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Research Article

The Dynamic Effects of the Foreign Economic Shocks on the Korean Port Industry

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Although the port industry is very important in the Korean economy, there are few literature studies that shed light on the macroeconomic implications of the business cycles in this industry. This paper examines the roles played by foreign economic factors in the business cycle in the Korean port industry. Specifically, it aims to estimate the impulse response of the seaborne freight volume in the port industry due to the shocks of the foreign economy and analyze the contributions of each shock considered on the variation in the freight volume. The structural FAVAR (SFAVAR) model was employed to extract the unobserved foreign economic factors. This paper estimates the four foreign economic factors and the parameters of the model using the one-step Bayesian Gibbs sampling method. The findings of this study show that foreign economic activity statistically affects the freight volume of the Korean ports. Specifically, the shocks to the foreign real economic activity increased freight transportation for nearly one year. Following the world inflation shocks, the freight transportation was enhanced. However, this impact disappeared after a year. Similarly, the rise in global liquidity was shown to encourage transportation activity; nevertheless, this activity declined after five quarters. Moreover, the increase in the world interest rates exerted a negative effect on the volume of transportation. Furthermore, the variance decomposition analysis shows that 49.2% of the variation in the transportation volume could be attributed to foreign economic activity. This analysis can contribute to drawing useful implications in establishing the port industry policy in response to the change in the economic environment such as the foreign economy.

1. Introduction

The port industry has grown to be a vital sector of the Korean economy, especially given the country's high level of economic openness, geographic advantages, and growing significance of seaborne freight transportation in global supply chains. Accordingly, there have been many studies that analyze the Korean port industry in the microeconomic perspective. However, there are few literature studies that shed light on the macroeconomic implication through the systematic analysis of this industry. For instance, despite the fact that the port sector in Korea has become more significant, the relationship between the Korean port industry and the country's business cycle has not been adequately evaluated. According to the previous study, the transportation industry, including the port industry, plays an important role in the propagation of the nation-wide business cycles [1]. Thus, the business cycle studies have important implications in the decision-making processes of government agencies and private sectors.

This study examines the business cycles in the Korean port industry triggered by foreign economic fluctuations. Specifically, the dynamic effects of shocks to foreign economic factors on the transportation volume of the Korean port industry are studied. In particular, in the Korean economy, where there is no alternative except for the port transportation channel, the port industry is a vital channel for export and import. It can be easily postulated that the business cycle in the port industry is related to that of the national and global economies.

However, there are many difficulties in undertaking a quantitative study of the dynamic impact of global

economic shocks on the domestic port industry, the most significant of which is the way to measure foreign economic activity. This problem is further related to other issues such as the empirical model to be employed and the method to identify the shocks to the foreign economy.

This paper focuses on the role played by foreign economic activity in the business cycle of the domestic port industry. Consequently, we hope that the existence of a one-to-one relationship between the foreign economy and the trade volume by the Korean port can be exploited. Traditionally, the VAR type model has traditionally been employed as the framework for analyzing the dynamic impact of economic shocks on the macroeconomy. However, the shocks must be identified for analyzing the effects using the VAR model. Incorrect identification of the shocks results in misleading inferences regarding the causality of the business cycle. The literature indicates that one important reason that the shocks cannot be accurately recognized is that the small-scale traditional VAR does not adequately account for an individual's economic activities while making decisions.

This difficulty in identifying the shocks remains a challenge when analyzing the effect of foreign economic shocks on small, open economies. In previous studies, foreign economic shocks have been measured as the unexpected movement of specific variables such as GDP. For example, Cushman and Zha [2] analyzed the economy of Canada considering the unexpected fluctuation in the U.S. GDP as shocks to the foreign economy. Further, Kim and Roubini [3] examined the effect of the U.S. monetary policy on other economies but not the dynamic effect of the foreign economy. This study uses the Structural FAVAR model to identify the foreign economic factor and shed light on the dynamic effects of foreign shocks on the Korean port industry.

The FAVAR model combines the VAR model typically used in the analysis of the macroeconomy with factor analysis [4]. As the FAVAR model offers the advantage of incorporating a large amount of information obtained from a large set of economic series into a VAR model, it is considered useful in modeling the central bank's reaction function or analyzing the international business cycles. However, it has a drawback in the sense that it does not provide an economic interpretation of the estimated factors. This problem can be overcome by using the Structural FAVAR (SFAVAR) model [5, 6]. The industry-level economy has not yet been studied using the SFAVAR model, which has been used to study the broader economy. However, this model can be applied to studying the dynamic effect of shocks to the foreign economy on a specific industry. Lee and Ni [7] studied the relationship between oil price shocks and the U.S. industry based on the VAR model, and Jo et al. [8] employed the FAVAR model to study the same subject.

The SFAVAR model adopted in this study offers the advantage of examining the transmission mechanism through the port industry by identifying the factor economically. In addition, this analysis can contribute to drawing useful implications for establishing port industry policy. To perform these purposes, we estimate the dynamic effect of the foreign economic shocks on the Korean port industry via the impulse response analysis and measure the relative importance of the domestic and foreign factors through the variance decomposition of forecast errors.

The remainder of the paper is organized as follows: Section 2 reviews the literature related. Section 3 presents the empirical methods adopted in this paper. Section 4 presents the estimation results and discussion. Section 5 concludes the paper.

2. Literature Reviews

This section provides a brief assessment of earlier studies on the relationship between foreign economy and seaborne freight transportation. The methodology for estimating the foreign economic factor that was described in the literature is also discussed.

2.1. Relationship between the Foreign Economy and the Port Industry. There are three economic aspects that imply the importance of the freight economy to the business cycles of the port industry. First, there is a direct relationship between the transportation industry and general economic activity. In their seminal paper on the relationship between economic activity and transportation, Lahiri and Yao [1] examined the business cycle in the U.S. transportation sector since the 1990s. They found a close relationship between the business cycle of the U.S. macroeconomy and the transportation service. Muller et al. [9] emphasized the strong relationship between economic activity and transportation. Consequently, they developed new economic indicators to study the business cycles in this industry. Pastowski [10] showed the strong interdependence between freight transport and GDP growth. Meersman and de Vande [11] analyzed the relationship between the general economic activity and the volume of seaborne transportation but concluded that the GDP measure is not a suitable variable for the determinant of freight transportation based on the cointegration analysis. Angelopoulos and Chlomoudis [12] examined the business cycle of the U.S. port industry using the dynamic factor model.

Second, the Korean economy is a small open economy, which helps to understand the relevance of the foreign economy to the business cycles of the Korean port industry. According to the OECD, the proportion of the sum of imports and exports in the Korean economy was 72.9% of the GDP in 2020. However, the relative contribution was 74% to the GNI, 35.5% to the U.S., and 34.1% to Japan. Thus, the importance of the foreign economy can be assessed as the driving force of the Korean economy. For example, many Korean economic analysts have stressed commerce with other nations as the driving force behind the Korean 10 industry. Consequently, the potential role played by the foreign economy in the port industry can be inferred. In addition, Pallis and de Langen [13] analyzed the effect of the economic recession on the port industry and concluded that the 2008 credit crunch and the subsequent economic crisis

generated the volume of freight transport and led to a significant reduction in the volume.

Finally, since the 1990s, the globalization of the economy or global value chain (GVC) has intensified, making international commercial activity increasingly significant for the variety of domestic port transportation. Thus, the proliferation of the global supply chain increased the link of the domestic economy to the foreign economy, thereby resulting in an increase in the production of the countries through the supply chain [14, 15]. Also, it was reported that the globally integrated international supply chain increased the interdependence between economies and the importance of trade economies [16]. It was showed that the demand for port transportation significantly affects the maritime industry and indicated the lack of quantitative studies on the role of the variation of the world economy [17]. In addition, based on the vector autoregression analysis, the study found that shocks to global GDP had a favorable impact on all freight transportation categories.

2.2. Identifications of Foreign Economic Factors. As mentioned earlier, the objective of this paper is to examine the dynamic effect of the foreign economy on the Korean domestic port industry. This study specifically seeks to evaluate the influence of foreign economic activity shocks on domestic freight transportation utilizing the impulse response function and the variance decomposition based on the VAR type framework. However, the important thing to tackle is measuring foreign economic activity. In many cases in the previous literature, the U.S. economy has been traditionally treated as the world economy [2, 3]. However, these identification methods are only applicable to the Canadian economy or when studying the international transmission mechanism originating from the U.S. economy. Hence, we cannot employ this idea for measuring the foreign economic activity as the world economy does not comprise only the U.S. economy. Moreover, the Chinese economy is very important to the Korean economy in terms of explaining the variation of the Korean economy. In this paper, we understand foreign economic activity as the economic factors that underlie the comovements of the aggregates across the different foreign countries.

In the literature, the dynamic factor model has been used to estimate the unobserved foreign economic factors in the empirical literature. Gregory et al. [18] used the Kalman filtering and dynamic factor model to identify the common factors across macroeconomic aggregates in G7 countries. They showed that fluctuations in all aggregates contain world common components that are both statistically significant and quantitatively important. Kose et al. [19] employed a Bayesian dynamic factor model to estimate the common components in macroeconomic aggregates in 60 countries. Their results indicate that a common world factor is an important source of volatility for aggregates in most countries. D'Agostino and Surico [20] constructed a measure of global liquidity using the first dynamic principal component of the growth rates of broad money across the G7 economies. They found that the global liquidity produces forecasts of U.S. inflation that are significantly more accurate than the forecast based on U.S. money growth. Their results support the fact put forward by Rogoff [21] that national inflation rates in several industrialized economies share a common significant international component. Also, the result shows the importance of the foreign economic factor in explaining the fluctuation of the national economy. Mumtaz and Surico [22] used a large panel of data for 17 industrialized countries to investigate the international transmission mechanism. In their analysis, the FAVAR model, which is a modification of the dynamic factor model, was used to show the dynamic effects on the U.K. economy of an unanticipated fall in the international interest rate factor and the world liquidity factor. They extracted four common foreign factors: real-world economic activity, world inflation, world liquidity, and world interest rate factors. For instance, they estimate the international real activity factor from all international real activity series in the data set. Similarly, the foreign inflation factor is identified as the only factor that is loaded by international inflation series in their analysis. The present study follows the methodology of that study [22].

3. Open Economy FAVAR Model

This section explains the empirical model adopted in this paper, SFAVAR, and the estimation method. As noted earlier, the SFAVAR model is an extension of the FAVAR model in which the estimated factor can have economic interpretations. Since the FAVAR model is an application of the dynamic factor model, the model can also be represented by the state-space form which consists of two equations, i.e., measurement equations and transition equations. The model explanation is as follows.

3.1. SFAVAR Model. This subsection describes the SFAVAR model. First, we discuss the measurement equation in the model. Let Y_t and X_t be the two vectors of economic variables. Y_t is an $M \times 1$ vector and X_t is a large dataset of economic variables, whose dimension is $N \times 1$, and$t = 1, 2, \cdots, T$ is the time index. Y_t includes the Korean GDP, the volume of the sum of Korea economy's import and export, and volume of seaborne freight transportation. Further, X_t is assumed to be explained by a variety of unobserved factors, which can be summarized by a $K \times 1$ vector of factors F_t, and error terms. Thus, we can write the model of X_t as

$$X_t = \Lambda F_t + e_t, \tag{1}$$

where e_t is the error term with $E(e_t) = 0$ and $\mathrm{Cov}(e_{m,t}, e_{n,t}) = 0$, $m, n = 1,2,., N$. Also, it is assumed that $e_t \sim i.i.d\ N(0, R)$ and that its covariance matrix, R, is the diagonal. Further, Λ is factor loading and its dimension is the $N \times K$ matrix. Here, assume that the series of observable datasets X_t can be grouped into $X_t^1, X_t^2, \cdots, X_t^I$ based on the approximate economic category, where X_t^i is an $N_i \times 1$ vector and $\sum_{i=1}^{I} N_i = N$. This study assumes that an arbitrary segment of X_t, for example, X_t^i, can be explained by F_t^i. This

implies that F_t is also partitioned by F_t^1, F_t^2, $\cdots$, and F_t^I, which correspond to various economic concepts. Here, F_t^i is the $K_i \times 1$ vector. In addition, $\sum_{i=1}^{I} K_i = K$ holds. Moreover, it is assumed that $K_i < N_i$. Thus, the above observation (measurement) equation (1) can be rewritten as

$$\begin{bmatrix} X_t^1 \\ X_t^2 \\ \vdots \\ X_t^I \end{bmatrix} = \begin{bmatrix} \Lambda_1^f & 0 & \cdots & 0 \\ 0 & \Lambda_2^f & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \Lambda_I^f \end{bmatrix} \begin{bmatrix} F_t^1 \\ F_t^2 \\ \vdots \\ F_t^I \end{bmatrix} + \mathrm{e}_t. \tag{2}$$

Second equation to be discussed is the transition equation. The foreign economic variables that are included in X_t are grouped to have a clear economic meaning. In addition, we assume that each subgroup of X_t is explained by only one factor; that is, $K_i = 1$. Next, the dynamics of $(F_t^1, F_t^2, \cdots, F_t^I, Y_t)$ is assumed to be the following vector autoregression model (VAR model):

$$\begin{bmatrix} F_t^1 \\ F_t^2 \\ \vdots \\ F_t^I \\ Y_t \end{bmatrix} = \Phi(\mathrm{L}) \begin{bmatrix} F_{t-1}^1 \\ F_{t-1}^2 \\ \vdots \\ F_{t-1}^I \\ Y_{t-1} \end{bmatrix} + \mathrm{v}_t, \tag{3}$$

where $\Phi(L)$ is a matrix of the polynomial of lag operator d and v_t is the error terms with conditional mean $E(v_t) = 0$. In addition, it is assumed that $v_t \sim i.i.d\ N(0, Q)$. As will be explained below, we assume that $d = 2$.

As evident from the above specification, the key difference between the FAVAR model of equations (2) and (3) and the standard VAR model is that the above equations include the unobserved factor while the standard VAR does not. Particularly, this model offers the advantage of having the economically interpreted factors because we impose the restrictions that F_t^i is related to X_t^i. In other words, the drawback of the original FAVAR model can be addressed. That is, while the estimated components of the FAVAR model cannot have a structural economic interpretation, our SFAVAR model may have it [4]. Thus, the factor that possesses an economic interpretation can be estimated. This can be achieved by first categorizing the variables in X_t based on the economic meaning and subsequently estimating each factor based on the categorized economic variables.

Following the previous study [22] that analyzed the U.K. economy in the context of a small open-open economy, this study categorized the foreign economic factors that affect the domestic port economy into four categories: world real economic activity, foreign inflation, world liquidity, and world interest rate factors. Specifically, the foreign real economic activity factor F_t^Y can be extracted from the subset X_t^1, the foreign inflation factor F_t^S from X_t^2, liquidity factor F_t^L from X_t^3, and finally the world interest rate factor F_t^M from X_t^4.

3.2. Estimation Method. In the previous subsection, we discussed the SFAVAR model used here in the dynamic factor model framework. Here, we explain the method for estimating the model parameters and the unobserved foreign economic factors. In general, two estimation strategies can be used to estimate the SFAVAR model introduced in the previous section. One is the principal component estimation method and the other is the Bayesian estimation based on the Gibbs sampling. Although the principal components method is more convenient than Bayesian estimation, this study implements the latter. This is because the principal component method estimates the unobserved factor using only equation (2), implying that the dynamics of the factor are not considered [23]. We use the dynamics of the factors formalized by equation (3) when estimating the factors.

To carry out the likelihood-based Gibbs sampling, we need to transform the model discussed in the previous section into the state-space form. As it is well known, the state-space model has two equations. One is the measurement equation and the other is transition equation. The measurement equation can be written as

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \Lambda & 0 \\ 0 & I_M \end{bmatrix} \begin{bmatrix} F_t \\ Y_t \end{bmatrix} + \begin{bmatrix} e_t \\ 0 \end{bmatrix}. \tag{4}$$

The above equation can be expressed by using the notations $\mathbf{X_t} = (X_\mathbf{t}', \mathbf{Y_t}')'$ and $\mathbf{F}_\mathrm{t} = (\mathrm{F_t}', \mathrm{Y_t}')'$.

$$\mathbf{X}_t = \Lambda \mathbf{F}_t + e_t. \tag{5}$$

The transition equation, another component of the model, is obtained as

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = \Phi(L) \begin{bmatrix} F_t \\ Y_t \end{bmatrix} + v_t. \tag{6}$$

Equation (6) can also be expressed as

$$\mathbf{F}_t = \Phi(L)\mathbf{F}_{t-1} + v_t, \tag{7}$$

where v_t and e_t are independent of each other.

It can be concluded that equations (5) and (7) represent the state-space form system. We follow the estimation procedure based on the Bayesian estimation which can be found in Belviso and Milani [5] and Fonseca and Pereira [6].

Following the Bayesian approach, we treat the model parameters $\theta = (\Lambda, R, Q, \Phi)$ and the factors F_t as random variables. Let $\widetilde{X}_T = (X_1, .., X_T)$ and $\widetilde{F}_T = (F_1, .., F_T)$ be the histories of X and F. We need to derive the posterior of F and θ, $p(\widetilde{F}_T|\theta, \widetilde{X}_T)$ and $p(\theta|\widetilde{F}_T, \widetilde{X}_T)$, respectively, to obtain the estimates of $\widetilde{F}_T$ and θ. The Gibbs sampling method proceeds as follows. First, we set the starting values for the parameter θ, say θ^0. We set the first element of $\Lambda_i^f, i = 1, .., I$, to 1 and other elements to 0. Also, R is the residual covariance matrix from the regression of X on an arbitrary proxy variable for F. We set $\mathrm{vec}(\Phi)$ and $Q = I$. Second, conditional on θ^0 and the data $\widetilde{X}_T$, draw values for $\widetilde{F}_T$ from the conditional density $p(\widetilde{F}_T|\widetilde{X}_T, \theta^0)$ based on the Kalman filter algorithm [24]. Third, conditional on the sampled values of $\widetilde{F}_T$ and the data, draw the parameter θ from the conditional distribution $p(\theta|\widetilde{X}_T, \widetilde{F}_T)$. In this step, we need the prior and the posterior for θ. We will use the prior and

the posterior shown in the Bernanke et al. [4]. The final two steps are one iteration and are repeated until the empirical distribution of $\widetilde{F}_T$ and θ converges. After that, we can obtain the empirical distribution to calculate the estimate of θ and $\widetilde{F}_T$.

4. Estimation and Interpretation

This section describes the data used in this paper and gives an interpretation of the obtained empirical results of the SFAVAR model developed in Section 3 based on the impulse response analysis and variance decomposition analysis.

4.1. Data. As mentioned earlier, this study assumes four common foreign economic factors that affect the Korean economy. Furthermore, it is assumed for expository purposes that the foreign economy may be represented by the economies of the G7 countries and China. The first foreign factor is the foreign real economic activity factor. The real economic growth of these nations can be utilized to identify and estimate this factor. Rogoff [21] used a variety of variables including real economic growth to estimate this factor. However, only one variable, that is, economic growth, is used to identify the factor.

Seaborne freight transportation volume can also be affected by world inflation in both directions. The number of exports rises and the volume of imports falls when world inflation rises because the increase in the price of products produced abroad relative to those of local goods indicates an increase in the domestic good's price competitiveness. In certain studies, the common factor in the inflation of the countries is often interpreted as the supply side. This study shows that this is not always the case since inflation can sometimes rise along with rising aggregate demand as a result of a rise in economic activity.

The inflation based on the CPI of the countries considered is used to identify the world inflation factor. Further, the M3 monetary aggregate of the U.S., U.K., and Canada, wherein the data are available to estimate the world liquidity factor, is used. Finally, the call rate of each country is used to estimate the world interest rate factor.

The domestic variables in the model comprise the quarterly real economic growth and the sum of the real export and real import. Furthermore, the nominal volume of imports and exports combined, divided by the CPI, is used to compute the real trade. In addition, the real trade volume is transformed into the growth of that relative to the same period of the previous year.

The relationship between seaborne freight transportation and US GDP growth, which plays the most significant role in the global economy, is necessary to understand before assessing the results estimated using the SFAVAR model. Figure 1 shows the variation of the log-transformed quarterly GDP around the trend calculated using the HP filter and the variation of the domestic freight transportation calculated using the same method. It indicates that the variation in transportation is larger than that of U.S. economic growth. In addition, it is evident that domestic transportation is correlated with the U.S. growth during the same period. Particularly, during the 2008–2009 financial crisis and the 2019–2020 COVID-19 epidemic eras, both values decreased significantly. However, even before the 2007 financial crisis, U.S. growth and domestic transportation increased constantly, while domestic transportation exhibited greater volatility. The figure suggests that there may be a possible correlation between the two values, even if it is not adequate to draw the conclusion that it is proof of the causal impact of global economic activity on domestic transportation.

4.2. Estimation of the Foreign Economic Factors. The foreign economic factors were extracted from a variety of foreign economic variables based on the SFAVAR model in this subsection. The estimated foreign real economic activity factor is associated with the existence of the international business cycle proposed by Kose et al. [19], which drives many countries in the world. The literature implies close comovements among the many countries' industrial productions [27, 28]. In addition, the evidence of a similar pattern in the business cycles was presented in many countries [29].

This research took Rogoff [21]'s insight into account while analyzing the effects of the international liquidity factor. It was shown that the industrialized countries shared the common components of these inflation fluctuations to the extent that there are high correlations between money growth and inflation and that world liquidity can affect world inflation. D'Agostino and Surico [20] showed that the world's liquidity is useful for explaining the inflation phenomenon in many countries. Figure 2 shows a plot of the four common foreign factors extracted using the SFAVAR model. It is evident that a certain portion of the pattern is almost consistent with conventional wisdom.

The 2001-2002 period, the 2007 financial crisis, and the COVID-19 outbreak all resulted in a severe economic downturn for the nations taken into consideration in this analysis. The pattern of these time series almost corresponds to the existence of the international business cycles [18]. The overall decreasing trend in the world inflation factor is consistent with the global disinflation [28]. The estimated liquidity factor, which is shown in the left-upper corner, also climbed from late 2004 to mid-2008, fell after that, and subsequently rapidly surged during the COVID-19 pandemic period. The right-upper corner shows the world interest rate factor identified by short-run interest rates in the countries considered in this study.

Since 2000-2001, the factor has shown a progressively falling tendency, followed by a rise until 2007. Consequently, this factor has been constantly decreasing since the 2008 financial crisis. The common factor for the interest rates is to show the approach to the recent historically low level.

4.3. Impulse Response Function Analysis. An essential feature of the globalization of the economy since the 1990s has been the growing importance of the seaborne container trade for supply chains. With 90% of nonbulk dry cargo globally being

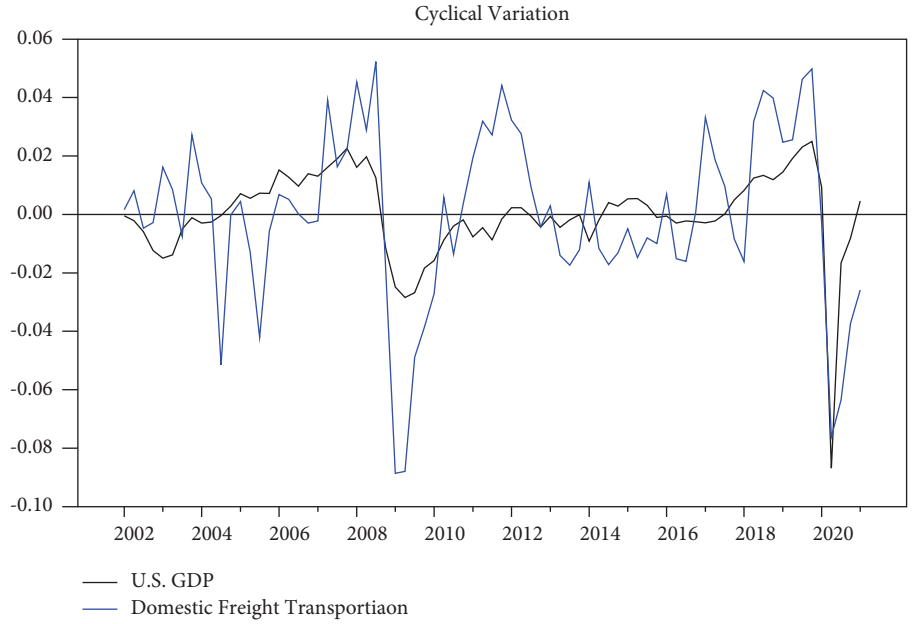

Figure 1: The cyclical variation of U.S. GDP and seaborne freight volume. Source: U.S. FRED and Korea Port-mis [25, 26].

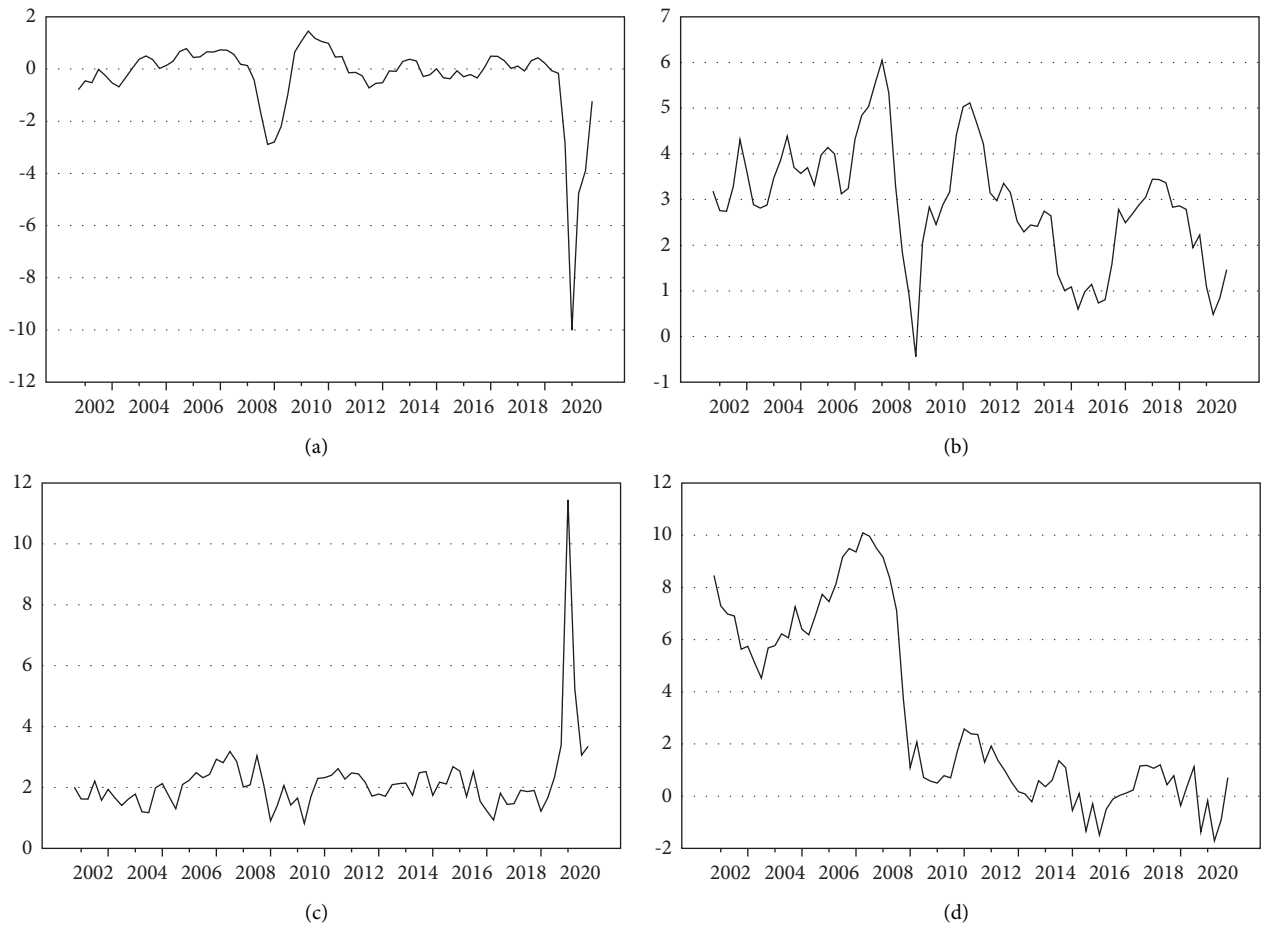

Figure 2: Estimated factors. (a) Foreign real economic factor. (b) Foreign inflation factor. (c) Global liquidity factor. (d) World interest rates factor. Note: the unit of the vertical line is % (percent).

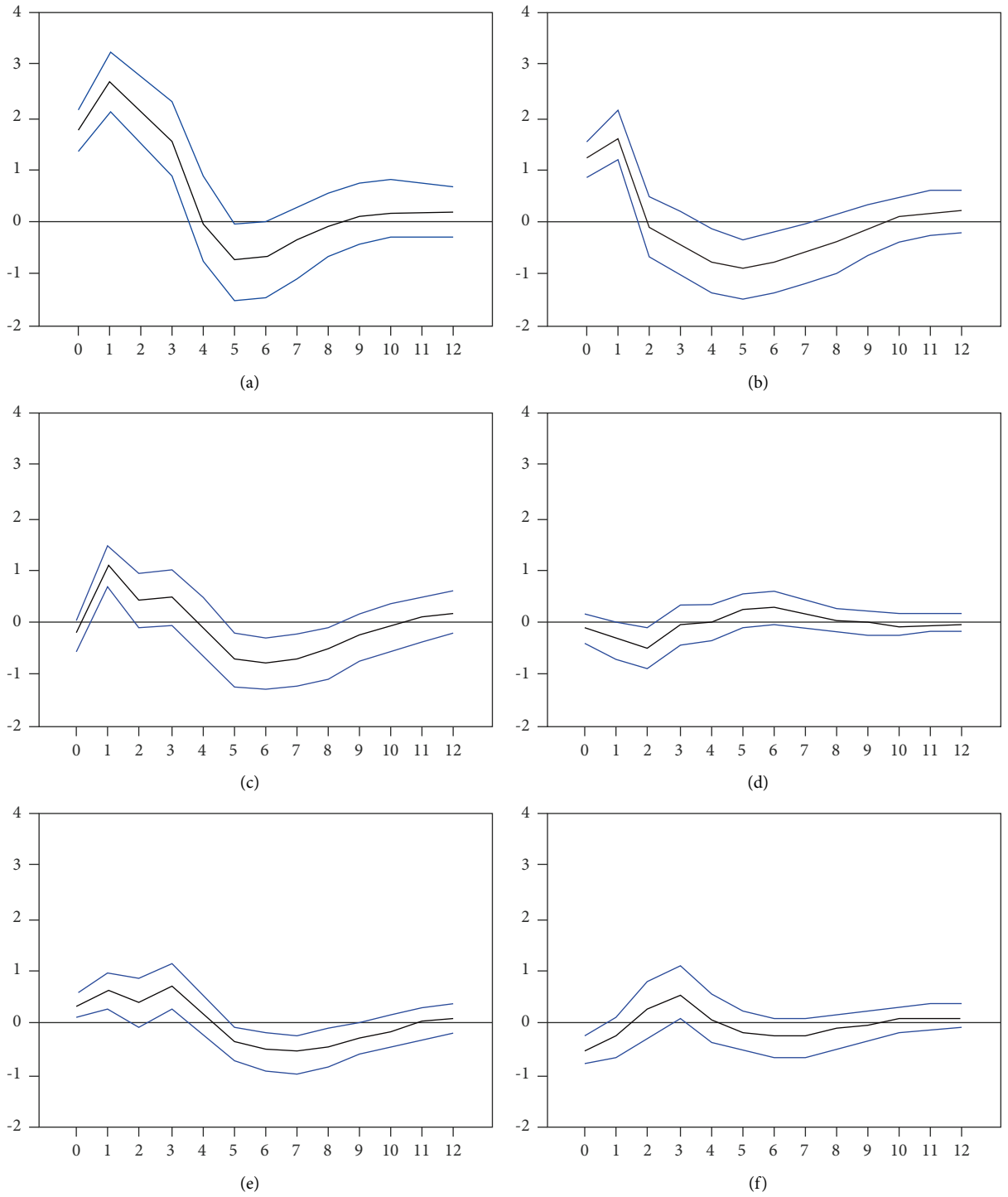

Figure 3: Impulse response function (IRF) of the seaborne freight volume. (a) Foreign real economic shocks. (b) Foreign inflation shocks. (c) Foreign liquidity shocks. (d) Foreign rates shock. (e) Domestic GDP shocks. (f) Import-export trade volume shocks. Note: the blue line represents the 90% confidence interval. The unit of the vertical line is % (percent).

shipped via containers, there exists a close relationship between the volume of container trade and domestic economic activity. For example, domestic manufacturing firms rely on imports of raw materials and intermediate goods transported through containers as well as exports of finished products through containers, which consumers routinely purchase.

The left-upper part of Figure 3 displays the estimate of the dynamic effects of shocks to the foreign real economic activity on domestic seaborne freight transportation. It is

Table 1: The variance of decomposition of the forecast errors.

Step	Real economic activity factor	Inflation factor	World liquidity factor	World interest factor	Domestic growth	Import-export	Seaborne freight
1	31.85	16.02	0.81	0.12	1.35	2.87	46.98
2	47.52	19.81	5.71	0.55	2.41	1.55	22.45
3	55.38	15.88	5.30	1.32	2.57	1.55	17.99
4	56.57	14.58	5.42	1.16	3.87	2.56	15.84
5	55.44	16.05	5.31	1.14	3.96	2.57	15.52
6	53.71	17.55	6.45	1.26	4.18	2.46	14.39
7	51.95	18.10	7.74	1.43	4.81	2.53	13.46
8	50.38	18.26	8.88	1.43	5.51	2.67	12.87
9	49.51	18.25	9.53	1.42	5.95	2.69	12.64
10	49.31	18.19	9.70	1.42	6.09	2.68	12.62
11	49.28	18.19	9.70	1.42	6.10	2.69	12.62
12	49.21	18.27	9.70	1.41	6.09	2.72	12.60

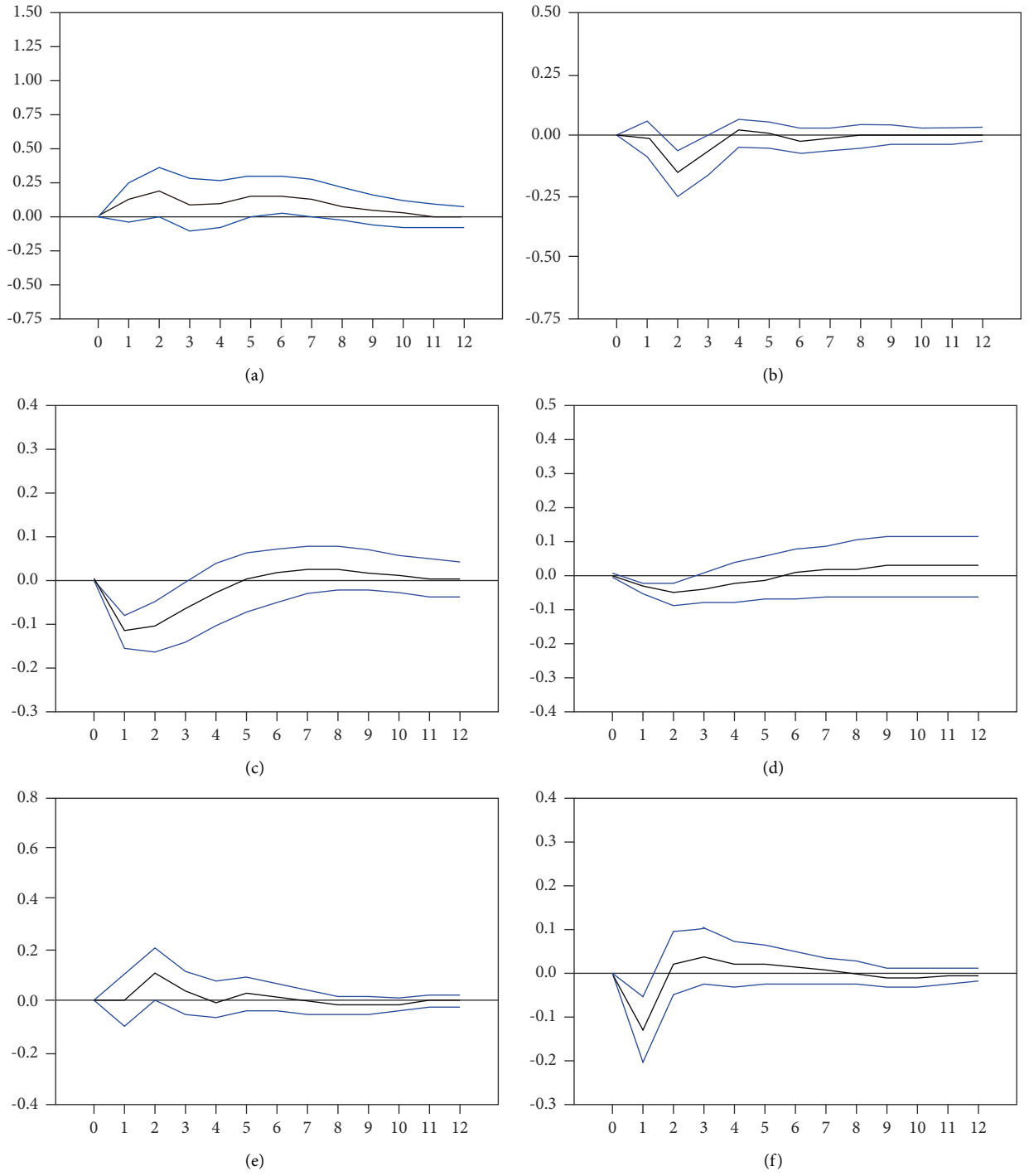

Figure 4: IRF of the seaborne freight volume based on the alternative aggregation. (a) Foreign real economic shocks. (b) Foreign inflation shocks. (c) Foreign liquidity shocks. (d) Foreign rates shocks. (e) Domestic GDP shocks. (f) Import-export trade volume shocks. Note: the blue line represents the 90% confidence interval. The unit of the vertical line is % (percent).

clear that an unanticipated growth in the world industrial production is projected to have a considerable impact on domestic freight transportation. Specifically, one standard increase in the foreign GDP growth results in a 2% increase in domestic freight transportation.

The variation in inflation can originate from a variety of sources. For example, the increases in the expectation of the consumer and business can trigger the variation in consumption and investment, resulting in higher inflation. In addition, the low level of interest rate owing to the higher liquidity can cause an increase in the aggregate demand. Moreover, the supply shocks originating from the increase in the oil price and wages can be a cause of the international inflation phenomenon. As this study only considered the

Table 2: The variance of decomposition based on the alternative aggregation.

Step	Real economic activity factor	Inflation factor	World liquidity factor	World interest factor	Domestic growth	Import-export	Seaborne freight
1	28.663	0.059	5.516	0.236	1.674	2.466	61.385
2	47.827	0.066	9.941	1.28	4.792	1.696	34.398
3	52.041	0.127	8.855	1.905	4.606	2.826	29.64
4	50.431	0.158	11.837	2.97	4.607	3.087	26.911
5	46.519	0.151	17.126	3.143	4.385	2.847	25.828
6	43.597	0.278	20.145	2.867	5.774	2.869	24.469
7	42.045	0.723	20.883	2.719	7.332	3.031	23.268
8	41.097	1.069	20.893	2.881	8.318	3.142	22.6
9	40.591	1.273	20.697	3.166	8.739	3.173	22.36
10	40.406	1.384	20.628	3.373	8.793	3.16	22.257
11	40.351	1.42	20.736	3.458	8.744	3.159	22.132
12	40.32	1.418	20.87	3.46	8.748	3.192	21.992

resulting values of inflation, it is possible to determine whether the cause originated from the demand or supply side. The left-middle part of Figure 3 shows that freight transportation exhibits positive responses following the global inflation shocks. Although the impact of shocks on freight transportation diminished with time, the effects were reversed five quarters after the shock.

In general, world liquidity can positively affect the world economy in the short run. However, the rise and subsequent crash in asset prices, as well as the drop in demand brought on by the weight of liabilities, may cause the economy to go through an adjustment phase and cause a decline in investment and consumption. Thus, if the liquidity increase is based on the credit from the bank, following the growth of the economy in a certain period, the economy exhibits an adjustment period and a certain recession. Moreover, this adjustment phase can affect the port industry negatively. The left-bottom part of Figure 3 shows the estimated response of domestic freight transportation to shocks to the world M3 growth. The domestic freight movement rose after the shocks by more than 1%, as is clear, and the reaction was statistically significant. However, the positive effect of the early phase reversed in five quarters following the shocks.

The world interest rate factor is interpreted as the common factor of all interest rates across countries. This factor originates from the behavior of the central banks; thus, the unexpected fluctuation of the factor can be regarded as shocks that cause central banks across the world to deviate from the path implied by the systematic component of their monetary policy. The right-upper part of Figure 3 shows the dynamic response of the volume of freight transportation to shocks to the world's interest rates based on the recursive identification scheme. The increase in world interest rates is estimated to reduce freight transportation in the early period of shocks. It is generally recognized that a contractionary monetary policy, in which the interest rate rises, reduces investment and consumption, which shocks industrial production. The results obtained were statistically significant. However, the effect of the shocks to world interest rates on the Korean port industry was proven to be smaller than that of the world's real economic activity.

The positive shocks to domestic real GDP growth were estimated to raise domestic freight transportation. According to the right-middle part of Figure 3, one standard increase in domestic real economic activity significantly increases freight transportation. In general, the variation in the trade is understood through a one-to-one relation with freight transportation. However, it was predicted that early in the trade shocks, the positive shocks would boost the amount of freight transported via ports. However, after 3 quarters following the shocks, the response to freight transportation became positive.

4.4. Variance Decomposition. In general, the forecast error variance decomposition indicates the proportion of the movement in a variable owing to its own shocks versus shocks to the other variables. Table 1 presents the results of the forecast error variance decomposition of freight transportation. It is evident that 49.2% of the variation in the seaborne transportation can be driven by the shocks to the real-world economic activity, 18.27% by the shocks to the world inflation factor, 9.7% by the shocks to the world factor, 9.7% by the shocks to the world liquidity factor, and only 6.09% by the shocks to the domestic economic growth.

4.5. VAR Model Analysis (Robust Analysis). This section presents the estimation results and provides the interpretation based on the factors constructed using the weighted mean over the estimation period of the time series taken into consideration in the earlier subsection. This is different from the econometric approach that was thought of before in this study. While there are certain advantages to estimating the common factor using this approach, there are limitations to weighing each series equally. For example, the degree to which the U.S. and UK economies can affect the Korean economy is different. Thus, the influence of each foreign economy on the Korean economy has to be correctly assessed when constructing the common factors.

In this mean method, the proportion of each country's GDP was used as the weight, and the estimation result of the VAR model was obtained using these alternative methods. Figure 4 shows the estimated impulse response of the variable. As evident, the increase in the world real activity increased domestic freight transportation. This result is the same as that of the previous analysis. The increase in world inflation is estimated to lower the volume of freight transportation. Furthermore, the transportation volume was also reduced by the global interest rate impact.

Table 2 presents the variance decomposition analysis results. Here, 40.32% of the variation in the transportation volume was driven by the world GDP shocks, 20.87% by the world liquidity shocks, and 8.75% by the domestic GDP shocks.

5. Conclusion

The port industry in Korea has grown in importance because of a high level of economic openness, the advantages of geographical positioning, and the increasing importance of sea freight transportation in the global supply chain. Thus, it is useful for correct decision-making by the related private agents and policy-making by the port authority to estimate the business cycle in this industry. This paper estimated the business cycles in the Korean port industry, focusing on the dynamic effect of shocks to the foreign economy on this port industry based on the SFAVAR model using the Bayesian Gibbs sampling method.

The major findings of this paper show that the Korean port industry is affected by the business cycle of the global economy. This study is the first to use the SFAVAR model to extract foreign economic factors and shocks; therefore, it can add methodologically to the literature on marine economics in addition to providing estimation findings. The results of this paper can be useful in establishing the correct policy in response to the fluctuations in the global economy.

However, this paper has some limitations. First, it considered the G-7 countries and the Chinese economy as the global economy for computational convenience. Second, this paper did not incorporate the business cycles of other countries' port industries. In fact, the volume of seaborne freight in the Korean port industry is related to that of other countries. In the future, we will be able to use a larger dataset, including the world economy and the data of other countries' port industries, to make the estimation results more robust.

Data Availability

The whole data used to support the findings of this study can be obtained from (1) https://Fred.stlouisfed.org/ for G7 and China data, (2) https://new.portmis.go.kr/ for Korea port data, and (3) https://ecos.bok.or.kr for Korea macroeconomic data.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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