The Predictive Ability of Ocean Freight Rates: Evidence from Japan and South Korea

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Abstract: This study examines the role of global ocean freight rates on local domestic transportation freight rates in East Asia. Japan and South Korea are chosen for this study because of extensive monthly domestic freight rate data available from their central banks, they are both highly globalized economies, and because prior research on the Japanese maritime industry has been limited. Data used for this study include monthly freight rate data on four different domestic freight transportation sectors in Japan. Measures of global ocean freight rates include measures from the Japanesee and South Korean central banks as well as the Baltic Dry Index (BDI). Our results indicate that the BDI can predict Japanese and South Korean ocean freight rates, and in turn Japanese and South Korean freight rates predict domestic transportation freight rates in their respective countries as well as domestic macroeconomic indicators. These results suggest that ocean freight rates may possess valuable economic information that can be used to predict future economic trends.

Keywords: Ocean freight rates, forecasting, Japanese freight transportation industry

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1. Introduction and Literature Review

Much prior research has shown that ocean freight rates can significantly other economic factors. For example, dry bulk freight rates have been shown to predict stock prices (Manoharan and Visalakshmi, 2019, Lin et al., 2019), GDP growth (Bildirici et al., 2016), and exchange rates (Han et al., 2020). Some research has also shown other freight rates may be important economic indicators with forecasting ability such as container freight rates (Hsiao, et al., 2016; Kim and Chang 2017), and clean tanker freight rates (Li et al., 2018). However, only limited research has been done showing the interrelationship between ocean freight rates and domestic freight rates. U.S. ocean freights were found in one study to have no significant impact on road, rail, or air transportation freight rates in the U.S. (Shackman et al., 2021). This may be a result of the U.S. Jones Act, which makes sectors of the U.S. transportation industry uncompetitive. Japan, unlike the U.S., has a vibrant ocean transportation industry including some leading global competitors such as K-Line, Mitsui, and NYK. Similarly, South Korea has a vibrant ocean transportation industry including the major liner Hyundai Merchant Marine.

Research on freight rates in Japan has been very limited. Studies on trucking freight rates between destinations in Japan has shown imbalances between front-haul and back-haul freights (Guerrero, et al., 2021; Tanaka and Tsubota, 2017). Little recent research has been done on ocean freight rates in Japan, but some research has shown that global freight rates may predict economic activity in South Korea. Container freight rates have been shown to predict Korean shipbuilding activity (Kim and Park, 2017), tanker rates have been shown to predict raw material imports to South Korea (Kim and Park, 2019), and dry bulk freight rates have been shown to predict South Korean agricultural commodity import prices (Ha and Shin, 2021).

2. Freight Transportation Industries in South Korea and Japan

The freight transportation industries are quite similar in both countries. Tables 1 and 2 show the breakdown of freight shipped by sector. Trucking dominates the freight transportation in both countries, counting for over 90% of domestic freight in both Japan and South Korea. Both countries have very fragmented trucking industries with a large number of small competitors. Water transportation comes next, with around seven percent of total domestic freight transported for each country. Air and rail only account for a small fraction of tons shipped, although air transportation likely accounts for a large portion of shipping by value rather than tonnage.

In terms of ocean transportation, Japan’s maritime shipping industry has three large competitors. South Korea has four of the top 30 container liners in the world (AXSMarine 2022). Japan’s Ocean Network Express is an alliance of three major Japanese airlines that is now the sixth-largest container liner in the world (AXSMarine, 2022). In terms of tonnage, South Korea's ocean freight industry is responsible for 63 million tons per year (Kim et al. 2022) whereas Japan accounts for 143 million tons this year (Japanese Shipowners' Association 2022). This is consistent with the relative size of their economies.

Table 1: Freight transported by sector in South Korea

Sector	Freight Transported (in million metic tons)	Percentage (ton-based)
Truck	1799.57	91.09%
Air Cargo	0.29	0.01%
Coastal	143.23	7.25%
Rail	32.56	1.65%
Total	1975.64	100%

From Korean Transport Institue (2018)

Table 2: Freight transportation by sector in Japan

Sector	Freight Transported (in million metric tons)	Percentage (ton-based)
Truck	4329.13	91.83%
Air Cargo	0.88	0.02%
Inland and Coastal	341.45	7.24%
Rail	42.66	0.90%
Total	4727	100%

From Japanese Shipowner Association (2021)

3. Data

Data for this involves monthly data from the Bank of Japan (BOJ) covering 1985-2022. The specific series used for this study includes data on domestic water transportation (inland and coastal), rail, road, and air freight rates. Similar data was taken from the Bank of Korea covering 1996-2022. Macroeconomic data on both countries were also taken from these sources, including industrial production, inflation (CPI), and trade volume (imports plus exports). We also obtained data on stock market indices from these two countries from MSCI Inc. For global ocean freight rates we used the BDI for dry bulk freight, the Baltic Clean Tanker Index (BCTI) for global tanker freight rates, and the Howe Robinson Container Index (HRCI) for global container freight rates.

Figures 1 and 2 show the trends of the freight rates up over time in South Korea and Japan. The data is relatively consistent between the two countries in that air and ocean freight rates are the most volatile in both countries whereas the other three freight rates are relatively steady. Ocean freight rates show a large spike in 2007 in both countries, whereas air freight rates show a spike in 2020 in both countries. Rail freight rates show the least volatility, as both countries' rail freight rates show a slow and steady increase.

Figure 1: Freight Rates in South Korea 1985-2002

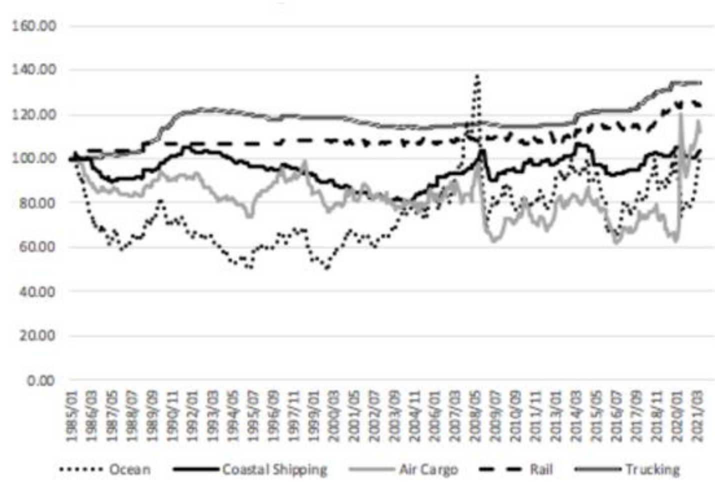
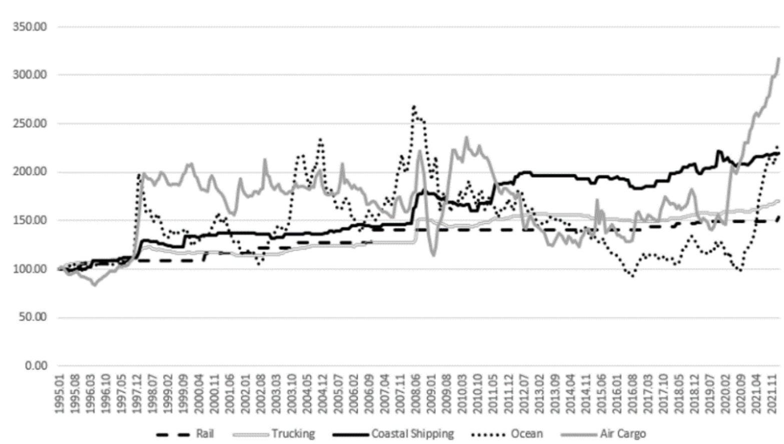


Figure 2: Freight Rates in South Korea 1985-2002



4. Methodology and Results

The method chosen for our analysis is based on the principle of Granger causality (Granger, 1969). We use this dynamic time series method to assess causal or predictive directions between different freight rates. The idea of Granger causality is that if a change in one variable in one period leads to a change in another period in the next period, it is evidence that the first variable has predictive power for the other variable. We use the vector autoregressive (VAR) model (Sims 1980) to assess Granger causality. VAR is a multivariate, multi-equation extension of simple Granger causality models, and allows us simultaneously to test multiple lead-lag relationships between the variables. We also transform our data into logged first-difference form, which means we are looking at how percentage changes in variables lead to percentage changes in other variables rather than levels.

VAR regression involves running a series of regressions of the first-differences of a dependent variable on lagged first differences of other explanatory variables along with lagged values of the dependent variable. In each regression, a different dependent variable is used so through these series of regressions causal direction can be examined. While numerous regressions were run as part of this process, an example of one equation is:

$$\Delta lnROAD_t = \alpha_0 + \alpha_1 \Delta \ln OCEAN_{t-1} + \alpha_2 \Delta lnOCEAN_{t-2} + \alpha_3 \Delta lnCOASTAL_{t-1} + \alpha_4 \Delta lnCOASTAL_{t-2} + \alpha_5 \Delta lnROAD_{t-1} + \alpha_6 \Delta lnROAD_{t-2} + \alpha_7 \Delta lnAIR_{t-1} + \alpha_8 \Delta lnAIR_{t-2} + \alpha_8 \Delta lnRAIL_{t-1} + \alpha_9 \Delta lnRAIL_{t-2} + \mu_t$$

In the above equation, current period's road freight rates is regressed against lagged values of other freight rates along with its own lagged values. This is done to see if past values of other freight rates can predict future values of road freight rates. Separate equations are run with ocean, coastal, air, or rail freight rates as the dependent variable but with the same set of independent variables to test for multiple directions of causality. Separate regressions are run with Japanese and South Korean data, and other models with BDI and other global ocean freight rates.

Figure 3 presents the main results of our Granger causality analysis:

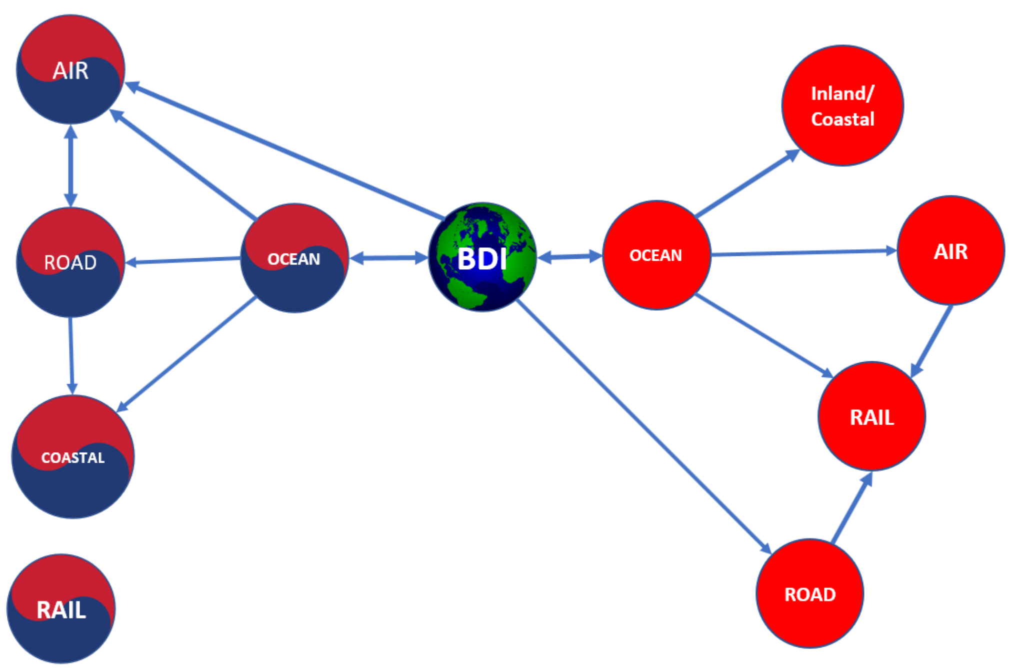


Figure 3. Causal relationships between ocean freight rates and domestic freight rates
On the left are South Korean freight rates, and on the right are Japanese freight rates

The order of our VAR models is as follows:

1. We run a VAR model with ocean freight rates only, including global rates (dry bulk (BDI), tanker, and container) as well as South Korean and Japanese ocean freight rates. We find no significant Granger causality for tanker or container rates. However, we do find bidirectional causality between BDI and Japanese and Korean ocean freight rates. We do not find any significant relationship between Japanese and Korean ocean freight rates. These results are seen in the center of Figure 1.

2. We run VAR models testing the relationship between BDI and domestic freight rates in South Korea and Japan. We find that BDI is a significant predictor only of Korean air freight rates and Japanese road freight rates.

3. We run a VAR model testing the relationship between Japanese ocean freight rates and the corresponding domestic freight, as well as a corresponding model with the South Korean data. We find that ocean freight rates have strong predictive power over domestic freight rates, with ocean freight rates significantly predicting three out of four domestic freight rates in each market. Most domestic freight rates only have little or no predictive power, with the exception of Korean road freight rates which significantly predict both air and coastal freight rates. Korean rail freight rates are not significantly predicted by any other freight rate, whereas Japanese rail freight rates are significantly predicted by three other rates.

As additional analysis, we ran another model with four domestic macroeconomic variables for each country included in place of domestic freight rates. Results for the model are shown in Figure 4 below. Of the four macroeconomic variables, industrial production, trade volume, and inflation are all significantly predicted by at least one ocean freight rate and in most cases two. While stock prices (MSCI) in South Korea are predicted by Japanese ocean freight rates, stock prices in Japan are not predicted by any ocean freight rate. Instead, stock prices in Japan predict both Japanese ocean freight rates and BDI in additional to industrial production and trade volume. A significant contrast between the macroeconomic model in Figure 4 and the freight rate model in Figure 3 is that the macroeconomic models show a more complex system of bidirectional causality between different indicators. The Figure 3 freight rate model has mostly unidirectional causality, mostly flowing from ocean freight rates to other freight rates.

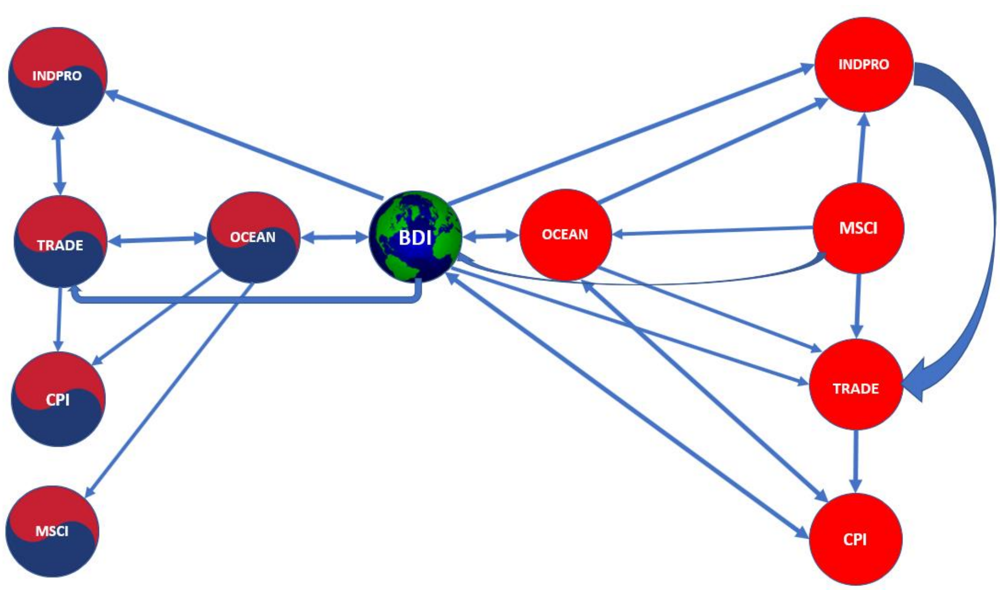


Figure 4. Causal relationships between ocean freight rates and macroeconomic indicators
On the left are South Korean freight rates, and on the right are Japanese freight rates

5. Conclusions

Overall these results demonstrate that both global ocean freight rates as well as national-level ocean freight rates are strong predictors of both domestic freight rates and domestic macroeconomic indicators. This confirms prior research that suggests that ocean freight rates possess valuable signals about future economic activity and freight rates in other modes of transportation. National level ocean freight rates have the strongest impact on domestic freight rates, with only minimal predictive power for BDI. Of the other transportation modes, road freight rates in South Korea show significant predictive power for two other freight rates. The predictive power may be due to the highly competitive and fragmented nature of the trucking industry in South Korea, which means freight rates are likely highly competitive and thus good indicators of economic conditions. Other non-ocean freight rates had little predictive power, which in the case of air and rail transportation may be due to the small amount of cargo carried in these sectors. Road freight rates in Japan only have minor predictive power, which may be a result of a shortage of truck drivers in Japan which makes rates less flexible.

Interestingly, ocean freight rates are shown to predict trade volume and not vice versa. Ocean freight rates seem to possess important informational signals that foreshadow future changes in international trade patterns. Future demand for freight services seems to be factored into freight rates. BDI is found to significantly predict industrial production in both countries. This may be because BDI is a specific measure of dry bulk freight rates, as it may predict future demand for raw materials needed by the industrial sector. A surprising result is that Japanese stock prices predict ocean freight rates, indicating a possible highly efficient stock market in Japan whose prices represent future economic trends. This may be a result of recent major equity market reforms in Japan.

The main implication of this study is that ocean freight rates at both the global level such as BDI or at the national level can be useful forecasting tools. Transportation logistics professionals may wish to use ocean freight rates to predict patterns of freight in other modes of transportation. Economic forecasts may be enriched and become more accurate if ocean freight rates are included in the forecasting models. A limitation of this study is that it only includes two countries. Whether or not the results of this study are unique just to these two countries could be assessed by examining similar models using data from other countries with strong maritime industries such as China or the EU region.

References:

Accessed 14 May 2022

[1] AXSMarine (2022) Alphaliner Top 100. Available at: https://alphaliner.axsmarine.com/PublicTop100/. Accessed 14 May 2022

[2] Bildirici, M., Kayıkçı, F., Onat, I.Ş. (2016) BDI, gold price and economic growth. Procedia Econom. Fin., 38, 280-286.

[3] Ghiorghe, B., Gianina, C. (2013) The causality relationship between the dry bulk market and worldwide economic growth. Ovidius University Annals, Economic Sciences Series 13(2):2-6.

[4] Granger, C. 1969. Investigating causal relations by econometric models and cross-spectral methods. Econometrica 37:424-438.

[5] Guerrero, D., Itoh, H., Tsubota, K. (2021) Freight rates up and down the urban hierarchy. Res. Transp. Bus. Manag. 100775.

[6] Ha, J. Y., Shin, Y. (2021) Lead-lag relationship between the shipping freight rate and agricultural commodity import price in Korea. J Navig Port Res. 45(2): 69-74.

[6] Han, L., Wan, L., Xu, Y. (2020) Can the Baltic Dry Index predict foreign exchange rates?. Finance Res. Lett., *32*, 101157.

[7] Hsiao, Y. J., Chou, H. C., Wu, C. C. (2014) Return lead–lag and volatility transmission in shipping freight markets. Marit. Policy Manage. 41(7):697-714.

[8] Japanese Shipowners' Association. (2022) Shipping Now 2021-2022. https://www.jsanet.or.jp/data/pdf/allpage2021.pdf. Accessed 14 May 2022

[9] Kim, Chang-Soo, et al. "Development of Collaborative Spirit Indices: The Case of South Korea's Maritime Industry." Asian J. Shipp. Logist. In press. https://doi.org/10.1016/j.ajsl.2022.01.001 Accessed 14 May 2022

[10] Kim, H. S. and Chang, M. H. (2017) Analysis of the synchronization between global dry bulk market and Chinese container market. J Navig Port Res. 41(1): 25-32.

[11] Kim, C. Y.,Park, K. S. (2019) Lead-lag relationships between import commodity prices and freight rates: The case of raw material imports of Korea. J Korea Trade, 23(2): 34-45.

[12] Kim, C. Y.,Park, K. (2017) An analysis on the causal relationship between freight rate and newbuilding orders: Implications for Korean trade and shipbuilding companies. J Korea Trade. 21(1):22-37.

[13] Korean Transport Institute (2018) Current Status of Korea's Freight Transportation in 2017. https://english.koti.re.kr/component/file/ND_fileDownload.do?q_fileSn=106033&q_fileId=d0187bf5-8250-4b61-af7f-db392ed8fd5a. Accessed 14 May 2022

[14] Li, K. X., Xiao, Y., Chen, S. L., Zhang, W., Du, Y., Shi, W. (2018) Dynamics and interdependencies among different shipping freight markets. Marit. Policy Manage. 45(7):837-849.

[15] Manoharan, M., Visalakshmi, S. (2019) The interrelation between Baltic Dry Index a practical economic indicator and emerging stock market indices. Afro-Asian J. Finance Account, Vol. 9, No. 2, pp.213-224.

[16] Shackman, J, Dai, Q., Schumacher-Dowell, B., Tobin, J. (2021) The interrelationship between ocean, rail, truck and air freight rates. Marit. Bus. Rev.,. Vol. 6 No. 3, pp. 256-277.

[17] Sims, C. A. (1980) Macroeconomics and reality. Econometrica, Vol. 48, pp.1–48.

[18] Tanaka, K., Tsubota, K. (2017) Directional imbalance in freight rates: evidence from Japanese inter-prefectural data. J. Econ. Geogr., 17(1), 217-232.