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Research on the Impact of Logistics Industry Efficiency and Agglomeration Effect on Import and Export Trade in Korea*

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Abstract

Purpose – The logistics industry is often featured by its location relevance and industrial concentration. Industrial concentration is conducive to the effective transmission of information by reducing transaction costs and improving transaction efficiency, thus promoting the development of trade. The main purpose of this paper is to measure the spatial total factor productivity and location quotient of the logistics industry in Korea, and to study the impact of the logistics industry efficiency and agglomeration effect on import and export trade in Korea.

Design/methodology – First, used the spatial stochastic frontier method to measure the spatial total factor productivity of the logistics industry in Korea, this serves as the efficiency index of the logistics industry in various regions of Korea. Second, calculated the location quotient (LQ) of the logistics industry to measure the industry's concentration degree. Third, employed a spatial econometric model to analyze the impacts of factors such as the efficiency and concentration levels of the logistics industry on import and export trade in Korea.

Findings – This study's main findings can be summarized as follows: this study found that the overall efficiency of the logistics industry in Korea needs to be improved, even though it showed an upward trend in all regions of the country; Moreover, the agglomeration level of Korea's logistics industry needs to be improved; Finally, the positive spatial correlation and industrial agglomeration effect of Korea's logistics industry had a positive impact on the country's import and export trade.

Originality/value – This study is innovative in terms of research perspective and methods. Most of the previous studies have measured the development level of the logistics industry using the logistics performance index (LPI), Fewer studies have assessed through the spatial total factor productivity and location quotient of the logistics industry in Korea to measure the efficiency index of the logistics industry in various regions of Korea and concentration degree, as well as there was almost no study on the impact of logistics industry efficiency and agglomeration effect on import and export trade in Korea. This study addresses this limitation by analyzing the impacts of the efficiency and agglomeration effect of the logistics industry on import and export trade in Korea.

Keywords: Logistics Industry Efficiency, Agglomeration Effect, Import and Export Trade
JEL Classifications: D12, F14, O53

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1. Introduction

In recent years, a three-dimensional and multi-tiered pattern of opening has taken place in Korea, including the rapid development of foreign trade. The data published by the Ministry of Trade, Industry and Energy showed that Korea's accumulated exports and imports in 2020 were US$ 512.85 billion and US$ 467.23 billion, respectively. This rapid growth of the import and export trade in Korea is strongly related to the modern logistics industry.

Higher efficiency of a country's logistics industry indicates a higher supply chain level, lower trade costs and better connection to the global value chain. And the logistics industry is often featured in term of location relevance and industrial concentration, industrial concentration is conducive to the effective transmission of information by reducing transaction costs and improving transaction efficiency, thus promoting the development of trade. In the current international trade market environment, various countries and regions such as China and the United States, Korea and Japan are experiencing trade frictions to varying degrees. Therefore, how to promote the further growth of Korea's import and export trade has become a pressing issue. Since the change of international trade market environment can't be controlled, this study focus on the logistics industry efficiency and agglomeration level in Korea. By improving the logistics efficiency and agglomeration level in Korea, it's a great practical significance for encouraging the development of import and export trade in Korea.

Although there have been abundant studies related to the logistics industry in Korea, most of them have emphasized the correlation between the current situation of the macro-logistics industry and international trade. Fewer studies have investigated the logistics performance in various regions of Korea and none have studied the logistics industry from a spatial perspective. Moreover, there are currently no studies analyzing the relationship between the spatial concentration of the logistics industry and international trade in Korea. This paper fills this gap by studying the impact of the efficiency and concentration of Korea's logistics industry on import and export trade.

This study is innovative in terms of research perspective and methods. Most of the previous studies have measured the development level of the logistics industry using the logistics performance index (LPI). However, this study uses the spatial stochastic frontier method to measure the spatial total factor productivity of the logistics industry in Korea, which corresponds to the efficiency index of the logistics industry in various regions of Korea. Also calculated the location quotient (LQ) of the logistics industry to measure the industry's concentration degree. Moreover, employed a spatial econometric model to analyze the impacts of factors such as the efficiency and concentration levels of the logistics industry on import and export trade in Korea.

Based on this, this empirical analysis is necessary, important and provides an in-depth understanding of the impact of the logistics industry on import and export trade in Korea. Moreover, the findings provide valuable information for decision makers regarding the development of import and export trade.

2. Literature Review

The issue of logistics industry and trade has been widely concerned by scholars. Scholars' research on logistics industry and trade is mainly based on two perspectives.

First, study on the influence of logistics performance on import and export trade; Korinek and Sourdin (2011) took LPI as an explanatory variable and concluded that logistics performance had a significant impact on trade, high-quality logistics services can significantly reduce the time and money costs in trade, thus increasing the competitiveness of exports. Hertel and Mirza (2009) added LPI to the traditional trade gravity model and empirically analyzed the impact of logistics performance on product export, the results showed that the logistics performance has a significant impact on the export trade of agricultural products and manufactured products. Hollweg and Wong (2009) showed that there is a significant positive relationship between international trade and logistics performance. Korez Vide, Tominc and Logožar (2009) analyzed the data of new and old EU members from 2005 to 2006 and found that the trade flows of countries with higher LPI grew faster and trade was more diversified. Puertas, Martí and García (2014) analyzed the data of the European Union and found that the performance of international logistics is more important for the exporting country than for the importing country, and the most important component of the performance index of international logistics is the ability to track and query goods. Felipe and Kumar (2010) used LPI to study and found that the improvement of trade facilitation facilities in Central Asian countries significantly increased the trade flow of complex and high-tech products. Freund and Rocha (2011) found in the study that the improvement of international logistics performance has increased Africa's foreign trade exports. Martí, Puertas and García (2014) by comparing the international LPI in 2007 and 2012, found that the improvement of logistics performance level or sub-index brought about the growth of trade flows in Africa, South America, the Far East, the Middle East and Eastern Europe. Nguyen and Tongzon (2010) studied that the improvement of logistics infrastructure does not directly improve Australia's international trade, while the development of international trade can promote the construction of domestic logistics infrastructure. In addition, Vilko, Karandassov and Myller (2011) found from the perspective of the relationship between international logistics performance and economic growth that the backward logistics infrastructure severely restricts the economic growth of Eastern European countries.

Second is study on the influence of logistics industry agglomeration on import and export trade; Wang Zhen-Zhen and Chen Gong-Yu (2009) used China's provincial panel data to carry out empirical results, showed that different agglomeration degrees of logistics industries in different regions can lead to differences in added value of import and export trade. Cao Rui-Zhang and Wu Yun-liang (2015) based on the experience of the prefecture level panel data analysis in China's Anhui province show that the logistics industrial agglomeration has significant positive effects on the added value of import and export trade.

In addition, Huh Eun-Sook (2020) and Jeong Han-Koo (2020) studied the logistics industry related to e-commerce, Bai Jin-Yan and Yin-Hua Li (2020), Cheng Wen-Si and Lee Shin-Kyuo (2019), Du Yan and Kang Tae-Wong (2019), Jiang Xiu-jing, Kim Jae-Bong and Oh Yong-Sik (2020), Li Jian, Seo Yong-Seok and Kim Seung-Chul (2019), Xu Yun-Jiao and Lee Shin-Kyuo (2019) and Zhang Yu-Meng and Kim Tae-In (2019) studied the logistics industry in China, and Cho Sung-Je (2019), Kim Young-Min, Jeon Ho-Jin and Hong Eui (2020), Ko Yoo-Bin and Lee Eon-Seong (2019), Lee Gi-Byung and Roh Tae-Woo (2020a/2020b), Li Jian and Seo Yong-Seok (2019), Yoon Jeong-Han, Kim Jin-Sup and Park Hong-Gyue (2020) studied the logistics industry in Korea.

To sum up, according to the existing literature analysis, there are the following deficiencies: first, as for the measurement of logistics performance, most of the articles use the data between countries to conduct research, while there are few articles on regional research. Second, there are many existing literatures on logistics and logistics performance, and the influence of logistics performance on international trade flow. However, there are still few literatures on the spatial perspective, especially those focusing on the spatial agglomeration effect of Korean logistics industry on import and export trade. Third, in terms of research methods, it is still in the stage of descriptive qualitative analysis. The design of research samples, indicators and the selection of research methods are important conditions for further research. Therefore, this paper uses spatial stochastic frontier, location entropy and other methods to calculate the spatial total factor productivity of the logistics industry in Korea and the agglomeration degree of the logistics industry in each region, and uses the spatial econometric model to analyze the impact of the logistics industry efficiency, agglomeration effect and other factors on the import and export trade of Korea.

3. The Status of the Logistics Industry and Import-Export Trade in Korea

3.1. Status of the Logistics Industry in Korea

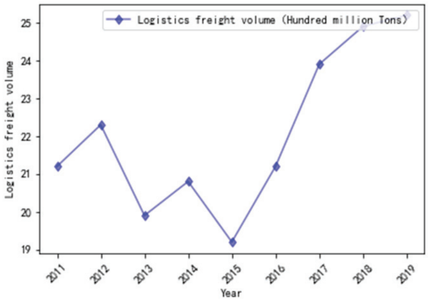
As of 2018, 121 productive berths have been built in the ports of Korea, enabling trade with 180 countries and regions. In the past three years, Korea opened 153 new sea routes, with a growth rate of 39.3% compared to 2017. The container through put was 1,743.567 TEUs, which increased by 27.7% compared to 2017. In this paper, the scale of freight volume, the added value of the logistics industry and the number of employees in the logistics industry in Korea are analyzed as follows.

At present, Korea has formed a modern logistics hub supported by three major logistics systems: seaport, airport and land. In 2018 the total investment of Korea’s logistics industry exceeded US$ 50 billion, and more than 100 logistics projects with an investment of more than 100 million yuan were constructed. The freight volume of Korea’s logistics grew slowly from 738 million tons in 1998 to 1.069 million tons in 2008. It then showed a sharp upward trend until it reached 1.898 million tons in 2011. Although Korea’s cargo volume has dropped slightly to 1.98 billion tons in 2015, it then sharply rose again, reaching an all-time high of 2.493 billion tons in 2018. From 738 million tons in 1998 to 2.493 million tons in 2018, Korea’s cargo volume has increased by nearly 3.5 times in just over 20 years. As can be seen from Fig. 1. (a), between 2011 and 2019 the freight volume of Korea's logistics industry presents an obvious upward trend.

Over the past 20 years, the added value of the logistics industry in Korea slowly increasing from US$ 47.8 billion in 1998 to US$ 58.7 billion in 2003, and showing a rapid upward trend in 2007. It is important to note that the global financial crisis in 2008 had a great impact on the added value of that industry in Korea, which fell from a peak of US$ 72 billion in 2007 to US$ 54.8 billion in 2009. After that, aided by the recovery of the financial crisis and the strong support for modernization from the Korean government, the added value of the logistics industry rebounded rapidly, rising to the level before the financial crisis by 2010. Thereafter, the added value of the logistics industry in Korea has been increasing at a high rate to almost US$ 91.3 billion by 2018. As shown in Fig. 1. (b) depicting the changing trend of the added value of the logistics industry in Korea from 2011 to 2019, the added value of the logistics industry in Korea experienced a wavy upward trend.

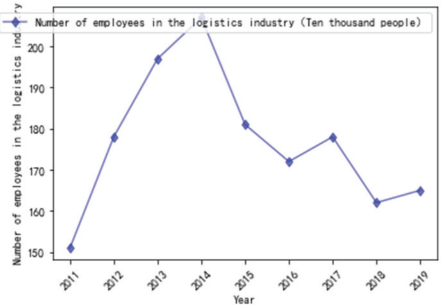
In 1998 the number of employees in the logistics industry was 933,301, which grew rapidly and reached 1.376 million in 2002. In 2006, it returned to an all-time high of 1.63 million. Affected by the 2008 financial crisis, the number of logistics industries in Korea dropped sharply, and the number of logistics industry employees were reduced, falling to 1.008 million in 2008. However, after experiencing this round of decline, the number of employees in the logistics industry in Korea has grown continually over seven years, peaking at 2,077,000 in 2014. Since then, due to the continual development of science and technology, a large number of logistics companies have introduced automation technology, and low-end practitioners in the logistics industry have been replaced by new technologies. This trend has continued to this day, with the number of people in the logistics industry in Korea reaching 1.61 million in 2018. Fig. 1. (c) shows the changing trend in the number of employees in the logistics industry in Korea between 2011 and 2019.

Fig. 1. The Scale of Freight Volume, the Added Value of the Logistics Industry and the Number of Employees in the Logistics Industry from 2011 to 2019



(a)

(b)



(c)

3.2. The Status of Import and Export Trade in Korea

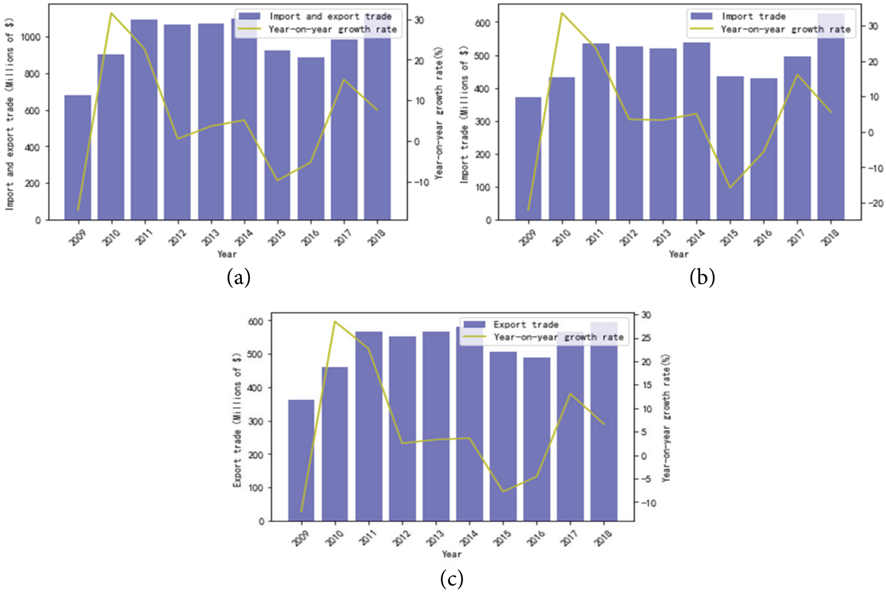
In the period from 2009 to 2018, the total volume of Korea's import and export trade showed an increasing trend and large fluctuations in the year-to-year growth rate, with negative values between 2015 and 2016 and a rebound from 2017 to 2018. Taken in its entirety, the year-over-year growth of import and export trade volume is not optimistic in Korea. Fig. 2. shows the import and export volume and year-to-year growth rate in Korea between 2009 and 2018.

Korea mainly imports from China, Japan, and the United States. The import trade volume from China, Japan, and the United States accounts for 20.5%, 11.5%, and 10.6% of the total import trade volume, respectively. These amount to a sum of 42.6%, which is almost half of the total import trade volume, while that of other countries accounts for <5% of the total. This is likely because Korea is relatively close to China and Japan, so the logistics cost is lower. Moreover, the United States has higher levels of scientific and technological development and many of its products have comparative advantages, which makes it the major exporter to Korea. The cost of water transportation is lower than that of air and land transportation, and water transportation lines are more developed between China, the United States, Japan, and

Korea, which facilitates their trade with Korea.

Korea mainly exports to China and the United States, with an export trade volume of 24.8% and 12.0% of the total volume, respectively. They amount to 36.8%, representing over one third of the total exports. In contrast, the total volume of Korea's exports to other countries is <10%. This due to relatively seamless water transport lines between China, the United States and Korea, as well as to higher levels of economic development in China and the United States.

Fig. 2. 2009-2018 Import and Export Volume and Growth Rate



4. Model Construction, Variable Selection and Data Sources

4.1. Calculation of the Efficiency of the Logistics Industry and the Degree of Industrial Concentration

4.1.1. Spatial Panel Stochastic Frontier Model for the Logistics Industry

The general expression of the panel data stochastic frontier model is as follows:

$$Y_{it} = f(X_{it}, \beta)e^{\varepsilon_{it}}$$

Where the subscript i represents the decision unit (DMU), t stands for the time, Y_{it} represents the output of the decision unit, X_{it} is the vector group of the element set, and $\varepsilon_{it} = v_{it} - u_{it}$ is the composite disturbance term. v_{it} is the general disturbance term for statistical noise, and it is usually assumed to be normally distributed $N(0, \sigma_v)$. $u_{it} \geq 0$ measures technical ineffectiveness and it is usually assumed to follow an exponential or a semi-normal distribution $u_{it} \sim N^+(0, {\sigma_u}^2)$. $Y_{it} = f(X_{it}, \beta)e^{v_{it}}$ is the production frontier and the Technical efficiency is expressed as follows:

$$TE_{it} = exp(-u_{it}) = \frac{exp(X_{it}{}'\beta - u_{it})}{exp(X_{it}{}'\beta)}$$

There may be a spatial correlation in the production of the logistics industry. therefore, this paper used a spatial panel stochastic frontier model to measure the technical efficiency of the logistics industry and to further calculate the total factor growth rate. The general matrix form of the spatial panel stochastic frontier model is as follows:

$$\begin{cases} ln\,Y = \lambda(I_T \otimes W_N)\,ln\,Y + [ln\,k \quad ln\,l]B + \alpha_i + v - u \\ v = \rho(I_T \otimes W_N)v + \xi \end{cases} \tag{1}$$

where Y represents the added value of the logistics industry in each region. k is the amount of investment and l is the number of employees in the logistics industry in each region. $B$is the regression coefficient vector whose columns have dimension $N \times T$, T and N represent the number of periods and spatial individuals, respectively. And the symbol ⊗ stands for the product $Kronecker$. v is the disturbance term vector, indicating the uncertain factors affecting production, and u is the inefficiency term, which is assumed to have a semi-normal distribution. W_N is the spatial weight matrix weighted by geographical distance in various regions of Korea, I_T is the unit matrix, λ and ρ are the spatial correlation coefficients, α_i and ξ are the individual effect and error term, respectively.

This paper uses the spatial stochastic frontier method to calculate the technical efficiency change rate expressed as follows:

$$\triangle TE = -\lambda(I_T \otimes W_N)^{-1}\frac{\partial u}{\partial t} \tag{2}$$

Through derivation, the non-limit form of technical efficiency change rate is easily obtained as follows:

$$\triangle TE = -\lambda(I_T \otimes W_N)^{-1}(\frac{TE_{it}}{TE_{it-1}} - 1) \tag{3}$$

Using the Divisia productivity change index, the corresponding change in TFP can be defined as follows:

$$\begin{aligned} \Delta TFP &= \dot{y} - \dot{x}_{index} \\ &= \frac{d\ln y}{dt} - \sum\nolimits_j (S_j \times \frac{d\ln x_j}{dt}) = \dot{y} - \sum\nolimits_j (S_j \dot{x}_j) \end{aligned} \tag{4}$$

Where $\dot{y}$ stands for the growth rate of output, S_j means the cost share of factor j, and $\dot{x}_j$ represents the growth rate of factor input.

4.1.2. Calculation of the Degree of Industrial Concentration

The major indicators for measuring the degree of industrial concentration include the spatial Gini coefficient, the industrial concentration index (CR_n) and the Hoover coefficient. In this paper, select LQ to measure the degree of concentration of the logistics industry in various regions. The formula for calculating LQ is as follows:

$$LQ_{ij} = \frac{q_{ij} / q_j}{q_i / q} \tag{5}$$

Where q_{ij} is a certain economic index of the industry i in the region j, q_j is the economic index of all industries in the region j, q_i is the economic index of the industry i in the country, and q is the economic index of all industries in the country. The higher the value of LQ_{ij} is, the higher the level of industrial concentration in this area will be.

4.2. The Impact of the Logistics Industry on the Import and Export Trade in Korea

Similarly to the logistics industry, there is also a significant spatial pattern regarding import and export trade. For this reason, the spatial measurement method was also considered when establishing this model. Spatial econometrics assumes that the data have a spatial correlation. The general spatial econometric models are as follows:

$$Y = \rho WY + \alpha l_N + X\beta + WX\theta + \mu$$
$$\mu = \lambda W\mu + \varepsilon$$

Where W is the spatial weight matrix, WY and WX are the spatial lag terms of the explained variables and explanatory variables, respectively, and αl_N is a constant term. When the spatial error autocorrelation coefficient λ is 0, the model is the spatial Durbin model (SDM). When the spatial regression coefficient θ and λ are 0 at the same time, the model is the spatial autoregressive model (SAR). When the spatial regression coefficient θ and ρ are 0 at the same time, the model is the spatial error autocorrelation model (SEM).

In order to more accurately estimate the impact of the efficiency and agglomeration of Korea's logistics industry on the import and export trade, we consider a regression model with spatial correlation. The model is established in log-log form to increase the stationarity and reduce the heteroscedasticity of variables. Specifically, we take logarithms of aggregate indicators such as population size and import and export trade volume, while the original values are taken for relative indicators such as rates. The models that we propose in this paper are given by the following equations:

Model I:

$$\ln TRADE_{it} = \beta_0 + \rho W \ln TRADE_{it} + \beta_1 WTF_{it} + \beta_2 LQ_{it} + \beta_3 \ln PP_{it} + \beta_4 \ln GDP_{it}$$
$$+\beta_5 \ln ER_{it} + \beta_6 ISU_{it} + \beta_7 ECE_t + \mu_j + \gamma_t + \varepsilon_{it}$$

Model II:

$$\ln TRADE_{it} = \beta_0 + \rho W \ln TRADE_{it} + \beta_1 WTF_{it} \times LQ_{it} + \beta_2 \ln PP_{it} + \beta_3 \ln GDP_{it}$$
$$+\beta_4 \ln ER_{it} + \beta_5 ISU_{it} + \beta_6 ECE_t + \mu_j + \gamma_t + \varepsilon_{it}$$

In the two models, $\varepsilon_{jt} = \lambda W \varepsilon_{jt} + \pi_{jt}$, where i represents administrative regions of Korea, t is the year and W is the $n \times n$ spatial weight matrix, which corresponds to the geographical distance between 17 administrative regions in Korea, and is rowed and standardized so that the sum of elements in each row is equal to 1. λ is the autocorrelation coefficient of the spatial error, β is the regression coefficient of explanatory variables, μ_j is the individual effect, γ_t is the time effect, and ε_{jt} and π_{jt} are random disturbance terms. The model I stresses the impact of the independent effect of logistics industry efficiency and the degree of logistics industry concentration on import and export trade, while model II stresses the impact of the synergistic effect of logistics industry efficiency and logistics industry concentration on import and export trade. The explanatory variables in the two models are shown in Table 1, and the descriptive statistics of partial variables are shown in Table 2.

This paper studies the impact of the logistics industry efficiency and agglomeration effect on import and export trade in Korea's 17 administrative regions from 2011 to 2019, $TRADE_{it}$ taken from the Korean trade association, and the country's administrative region logistics industry fixed assets investment, the number of logistics professionals, the regional population, GDP, exchange rate, industrial structure data, from KOSIS.

Table 1. Explanatory variables in Models I and II

Variable	Variable name	Meaning and explanation
$TRADE_{it}$	Total import and export trade volume in various administrative regions of Korea	Total import and export trade volume of the ith administrative district of Korea during period t
TF_{it}	Efficiency of the logistics industry in various administrative regions of Korea	TFP of the logistics industry in the ith administrative region of Korea during period t
LQ_{it}	Concentration degree of the logistics industry in various administrative regions of Korea	The LQ of logistics industry in the ith administrative region of Korea during period t
$TF_{it} \times LQ_{it}$	The synergistic effect of the efficiency concentration of the logistics industry	The product of TFP and LQ of logistics industry in the ith administrative region of Korea during period t
$ln\,P\,P_{it}$	Population of various administrative regions in Korea	The logarithm of the population in the ith administrative district of Korea during period t
$ln\,G\,DP_{it}$	Economic aggregate	The GDP logarithm of the ith administrative district of Korea during period t
$ln\,E\,R_{it}$	Exchange rate level	The exchange rate of Korea surpassing the US dollar during period t
ISU_{it}	Industrial structure level	The ratio of the output value of secondary and tertiary industries to GDP in the ith administrative region of Korea during period t
ECE_t	External economic shock	The outbreak of the European sovereign debt crisis in 2010 still had an impact in 2011. Trade wars broke out between the United States and China in 2018 and 2019, seriously affecting the global economy and trade for two consecutive years. When considering the impact of epidemics, due to the lack of data for 2020, the Middle East Respiratory Syndrome, which seriously affected Korea in 2015, has been taken as a key consideration: The values for 2011, 2015, 2018 and 2019 were 1, and the values for other years were 0.

Table 2. Descriptive Statistics of Partial Variables

	$TRADE_{it}$	PP_{it}	GDP_{it}	ER	ISU_{it}
Mean	63167485	3044947	99235186	1128.882	97.84111
Median	29596026	1906476	70449724	1126.87	97.82
Maximum	2.75E+08	13239666	4.62E+08	1180.05	98.14
Minimum	25	113117	6883305	1092.59	97.58
Std. Dev.	67566231	3176391	1.08E+08	32.95661	0.192448

5. Empirical Analysis

5.1. Spatial Correlation Test

When considering whether to choose the ordinary panel data model or the spatial panel data model during the stochastic frontier estimation, we should not only compare the results of the model estimation, but also verify whether there is a spatial correlation in the development of the logistics industry. There are many methods to test spatial correlation in spatial econometrics, the most common of which is Moran's I index, which generally takes values between -1 and 1. A value I >0 suggests a positive correlation, implying spatial agglomeration, while a valueI<0 means negative correlation, indicating spatial dispersion. The Moran's I index is explicitly given by:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}$$

Where w_{ij} is the element in row i and column j of the spatial weight matrix, and $\{x_i\}_{i=1}^{n}$ is the variable sequence of the spatial relationship to be measured.

Fig. 3. 2011-2019 Moran's I Index of the Added Values of the Logistics Industry and Import and Export Trade in Korea

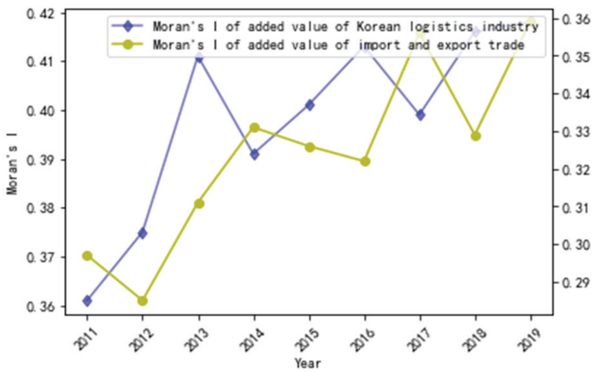


Fig. 3. shows the global Moran's I index of the added values of the logistics industry and import and export trade in Korea during 2011-2019. As we can see from the figure, these added values were characterized by a positive spatial autocorrelation, and both showed a stronger and stronger spatial autocorrelation. Besides, the Moran's I index of the added values of the logistics industry and import and export trade in Korea reached a maximum of 0.418 and 0.359 in 2019, respectively. In addition, it was also figured out that the corresponding p of Moran's I index in all years was <0.01, suggesting significant correlations in each year. On the whole, the spatial positive correlation of logistics industry was stronger than that of import and export trade.

5.2. Stochastic Frontier Estimation

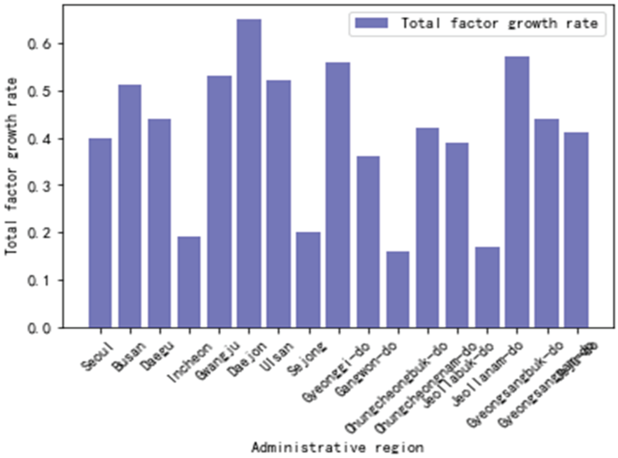
The estimation results of the fixed-effects and random-effects static panel spatial stochastic frontier models are shown in Table 3., and both models pass the significance test. The estimated values of the spatial autoregressive coefficient λ and the spatial error autocorrelation coefficient ρ of the two models meet the significance level of 1%, verifying the presence of the spatial interaction effect. Moreover, the estimated values of the two parameters in the two models are both positive, indicating that the spatial interaction facilitates the development of Korea's logistics industry. Furthermore, comparison of the values of γ among several models reveals that the value of this coefficient in the spatiotemporal stochastic frontier model is larger than in the others, indicating that the inefficiency accounts for a larger proportion of the composite error items. Thus, it is more reasonable to accept the stochastic frontier model rather than other regression models. The Hausman test results of the two stochastic frontier models validate the random effects model. The estimated results also show that the sum of the elasticity coefficients of capital and labor input is larger than 1, and the elasticity of labor input is higher than that of capital input, indicating that Korea's logistics industry is in the stage of weak returns to scale and relatively labor intensive.

Table 3. Spatial Stochastic Frontier Model Estimation for Logistics Industry

Dependent variable	**Ln y**			
Model	Static panel spatial stochastic frontier			
Variable	Fixed effects		Random effects	
	Coefficients	P-value	Coefficients	P-value
$ln\, k$	0.423	0.000	0.306	0.000
$ln\, l$	0.699	0.000	0.877	0.000
λ	0.570	0.011	0.369	0.009
ρ	0.752	0.001	0.811	0.000
σ_u^2	4.34E-05		0.316	
σ_v^2	0.352		0.110	
γ	1.605E-04		0.742	
Hausman Statistics	10.852			

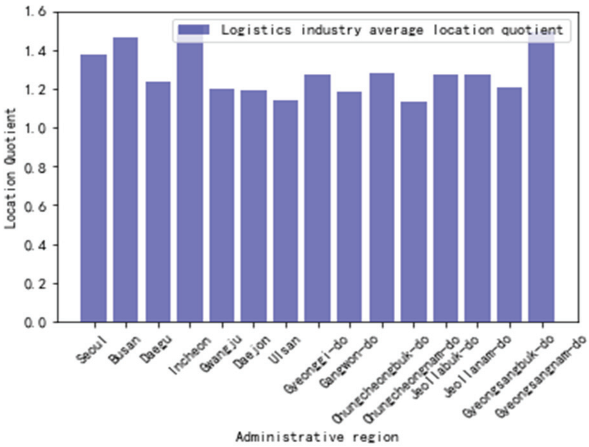
After model comparison, a well-fitted stochastic frontier model is selected to measure the technical efficiency of the logistics industry in various cities of Korea, and to calculate the spatial total factor growth rate of the logistics industry, according to Formula (4). By the calculation, the total factor growth rate of the 17 administrative districts in Korea during 2011-2019 is obtained. Due to space limitation, Fig.6. only displays the total factor growth rate of each region in the past nine years, and does not show the annual total factor growth rate of the regions year by year. The results reveal that, among the 17 administrative regions of Korea, the highest average total factor growth rate was in Daejeon Wide-area City (0.15) and the lowest in South Chungcheong Province (0.03). On the whole, the total factor growth rate of logistics industry was not high.

Fig. 4. Calculation of TF



In addition to the spatial correlation test, calculated the LQ of logistics staff input in each administrative region of Korea to verify the concentration degree of the logistics industry in various regions. Then, the LQ is incorporated into the model as the factor influencing the inefficiency component for parameter estimation. In this paper, the average location quotient of logistics industry in each administrative region from 2011 to 2019 as shown in Fig. 7. is obtained through calculation. It can be seen that the LQ of coastal logistics industry was obviously higher than that of inland logistics industry, indicating that the logistics industry in Korea indeed depends on the marine transportation to a certain extent.

Fig. 5. Calculation of LQ



5.3. Estimation of the Econometric Models

The SAR and SEM are used to estimate the models I and II, respectively, and the tests of $RobustLMlag$ and $RobustLMerr$ are conducted to determine the specific form of the spatial model. The test results show that, for Model I, the statistical values of $RobustLMlag$ and $RobustLMerr$ are 19.593 and 3.8035, respectively. For Model II, the statistical values of $RobustLMlag$ and $RobustLMerr$ are 26.705 and 4.620, respectively. As a result, the tests $RobustLMlag$ and $RobustLMerr$ for the above two models are of significance. However, for the two models, the statistical value of $RobustLMlag$ is much more significant, and according to this result, the SAR is applied to both models. Table 4. shows the estimation results of SAR for Models I and II. To clearly compare the coefficients of the two models, the standardized estimation method is adopted for parameter estimation in this paper. According to the results of the Hausman test for the two models, the fixed effect model is accepted. The spatial autoregressive coefficients ρ of the two models are both positive and significant at the 1% level, indicating that both spatial complementary and spatial spillover effects exist in the import and export trade in various administrative regions of Korea. In other words, the growth of import and export trade in surrounding areas can drive the development of import and export trade in a given region.

According to the estimated results of Model I, the coefficient of the total factor growth rate TF_{it} of the logistics industry is positive and significant at the 1% level, suggesting that improvement of the logistics industry efficiency is an effective booster for the expansion of the bilateral import and export trade between Korea and its trading partners. The degree of concentration of the logistics industry LQ_{it} has a significant positive impact on the scale of import and export trade in Korea, implying that a higher logistics industry concentration degree in various regions is conducive to the development of import and export trade.

Table 4. Estimation of Spatial Econometric Models

Dependent variable	$\ln TRADE_{it}$			
Model	**SAR**		**SEM**	
Variable	**Fixed effects**	**Random effect**	**Fixed effects**	**Random effect**
$\ln TRADE_{it}$	0.397*** (3.56)	0.526*** (5.77)	0.867*** (7.78)	0.126** (2.35)
TF_{it}	0.066*** (5.16)	0.018* (1.87)	0.144*** (8.28)	0.004*** (4.31)
LQ_{it}	1.426** (2.63)	1.902*** (3.18)		
$TF_{it} \times LQ_{it}$			3.117*** (4.75)	0.457*** (7.4)
$\ln PP_{it}$	0.728** (2.38)	1.333*** (3.58)	1.591*** (6.21)	3.133 (0.84)
$\ln GDP_{it}$	1.217*** (6.18)	1.672*** (3.07)	2.660*** (3.51)	0.392*** (7.21)
ER_{it}	-0.379* (1.97)	0.702** (2.29)	-0.828** (-4.31)	-0.165*** (5.38)
ISU_{it}	0.387*** (5.72)	0.159*** (2.89)	0.850** (2.51)	0.373 (0.68)
ECE_t	-6.85* (-2.02)	-8.116** (-2.38)	-15.957* (-1. 18)	-1.907*** (-5.59)
Adjusted R2	0.711436	0.715616	0.678832	0.674652
$Hausman$Statistics	22.87***		51.36***	

It can be seen from the results estimated by Model II that the coefficient for the synergistic effect (3.117) is significantly greater than the coefficient of the total factor growth rate TF_{it} of the logistics industry (0.066) and the coefficient of the logistics industry's concentration degree LQ_{it} (1.426), as well as being greater than the sum of the two. This reflects that there is a significant interaction between the efficiency and the concentration of the logistics industry. Besides, the synergistic ("1+1>2") effect of the two factors on the development of regional import and export trade is demonstrated.

All the control variables pass the significance test at a certain significance level. Among them, both the industrial structure ISU_{it} and economic development GDP_{it} pass the significance test at the 1% level and their regression coefficients are positive. This indicates that the two variables play the most significant role among the different factors affecting the import and export trade in Korea. Among the control variables, the population PP_{it} pass the significance test at the 5% level and its regression coefficient is positive. Meanwhile, the Korea-US exchange rate ER_{it} and external shocks ECE_t pass the significance test at the 10% level and their regression coefficients are negative. This indicates that the import and export trade in Korea is also greatly affected by the population base and the Korea-US exchange rate. Specifically, the former serves as a driver of import and export trade, while the latter is a barrier to its development to some extent. The change of the international situation in the past decade and the recent epidemic situation have also impacted on trade in Korea.

6. Conclusion and Suggestions

6.1 Conclusion

First of all, although the overall efficiency of the logistics industry in Korea shows and upward trend in all regions, it needs to be improved. This industry is characterized by increasing returns to scale, and the sum of the elasticities of the two input factors is larger than 1, indicating that an increase in that factors in each region will accelerate the development of the industry. The output elasticity of the labor factor is greater than that of the capital factor, which reflects that the current growth model of Korea's logistics industry is still labor-intensive, and the investment in advanced technology and capital has not yet played a decisive role.

Secondly, the agglomeration level of Korea's logistics industry also needs to be improved. We have found a positive spatial relationship and spatial concentration effect on the development of the logistics industry in various regions of Korea, but the degree of concentration is still low. On a national scale, the logistics industry in Korea is highly concentrated in coastal areas. In terms of regional concentration, Daegu, Gwangju, Daejon and Ulsan have a less developed logistics industry, and only Ulsan is a coastal area. In addition, the efficiency of the logistics industry decreases as we move from coastal to inland areas. The logistics industry develops earlier in coastal areas, and the efficiency and degree of concentration of the logistics industry in inland areas is lower. These facts show that after years of development, the logistics industry in Korea is still excessively dependent on coastal areas and labor factor.

Thirdly, the positive spatial correlation and industrial agglomeration effect of Korea's logistics industry have a positive impact on the country's import and export trade. The concentration effect of the logistics industry drives its development and, together with efficiency, promotes import and export trade.

Last but not least, the import and export trade in Korea is also obviously affected by multiple factors, such as industrial structure, economic development, population base, the

US-Korea exchange rate and external shocks. In particular, the industrial structure, economic development, and population base positively affect the import and export trade, while the US-Korea exchange rate and the external shocks limit the growth of international trade. It can be concluded that, although Korea has an important foreign trade sector that has a great impact on its economy, it still has a not very robust level of trade development, which makes it susceptible to external shocks.

6.2 Policy-Related Suggestions

The import and export trade in Korea, the developed country in Asia, has been one of main pillars for its economic growth. Up till now, the logistics industry in Korea has developed on a large scale and is still on the rise. To maintain the crucial role of this industry in foreign trade, efficiency, capital investment, rate of technological progress and technical efficiency should be further improved, in order to move toward an automated logistics industry.

For coastal areas, regional advantages should be maintained and logistics resources should be appropriately arranged to produce a radiation effect, thus promoting the development of the logistics industry in inland areas. At the same time, input to the logistics industry in inland areas should be increased to progressively lessen its dependence on coastal areas. In addition, logistics companies in inland areas must follow the example of excellent companies in coastal areas and advance in technological management, constantly improving the rationality of resource allocation, to bring the industry into a mature period.

Top-ranking infrastructures should be actively built. The logistic performance significantly drives the development of import and export trade in Korea, and the construction of infrastructures is one of the key factors to improve it. For these reasons, the Korean government should rapidly implement the development strategy of “building a smooth and efficient transportation system in the country and strengthen the importance of its transportation system to the international trade transportation” by creating a logistics system with complete functions, distinct levels and efficient operation. In addition to maintaining the location advantage of marine logistics, the government should move faster to improve inland logistics channels and further develop all-weather air transport channels. Furthermore, the construction of infrastructures such as port and station transportation hubs, logistics parks and logistics centers should be rapidly performed. Additionally, emphasis should be put on the intelligent, modernized and computerized development of logistics links in all regions. As a result, the upgrading of the trade industry chain should be driven by both infrastructure construction and the improvement of the logistics industry.

The way of organizing transportation should be improved to further increase the efficiency of the logistics industry. The construction of infrastructures for this industry is a “quantitative” change while the improvement in transportation organization is a “qualitative” change. Therefore, Korea should accelerate the construction of its multimodal transport service network by relying on its railway stations, ports, airports and trans-regional inland ports, and establish a comprehensive logistics service system, led by port and international logistics. It should also be supported by key parts of urban distribution, cold chain logistics, dangerous goods logistics, manufacturing logistics, and e-commerce logistics. In short, the Korean government should create more favorable conditions for the import and export trade by improving the efficiency of the domestic logistics industry.

A talent pool should be promoted. The government should increase the recruitment of talented people within logistics companies and improve the quality of their training, in order to secure abundant human resources for the reform and innovation of the logistics industry. In addition, high-level talents should be encouraged to make a key contribution to the efficiency of the logistics industry.

In addition to the basic factors affecting the import and export trade in Korea such as the economic aggregate and the population base, there are other important factors, such as exchange rate and external shocks. To combat the adverse impacts of the trade war and the epidemic, Korea should also enhance its comparative advantage and the core competitiveness of its products, in order to achieve the sustained and stable growth of import and export trade.

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