus, the implementation of government network policies can enhance economic growth in Korea.

Table 2.4
Causality Tests

Panel A

Dependent variable	*Source of causation*	
	Short run	
	Δlg	*Δr*
Δlg		0.08
Δ*r*	0.00	

Panel B

Dependent variable	*Source of causation*
	Long run
	ect
Δlg	–0.025***
Δ*r*	–0.0003

4. CONCLUSIONS AND POLICY IMPLICATIONS

This study showed that an international network is a promising tool for empirically investigating growth, because an international network index measure interaction and knowledge flows between countries. The main results are as follows.

First, short-run and long-run dynamic causal relationships are examined between international network policies in the petroleum refinery industry and economic growth employing Korean data for 1980–2003. This analysis used the unit-root test for stability, the cointegration of ARDL bounds test, and causality tests by employing VECM.

Second, the cointegration technique of ARDL bound tests shows the existence of a long-run relationship between international network and economic growth variables. Further, the findings of the causality test by employing a VECM indicate that there is no short-run causality between variables, but there is a unidirectional long-run causality from the network variable to the economic growth variable. The results suggest that international network policy implementation would be desirable for the long-run economic growth of Korea.

Third, the international network index varies annually, but not by country. By including the network index as a variable, we can investigate the effects of the network index on growth in South Korea. We showed that the network index accelerates growth. That is, when the network index is introduced, trade between South Korea and other countries could further increase with GDP.

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