

A Monthly Forecasting Model of Container Movement on East Asia to North America

Tomoya KAWASAKI¹, Takuma MATSUDA², Shinya HANAOKA³ and Yun GU⁴

¹Member of JSCE, Researcher, Planning and Research Dep., Japan Maritime Center
(Kaiji Center Bldg. 4F 4-5, Koji-machi, Chiyoda-ku, Tokyo 102-0083, Japan)
E-mail: t-kawasaki@jpmac.or.jp

²Non-member of JSCE, Researcher, Planning and Research Dep., Japan Maritime Center
E-mail: t-matsuda@jpmac.or.jp

³Member of JSCE, Associate Professor, Dep. of International Development Eng., Tokyo Institute of Technology
(2-12-1-14-12, O-okayama, Meguro-ku, Tokyo, 152-8550, Japan)
E-mail: hanaoka@ide.titech.ac.jp

⁴Non-member of JSCE, Master Student, Dep. of International Development Eng., Tokyo Institute of Technology
E-mail: gu.y@tp.ide.titech.ac.jp

This study examines Granger causality from economic indicators to container movement on Asia to North America sea route. The models are developed for four sea routes, China, South Korea, Japan, and Taiwan for comparison purpose. On China sea route, Dow Jones receives the highest Granger causality. Similarly, it is revealed that the manufacturing index, exchange rate, and LEI are the highest Granger causality on the sea route of South Korea, Japan, and Taiwan, respectively.

Key Words : *container movement, monthly forecasting, vector auto regression*

1. INTRODUCTION

The container movement on North America sea routes from 18 countries and regions of Asia in November 2011 is dominated by four countries such as China (64.6%), Korea (5.3%), Japan (4.8%), and Taiwan (4.0%), which accounts for approximately 80%.

There is a close link between the volume of container movement and US economic condition for outbound shipping. In many cases, the relationship with real Gross Domestic Product (GDP) is used for forecasting container freight movement. In reality, the coefficient of determination for the relationship between real GDP of the US and container freight movement from Asia to North America route is received fairly high value such as 0.89, which indicates strong positive correlation. As a result of the regression analysis, it can be revealed that as 1% increase in real GDP, outbound freight volume increases 3.8%.

In this way, forecasting for container movement can be conducted using a relationship with real GDP. Nevertheless, the data of GDP is only provided for every quarter. This means the monthly-based forecasting is not possible by GDP. In order to forecast

monthly demand of freight movement, one needs to develop the model which is based on monthly-based data. In addition, for practical usage, one would be preferable to clarify the precedence of the economic indicator to container freight movement. In case past data of economic indicators have causality with explained variable, this is called as Granger causality. A demand forecasting model developed in this study assumes that the shipping liners demands the model for short range forecasting on outbound container movement.

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2. ASIA-NORTH AMERICA ROUTE

The volume of container movement from Asia to North America (outbound route) in 2011 recorded as 13.1 million TEU. On the other hand, the volume from North America to Asia (inbound route) is 6.7 million TEU, thus, the imbalance occurred in this route. Here, Asia is consist of 18 countries and re-

gions, which are Japan, South Korea, Taiwan, China, Hong Kong, Macau, Singapore, Philippines, Malaysia, Indonesia, Thailand, Vietnam, Cambodia, Myanmar, India, Pakistan, Sri Lanka, and Bangladesh. The data of container freight movement is all from the database of Port of Import/Export Reporting Service (PIERS). Since PIERS bases B/L data, transshipment is not considered in the data. For example, container loading in Shanghai port to US via Yokohama port, this container is counted as a container movement from Japan to US.

The volume and share of container movements by country in 2011 is shown in Table 1. Obviously, China has the strong influences on outbound route with 60% occupancy of total freight movement in 2011. However, the volume from China was 0.2% decreased against the year 2010. This is due to the dull market of housing in the US. Regarding the cargo from China, housing related goods are the highest share of total exporting goods in outbound. This affects the slight decrease in China cargo. Although top five countries are unchanged for more than

Table 1 Top 10 countries of volume and share from Asia to North America in 2011

Country loading	Volume	Share
China	8,487.5	64.6%
South Korea	699.0	5.3%
Japan	628.3	4.8%
Taiwan	525.0	4.0%
Hong Kong	506.6	3.9%
Vietnam	499.2	3.8%
India	414.6	3.2%
Thailand	350.7	2.7%
Indonesia	308.7	2.4%
Malaysia	237.2	1.8%
Others	477.7	3.5%
Total	13,134.5	

Unit: thousand TEU

Source: PIERS database

10 years, Taiwan finally exceeded Hong Kong in 2011. As can be seen in Table 1, East Asian countries and regions, China, Korea, Japan, and Taiwan, are the important countries for outbound route due to its high occupancy in total freight movements.

The volume and share of container movements by item in 2011 is shown in Table 2. In outbound route, furniture and household goods and Fiber and its products are ranked the two highest volumes by 1.8 and 1.6 million TEU in 2011. The share of sum of two items reaches 25% of total freight movements. This implies that the impact of these two goods is fairly high. This is one of the characteristics of the outbound route. Another characteristic is that housing and automobile related goods are also high in terms of cargo volume in this route, which are recorded as 19.1% and 8.7%, respectively. Housing related goods is primary transported from China, whereas automobile related goods is largely exported from other East Asian countries, Korea, Japan, and Taiwan. In this way, items transported from East

Table 2 Top 5 items of volume and share from Asia to North America in 2011

Rank	Items	Volume	Share
1	Furniture and household goods (1)	1,786.2	13.6%
2	Fiber and its products	1,565.6	11.9%
3	Electronic products	1,021.3	7.8%
4	Toys	541.1	4.1%
5	Automobile components (2)	490.6	3.7%
8	Construction material and tools (3)	367.1	2.8%
9	Tube of automobile and trucks (4)	359.9	2.7%
10	Plastic for flooring and blind (5)	357.0	2.7%
12	Equip. and parts of automobile (6)	290.7	2.2%
	Others	6,355.0	48.5%
	Housing subtotal (1)+(3)+(5)	2,510.2	19.1%
	Automobile subtotal (2)+(4)+(6)	1,141.2	8.7%
	Total	13,134.5	

Unit: thousand TEU

Source: PIERS database

Table 3 Volume and share by items from China, South Korea, Japan, and Taiwan to North America in 2011

Country	Item	Volume	Share	Item	Volume	Share	Total
China	Furniture and household goods	1,340.3	15.9%	Fiber and its product	837.2	9.9%	8,487.5 (100%)
				Electronic products	690.7	8.2%	
South Korea	Electronic products	157.8	22.7%	Automobile components	95.7	13.8%	699.0
				Tube of automobile and trucks	63.2	9.1%	
Japan	Automobile components	157.3	25.2%	Equip. and parts of automobile	66.5	10.7%	628.3
				Equip. and parts of automobile	66.5	10.7%	
Taiwan	Automobile components	64.6	12.3%	Construction material and tools	61.0	11.6%	525.0
				Furniture and household goods	43.8	8.3%	

Unit: thousand TEU (share in basket)

Source: PIERS database

Asian countries are different. From these characteristics, it can be understood that the maritime cargo volume from China and other three countries are affected by different demand of US economy. In other words, China may be sensitive to housing market of US whereas other three countries may be sensitive to automobile market of US.

3. VARIABLES

In this study, ten economic indicators are used for examining Granger causality on container movement. US economic condition can be an important factor to forecast the container movement. For examining Granger causality, data should be time-series data as followings. Sample period is 16 years between 1997 January and 2011 December.

- Exchange rate
- CLI
- LEI
- consumer sentiment
- Nonfarm payrolls
- Building permits
- Index of Industrial Production (IIP)
- Manufacturing index
- Unemployment rate
- Dow Jones

4. MODEL DEVELOPMENT

(1) Stationary of data

The data will be used are time series data. A stationary time series is one of the requirements of employing Vector Auto regression (VAR) analysis. The conditions of stationary of time-series data (y_1, y_2, \dots, y_n) are followings;

$$\mu_t = E[y_t] = \mu = \text{constant} \quad (1)$$

$$\text{var}(y_t) = E[(y_t - \mu)^2] = \text{constant} = \gamma_0 \quad (2)$$

$$\text{cov}(y_t, y_{t-k}) = E[(y_t - \mu)(y_{t-k} - \mu)] = \text{constant} = \gamma_k \quad (3)$$

The mean, variance and autocorrelation of time-series data are all constant over time. This is the conditions of stationary data. In order to examine stationary, Augmented Dicky-Fuller (ADF)¹⁾ test for all time-series data.

As a result of unit root test, there are several series that are naturally non-stationary data, which is called as zero-degree integration series, $I(0)$. For example, exchange rate of South Korea and Taiwan, CLI, Nonfarm payrolls, IIP, manufacturing index, and

Dow Jones. Other variables are analyzed as Difference Stationary (DS), which means data is originally not stationary, however, it returns to non-stationary data by taking differences. Nevertheless, these variables barely satisfy the 95% significance. Taking a one-difference, first degree integration series, $I(1)$. In this case, t-statistic of ADF test receives much more robust result. Thus, one-difference is employed for all variables.

There is obvious seasonal effect on container volume. In this study, in order to remove seasonal effect, seasonal adjustment for container volume is applied. In this case, one-difference would be meaningful to apply to freight volume. Seasonal adjustment for freight volume data is conducted by the X-12-ARIMA²⁾. X-12-ARIMA is used for all official seasonal adjustments produced by the U. S. Census Bureau.

(2) Lag selection

For specifying appropriate model, one needs to determine the lag. For the lag selection, Akaike Information Criteria (AIC) is used. In this criterion, the model is adopted when the value of AIC is the smallest.

5. RESULTS

(1) Variable selection

The number of variable adopting VAR model is preferable not to be too big since the degree of freedom become small. In this study, first of all, Granger causality from each economic variable to container movement is examined. As a result, variables which have Granger causality on container movement is included for model development. Granger causality can be examined by F-test as null hypothesis is that the coefficient of economic indicators is zero.

The results of test for Granger causality are shown in Table 4-7 for China, South Korea, Japan, and Taiwan sea route. Granger causality is judged at 95% significant level. As a result of the analysis, on China route, seven economic indicators have Granger causality on container movement. South Korea, Japan, and Taiwan sea route have five, ten, and two economic indicators, respectively. On South Korea sea route, strong Granger causality from manufacturing index to container movement is found. On the other hand, manufacturing index is barely statistically significant on China sea route. On Japan sea route, appropriate lag is four according to the result of AIC, nevertheless, t-1 receives the strongest Granger causality. LEI on Taiwan sea route is that there is Granger causality at t-10, however, it is not found at

Table 4 Result of test for Granger Causality of economic indicators on container movement of China route

	Lag	Test statistic	p-value	Granger causality
Exchange rate	3	12.81757	0.3073	no
CLI	5	9.340528	0.6010	no
LEI	2	20.51035	0.0042	yes
Consumer sentiment	4	10.57184	0.0004	yes
Nonfarm payrolls	5	12.27101	0.0027	yes
Building permits	3	13.88348	0.0096	yes
IIP	8	8.458700	0.0033	yes
Manufacturing index	3	13.57524	0.0401	yes
Unemployment rate	2	19.31654	0.0214	yes
Dow Jones	2	19.36741	0.0502	no

Table 5 Result of test for Granger Causality of economic indicators on container movement of South Korea route

	Lag	Test statistic	p-value	Granger causality
Exchange rate	3	9.143279	0.2441	no
CLI	5	8.075409	0.1229	no
LEI	3	12.58313	0.0356	yes
Consumer sentiment	2	12.96525	0.4857	no
Nonfarm payrolls	3	11.60315	0.0042	yes
Building permits	3	11.27935	0.0004	yes
IIP	7	6.557360	0.0047	yes
Manufacturing index	2	24.25736	1.37e-06	yes
Unemployment rate	2	13.89200	0.7492	no
Dow Jones	2	14.22521	0.2805	no

Table 6 Result of test for Granger Causality of economic indicators on container movement of Japan route

	Lag	Test statistic	p-value	Granger causality
Exchange rate	5	10.64579	0.0097	yes
CLI	10	8.122554	0.0320	yes
LEI	4	16.45832	0.0032	yes
Consumer sentiment	2	23.09746	0.5754	no
Nonfarm payrolls	5	14.46457	0.0009	yes
Building permits	4	13.26571	0.0179	yes
IIP	4	18.35019	0.0003	yes
Manufacturing index	4	13.74866	0.0092	yes
Unemployment rate	2	26.66237	0.0169	yes
Dow Jones	2	27.18584	0.0021	yes

Table 7 Result of test for Granger Causality of economic indicators on container movement of Taiwan route

	Lag	Test statistic	p-value	Granger causality
Exchange rate	2	23.71671	0.5537	no
CLI	10	6.138439	0.0174	yes
LEI	2	26.58616	0.0056	yes
Consumer sentiment	2	24.04304	0.4903	no
Nonfarm payrolls	2	24.68081	0.2245	no
Building permits	2	24.17948	0.2129	no
IIP	7	8.815704	0.1780	no
Manufacturing index	3	17.23445	0.0718	no
Unemployment rate	2	24.96764	0.0561	no
Dow Jones	2	23.60319	0.8082	no

t-1 to t-9.

(2) Monthly forecasting model

After checking Granger causality of each variable to container movement, several variables can be extracted as variable which might be useful to be included in the model. These variables are shown as “yes” in Table 4-7. Using these variables, the model is developed for each sea route.

a) China case

Using variables which have Granger causality as a form of two-variable VAR. AIC gives information that this model is suitable to adopt two period that can be expressed as VAR(2).

Dow Jones of one month ago has the highest positive Granger causality among the variables on LEI with p-value of $3.36e-05$ and t-value of 1.693. IIP of one month ago and manufacturing index of two months ago have positive Granger causality on Dow Jones.

b) South Korea case

Similarly, five variables are used for South Korean case. The form of the model is VAR(2).

Manufacturing index of one and two months ago receives the highest Granger causality with 0.0068 and $7.99e-06$ of p-value, respectively. Two months preceding IIP and one month preceding building permits also have positive effect. LEI of one month ago data has precedence on manufacturing index.

c) Japan case

Similarly, five variables are used for Japan case. The form of the model is VAR(3).

Exchange rate of two and three months ago re-

ceives the highest Granger causality with 0.0452 and 0.0468 of p-value, respectively. Conversely, three months preceding container movement also has positive effect on exchange rate.

d) Taiwan case

Similarly, five variables are used for Taiwan case. The form of the model is VAR(8). In Taiwan case, only two variables are included in the model.

LEI of six months ago receive the highest Granger causality with 0.0037 of p-value.

6. CONCLUSION

In this study, Granger causality from economic indicators to container movement on Asia to North America sea route is examined. The model is divided into four sea routes, China, South Korea, Japan, and Taiwan. On China sea route, Dow Jones receives the highest Granger causality. Similarly, it is revealed that the manufacturing index, exchange rate, and LEI are the highest Granger causality on the sea route of South Korea, Japan, and Taiwan, respectively.

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