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# A Study on the Causal Relationship between Logistics Infrastructure and Economic Growth: Empirical Evidence in Korea*

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## Abstract

***Purpose*** – This paper investigates the causal relationship between logistics infrastructure development and the economic growth of Korea. Considering the industrial and economic structure of Korea, it is likely that logistics infrastructure is positively associated with the economic growth of the country.

***Design/methodology*** – The causal relationship between logistics infrastructure and economic development is estimated using Vector Autoregressive (VAR) and Vector Error Correction Model (VECM) considering long-run equilibrium between the two factors. To this end, a dataset consisting of 7 logistics infrastructure proxies and 5 economic growth indicators covering the period of 1990-2017 is used.

***Findings*** – It was found that causality, in general, runs from logistics infrastructure development to economic growth. Specifically, the results indicate that maritime transport is positively associated with the economic growth of Korea in terms of GDP and international trade. In addition, other modes of transport also have a positive impact on either the GDP or international trade of Korea.

***Originality/value*** – While existing studies in this area are based on either regional observations or a specific mode of transport, this study presents empirical evidence on causality between logistics infrastructure and the economic growth of Korea using a more comprehensive dataset. In addition, the findings in this paper can provide valuable implications for transport infrastructure development policies.

**Keywords**: Economic Growth, Granger Causality, Logistics Infrastructure, Maritime Transport
**JEL Classifications**: F14, O18, R40

## 1. Introduction

One of the few words that describe the economic achievement of Korea since the 1960s is 'miracle'. The country, once placed at the bottom of the world economic ranking table, has

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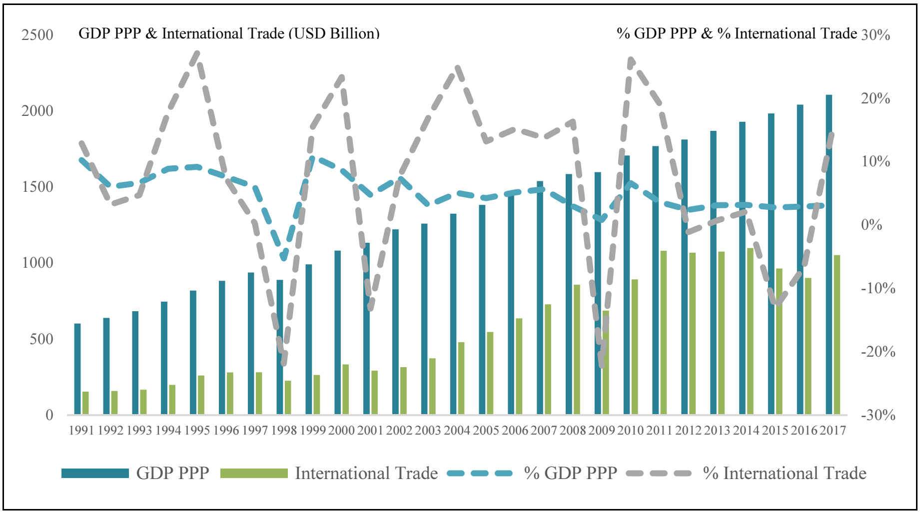
grown into a major player in the international arena. In terms of economic size, Korea ranked 12th in 2019 with a GDP of 1,642,383 million US dollar (USD).[1] Recently, the country plans to join an expanded Group of Seven (G7) summit as a major economic power. With regard to international trade, success of the export-driven growth strategy has cemented Korea as an export powerhouse, taking 6th place in 2018.[2] Fig. 1 depicts the development of GDP Purchasing Power Parity (PPP) and the international trade (the sum of exports and imports) of Korea since 1990s. Despite some declines due to downturns in the global economy (for example, the Asian Financial Crisis in 1997, Dotcom Bubble in 2000, Subprime Mortgage Crisis in 2007, and Eurozone Crisis in 2014), the Korean economy has sustained fairly robust growth among industrialized countries.

**Fig. 1.** GDP PPP and the International Trade of Korea (1991-2017)




**Source**: World Bank (for GDP PPP), Korea International Trade Association (for International Trade)

A variety of factors are regarded as critical in boosting the economic growth of Korea. Mostly cited are well-educated human resources, successful implementation of government policies (export-oriented growth since 1960s, transformation into heavy industries, and investment in research and development), and favorable geopolitical situations during the Cold War.

Among a plethora of elements, this paper highlights the significant role of logistics infrastructure development in promoting the GDP and international trade of Korea. Given the industrial and economic structure of Korea, it is highly likely that logistics infrastructure played a pivotal role in supporting economic development. Korea is an open economy that depends heavily on international trade with foreign countries. The degree of trade dependency of Korea was 66.25% in 2018, behind only Germany at 71.22% among industrialized countries.[3] Specifically, due to the lack of natural resources, Korea must import

[1] World Development Indicators, The World Bank. Accessed on August 21st, 2020.

[2] Statistics, United Nations Conference on Trade and Development (UNCTAD). Accessed on August 21st, 2020.

[3] KOSTAT, Statistics Korea. Accessed on August 23rd, 2020

the vast majority of its commodity consumption for industrial inputs from foreign countries. Moreover, as a kind of *de facto* island country because of the geopolitical relationship with North Korea, maintaining maritime connectivity with other countries is crucial for economic activity. Indeed, 69.9% of the international trade of Korea in terms of value was transported ship in 2019. The share of maritime transport becomes much higher when it comes to weight. Approximately 755 million metric tons of Korean exports and imports are performed by shipping transport, and the weight is equivalent to 95.1% of cross-border transactions.

Therefore, the impact of logistics infrastructure development on the economic growth of Korea deserves academic attention. In this regard, this paper investigates the causal relationship and the direction of causality between the two factors. To this end, we estimate the causal relationship under the Vector Autoregressive (VAR) and Vector Error Correction Model (VECM) frameworks using the dataset covering the 1990-2017 period. The dataset for logistics infrastructure consists of 7 variables that represent three major modes of transport (air, maritime and land) and government expenditure on social overhead capital. Economic growth is proxied by the sum of exports and imports, exports, imports, GDP, and GDP per capita.

The rest of this paper is structured as follows. Section 2 provides the review of previous theoretical and empirical literature on the relationship between logistics and economic development. Section 3 explains the methodologies and the dataset used in this paper. Section 4 presents the empirical results. Finally, Section 5 discusses the findings and concludes the study.

## 2. Literature Review

It is generally believed that logistics or transport infrastructure development stimulates regional or national economies. Earlier literature on this subject highlighted the impact of public capital expenditure on the private sector, which states that public infrastructure provides social overhead capital augmenting capital and productivity in the private sector. For example, investment in the public sector in transport infrastructure, such as highways, seaports, and airports, allows the distribution of goods and services in an efficient way, leading to output growth of the private sector. Aschauer (1989) documented a positive impact of public non-military capital investment on productivity in the public sector of G7 industrialized countries (i.e. USA, Japan, West Germany, France, United Kingdom, Italy, and Canada). Similar findings were also reported in the cases of Belgium (Everaert and Heylen, 2001) and Canada (Brox and Fader, 2005). Specifically, Miller and Tsoukis (2001) presented more comprehensive evidence on the positive association between government expenditure on public capital and the economic growth of 44 countries in Europe, Asia, the Middle East, and Latin America.

Another voluminous body of research analyzed the impact of logistics infrastructure development on the facilitation of international trade. Indeed, Behar and Venables (2011) argued that changes in transport costs play a key role in determining the volume and nature of international trade. In a similar vein, Lee In-Koo (2011) found that transport cost explained the deviations from the law of one price and imperfect risk sharing in the international market. Moreover, well-established national transport systems can reduce the costs of distance, and as a result, promote international trade (Halaszovich and Kinra, 2018). The trade facilitation effect of transport infrastructure is especially significant for low-income economies via the increase in exports (Celebi, 2019). Hummels (2007) documented that the decline in ocean shipping costs was a major cause of post-war trade growth in 1950s, while the growth of airborne trade in the early 2000s was driven by the decline in air transport costs. Wessel (2019) found that improvement in airport and railroad infrastructures resulted in a trade increase among European countries. Lai Kee-Hung et al. (2019) reported the mutual reinforcing relationship between trade growth through the Free Trade Agreement (FTA) and logistics infrastructure development among ASEAN countries.

Despite the important and self-evident role of logistics infrastructure in stimulating the economic development and international trade of a country, there is no unequivocal agreement on the direction of causality between the two factors. From the theoretical perspective, the endogenous growth theory highlights that the economic growth of a country results from investment in endogenous elements such as health, education, technology, and transport (for instance, see Arrow, 1962; Romer, 1987). In stark contrast, Wagner's Law (Wagner and Weber, 1977) states that infrastructure development is an outcome of economic growth. Empirical evidence on the causal relationship between logistics infrastructure and economic growth is also mixed. A review of empirical studies on this issue by Ayogu (2007) revealed that there were variations in the magnitude of the positive impact of a transport system on the economic growth of African countries, and even a negative relationship was found in some studies. Lall (2007) found that investment in transport and communications were significant determinants on the economic growth of Indian states, and similar results were found in provincial areas of China (Fan Shengen and Zhang Xiaobo, 2004; Lee Sung-Joon and Ning Cui Ying, 2014). Studies on African countries also reported a positive association between transport infrastructure and economic development (Calderon and Serven, 2010; Kodongo and Ojah, 2016). On the other hand, Kustepeli, Gulcan, and Akgungor (2012) documented the relationship between investment in highways, economic growth, and international trade in Turkey as insignificant. Rather, Maparu and Mazumder (2017) found causality running from transport infrastructure variables to economic growth indicators in India.

Considering the industrial structure and the economic features of Korea (mentioned in the previous section), sustaining an efficient logistics system is instrumental to keeping national competitiveness in the international arena. Nonetheless, only a few studies have paid academic attention to the causal relationship between logistics infrastructure and the economic growth of Korea. Kim Yong-Ho (2009) proposed a model for measuring the contribution of the logistics industry to the growth of the Korean economy. Empirical studies focusing on the logistics industry of Korea are mostly based on regional observations or limited aspects of transport. Lee Min-Kyu and Lee Ki-Youl (2016) examined the economic stimulus effect of the port logistics industry in Busan, Incheon, and Ulsan. Kim Sang-Choon and Choi Bong-Ho (2008, 2015) analyzed the impact of liquid and container freight activities on the regional economies of Ulsan and Busan, respectively. Choi Bong-Ho and Lee Gi-Whan (2019) and Jeong Dong-Won and Han Jong-Ho (2012) measured the economic stimulus effect of the logistics industry based on the regional-level and the national-level datasets, respectively.

From the above literature review, it is obvious that previous research lacks an understanding of causality between logistics infrastructure and economic growth on the national level. As such, this study aims to explore the unfilled research gap by investigating the causal relationship using a country-level dataset. In addition, this study examines four key aspects of logistics (maritime, air, land, and government expenditure) as well as by considering the national economy in terms of GDP and international trade. By doing so, the findings can offer valuable implications for further research.

## 3. Methodology and Data

In order to investigate the causal relationship between logistics infrastructure development and the economic growth of Korea, we use Granger causality (Granger, 1969) tests on the basis of VAR models. Under the assumption that a time-series variable is a linear function of the past values of itself and others, a VAR model examines the underlying causal relationship. In this paper, the VAR model is mathematically written as:

$$\Delta E_t = c_1 + \sum_{i=1}^{p} \alpha_{1i}\Delta E_{t-i} + \sum_{j=1}^{p} \beta_{1j}\Delta L_{t-j} + \varepsilon_{1t}$$

$$\Delta L_t = c_2 + \sum_{i=1}^{p} \alpha_{2i}\Delta E_{t-i} + \sum_{j=1}^{p} \beta_{2j}\Delta L_{t-j} + \varepsilon_{2t}$$

where $\Delta E_t$ and $\Delta L_t$ are the logarithmic differences in the economic growth and logistics infrastructure indicators, respectively. $c$ is the constant. $p$ is the optimal order of lags of the time-series determined by Schwarz Bayesian Information Criteria (Schwarz, 1978). $\alpha$ and $\beta$ denote the coefficients for economic growth and logistics infrastructure variables, respectively. $\varepsilon_t$ is the error term assumed to be normally distributed.

To be examined in a VAR model, a time-series should be statistically stationary. Therefore, the stationarity of time-series dataset is tested in ADF (Dickey and Fuller, 1981), PP (Phillips and Perron, 1988), and KPSS (Kwaitkowski et al., 1992), respectively. In addition, we also examine the existence of cointegration between pairs of economic growth and logistics infrastructure indicators. According to Engle and Granger (1987), when a linear combination of two individually non-stationary time-series is stationary, they are regarded as cointegrated. In economics, cointegration implies that there exists long-run equilibrium between a pair of time-series variables. The existence of cointegration is investigated through a Johansen (1988) test. The null hypotheses of the Johansen test are no cointegration, and at most, one cointegration. The test suggests two likelihood ratio statistics to examine the number of cointegration vectors. When the two statistics values are greater than critical values, a pair of time-series variables is regarded as cointegrated. The likelihood ratio statistics are calculated as following:

$$\lambda_{trace} = -T\sum_{i=r+1}^{p} \ln\left(1-\hat{\lambda}_i\right) \qquad \lambda_{max} = -T\ln\left(1-\hat{\lambda}_{i+1}\right)$$

where $\lambda_{trace}$ and $\lambda_{max}$ are the testing statistics of the trace and the maximum eigenvalue, respectively. T is the number of observations. $\hat{\lambda}_i$ is the estimated value for the $i$th ordered eigenvalue. $p$ is the number of variables.

When cointegration is found in a pair of time-series, the causal relationship is investigated using VECM. In this study, the bi-variate VECM of the economic growth and the logistics infrastructure indicators is estimated as follows:

$$\Delta E_t = c_1 + \sum_{i=1}^{p} \alpha_{1i}\Delta E_{t-i} + \sum_{j=1}^{p} \beta_{1j}\Delta L_{t-j} + \gamma_1 ECT_{t-1} + \varepsilon_{1t}$$

$$\Delta L_t = c_2 + \sum_{i=1}^{p} \alpha_{2i}\Delta E_{t-i} + \sum_{j=1}^{p} \beta_{2j}\Delta L_{t-j} + \gamma_2 ECT_{t-1} + \varepsilon_{2t}$$

where $ECT_{t-1}$ is the error correction term containing information on the long-term equilibrium between the pairs of variables. $\gamma$ is the coefficient for the error correction term.

The Granger causality test assumes that all coefficients are zero. Accordingly, when the null hypothesis is rejected, it indicates that one variable causes the other (uni-directional causality), or that variables cause each other (bi-directional causality). From the above equation, when a null hypothesis with $\beta_{1j}$ as zero is rejected, it indicates uni-directional causality running from logistics infrastructure to economic growth. When a null hypothesis with $\alpha_{2i}$ as zero is rejected, it indicates uni-directional causality running from economic growth to logistics infrastructure.

We collected data from various sources covering the period from 1990 to 2017. Our dataset consists of several indicators representing logistics infrastructure development and economic growth. For air transport infrastructure, the ton-kilos of cargo freight by air (Air Freight) and the number of aircraft departure and arrivals (Aircraft Departure/Arrival) were selected. Maritime transport infrastructure was measured in terms of the number of vessel departures and arrivals (Vessel Departure/Arrival) and the cargo handling capacity in revenue tons at Korean seaports (Port Cargo Handling Capacity. The lengths of paved roads (Paved Road) and highways (Highway) were chosen for the analysis of land transport. Government investment in logistics infrastructure (Infra) is also included in the logistic indicators.[4] For economic growth indicators, the sum of exports and imports (EXIM), the sum of exports (Exports), the sum of imports (Imports), the gross domestic product (National GDP), and the gross domestic product per capita (GDP per capita) were analyzed.[5] Table 1 reports the descriptive statistics and the measurement units of the time-series dataset.

**Table 1.** Descriptive Statistics for Logistics Infrastructure and Economic Growth Indicators

| Variables | Unit | Mean | Median | Maximum | Minimum |
|---|---|---|---|---|---|
| Panel A: Logistics Indicators | | | | | |
| Air Freight | (mil. Ton-kilo) | 8,255.5 | 7,892.9 | 15,162.6 | 2,459.4 |
| Aircraft Departure/Arrival | (no. of aircrafts) | 253,865.5 | 230,688.5 | 496,326.0 | 120,100.0 |
| Vessel Departure/Arrival | (no. of vessels) | 349,940.1 | 376,214.5 | 418,548.0 | 232,365.0 |
| Port Cargo Handling Capacity | (thousand ton) | 623,929.0 | 516,873.5 | 1,164,452.0 | 224,323.0 |
| Paved Road | (kilometer) | 72,507.7 | 75,492.0 | 94,548.8 | 40,545.0 |
| Highway | (kilometer) | 2,891.4 | 2,850.5 | 4,717.4 | 1,550.7 |
| Infra | (tril. KRW) | 14.5 | 15.9 | 20.3 | 4.5 |
| Panel B: Economic Indicators | | | | | |
| EXIM | (mil. USD) | 553,314.2 | 425,475.7 | 1,098,179.0 | 134,859.4 |
| Exports | (mil. USD) | 287,717.7 | 223,831.1 | 573,694.4 | 65,015.7 |
| Imports | (mil. USD) | 265,596.5 | 201,644.7 | 525,514.5 | 69,843.7 |
| National GDP | (mil. USD) | 1,161,776.0 | 1,155,465.0 | 1,849,612.0 | 498,681.2 |
| GDP per Capita | (USD) | 23,993.4 | 24,077.5 | 35,938.4 | 11,632.6 |

**Source:** World Bank (for Air Freight, Aircraft Departure/Arrival, National GDP, GDP per Capita), Korea International Trade Association (for EXIM, Exports, Imports), Ministry of Land, Infrastructure, and Transport (for Paved Road, Highway), Ministry of Oceans and Fisheries (for Vessel Departure/Arrival, Port Cargo Handling Capacity), and National Assembly Budget Office (for Infra).

[4] Due to a lack of data, the dataset for Infra covers for the period of 1994-2017.

[5] Both National GDP and GDP per Capita are reported in PPP with the 2017 International Dollar.

## 4. Empirical Results

In this section, we present empirical results on causality between logistics infrastructure development and economic growth in Korea. Firstly, we examine the stationarity of time-series employed in this study. Table 2 presents the results of three unit root tests (i.e. ADF, PP and KPSS) for the level and the first logarithmic difference, respectively. The test results for the level indicate that most logistics infrastructure and economic growth variables are non-stationary. Therefore, we use the logarithmic difference of the time-series variables as the results of unit root tests.

**Table 2.** Results of Unit Root Tests

| Variables | Level | | | Difference | | |
|---|---|---|---|---|---|---|
| | ADF | PP | KPSS | ADF | PP | KPSS |
| Panel A: Logistics Indicators | | | | | | |
| Air Freight | -1.803 | -1.803 | 0.598** | -5.813*** | -5.763*** | 0.335 |
| Aircraft Departure/Arrival | 1.601 | 1.818 | 0.612** | -4.876*** | -4.880*** | 0.173 |
| Vessel Departure/Arrival | -1.252 | -1.148 | 0.568** | -4.950*** | -4.951*** | 0.155 |
| Port Cargo Handling Capacity | 0.970 | 1.207 | 0.651** | -4.705*** | -4.697*** | 0.178 |
| Paved Road | -3.192** | -8.194*** | 0.673** | -4.017*** | -3.995*** | 0.704 |
| Highway | 1.035 | 1.135 | 0.664** | -4.685*** | -4.750*** | 0.118 |
| Infra | -3.377** | -5.925*** | 0.659** | -2.818** | -2.610 | 0.571 |
| Panel B: Economic Indicators | | | | | | |
| EXIM | -0.374 | -0.223 | 0.621** | -4.852*** | -4.889*** | 0.167 |
| Exports | -0.045 | 0.109 | 0.630** | -4.725*** | -4.708*** | 0.180 |
| Imports | -0.676 | -0.537 | 0.609** | -5.049*** | -5.326*** | 0.199 |
| National GDP | 0.151 | 1.323 | 0.675** | -4.911*** | -4.912*** | 0.666** |
| GDP per Capita | -0.441 | -1.028 | 0.674** | -5.146*** | -5.161*** | 0.569** |

**Note:** 1. *$p<0.1$, **$p<0.05$, ***$p<0.001$.

We further examined the existence of cointegration between the logistics infrastructure and the economic growth indicators using a Johansen test. Table 3 shows the Johansen test results with the null hypotheses of no cointegration ($r$=0) and, at most, one cointegration ($r\leq1$). The two likelihood ratio statistics ($\lambda_{trace}$ and $\lambda_{max}$) suggest the existence of long-run equilibrium between the logistics infrastructure and the economic growth variables, and the statistical significance was examined at the 1% and 5% levels. The results indicate variations in cointegration among the pairs of time-series. The most significant cointegration was found in indicators relevant to land transport. Specifically, Highway is cointegrated with Exports, Imports, National GDP, and GDP per Capita. In addition, there exist long-run equilibriums in the pairs of (1) Paved Road and National GDP and (2) Paved Road and GDP per Capita. For other pairs of logistics infrastructure and economic growth variables, cointegration was found only for the combination of Vessel Departure/Arrival and National GDP.

Based on the results of the cointegration investigation, causality tests were performed. As Bekiros and Diks (2008) suggested that cointegration affects the model specification of causality tests, we performed a VECM-based causality tests for the cointegration pairs , and VAR-based tests otherwise. Table 4 presents the causality test results for the air transport variables. We find causality running from Aircraft Departure/Arrival to Exports of Korea, which is statistically significant at a 5% level. However, the causal relationships between air transport infrastructure and the economic growth variables are uncertain in most cases.

**Table 3.** Results of Johansen Tests

| Variables | $H_0$ | EXIM | | Exports | | Imports | | National GDP | | GDP per capita | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\lambda_{trace}$ | $\lambda_{max}$ | $\lambda_{trace}$ | $\lambda_{max}$ | $\lambda_{trace}$ | $\lambda_{max}$ | $\lambda_{trace}$ | $\lambda_{max}$ | $\lambda_{trace}$ | $\lambda_{max}$ |
| Air Freight | $r$=0 | 9.50 | 8.64 | 8.67 | 8.20 | 10.36 | 9.07 | 5.80 | 5.80 | 6.89 | 6.66 |
| | $r$≤1 | 0.86 | 0.86 | 0.46 | 0.46 | 1.29 | 1.29 | 0.00 | 0.00 | 0.22 | 0.22 |
| Aircraft | $r$=0 | 10.49 | 10.34 | 13.47 | 13.09 | 8.69 | 8.62 | 3.01 | 3.01 | 3.01 | 2.95 |
| Depature/Arrival | $r$≤1 | 0.15 | 0.15 | 0.38 | 0.38 | 0.07 | 0.07 | 0.00 | 0.00 | 0.06 | 0.06 |
| Vessel | $r$=0 | 7.26 | 6.91 | 7.42 | 7.24 | 7.29 | 6.74 | 19.62$^{**}$ | 19.57$^{***}$ | 14.70 | 14.64$^{**}$ |
| Depature/Arrival | $r$≤1 | 0.36 | 0.36 | 0.19 | 0.19 | 0.55 | 0.55 | 0.04 | 0.04 | 0.06 | 0.06 |
| Port Cargo | $r$=0 | 14.93 | 14.51$^{**}$ | 9.41 | 8.97 | 12.09 | 11.90 | 14.27 | 12.01 | 13.37 | 13.06 |
| Handling Capacity | $r$≤1 | 0.42 | 0.42 | 0.45 | 0.45 | 0.19 | 0.19 | 2.26 | 2.26 | 0.31 | 0.31 |
| Paved Road | $r$=0 | 15.23 | 11.65 | 9.39 | 9.06 | 11.33 | 10.73 | 22.15$^{***}$ | 22.15$^{***}$ | 21.65$^{***}$ | 20.90$^{***}$ |
| | $r$≤1 | 3.58 | 3.58 | 0.33 | 0.33 | 0.59 | 0.59 | 0.00 | 0.00 | 0.75 | 0.75 |
| Highway | $r$=0 | 10.21 | 9.54 | 16.16$^{**}$ | 15.61$^{**}$ | 24.73$^{***}$ | 22.25$^{***}$ | 19.71*** | 19.70$^{***}$ | 26.21$^{***}$ | 22.95$^{***}$ |
| | $r$≤1 | 0.67 | 0.67 | 0.54 | 0.54 | 2.49 | 2.49 | 0.01 | 0.01 | 3.27 | 3.27 |
| Infra | $r$=0 | 10.50 | 8.73 | 9.96 | 8.68 | 11.01 | 8.77 | 9.02 | 8.49 | 10.09 | 8.69 |
| | $r$≤1 | 1.77 | 1.77 | 1.28 | 1.28 | 2.24 | 2.24 | 0.54 | 0.54 | 1.40 | 1.40 |

**Note:** 1. **$p<0.05$, ***$p<0.001$.

**Table 4.** Causality Test Results for Air Transport Infrastructure

| | | EXIM | | Exports | | Imports | | National GDP | | GDP per Capita | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ |
| Air Freight | $\Delta E_{t-1}$ | 0.040 | 0.146 | 0.071 | 0.154 | -0.011 | 0.108 | 0.021 | 0.371 | -0.025 | 0.222 |
| | $\Delta L_{t-1}$ | 0.172 | -0.147 | 0.194 | -0.154 | 0.133 | -0.149 | 0.019 | -0.186 | 0.017 | -0.179 |
| | $c$ | 0.061$^{**}$ | 0.053$^{*}$ | 0.063$^{**}$ | 0.052 | 0.061$^{*}$ | 0.057$^{*}$ | 0.044$^{***}$ | 0.048 | 0.040$^{***}$ | 0.056 |
| $\Delta E$ does not cause $\Delta L$ | | 0.401 | | 0.290 | | 0.372 | | 0.147 | | 0.050 | |
| $\Delta L$ does not cause $\Delta E$ | | 0.835 | | 1.732 | | 0.293 | | 0.192 | | 0.165 | |
| Aircraft | $\Delta E_{t-1}$ | 0.002 | -0.061 | -0.310 | -0.453 | -0.024 | -0.006 | 0.103 | 0.465 | 0.056 | 0.455 |
| Departure/Arrival | $\Delta E_{t-2}$ | | | -0.381 | 0.219 | | | | | | |
| | $\Delta E_{t-3}$ | | | 0.024 | 0.092 | | | | | | |
| | $\Delta E_{t-4}$ | | | 0.199 | -0.327 | | | | | | |
| | $\Delta E_{t-5}$ | | | -0.563 | 0.475$^{**}$ | | | | | | |
| | $\Delta E_{t-6}$ | | | -0.007 | -0.390 | | | | | | |
| | $\Delta L_{t-1}$ | -0.520 | 0.013 | -1.045 | 0.340 | -0.697 | 0.015 | -0.110 | -0.038 | -0.113 | -0.034 |
| | $\Delta L_{t-2}$ | | | -0.637 | -0.267 | | | | | | |
| | $\Delta L_{t-3}$ | | | 0.434 | -0.430 | | | | | | |
| | $\Delta L_{t-4}$ | | | -0.161 | 0.540$^{*}$ | | | | | | |
| | $\Delta L_{t-5}$ | | | 0.357 | -0.516 | | | | | | |
| | $\Delta L_{t-6}$ | | | -1.343 | 0.101 | | | | | | |
| | $c$ | 0.101$^{***}$ | 0.058$^{***}$ | 0.261$^{***}$ | 0.077 | 0.106$^{**}$ | 0.054$^{***}$ | 0.047$^{***}$ | 0.034 | 0.044$^{***}$ | 0.037$^{*}$ |
| $\Delta E$ does not cause $\Delta L$ | | 0.292 | | 1.729 | | 0.004 | | 0.957 | | 0.862 | |
| $\Delta L$ does not cause $\Delta E$ | | 2.001 | | 4.465$^{**}$ | | 2.150 | | 1.551 | | 1.767 | |

**Notes:** 1. $\Delta E$ and $\Delta L$ denote the logarithmic differences of the economic growth and logistics infrastructure variables, respectively.

2. The results of Granger causality tests are reported in $\chi^2$ statistics.

3. *$p<0.1$, **$p<0.05$, ***$p<0.001$.

In stark contrast, we find that maritime transport is highly associated with the economic growth of Korea. As seen in Table 5, causality (with statistical significant at 1% or 5%, respectively) was found to run from Vessel Departure/Arrival to EXIM, Imports, National GDP, and GDP per Capita. However, in the case of Port Cargo Handling Capacity, we failed to find causality running from logistics infrastructure to economic growth. Rather, it was found that Exports cause Port Cargo Handling Capacity.

**Table 5.** Causality Test Results for Maritime Transport Infrastructure

| | | EXIM | | Exports | | Imports | | National GDP | | GDP per Capita | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *ΔE* | *ΔL* | *ΔE* | *ΔL* | *ΔE* | *ΔL* | *ΔE* | *ΔL* | *ΔE* | *ΔL* |
| Vessel Departure/Arrival | *ECT* | | | | | | | 0.944$^{*}$ | -0.703 | | |
| | $\Delta E_{t-1}$ | -0.080 | -0.126 | -0.018 | -0.134 | -0.100 | -0.107 | 0.704 | -0.845 | -0.232 | 0.879 |
| | $\Delta E_{t-2}$ | -0.352 | -0.037 | -0.254 | -0.072 | -0.391 | -0.014 | 0.047 | -1.326 | -0.373 | 0.280 |
| | $\Delta E_{t-3}$ | 0.308 | 0.076 | 0.211 | 0.136$^{*}$ | 0.269 | 0.023 | -0.020 | -0.626 | 0.109 | 0.723 |
| | $\Delta E_{t-4}$ | 0.141 | 0.060 | 0.098 | 0.095 | 0.114 | 0.030 | -0.352 | -0.563 | 0.086 | 0.091 |
| | $\Delta E_{t-5}$ | -0.251 | -0.023 | -0.238 | 0.031 | -0.287 | -0.051 | -0.497 | -0.718 | -0.055 | -0.367 |
| | $\Delta E_{t-6}$ | | | | | | | -0.292 | 0.087 | 0.182 | 0.601$^{**}$ |
| | $\Delta L_{t-1}$ | 0.149 | 0.404$^{*}$ | 0.222 | 0.301 | -0.071 | 0.445$^{*}$ | -0.806 | 0.168 | 0.193 | 0.173 |
| | $\Delta L_{t-2}$ | 0.557 | 0.161 | 0.267 | 0.242 | 0.779 | 0.052 | -0.520 | 0.139 | 0.156 | -0.098 |
| | $\Delta L_{t-3}$ | 0.602$^{*}$ | -0.103 | 0.760$^{**}$ | -0.063 | 0.481 | -0.106 | -0.425 | -0.333 | 0.063 | -0.459 |
| | $\Delta L_{t-4}$ | 0.179 | 0.045 | 0.232 | 0.053 | 0.073 | 0.030 | -0.249 | -0.327 | -0.082 | -0.071 |
| | $\Delta L_{t-5}$ | 1.755$^{***}$ | 0.523$^{***}$ | 0.952$^{**}$ | 0.566$^{***}$ | 2.503$^{***}$ | 0.485$^{***}$ | 0.137 | 0.237 | 0.364$^{***}$ | 0.493$^{***}$ |
| | $\Delta L_{t-6}$ | | | | | | | -0.011 | -0.342 | -0.097 | -0.526 |
| | *c* | 0.028 | -0.002 | 0.050 | -0.013 | 0.024 | 0.007 | -0.005 | -0.012 | 0.032 | -0.061 |
| *ΔE* does not cause *ΔL* | | 0.987 | | 1.104 | | 1.024 | | 1.713 | | 1.588 | |
| *ΔL* does not cause *ΔE* | | 3.045$^{**}$ | | 1.328 | | 5.401$^{***}$ | | 3.586$^{**}$ | | 3.719$^{**}$ | |
| Port Cargo Handling Capacity | $\Delta E_{t-1}$ | 0.015 | -0.242 | 0.034 | 0.009 | -0.067 | 0.032 | -0.010 | 0.173 | -0.065 | 0.182 |
| | $\Delta E_{t-2}$ | | | -0.171 | 0.237$^{***}$ | | | | | | |
| | $\Delta L_{t-1}$ | -1.307 | -1.307 | 0.046 | 0.060 | -0.470 | 0.070 | -0.123 | 0.069 | -0.133 | 0.069 |
| | $\Delta L_{t-2}$ | | | 0.390 | -0.183 | | | | | | |
| | *c* | 0.000 | -0.003 | 0.064 | 0.048$^{**}$ | 0.102$^{*}$ | 0.053$^{***}$ | 0.055$^{***}$ | 0.047$^{**}$ | 0.051$^{***}$ | 0.047$^{**}$ |
| *ΔE* does not cause *ΔL* | | 0.140 | | 3.425$^{*}$ | | 0.259 | | 0.266 | | 0.277 | |
| *ΔL* does not cause *ΔE* | | 0.102 | | 0.333 | | 0.403 | | 0.903 | | 1.115 | |

**Notes:** 1. *ΔE* and *ΔL* denote the logarithmic differences of the economic growth and logistics infrastructure variables, respectively.
2. *ECT* is reported in VECM estimations only.
3. The results of Granger causality tests are reported in $\chi^2$ statistics.
4. $^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.001$.

Further, we investigate the causal relationship between land transport and economic growth. In the case of land transport infrastructure, we find the impact of logistics infrastructure development on national income, rather than international trade. It was found that Paved Road was highly associated with National GDP and GDP per Capita. However, there is no causality running from Highway to economic growth indicators.

**Table 6.** Causality Test Results for Land Transport Infrastructure

| | | EXIM | | Exports | | Imports | | National GDP | | GDP per Capita | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ |
| Paved Road | *ECT* | | | | | | | -0.025 | 0.035$^{*}$ | 0.294 | -0.254 |
| | $\Delta E_{t-1}$ | 0.110 | -0.024 | -0.032 | -0.014 | -0.073 | -0.004 | -1.449 | 0.719$^{**}$ | -1.498 | 0.574$^{**}$ |
| | $\Delta E_{t-2}$ | -0.203 | 0.018 | 0.072 | -0.005 | -0.093 | 0.005 | -1.409 | 0.859$^{**}$ | -1.467 | 0.726$^{***}$ |
| | $\Delta E_{t-3}$ | 0.107 | -0.020 | 0.178 | -0.056 | 0.054 | -0.031 | -1.595 | 0.720$^{**}$ | -1.638 | 0.625$^{**}$ |
| | $\Delta E_{t-4}$ | -0.067 | -0.022 | 0.120 | -0.018 | -0.150 | -0.024 | -1.560 | 0.389$^{*}$ | -1.621 | 0.315 |
| | $\Delta E_{t-5}$ | | | -0.280 | -0.017 | -0.118 | -0.024 | -1.029 | 0.231 | -1.068 | 0.192 |
| | $\Delta E_{t-6}$ | | | | | | | -0.344 | 0.143 | -0.354 | 0.127 |
| | $\Delta L_{t-1}$ | 1.164 | -0.494 | 2.466 | -0.253 | -0.189 | -0.227 | 0.344 | -1.454 | 0.125 | -1.173 |
| | $\Delta L_{t-2}$ | 1.401 | -0.084 | 2.676$^{*}$ | -0.064 | 2.099 | 0.008 | 1.459 | -1.096 | 1.412$^{*}$ | -0.873 |
| | $\Delta L_{t-3}$ | 2.197$^{**}$ | 0.144 | 2.180$^{**}$ | 0.106 | 4.068$^{**}$ | 0.168$^{*}$ | 2.082$^{**}$ | -0.722 | 2.153$^{***}$ | -0.603 |
| | $\Delta L_{t-4}$ | -2.360 | 0.318$^{**}$ | -1.247 | 0.335$^{***}$ | -2.902 | 0.270$^{**}$ | 1.123$^{**}$ | -0.422 | 1.214$^{**}$ | -0.378 |
| | $\Delta L_{t-5}$ | | | -2.894 | 0.192$^{*}$ | -2.509 | 0.093 | 0.379 | -0.151 | 0.475 | -0.155 |
| | $\Delta L_{t-6}$ | | | | | | | 0.356 | -0.015 | 0.379 | -0.043 |
| | *c* | 0.020 | 0.026$^{***}$ | 0.021 | 0.020$^{**}$ | 0.100 | 0.018$^{**}$ | -0.006 | 0.000 | -0.004 | -0.001 |
| $\Delta E$ does not cause $\Delta L$ | | 0.849 | | 1.078 | | 1.542 | | 2.405 | | 2.481 | |
| $\Delta L$ does not cause $\Delta E$ | | 1.596 | | 1.414 | | 2.022 | | 3.929$^{**}$ | | 3.729$^{**}$ | |
| Highway | *ECT* | | | 13.932$^{***}$ | -3.474 | 22.342$^{***}$ | -2.002 | 1.417$^{***}$ | -1.387 | 1.496*** | -1.606 |
| | $\Delta E_{t-1}$ | -0.340 | 0.127 | -0.042 | 0.062 | 0.555$^{**}$ | -0.117 | 0.162 | -1.382 | 0.310 | -1.606 |
| | $\Delta E_{t-2}$ | -0.467 | -0.056 | -1.190 | 0.083 | -0.528 | -0.053 | -0.364 | -0.711 | -0.207 | -0.845 |
| | $\Delta E_{t-3}$ | -0.133 | -0.038 | -1.135 | 0.189$^{*}$ | -1.050 | -0.090 | -0.802 | -1.178 | -0.647 | -1.253 |
| | $\Delta E_{t-4}$ | 0.317 | -0.055 | -0.961 | 0.119 | -1.010 | -0.086 | -0.515 | -1.111 | -0.381 | -1.103 |
| | $\Delta E_{t-5}$ | 0.035 | -0.008 | -0.495 | 0.034 | -0.779 | -0.075 | 0.002 | -0.530 | 0.075 | -0.499 |
| | $\Delta E_{t-6}$ | 0.285 | 0.141 | -0.195 | 0.192$^{**}$ | -0.356 | 0.024 | 0.053 | -0.162 | 0.082 | -0.148 |
| | $\Delta L_{t-1}$ | 1.548$^{*}$ | 0.242 | -12.655 | 3.298$^{***}$ | -20.512 | 1.180 | -0.726 | 0.430 | -0.802 | 0.669 |
| | $\Delta L_{t-2}$ | 1.353 | -0.328 | -12.368 | 2.670$^{**}$ | -18.067 | 1.091 | -0.376 | 0.530 | -0.483 | 0.718 |
| | $\Delta L_{t-3}$ | 1.098 | 0.305 | -9.138 | 2.440$^{***}$ | -14.156 | 1.064 | -0.393 | 0.404 | -0.489 | 0.521 |
| | $\Delta L_{t-4}$ | 2.001$^{**}$ | -0.488 | -6.852 | 1.351$^{**}$ | -10.740 | 0.572 | -0.355 | 0.191 | -0.413 | 0.287 |
| | $\Delta L_{t-5}$ | 1.249$^{*}$ | -0.061 | -3.230 | 0.830$^{**}$ | -6.962 | 0.238 | -0.181 | 0.045 | -0.200 | 0.107 |
| | $\Delta L_{t-6}$ | 1.842$^{**}$ | 0.198 | -1.601 | 0.737$^{**}$ | -3.410 | 0.340 | 0.022 | 0.109 | 0.024 | 0.149 |
| | *c* | -0.332 | 0.042 | -0.068 | 0.014$^{*}$ | -0.062 | 0.004 | -0.006 | -0.007 | -0.004 | -0.006 |
| $\Delta E$ does not cause $\Delta L$ | | 1.117 | | 2.033 | | 0.996 | | 1.584 | | 1.564 | |
| $\Delta L$ does not cause $\Delta E$ | | 2.024 | | 1.287 | | 2.499 | | 2.331 | | 2.131 | |

**Notes:** 1. $\Delta E$ and $\Delta L$ denote the logarithmic differences of the economic growth and logistics infrastructure variables, respectively.
2. *ECT* is reported in VECM estimations only.
3. The results of Granger causality tests are reported in $\chi^2$ statistics.
4. *$p<0.1$, **$p<0.05$, ***$p<0.001$.

These results can be possibly explained by the geographical terrain and industrial structure of Korea. The Korean Peninsula is narrow from east to west and from north and south, surrounded by the sea on three sides. The world-class mega-ports (Busan and Incheon) are located at the northwest and the southeast. Also, there are a large number of logistics hubs distributed in the main transportation trunk lines, which can greatly meet the demand of import and export cargo shipping in the region. Compared with other modes of transportation, land transport (i.e. trucking) has better flexibility in short and medium distance freight forwarding. Therefore, in the increasingly modern comprehensive transport system, the function of paved road transport is mainly reflected in effective connection with other transport modes. Using a logistics hub as the center, the paved road transport completes the logistics distribution function at the end of transport system, and then promotes the development of multimodal transport, such as the connection between road transport and maritime, railway, and air freight. In addition, the national economic development strategy of "Developing industry by sea ports" matters. The vast majority of Korean industrial parks are close to ports. Although Korea has a relatively developed highway network, actual paved road transport is mainly to promote the flow of production factors in the regions. This is why, while there is no causality running from highway construction to the economic development, the paved road transport dominating short distance transportation is highly correlated with National GDP and GDP per capita.

Furthermore, Table 7 reports the results of causality tests for government investment in logistics infrastructure development. The results are similar to those of land transport. It was found that there exists causality running from Infra to National GDP and GDP per Capita.

**Table 7.** Causality Test Results for Government Investment on Logistics Infrastructure

| | | EXIM | | Exports | | Imports | | National GDP | | GDP per Capita | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ | $\Delta L$ | $\Delta E$ |
| Infra | $\Delta E_{t-1}$ | -0.015 | 0.118 | 0.005 | 0.149 | -0.053 | 0.081 | -0.726 | -4.065 | -0.921 | -4.359 |
| | $\Delta E_{t-2}$ | | | | | | | -0.245 | -2.116 | -0.312 | -2.364 |
| | $\Delta E_{t-3}$ | | | | | | | -0.072 | -0.654 | -0.069 | -0.674 |
| | $\Delta E_{t-4}$ | | | | | | | -0.097 | 0.014 | -0.058 | 0.091 |
| | $\Delta E_{t-5}$ | | | | | | | 0.153* | -0.633 | 0.159** | -0.614 |
| | $\Delta E_{t-6}$ | | | | | | | 0.222** | 2.146* | 0.293** | 2.271 |
| | $\Delta L_{t-1}$ | 0.110 | 0.461** | 0.168 | 0.449** | 0.034 | 0.462** | 0.137*** | 0.518 | 0.160*** | 0.610 |
| | $\Delta L_{t-2}$ | | | | | | | 0.037 | 0.302 | 0.065 | 0.371 |
| | $\Delta L_{t-3}$ | | | | | | | 0.008 | -0.008 | 0.005 | 0.012 |
| | $\Delta L_{t-4}$ | | | | | | | 0.025 | 0.337 | 0.035 | 0.339 |
| | $\Delta L_{t-5}$ | | | | | | | 0.124*** | -0.553 | 0.112*** | -0.566 |
| | $\Delta L_{t-6}$ | | | | | | | 0.082 | 1.283 | 0.112 | 1.326 |
| | $c$ | 0.057 | 0.017 | 0.058* | 0.015 | 0.059 | 0.020 | 0.045** | 0.128 | 0.037** | 0.103 |
| $\Delta E$ does not cause $\Delta L$ | | 0.723 | | 0.781 | | 0.566 | | 1.004 | | 0.942 | |
| $\Delta L$ does not cause $\Delta E$ | | 0.100 | | 0.385 | | 0.005 | | 10.808** | | 11.813** | |

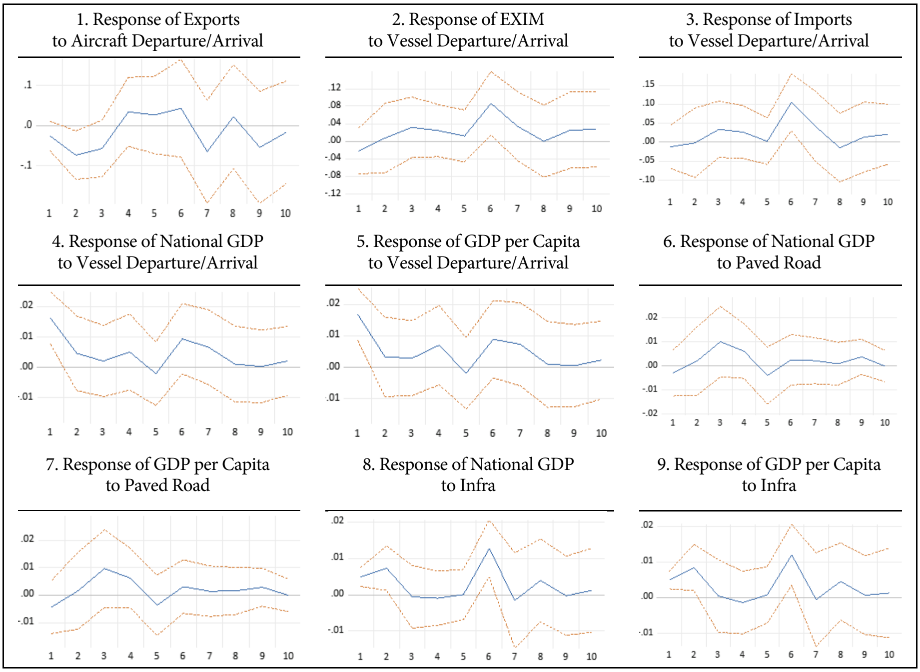
**Notes:** 1. $\Delta E$ and $\Delta L$ denote the logarithmic differences of the economic growth and logistics infrastructure variables, respectively.
2. The results of Granger causality tests are reported in $\chi^2$ statistics.
3. *$p<0.1$, **$p<0.05$, ***$p<0.001$.

Finally, we examine the impulse response of the economic growth indicators with regard to logistics infrastructure development for the variables pairs with statistically significant causality. The impulse response analysis describes the evolution of the economic growth indicators in reaction to a shock (generally, as much as one standard deviation) in the logistics infrastructure variables. Table 8 presents the results of impulse response analysis, while Fig. 2 shows the graphical descriptions. A remarkable observation from impulse response analysis is that the period when the positive impact of logistics infrastructure development realizes differs according to economic growth indicators. Specifically, National GDP and GDP per Capita, in general, react immediately to a one-standard-deviation shock in logistics infrastructure development (see 4, 5, 8, and 9, in Fig. 2). The positive impact decays gradually for a few years. In stark contrast, the positive association between economic growth and infrastructure development takes a few years to be realized for international trade of Korea (see 1, 2, and 3). The implication of this observation is twofold. First, the development of logistics infrastructure has an economic stimulus effect in the short-term. It is well known that infrastructure construction boosts a regional economy by inducing investment and employment. The immediate reaction of income-related indicators (National GDP and GDP per capita) to logistics infrastructure development in this study can be explained in a similar vein. Second, despite the direct impact on GDP growth, logistics infrastructure development should be implemented as a long-term strategy since its economic effect on international trade, a major pillar of the Korean economy, takes a considerably long time-span.

**Table 8.** Results of Impulse Response Analysis

| | Aircraft Departure /Arrival ↓ | Vessel Departure /Arrival ↓ | | | | Paved Road ↓ | | Infra ↓ | |
|---|---|---|---|---|---|---|---|---|---|
| Period | Exports | EXIM | Imports | National GDP | GDP per Capita | National GDP | GDP per Capita | National GDP | GDP per Capita |
| 1 | -0.0252 | -0.0218 | -0.0118 | 0.0161 | 0.0167 | -0.0029 | -0.0043 | 0.0049 | 0.0049 |
| 2 | -0.0738 | 0.0076 | -0.0016 | 0.0046 | 0.0033 | 0.0020 | 0.0016 | 0.0073 | 0.0084 |
| 3 | -0.0569 | 0.0319 | 0.0341 | 0.0021 | 0.0029 | 0.0102 | 0.0097 | -0.0006 | 0.0005 |
| 4 | 0.0341 | 0.0244 | 0.0268 | 0.0051 | 0.0070 | 0.0062 | 0.0061 | -0.0010 | -0.0014 |
| 5 | 0.0265 | 0.0119 | 0.0026 | -0.0021 | -0.0019 | -0.0039 | -0.0037 | 0.0000 | 0.0008 |
| 6 | 0.0429 | 0.0865 | 0.1052 | 0.0094 | 0.0089 | 0.0026 | 0.0031 | 0.0127 | 0.0119 |
| 7 | -0.0649 | 0.0343 | 0.0415 | 0.0066 | 0.0073 | 0.0023 | 0.0014 | -0.0016 | -0.0005 |
| 8 | 0.0222 | 0.0001 | -0.0145 | 0.0011 | 0.0009 | 0.0010 | 0.0015 | 0.0039 | 0.0045 |
| 9 | -0.0541 | 0.0256 | 0.0135 | 0.0003 | 0.0005 | 0.0038 | 0.0029 | -0.0003 | 0.0007 |
| 10 | -0.0172 | 0.0272 | 0.0211 | 0.0021 | 0.0023 | -0.0001 | -0.0001 | 0.0012 | 0.0013 |

**Fig. 2.** Graphical Descriptions of Impulse Response Analysis



# 5. Conclusions

## 5.1. Discussion

In this paper, we investigated the causal relationship between logistics infrastructure development and economic growth in Korea. It is found that, in general, causality runs from logistics infrastructure factors to economic growth indicators. Specifically, while the impact of other logistics factors (land transport and government expenditure on logistics infrastructure) is significant only for income related indicators, maritime transport was positively associated with both international trade and the GDP of Korea. Therefore, the findings in this study highlight the importance of maritime infrastructure development in promoting the economic growth of Korea. This result is quite compelling given the fact that Korea is an open economy heavily dependent on international trade, and the vast majority of its cross-border transactions are serviced by shipping transportation (95.1% and 69.9% in terms of weight and value, respectively). As such, it is of paramount importance to build a well-connected maritime transport network for facilitating the economic growth of Korea.

Further, the result that maritime transport has a positive impact on the economic growth of Korea does not necessarily mean other modes of transport infrastructure are of lesser importance. Rather, synthesizing the empirical results of the three modes of logistics (air, maritime and land) and public investment in transport infrastructure possibly suggest that the coordination of an intermodal logistics network across the country is a top priority in policy-making. In particular, as the concept of supply chain management has emerged in recent decades, the importance of optimizing all the processes of logistics, from sourcing to delivering to end-users, is ever-increasing. Thus, improved connectivity between various transport modes plays a key role in supporting the international competitiveness of Korean firms, which ultimately promotes the economic growth of the country.

## 5.2. Contributions and Implications

This study offers some valuable implications to the literature and practice alike. First, this study provides empirical evidence on the causal relationship between logistics infrastructure development and economic growth in Korea. While previous studies on this issue were based on either regional observations or a specific mode of transport, this study examined three major modes of logistics, air, maritime, and land, as well as government expenditure at a national level. In addition, by considering international trade, the backbone of the Korean economy, this study presents more comprehensive findings with regard to the perspective of economic growth. Second, this study enriches previous research on the economic contributions of logistics. While those studies focused on the direct effect of the logistics industry, such as employment and the value added ratio, this study investigated the role of logistics infrastructure development in promoting income and facilitating the international trade of Korea. Finally, empirical results in this paper provide practical implications for policy-making with regard to logistics infrastructure development. Specifically, since the bankruptcy of Hanjin Shipping, the country's largest ocean shipping carrier, in 2017, Korea has witnessed the contraction of its maritime power. As such, the Korean government revealed its ambitious 5-Year Plan for Shipping Revitalization in 2018. Aiming to rebuild Korean-flagged fleets, several programs, such as investment in ships and port terminals and debt guarantees, are running according to the national plan. Accordingly, the finding that maritime transport is a key to the economic growth of Korea can provide policymakers with valuable insights on priority in logistics infrastructure development.

## 5.3. Suggestions for Future Research

Despite the valuable findings in this study, further academic attention is called for to fill the research gap. Foremost, future research can explore better proxies for logistics infrastructure development. For example, the Logistics Performance Index (LPI) released by the World Bank is an interactive benchmarking tool to help countries identify the challenges and opportunities they face in their performance in trade logistics, and what they can do to improve performance.[6] In addition, UNCTAD has announced the Liner Shipping Connectivity Index (LSCI), a composite index derived from the number of ships, the total container-carrying capacity, the maximum vessel size, service frequency, and seaport vessel traffic.[7] Both indicators can provide the quantified degree of logistics infrastructure development of a country in a more comprehensive way. However, those indicators have been released since 2007 and 2006, respectively; it is not possible to employ data derived from them due to the low number of observations. Therefore, researchers in this field can benefit from a more enriched dataset from these indexes once an abundant amount of observations are available.

Moreover, further research attention is required on the impact of air transport infrastructure on economic growth of Korea. As Korea has been transforming itself into a high-tech economy, the shares of semi-conductors, mobile phones, and other information and communication devices are increasing in terms of GDP and international trade. Since most of these high-tech products are transported by air, there has been a growing importance of relevant logistics infrastructure. Thus, it is highly likely that air transport infrastructure is associated with the economic growth of Korea.

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