Asia-Pacific Journal of Business & Commerce (2021) 13(1), 103-120
https://doi.org/10.35183/ajbc.2021.03.13.1.103

Export Behavior Analysis of Incheon Port*

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Abstract

In this paper we analyse the long-run and short-run relationship between Incheon port's export and its determinants, foreign income and exchange rate, using the techniques of cointegration and error correction, the rolling regression analysis, and impulse response function. This study employs the Ordinary Least Squares method to choose the most appropriate the export demand function and finds that the model with broad nominal effective exchange rate is more suitable for explaining the Incheon port's export behaviors than the models with the other effective exchange rates or nominal exchange rate. The model is estimated using monthly data for the period 2000-2020. The cointegration technique finds a favorable evidence of a long-run relationship between export demand, foreign income and exchange rate for Incheon port. The error correction model indicates a slow disequilibrium adjustment and the variance decomposition analysis shows that Incheon port's exports are very exogenous to economic variables. The response of exports following a positive shock to foreign income increases onwards in a consistent manner, while a positive shock to the nominal effective exchange rate has a lasting and negative impact on exports over the forecast horizon.

Keyword : impulse response function, cointegration, rolling regression, nominal effective exchange rate, Incheon port

Received January 28, 2021
Revised February 16, 2021
Accepted March 02, 2021

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* All papers comply with the ethical code set by the National Research Foundation and the Asia-Pacific Journal of Business and Commerce. This research was supported by the 4th Educational Training Program for the Shipping, Port and Logistics from the Ministry of Oceans and Fisheries.

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1. Introduction

There is little disagreement on the importance of ports to Korea's economy. It is not only because our country is cut off to the north and south, so it is impossible to move by land, but because Korea is a small open economy. As of 2019, it can be easily seen that 70% of the trading volume and 95% of the trade value were carried out through ports, and the trade dependence was 64%. It is undeniable that the role of ports was important for Korea to become the world' s 7th exporter in 2020. Recognizing the importance of the port, each country is making active investments to foster and revitalize ports. In addition, since ports have a significant impact on the development of the local economy, the central and local governments are actively supporting the securing of cargo volume.

Incheon Port's total exports amounted to 39.7 billion dollars in 2019, less than 46.9 billion dollars in 2011. Accordingly, the share of Incheon Port's exports in the nation's port exports fell from 12.3% in 2016 to 10.6% in 2019. In addition, the proportion of Incheon Port's exports to China was 51.2% in 2019, much higher than 22.1% of the exports of nation' s ports to China, so the dependence on exports to China is very high. It can be seen that Incheon Port is heavily concentrated in the market of a specific country. However, the export trend of Korean ports differs according to the hinterland, export items, and export markets, and the effects of the exchange rate and the income on port' s exports are also different.

Few studies have, however, analyzed port export behavior using economic variables such as exchange rate and economy. In general, income indicators such as GDP or industrial production index, which are the main variables that make up the export function, have significant positive signs, while it is common that price variables such as exchange rates show signs different from expectations or are not significant. For this reason, researchers are hesitant to construct an export function that includes exchange rates. However, it is normal that the demand for goods and services is a function of price and income, and an increase (decrease) in price has the effect of suppressing (encouraging) demand. Therefore, if the effect of the exchange rate on exports appears to be contrary to the theory, it’ s necessary to employ various kinds of exchange rates. For example, in estimating the Incheon Port’s export function to China, the nominal exchange rate is likely to lead to incorrect results. That is because competition in the Chinese market is for many countries, including China. Therefore, in order to estimate exchange rate effect, it is reasonable to use the nominal effective exchange rate or the real effective exchange rate, which is a weighted average of the exchange rates of many countries. This study selects the most suitable model by setting and estimating various export functions for Incheon Port.

2. Export demand function and rolling regression

Following previous studies (see Narayan and Narayan, 2005a,b), our export demand model takes the following form:

$$\ln ex_t = \alpha_0 + \alpha_1 \ln s_t + \alpha_2 \ln wip_t + \epsilon_t \qquad (1)$$

where, at period t, lnex_t is the log of Incheon Port’ s exports of goods; lns_t is the log of the exchange rate; and lnwip_t is the log of the industrial production index of the U.S. α_0 is the constant; ϵ_t is the error term; and α_1 and α_2 are the exchange rate and the income elasticities, respectively(Thorbecke and Smith, 2010; Bahmani-Oskooee and Hegert, 2009; Baak, 2008; Akal, 2008; Thorbecke, 2011; Ketenci and Idil, 2011).

For the income variable, some studies, (see Senhadji and Montenegro, 1999), used trade weighted average of trading partners’ income as a proxy. We use the index of industrial production of U.S.A. to capture the effect of income in the export demand model. Bahmani-Oskooee and Niroomand (1998) used industrial production index as a proxy of income.

The exchange rate is composed of nominal exchange rate, nominal effective exchange rate (broad and narrow) and real effective exchange rate (broad and narrow). The nominal exchange rate is the exchange rate of Korea' s currency Won per US$. An effective exchange rate provides a better indicator of the macroeconomic effects of exchange rates than any single bilateral rate. A nominal effective exchange rate (NEER) is an index of some weighted average of bilateral exchange rates. A real effective exchange rate (REER) is the NEER adjusted by some measure of relative prices or costs; changes in the REER thus take into account both nominal exchange rate developments and the inflation differential vis-a-vis trading partners. Broad indices comprise 60 economies and narrow indices comprise 27 economies for the nominal and real indices, respectively. This model is estimated using monthly time series data, covering the period Jan. 2000 to Oct. 2020. The data are sourced from the Bank for International Settlements and the Bank of Korea and the Korea International Trade Association.

<Table 1> Regression results of Korea' s export demand function

	const	ks	neern	neerw	reern	reerw	wip	R^2
A	-27.72* (5.237)	0.378 (0.894)					8.688* (12.76)	0.464
B	-15.02* (7.509)		-3.962* (15.07)				10.59* (23.80)	0.721
C	-14.36* (7.287)			-4.078* (15.67)			10.57* (24.29)	0.732
D	-26.53* (9.599)				-1.828* (3.192)		10.89* (11.18)	0.483
E	-17.92* (7.753)					-3.602* (10.03)	10.83* (19.74)	0.619

Notes: Numbers in parentheses below the statistics indicate t-statistics
- An asterisk denotes significance at the 5 percent level.
- Neern and neerw indicate narrow and broad neer, reern and reerw indicate narrow and wide reer, respectively.

<Table 1> presents the regression analysis of export demand along with the estimated coefficients and corresponding t-statistics. The signs of the

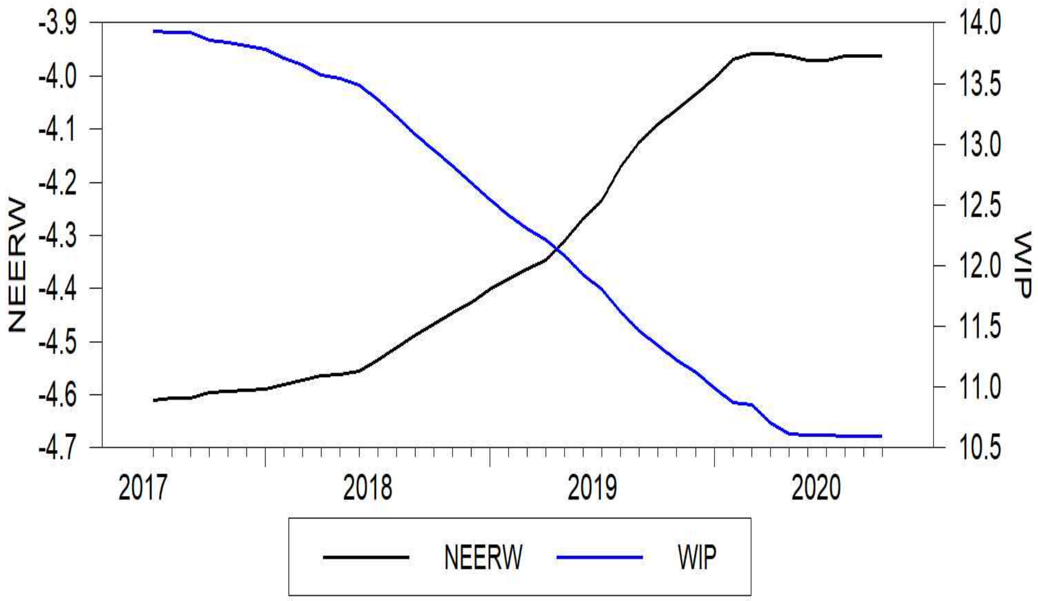
coefficients are correct as economic theory suggests and the nominal real effective exchange rates are all statistically significant at the five percent level irrespective of narrow and broad. The given from the regression analysis is 0.721 and 0.732 for neern and neerw, respectively, pointing that the model with neerw is slightly more appropriate than the model with neern. This paper, hence, employs the neerw as an exchange rate.

Next we perform the rolling regression to show the effect of industrial production and exchange rate on export. <Table 2> shows the estimation results. The exchange rate coefficients fell from -4.589 in July 2017 to -3.962 in October 2020 and the coefficient of industrial production declined from 13.748 to 10.592 for the same period. This indicates that the influence of both exchange rate and industrial production on the exports would reduce.

<Table 2> Rolling regression coefficients

date	neerw	wip	date	neerw	wip
2017:07	-4.61	13.932	2019:03	-4.364	12.304
2017:08	-4.607	13.919	2019:04	-4.347	12.211
2017:09	-4.607	13.919	2019:05	-4.31	12.082
2017:10	-4.595	13.855	2019:06	-4.268	11.928
2017:11	-4.594	13.836	2019:07	-4.234	11.804
2017:12	-4.592	13.811	2019:08	-4.171	11.618
2018:01	-4.59	13.782	2019:09	-4.124	11.461
2018:02	-4.58	13.71	2019:10	-4.092	11.347
2018:03	-4.573	13.653	2019:11	-4.063	11.225
2018:04	-4.564	13.574	2019:12	-4.035	11.119
2018:05	-4.561	13.542	2020:01	-4.005	10.998
2018:06	-4.555	13.486	2020:02	-3.969	10.874
2018:07	-4.535	13.369	2020:03	-3.959	10.854
2018:08	-4.512	13.227	2020:04	-3.958	10.711
2018:09	-4.488	13.082	2020:05	-3.963	10.613
2018:10	-4.467	12.955	2020:06	-3.97	10.607
2018:11	-4.447	12.824	2020:07	-3.97	10.606
2018:12	-4.426	12.685	2020:08	-3.962	10.594
2019:01	-4.402	12.542	2020:09	-3.963	10.596
2019:02	-4.383	12.417	2020:10	-3.962	10.592

<Fig 1> Rolling regression coefficients



3. Methodologies and Analysis

The stationary level for each time series of the variables is determined by using Augmented Dickey-Fuller unit root test(Dickey and Fuller, 1979). The optimal number of lags for autoregressive time series model, for which the stationary assumption is to be tested, is examined by application of Schwartz criteria.

Augmented Dickey-Fuller unit root test implies the following expressions

$$\Delta X_t = b_1 X_{t-1} + \sum_{i=1}^{p} c_i \Delta X_{t-i} + \epsilon_t$$

$$\Delta X_t = c_0 + b_1 X_{t-1} + \sum_{i=1}^{p} c_i \Delta X_{t-i} + \epsilon_t$$

$$\Delta X_t = c_0 + b_0 (Time) + b_1 X_{t-1} + \sum_{i=1}^{p} c_i \Delta X_{t-i} + \epsilon_t$$

The above expressions comprise the unit root test, the unit root test with intercept and unit root test with intercept and trend. The null hypothesis of the existence of unit root is the hypothesis of non-stationarity, or in other words, the hypothesis of the existence of unit root in a time series, what implies that the coefficient b_1 is equal to zero ($b_1 = 0$). This test should be very simple if the distribution of $\hat{b_1}$ possessed standard normal distribution when checking the null hypothesis. However, the distribution of $\hat{b_1}$ under the null hypothesis is not a standard normal, because X_{t-1} is the unit root and variance of such process increases as the number of observations increases(Sheppard, 2013). For this reason, when making conclusion about the value of the t test, it is necessary, instead of standardized normal to use Dickey-Fuller distribution(Dickey and Fuller, 1981)). The results of ADF test indicate whether the null hypothesis should be rejected or not. In the case that the null hypothesis is rejected, the alternative to the null hypothesis (hypothesis of stationarity of a time series) is accepted ($b_1 < 0$) for all data on the level, while accepting the null hypothesis leads to a repetition of the test procedure for differentiated data series, until it comes to the level of difference in which the condition of stationarity is fulfilled. The following expressions comprise the equations for time series of first differences, where the application of Augmented Dickey-Fuller unit root test, for most economic variables, indicates the existence of stationarity of the time series.

$$\Delta^2 X_t = b_1 \Delta X_{t-1} + \sum_{i=1}^{p} c_i \Delta^2 X_{t-i} + \epsilon_t$$

$$\Delta^2 X_t = c_0 + b_1 \Delta X_{t-1} + \sum_{i=1}^{p} c_i \Delta^2 X_{t-i} + \epsilon_t$$

$$\Delta^2 X_t = c_0 + b_0 (Time) + b_1 \Delta X_{t-1} + \sum_{i=1}^{p} c_i \Delta^2 X_{t-i} + \epsilon_t$$

It will be shown below that the time series of nominal effective exchange rate, industrial production stock indices, and exports for Incheon Port analyzed in this paper, are also stationary at the first level of difference $I(1)$. The next step is to choose the maximum order of lags could be used in the unitroot tetst. The study used the Schwarz-Bayesian criteria (SBC) to determine the optimal number of lags. The lag length that minimizes SBC is three for level variables and one for differenced variables.

<Table 3> Results of ADF unit root test for individual time series data

	level			first difference		
	$t\hat{\alpha}$	$t\alpha^*$	$t\tilde{\alpha}$	$t\hat{\alpha}$	$t\alpha^*$	$t\tilde{\alpha}$
neerw	-0.1544	-2.0408	-1.9823	-10.086	-10.066	-10.055
wip	0.3806	-1.8445	-2.5626	-11.966	-11.955	-11.930
ex	1.3571	-1.2473	-0.7758	-15.931	-15.989	-15.989

Notes: An asterisk denotes significance at the 5 percent level.
The critical values of the $t\hat{\alpha}$, $t\alpha^*$, and $t\tilde{\alpha}$ at the 5(1) per cent significance level with sample of size 250 are -1.95(-2.58), -2.88(-3.46), and -3.43(-3.99) respectively. The critical values for the unit root tests are tabulated in Fuller(2009, p.373).

In <Table 3>, the results of ADF test show that none of the tested variables is not stationary at level with significance of 5%. However, stationarity for all tested variables is achieved for first-differentiated time series, what represents the basis for the use of Engle Granger cointegration test.

Now we will perform Engle-Granger Two step procedure for testing long-run cointegration. Engle and Granger (1987) presented a solid theoretical basis for testing, evaluation and modeling of cointegration between non-stationary time series(Engle and Granger, 1987). Cointegration analysis allows that the non-stationary time series can be used in a way that spurious regression is avoided(Kate and Fabiola, 2005). This approach has enabled analysts to test the long-run relationship between the variables, based on the actual value of the time series. It should be noted that Engle-Granger cointegration test is used for variables that are stationary at the same level, while for the variables of different levels of stationarity some other tests are mainly used, such as Johansen cointegration tests. In the case of analyzing the existence of cointegration between more than two variables, Engle-Granger test would show its drawbacks, meaning that it does not provide information about the number of cointegration relationships between variables, but only information about whether cointegration is present or not. However, in our case, where we consider the existence of cointegration between variables, the application of Engle-Granger cointegration test will undoubtedly provide satisfactory results.

Engle-Granger procedure consists of the evaluation of cointegration regression in both directions by using OLS estimation method. In other words, it is necessary to form two cointegration regression models of the form:

$$y = \beta_0 + \beta_1 x_t + e_t$$

After estimating the regression models, we test the stationarity of residuals, in order to determine whether there is cointegration between two analyzed variables. Testing the stationarity of the residuals is performed using Augmented Dickey-Fuller test, where the residual regression equation has the form:

$$\Delta \hat{e_t} = \alpha_1 \hat{e}_{t-1} + \sum_{p=1}^{k} \alpha_{p+1} \Delta \hat{e}_{t-p} + \epsilon_t$$

The null and alternative hypotheses are the same as for testing stationarity of time series of variables. The result of ADF test of residuals will provide information about the existence of cointegration between considered variables, what in other words means that the acceptance of the null hypothesis would indicate the lack of cointegration and vice versa.

The first step is to identify the root of the variable and it is performed earlier and we found that all the variable in our study are I (1) on their level that is after first difference all the variables become stationary. EG states that if the variables are I (1) on their level but the linear combination is I (0) then the variables are co-integrated; and according to the EG representation theorem if they are co-integrated then there might have ECM (Error Correction Mechanism).

The following table shows the results of ADF test of residuals.

<Table 4> Engle-Granger cointegration test

lags	0	1	2	3	4
statistics	-5.5210*	-5.4011*	-4.6710*	-4.2791*	-4.1220*

Notes: An asterisk denotes significance at the 5 percent level. Critical values are found in Engle and Yoo (1987).

The results shows that this is stationary. So from this it can be said that there exists a long run relationship among the variables and there exists an error correction mechanism like <Table 6>. From the above equation it is evident that nominal effective exchange rate is not influencing the export in short run as this coefficient is not significant and surprisingly it has a wrong sign. But the industrial production has positive effect in short run and has a positive effect in the long run.

The error correction term, e_{t-1}, which measures the speed at which export demand adjusts to changes in the explanatory variables before converging to their equilibrium levels, is negative and statistically significant for Incheon Port, ensuring that the series is non-explosive and that long-run equilibrium is attainable(Chen and Wu, 2005). The coefficient of -0.097 for Incheon Port's export demand model implies that a deviation from the long-run level of exports this period is corrected by about 10 per cent in the next period if there is a shock(Doyle, 2001; Banerjee et al., 1998), point to a slow adjustment of exports: 9.7% of the adjustment is completed after one month.

<Table 5> Error-correction model

$$\Delta icx_t = \underset{(0.971)}{0.0064} + \underset{(1.185)}{0.3939}\Delta neerw_{t-1} + \underset{(2.358)}{1.3422}\Delta wip_{t-1} - \underset{(3.682)}{0.2293}\Delta icx_{t-1} - \underset{(3.135)}{0.0974}e_{t-1}$$

R^2=0.1226

Note: Numbers in parentheses below the statistics indicate t-statistics

Without imposing theoretical restrictions on endogeneity among variables, a vector auto regression(VAR) procedure is appropriate for establishing the dynamics between the exports and exchange rate and industrial production.

These three variables are treated as endogenous jointly and are assumed to have no restrictions on the structural relationships in our analysis.

The VAR is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on a system of variables. The VAR procedure avoids the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system.

The mathematical representation of a VAR model is:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + Bx_t + \epsilon_t$$

where

y_t is a vector of endogenous variables,

x_t is a vector of exogenous variables,

$A_t, \ldots, A_p$ and are matrices of coefficients to be estimated, and

ϵ is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables.

A shock to the th variable not only directly affects the th variable but is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the VAR. The effects of the shocks on the variables are assessed by estimating variance decomposition and impulse response functions. The variance decomposition and impulse response functions are unique and invariant to the ordering of the variables in the VAR.

The variance decomposition is used when dealing with dynamic stochastic system. Stochastic system is a random value process. The variance decomposition of VAR gives information about the relative importance of random innovations. This breaks down the variance of the forecast error for each variable into components that can be contributed to each of the endogenous variables. The VAR model provides option to display the variance decomposition in tabular form. This is useful in evaluating how shocks reverberate through a system in order to assess the external shocks to each variable.

Another way of illustrating the dynamic behavior of the model is through impulse response functions. An impulse response function is the response of an endogenous variable to one of the innovations(Sims, 1980). It traces the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables. Specifically, it identifies the effect on current and future values of the endogenous variable of one standard deviation shock in one of the innovations. The response graph option plots the decomposition of each forecast variance as line graphs measuring the relative importance of each innovation. Plotting the impulse response function is a practical way to explore the response of a variable to a shock immediately or with various lags.

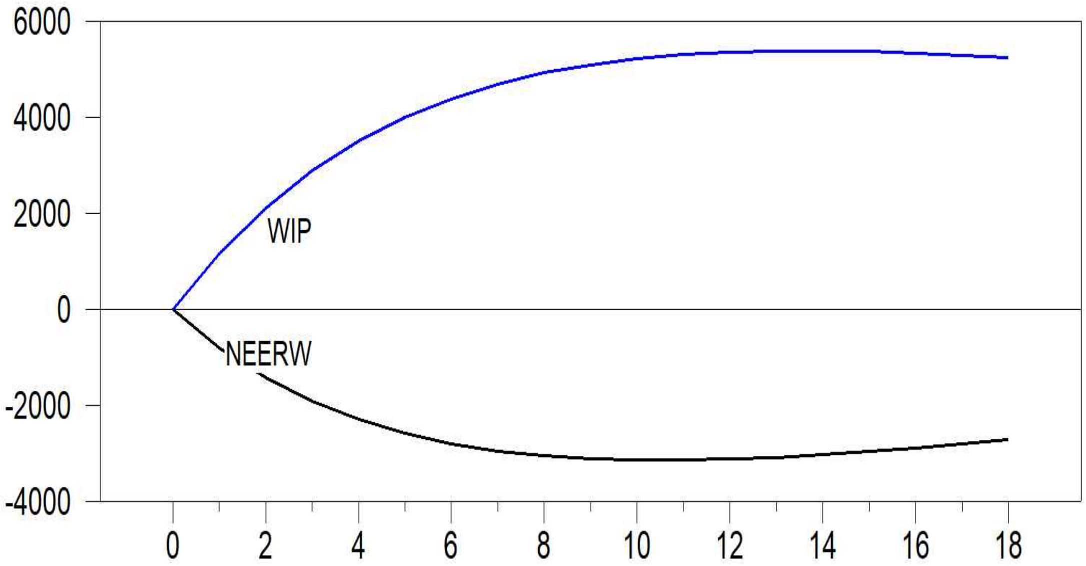
<Table 6> Variance Decomposition

month	std. dev.	ex	neerw	wip
1	0.07504	98.139	0.816	1.046
2	0.08779	94.266	2.592	3.142
3	0.09838	90.857	4.761	4.382
4	0.11188	84.246	11.286	4.468
5	0.12172	83.34	11.393	5.268
6	0.13113	83.363	11.448	5.189
7	0.13989	83.402	11.69	4.909
8	0.14774	83.216	12.237	4.547
9	0.15522	83.219	12.57	4.211
10	0.16226	83.474	12.617	3.909
11	0.16882	83.872	12.497	3.631
12	0.17501	84.271	12.35	3.38

<Table 6> presents results of variance decomposition. The reported numbers indicate the percentage of the forecast error in each variable that can be

attributed to innovations in other variables at 12 different horizons: from 1 to 12 months ahead (short-run to long-run). In the first month, 98% of the variability in export is explained by its own innovations(Lastrapes and Koray, 1990). After 1 year, approximately 84% of the variability is explained by its own innovations. This finding supports that export in the current period is closely related to the future export and also confirms that the short-run shocks have the long term effect on the export. In general exports are affected by industrial production changes at a very minimal level. In the first month, approximately 1.0% of the variability in export changes is explained by exchange rate shock. The highest variability of 5.268% in the fifth month is explained by industrial production shock. In the short run and the long run, exchange rate shocks have no significant impact on export changes. For the exchange rate variable, approximately 0.8% and 2.6% are attributed to export changes to exchange rate changes in the first month and the second month, respectively. After 12 months, exchange rate accounts for approximately 12% of the export forecast error variance. The magnitudes of the explained variability of export by exchange rate shock remain almost the same as in the long run (12 months). In the medium run and the long run, exchange rate shocks have significant impacts on export changes.

<Fig 2> Impulse responses-the shock analysis



<Table 7> Impulse responses-the shock analysis

(10 thousand dollars)

month	neerw	wip	month	neerw	wip
1	-786	1170	10	-3138	5232
2	-1412	2121	11	-3138	5317
3	-1904	2891	12	-3116	5368
4	-2285	3510	13	-3076	5392
5	-2576	4005	14	-3022	5394
6	-2792	4395	15	-2956	5377
7	-2945	4700	16	-2882	5346
8	-3049	4933	17	-2801	5302
9	-3110	5107	18	-2715	5248

An alternative method for obtaining the information regarding the relationships among the variables is through the analysis of impulse response functions. The impulse response functions analyze the time profile of the effects of shocks on the future behavior of exchange rate and industrial production. <Fig. 2> presents the impulse response for exchange rate changes and industrial production changes from one-standard deviation shock to exchange rate and industrial production. <Fig. 2> shows the response of exports to exchange rate shock and industrial production shock. The exchange rate shock has a significant negative impact on exports. The graph shows that the response of exports to shocks in exchange rate starts to decline in the first month, and lasts until the eighteenth month. <Fig. 1> also displays the impulse response of the export variable to industrial production shock. The industrial production shock has a positive impact on exports from the first month to the eighteenth month.

4. Conclusion

This study estimated the export function of Incheon port made up of the exchange rate and income variable but dividing exchange rate into the nominal exchange rate, the nominal effective exchange rate and the real effective exchange rate of broad and narrow terms. As a result, all five exchange rates had signs consistent with the theory, but the nominal exchange rate was not significant, and among the effective exchange rates, the model with the broad nominal effective exchange rate showed the highest coefficient of determination. Therefore, this study was analyzed using a model consisting of the nominal effective exchange rate and world income.

The results of rolling regression analysis showed that the effects of the exchange rate and foreign industrial production on the Incheon port’s exports continued to decrease. As a result of estimating the error correction model, it was found that the disequilibrum adjusting speed was not so fast, and lasted for a long time if there was a sluggish export for Incheon Port. The variance decomposition indicated that exports were very exogenous to the economic variables, so the exports of Incheon Port were greatly influenced by variables other than exchange rate and foreign income. This means that economic variables such as exchange rates and world industrial production play an important role in port exports, but non-economic variables also play an important role as economic variables. The fact that port exports are very exogenous to price and income means that macroeconomic variables do not contribute much to securing export volume. We also showed that through the impulse response analysis, the shock to the exchange rates and industrial production lasted long.

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인천항의 수출행태분석*

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요 약

인천항의 수출은 침체되어 있으며 전국 항만에서 차지하는 위상도 하락하고 있다. 이에 본 연구는 인천항의 수출행태를 밝히기 위해 인천항의 수출함수를 환율과 해외경기와 같은 경제변수로 구성하되, 환율변수로 미달러화에 대한 원화 환율, 광의의 명목실효환율과 실질실효환율, 협의의 명목실효환율과 실질실효환율을 투입한다. 최소제곱법을 적용하여 광의의 명목실효환율로 구성된 모형이 가장 적합함을 보인다. 변수에 대한 ADF 단위근 검정과 모형에 대한 EG 공적분 검정을 실시한 후 차분변수는 안정적이며 수출함수는 공적분 관계를 갖는다는 것을 밝힌다. 모형이 안정적임에 따라 오차수정모형을 도출하여 오차수정계수가 음의 부호로 유의하나 그 크기가 그다지 크지 않아 수출에서 불균형이 발생할 경우 이를 조정하여 다시 균형으로 수렴하는데 많은 시간이 소요된다는 것도 보인다. 이러한 완만한 조정속도는 분산 분해분석에서 인천항의 수출이 환율과 경기와 같은 경제 변수에 대단히 외생적인 것에 원인을 둔다는 것도 보인다. 충격반응분석을 실시하여 해외경기와 환율 충격이 인천항의 수출에 지속적으로 양의 효과를 미치나 이동회귀분석을 통해 환율과 경기가 인천항의 수출에 미치는 영향력이 비교적 빠른 속도로 약해진다는 것도 밝힌다.

핵심주제어 : 충격반응함수, 공적분, 이동회귀, 명목실효환율, 인천항

논문접수일 2021년 01월 28일
심사완료일 2021년 02월 16일
게재확정일 2021년 03월 02일

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* 본 논문은 한국연구재단과 아태경상저널에서 정한 윤리규정을 준수함. 본 연구는 해양수산부의 제4회 해운항만물류교육프로그램으로부터 지원을 받음.

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