Journal of Korea Trade Vol. 25, No. 3, May 2021, 116-133
https://doi.org/10.35611/jkt.2021.25.3.116
ISSN 1229-828X

JKT 25(3)

Received 17 November 2020
Revised 10 January 2021
Accepted 8 February 2021

Research on Spatial Dependence and Influencing Factors of Korean Intra-Industry Trade of Agricultural Products: From South Korea's Agricultural Trade Data*

Hong-Qu Lv
School of Businesss, Shandong University of Political Science and Law, Jinan Shandong, China

Chen-Yang Huang†
School of Modern Service Management, Shandong Youth University of Political Science, Jinan Shandong, China

Abstract

Purpose – Intra-industry trade of agricultural products can eliminate the disadvantage of Korea's traditional agriculture and improve its lack of comparative advantage. The main purpose of this paper is to measure the level and index of intra-industry trade of Korean agricultural products and to explore the spatial dependence and spillover effect associated with this type of trade. The main factors influencing intra-agricultural trade are analyzed from two perspectives: the population and the classification of agricultural products.
Design/methodology – First, the level of intra-industry trade of Korean agricultural products is measured. Second, to obtain a more accurate estimate of the influence of various factors, and based on two types of weight matrices, a spatial econometric model is constructed from two aspects: population and classification of agricultural products. The status and the factors influencing intra-industry trade are also studied.
Findings – It is concluded that there is a positive spatial correlation between Korea's intra-industry trade in agricultural products and that of its trading partners. The spatial spillover effect of this type of trade is verified by using the spatial autoregressive model (SAR). Labor-intensive agricultural products are found to have a positive spillover effect on intra-industry trade, while land-intensive products do not have a significant effect.
Originality/value – In this paper, the two types of agricultural products are meticulously distinguished, and the spatial effect of the intra-industry trade of agricultural products as well as the influence of various factors are analyzed. In addition, the accuracy of the estimation of the coefficients of the factors by using the spatial econometric model is higher than that of the ordinary panel data model.

Keywords: Agricultural Products, Intra-industry Trade, Panel Data
JEL Classifications: D12, F14, O53

* This work was supported by the National Natural Science Foundation of China project "Statistical Analysis and Application Research of A Class of Econometric Models" (11571073), Special Research project of Shandong Social Science Fund on The Conversion of Old And New Driving Forces "Study on the Space-time Evaluation Mechanism of Production Efficiency of New Industry and New Format in Shandong" (19CDNJ37), Social Science Research Project of Shandong University of Political Science and Law "Study on The Conversion of Old And New Driving Forces and Efficiency Index of Cultural Industry" (2019Q14B), Shandong Province Humanities Social Science Finance Application Key Project "Research on Rural Supply Chain Finance Model and Credit Risk Early Warning in Shandong Province under the Environment of Internet +"(2020-JRZZ-11).

† **Corresponding author:** setup521@naver.com

1. Introduction

In the new round of multilateral trade negotiations within the Doha Round of the Fourth Ministerial Conference of the World Trade Organization (WTO), market access for agricultural and non-agricultural products are regarded as the two most important and divisive areas among WTO members. In such negotiations, the Korean government has always resisted opening the agricultural market in order to protect its own agricultural sector.

Although not exclusively, agriculture has dominated South Korea's participation in bilateral and multilateral free-trade agreements. By 2019, South Korea's domestic agriculture, forestry and fishery will only account for 2.2% of GDP. Intra-industry trade, that is, the import and export of the same type of products, has a lower cost of adjusting to trade liberalization and the possibility of trade friction is relatively low. Therefore, for South Korea, which is one of the major importers of agricultural products, it is imperative to develop intra-industry trade, as it could improve the lack of competitive advantages of its traditional agriculture.

The academic literature has so far devoted little effort to study the spatial relationship of intra-industry trade of agricultural products in Korea, especially with its major trading partners, or whether there are differences in the spatial effects of different types of intra-industry trade of agricultural products. However, with the development of regional economic integration, it would be desirable for the Korean government to clarify its position in the world trade pattern, promoting the development of regional agricultural trade and formulating trade policies that meet the requirements of product diversity, according to the development goals of the country and to the factor endowment of neighboring countries.

The main purposes of this study are the following. First, to measure the level and index of intra-industry trade of Korean agricultural products. Second, to explore the spatial dependence and spillover effect of such trade. Third, analyze the main factors affecting Korea's intra-agricultural trade with its major trading partners through panel data, from the general and the product classification perspectives. Fourth, to present policy suggestions according to the characteristics and influencing factors of intra-industry trade of Korean agricultural products.

2. Literature Review

The issue of intra-industry trade of agricultural products has been widely concerned by scholars, and the influential factors of intra-industry trade of agricultural products have been studied. Scholars' research on intra-industry trade of agricultural products is mainly based on two perspectives. First, from the perspective of intra-industry trade of individual agricultural products, Liu Yi-Zhuo, Zuo Chang-Sheng and Xu Hong-Yuan (2006), Yang Yue-Hui and Yang Jian-Zhou (2012) respectively studied intra-industry trade of forest products and flower products. Second is national or regional agricultural intra-industry trade Angle, Lu Wen-Cong and Mei Yan (2005), Liao Dong-Sheng and Zhou Yuan (2014), Gong Xin-Shu and Liu Ning (2015), respectively, studied the measurement of the level and structure and the influence factors, from the point of view of the agricultural intra-industry trade among EU-China, Thailand-China and Russia-China. Economy scale, technology of production, per capita income differences, foreign direct investment and trade openness, geographic distance, and so on are the main factors influencing the intra-industry trade of agricultural products. McCorriston and Sheldon (1991) studied the measurement methods of intra-industry trade and specialization of processed agricultural products by taking the United States and the European Union as examples. Fertő (2007) studied the horizontal and vertical intra-industry trade of differentiated agricultural products between Hungary and the EU. Rasekhi and Shojaee (2012) studied the determinants of vertical intra-industry trade between Iran and its major trading partners in the agricultural sector. Hoang (2019) studied the dynamics of intra-industry trade in agriculture with a comprehensive case of Vietnam.

Many scholars have found that intra-industry trade data often have spatial dependence or spatial correlation, and geographical distance has a significant impact on trade. The market and industry scale and the spillover effect between countries will have impacts on intra-industry trade of a country. In the study of intra-industry trade among countries, if the spatial heterogeneity and spatial dependence among countries are ignored, it will lead to misestimation of the influence degree of each factor. Uttama (2012) verified the spillover effect of FDI from neighboring countries on the intra-industry trade of ASEAN countries by building a spatial panel model of intra-industry trade of ASEAN countries. Yong Chen-Chen, Yew Siew-Yong and Chin Mui-Yin (2019) believed that FDI and GDP had a significant impact on intra-industry trade among ASEAN countries.

To sum up, according to the existing literature analysis, there are the following deficiencies: first, only research on intra-industry trade of agricultural products of the same category among countries is conducted, and no further research is conducted on intra-industry trade of agricultural products of different categories, ignoring the differences in characteristics of agricultural products of different trade structures; second, research on intra-industry trade of agricultural products of different categories is conducted. Second, it is limited to the analysis of the spatial effect of manufactured goods and does not explore the spatial effect of intra-industry trade of agricultural products (Sun Jiang-Ming and Chu Xin-Yi, 2019). Based on this, this paper uses spatial econometric model, selection of 30 countries in 2010-2019 data, build space geographic weighting matrix and uses exploratory spatial data analysis method for the research of spatial effect of Korea's agricultural intra-industry trade, the study of South Korea's agricultural intra-industry trade influence factors and spatial spillover effect. In accordance with the structural differences, agricultural products will be divided into two types: labor-intensive agricultural products and land intensive agricultural products, and further divided into five categories: the processing agricultural products, animal products, cereals and oilseeds products, horticultural products and textile materials, accurately grasp the influence factors of intra-industry trade under different categories; and provide scientific basis and experience support for Korea to develop intra-industry trade of agricultural products.

3. The Status of Intra-Industry Trade of Agricultural Products between South Korea and Its Trading Partners

3.1. The Overall Situation of Intra-Industry Trade of South Korean Agricultural Products

This paper studies the import and export of agricultural products between South Korea and its 32 agricultural product trading partners from 2010 to 2019. The total import and export data as well as those corresponding only to agricultural products have been taken from the UN Comtrade database. The data of South Korea's foreign direct investment stock for its trading partners have been obtained from the Korea Statistics Office, while the data on GDP, per capita income and the value added of agriculture of each country comes from the World Bank database. Finally, the data on the distance between the central cities of South Korea and its trading partners come from the CEPII database.

South Korea's 30 major trade partners for agricultural products are: Argentina, Brazil, Canada, Mexico, United States, Australia, New Zealand, Belgium, Switzerland, Czech Republic, Germany, Denmark, Spain, France, United Kingdom, Hungary, Italy, Poland, Russian Federation, Sweden, Indonesia, India, Japan, China, Malaysia, Philippines, Singapore, Thailand, Turkey and Vietnam.

For the measurement of the level of intra-industry trade, this paper adopts the method of Grubel & Lloyd (1975). These authors propose the following expression:

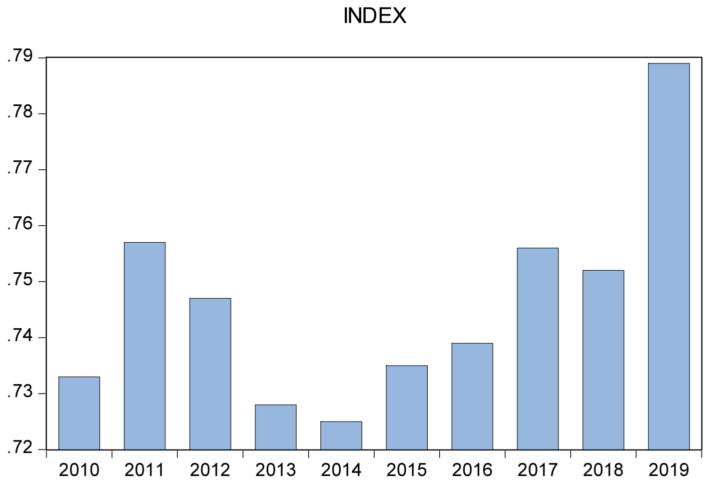
$$TOTAL_{it} = INTER_{it} + INTRA_{it}$$
$$TOTAL_{it} = X_{it} + M_{it} \quad (1)$$
$$INTER_{it} = |X_{it} - M_{it}|$$

where $TOTAL_{it}$, $INTRA_{it}$, $INTER_{it}$, X_{it} and M_{it} represent the total trade volume, intra-industry trade volume, inter-industry trade volume, total exports and total imports of product i in period t, respectively. The formula for calculating the level of intra-industry trade of agricultural products is as follows:

$$INDEX = \sum_{i=1}^{n} \gamma_i INDEX_i = 1 - \frac{\sum_{i=1}^{n} |X_i - M_i|}{X+M} \quad (2)$$

where $INDEX_i = |X_i - M_i|/(|X_i| + |M_i|)$, $INDEX$ represents the total intra-industry trade index of agricultural products, $\gamma_i = (X_i + M_i)/(X + M)$, and X, M represent the exports and imports of agricultural products, respectively. An INDEX value greater than 0.5 indicates that trade in agricultural products is dominated by intra-industry trade, while a value less than 0.5 means that such trade is dominated by inter-industry trade. Applying the above formula to the data taken from UN Comtrade, we have obtained the intra-industry trade volume and the intra-industry trade level between South Korea and its trading partners. The results are depicted in Fig. 1.

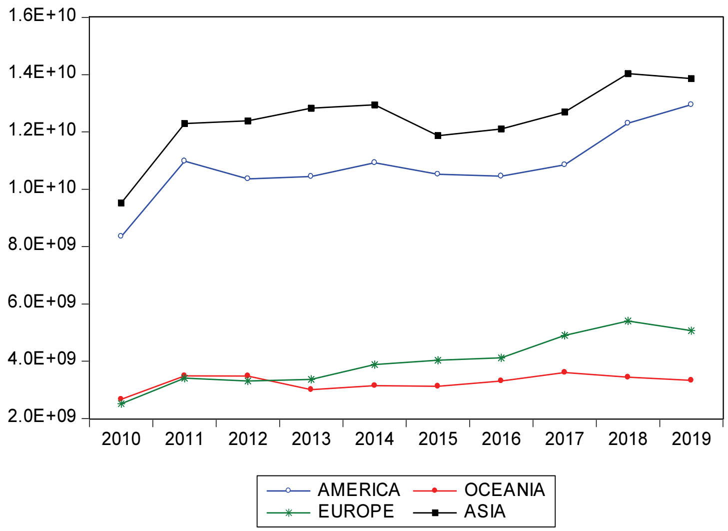
Fig. 1. Changes of Intra-industry Trade Index of Agricultural Products Between South Korea and Its Trading Partners From 2010 to 2019



It can be seen from Fig. 1 that, from 2010 to 2019, the trade of agricultural products between South Korea and its trading partners has been dominated by intra-industry trade, and the overall intra-industry trade index of agricultural products has shown an increase of its fluctuations during this period. The index remained low between 2013 and 2014, showing an increasing trend since then. In 2019, the intra-industry trade index of Korean agricultural products reached its all-time high of 0.789, with intra-industry trade accounting for the main part of the trade of agricultural products.

The overall increasing trend in the intra-industry trade index of agricultural products between South Korea and its major trading partners has not affected all regions equally. The difference between geographical areas is evident and shows an increasing trend. From Fig. 2 we can see that, from 2010 to 2019, South Korea's intra-industry trade in agricultural products reached its highest volumes and growth rates with Asian countries, while the lowest values of these variables occurred with the Oceania region. The gap in the volume of trade between regions has shown an expansionary trend.

Fig. 2. Intra-industry trade volume of agricultural products between South Korea and its major trading partners from 2010 to 2019



3.2. The Status of Intra-Industry Trade of Different Categories of Agricultural Products

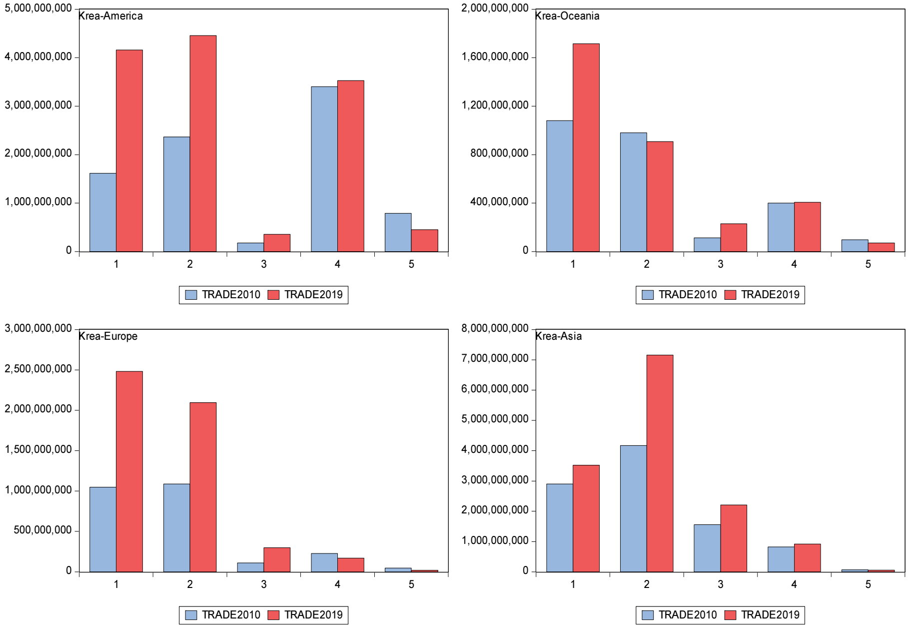
According to the standards of the "International Convention on the Harmonized Commodity Description and Coding Systems" (HS96), agricultural products are divided into five categories: animal products, processed agricultural products, cereals and oilseeds, plant products, and textile raw materials. For specific classification standards, please refer to Table 1. Taking into account the differences in the endowment of agricultural resources and the intensity of production factors, agricultural products are divided into land-intensive products (cereals and oilseeds and textile raw materials) and labor-intensive products (animal products, processed agricultural products, and plant products).

Table 1. Categories of Agricultural Products

Type	Product Categories	(HS) Codes
Mainly on Labor	Animal products	01 Animals; live 02 Meat and edible meat offal 03 Fish and crustaceans, molluscs and other aquatic invertebrates 04 Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included 05 Animal originated products; not elsewhere specified or included
	Processed agricultural products	11 Products of the milling industry; malt, starches, inulin, wheat gluten 16 Meat, fish or crustaceans, molluscs or other aquatic invertebrates; preparations thereof 17 Sugars and sugar confectionery 20 Preparations of vegetables, fruit, nuts or other parts of plants 21 Miscellaneous edible preparations 22 Beverages, spirits and vinegar 23 Food industries, residues and wastes thereof; prepared animal fodder 24 Tobacco and manufactured tobacco substitutes
	Plant Products	06 Trees and other plants, live; bulbs, roots and the like; cut flowers and ornamental foliage 07 Vegetables and certain roots and tubers; edible 08 Fruit and nuts, edible; peel of citrus fruit or melons 09 Coffee, tea, mate and spices 14 Vegetable plaiting materials; vegetable products not elsewhere specified or included 1210-1214 Other vegetable produces
Mainly on Land	Cereals and oilseeds	10 Cereals 1201-1209 vegetable oilseeds 1507-1519 Vegetable oil
	Textile raw materials	4101-4103,4301 Raw hides and skins, leathers, furs and crafts 50001-5003 silk and raw silk 5101-5103 Wool and animal hair, not carded or combed 5201-5203 Cotton; not carded or combed 5301-5302 Other textile fibres; paper yarn and woven fabrics of paper yarn

The current international division of labor has been seriously refined, and the regional differences of similar products have become increasingly obvious. Figure 3 compares the intra-industry trade of agricultural products between South Korea and four continents from 2010 to 2019. From Fig. 3, it can be seen that the intra-industry trade status of South Korea and its trading partners for different types of agricultural products showed significant differences. The intra-industry trade volume with most of its trading partner regions increased tremendously in that period, but the trade volume of textile raw materials showed a downward trend. Animal products and processed agricultural products were the major components in the intra-industry trade of agricultural products between Korea and these regions, while the trade volume of plant products and textile raw materials was not high in general. On the whole, South Korea's trade volume with Asia and the Americas was much larger than that with the other two continents. Among the five categories of agricultural products, the trade volume of labor-intensive agricultural products was higher than that of land-intensive agricultural products, with the former products achieving an advantageous position.

Fig. 3. Intra-industry Trade Volume of Agricultural Products between South Korea and Major Trading Partners in 2010 and 2019



Note: The types of agricultural products numbered 1-5 are animal products, processed agricultural products, grain and oilseed products, horticultural products and textile raw material products

4. Factors Influencing Intra-industry Trade of Agricultural Products

Taking into account the existing literature, we propose a regression model with ten factors as explanatory variables in order to analyze the factors influencing the intra-industry trade of agricultural products. As a significant spatial correlation has been found in intra-industry agricultural trade, we will base our model on the general spatial econometric model, which can be expressed as follows:

$$\begin{aligned} y_{it} &= \lambda w_i' y_t + x_{it}\beta + d_i' X_t \delta + u_i + \gamma_t + \varepsilon_{it} \\ \varepsilon_{it} &= \rho m_i' \varepsilon_t + v_{it} \end{aligned} \tag{3}$$

In Equation (3), $d_i' X_t \delta$ is the spatial lag term of explanatory variables; w_i, d_i and m_i are the ith rows of the corresponding spatial weight matrices; y_t represents the vector composed of the t-time values of all individual explained variables and u_i, γ_t are the individual and time effects, respectively. Obviously, taking $\rho=0$, the model reduces to the panel spatial Durbin model; if $\delta=0$, $\rho=0$, the model represents the panel spatial autoregressive model and with $\lambda=0$, $\delta=0$, we obtain the panel spatial error model.

Based on the previous model, we propose a model that considers the factors that affect the intra-industry trade of agricultural products between South Korea and its trading partners under the conditions of spatial correlation. In order to increase the stability of the variables and reduce heteroscedasticity, we consider a double logarithmic model that can be written as follows:

$$\begin{aligned} ln\, INTRA_{it} = \beta_0 + \rho W\, ln\, INTRA_{it} + \beta_1 AFDI_{ijt} + \beta_2 HUM_{jt} + \beta_3 DE_{jt} + \beta_4\, ln\, ES_{jt} \\ + \beta_5\, ln\, DPG_{jt} + \beta_6\, ln\, OP_{jt} + \beta_7\, ln\, DI_{jt} + \beta_8\, ln\, TC_{jt} + \beta_9\, ln\, DIS_j \\ + \beta_{10} EC_t + \mu_j + \gamma_t + \varepsilon_{jt} \end{aligned}$$

In the above expression, $\varepsilon_{jt} = \lambda W \varepsilon_{jt} + \pi_{jt}$, i represents the category of agricultural products, j indicates the country, t represents the year and W is an $n \times n$ spatial weight matrix. The weights of the matrix W are given by the reciprocals of the squares of the distances between the central cities of South Korea and its trading partners, and the matrix is normalized so that the sum of the elements in each row is 1. λ is the autocorrelation coefficient of the spatial error, the β's are the regression coefficients of the 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 implications of the explanatory variables in the model is shown in Table 2.

Based on the study of the previous literature and on the classical theory of intra-industry trade, we consider the following factors affecting intra-industry trade in agriculture.

(1) Factor endowment: The influence of factor endowment on the intra-industry trade of agricultural products is examined from two perspectives. Human capital differences: As an important aspect of factor endowment difference, human capital determines the quality of labor force, which in turn affects the product quality and is transmitted to the country's foreign trade. Similar or obvious differences in human capital among countries will also promote the development of horizontal or vertical intra-industry trade. Foreign direct investment: Differences in motivation will lead to different relationships between foreign direct investment and the development of intra-industry trade. The efficiency-oriented investment will promote intra-industry trade, while the market-oriented investment will hinder it.

(2) Situation of economic development: We consider its influence on the intra-industry trade of agricultural products from three perspectives. The first is the impact of the stage of economic development. Previous studies have found that horizontal intra-industry trade mostly takes place among countries with the same level of economic development, vertical intra-industry trade occurs among countries with different levels of development, and there is a negative correlation between the level of economic development and the overall intra-industry trade. Unlike previous studies, which use the proportion of high-tech products in exports to reflect different development stages, we will use the proportion of agricultural value added in GDP. The second perspective refers to economic scale. According to the theory of economies of scale the expansion of the economic scale of both sides of the trade will lead to the similarity of their consumption structures and will promote intra-industry trade. The third perspective is related to the demand structure. Based on the mutual demand theory, similar demand structures should produce the trade of similar products, namely, intra-industry trade. The smaller the per capita income scale difference is, the more similar the consumption demand will be, which promotes the occurrence of intra-industry trade

between the two sides. Previous empirical studies have used per capita GDP to measure the similarity of demands among countries, and the difference of per capita income scale to reflect the heterogeneity of demand among countries.

(3) Trade environment: We consider the influence of trade environment on intra-industry trade of agricultural products from three perspectives, namely, the degree of trade opening, trade imbalance and trade competitiveness. First, the more open a country's trade, the more conducive it is to the introduction of FDI, which will significantly promote intra-industry trade. Second, trade imbalance has a hindering effect on the development of intra-industry trade between two countries. Third, it is generally believed that the greater the trade competitiveness of a product, the less conducive it is to the development of its intra-industry trade.

(4) Other influencing factors: Geographical distance will also have an impact on the development of intra-industry trade. On the one hand, geographic distance is positively correlated with the transmission cost of internationally differentiated product information. On the other hand, transportation cost is positively correlated with geographic distance, which in turn affects intra-industry trade. In addition, sudden international shocks may have an impact on the international economy and trade behavior. This paper focuses on the European sovereign debt crisis that broke out in 2010 and the trade war between the United States and China in 2018 and 2019 as major international events.

Table 2. Explanatory Variables of the Model

	Variables	Significance
Indicators of factor endowments	$AFDI_{ijt}$	Foreign direct investment in agricultural products: Stock of foreign direct investment of South Korea's ith agricultural product to its trading partner j in period t
	HUM_{jt}	Difference in human capital: Absolute difference in the proportion of higher education enrollment in the total population between trading partner j and South Korea in the period t
Indicators of economic development	DE_{jt}	Stage of economic development: Proportion of agricultural added value in GDP of trading partner j in period t minus the proportion of agricultural added value in GDP of South Korea taken as absolute value
	$ESjt$	Economic scale: GDP gap between South Korea and its trading partner country j in period t
	$DPGjt$	Difference in demand structure: Difference in per capita income between Korea and its trading partner j during period t
Indicators of trade environment	$OPjt$	Trade openness level: Ratio of the total global volume of import and export of trade partner j to the GDP of country j during period t
	$DIjt$	The ratio of the absolute value of the import and export difference between Korea and its trading partner j to that between Korea and its trading partner j during the period t of trade imbalance.
	$TCjt$	Agricultural product trade competitiveness: Ratio of country j to the world's agricultural product imports and exports during period t
Other influencing factors	$DISj$	Geographical distance: Distance between the central cities of South Korea and its trading partner j
	EC_t	External shocks to economy: Its value is 1 in 2010, 2018, and 2019, and 0 in other years.

5. Empirical Analysis

5.1. Spatial Autocorrelation Tests

Before estimating the spatial econometric model, it should be checked whether the intra-industry trade of agricultural products of various countries is spatially related. There are several methods to test spatial correlation in spatial econometrics, and among the most common we can mention Moran's I index, Geary's C index and Getis-Ord G index. The Moran's I index usually ranges from -1 to 1, and values greater than 0 indicate positive correlation, which means spatial agglomeration, while values less than 0 represent negative correlation, that is, spatial dispersion. The Geary's C index ranges from 0 to 2, and values greater than 1 suggest negative correlation, and smaller than 1 denote positive correlation. There is an inverse relationship between the two indexes.

Table 3 reports Moran's I and Geary's C indexes as well as their significance levels between the data of the intra-industry trade volume of agricultural products in various countries from 2010 to 2019. The data are used in order to examine the overall spatial correlation of the intra-industry trade volume of agricultural products in these countries.

Table 3. 2010-2019 Spatial Autocorrelation Moran's I Index and Geary's C Index and Tests

	Index	**P Value**	**Index**	**P Value**	**Index**	**P Value**	**Index**	**P Value**
	2010		2011		2012		2013	
Moran's I	0.341	0.000	0.355	0.000	0.368	0.000	0.375	0.000
Geary's c	0.425	0.000	0.415	0.000	0.418	0.000	0.412	0.000
	2014		2015		2016		2017	
Moran's I	0.386	0.000	0.405	0.000	0.416	0.000	0.438	0.000
Geary's c	0.406	0.000	0.396	0.000	0.392	0.000	0.375	0.000
	2018		2019		Mean			
Moran's I	0.436	0.000	0.442	0.000	0.397	0.000		
Geary's c	0.385	0.000	0.370	0.000	0.392	0.000		

As can be seen in Table 3, the P value of the two indexes in each year is less than 0.01, indicating that both indexes are significant at the level of 1%. The average Moran's I index and the average Geary's C index are also significant in each of the 10 years. It can be considered that the intra-industry trade of agricultural products in each country has a significant spatial correlation each year. Table 3 also indicates the changing characteristics of the two indexes. Moran's I basically shows an annual increasing trend, reaching the lowest value of 0.341 in 2010 and the highest value of 0.442 in 2019. Geary's C coefficient has been gradually decreasing in these years. It reached the highest value of 0.425 in 2010 and the lowest value of 0.370 in 2019. The Moran's I and the Geary's C indexes are obviously negatively correlated, which is consistent with their trends. It can be concluded that the data of the intra-industry trade volume of agricultural products in various countries present obvious spatial agglomeration effects.

5.2. Overall Research on Agricultural Products Industry

In order to estimate the spatial autoregressive and the spatial error autocorrelation coefficients, we will use the maximum likelihood (ML) estimation method. According to the results of Stata 16.0 testing, all variables are stable. The Hausman test statistic rejects the null hypothesis at the significance level, so the fixed effects model is selected. The spatial measurement test results show that LMlag is more significant than LMerr, indicating that SAR estimation results are better than SEM estimation results in model selection, and the higher R2 value in SAR than in SEM corroborates this conclusion. Based on the results of the above test, we will use the fixed-effect SAR model in order to analyze the influencing factors of intra-industry trade of agricultural products between South Korea and its trading partners.

Table 4. Model Estimation Results of Factors Affecting Intra-industry Trade of Agricultural Products between South Korea and Its Trading Partners

Variables/ parameters	OLS		SAR		SEM	
	FE	RE	FE	RE	FE	RE
$\ln AFDI_{ijt}$	0.147*** (8.95)	0.156*** (10.09)	0.059*** (3.90)	0.667*** (4.29)	0.129*** (8.28)	0.157*** (9.80)
HUM_{jt}	0.021*** (3.18)	0.068*** (10.30)	0.027*** (4.09)	0.072*** (10.90)	0.020*** (3.03)	0.069*** (10.45)
DE_{jt}	0.099*** (5.89)	0.073*** (7.70)	0.053*** (3.66)	0.056*** (5.99)	0.087*** (5.18)	0.067*** (6.09)
$\ln ES_{jt}$	0.221*** (5.35)	0.255*** (6.06)	0.156*** (4.37)	0.158*** (4.31)	0.252*** (6.50)	0.271*** (6.74)
DPG_{jt}	-2.031*** (-6.08)	-1.367*** (-4.33)	-0.899*** (-3.08)	-0.716*** (-2.50)	-2.056*** (-6.27)	-1.622*** (-4.82)
OP_{jt}	0.865*** (8.77)	0.859*** (8.75)	0.528*** (6.10)	0.535*** (6.09)	0.808 (7.95)	0.818*** (7.95)
DI_{jt}	-1.405*** (-15.90)	-1.435*** (-15.92)	-1.287*** (-17.42)	-1.326*** (-17.39)	-1.372*** (-16.34)	-1.385*** (-15.95)
TC_{jt}	-0.962*** (-3.75)	-0.867*** (-3.80)	-0.938*** (-4.43)	-0.876*** (-4.32)	-0.901*** (-3.71)	-0.828*** (-3.58)
$\ln DIS_j$	0.169 (0.63)	0.056 (0.21)	0.146 (0.54)	0.229*** (0.84)	0.175 (0.61)	0.020 (0.07)
EC_t	0.036 (-0.89)	0.019 (0.44)	0.026 (0.76)	0.026 (0.75)	0.052 (1.09)	0.036 (0.73)
β_0	-6.100 (-0.92)	-9.636** (-2.08)	-4.972 (-1.00)	-8.065 (-0.85)	-5.682 (-0.95)	-6.585 (-1.21)
ρ	—	—	0.468*** (3.29)	0.480*** (3.37)	—	—
σ	—	—	—	—	0.217** (2.14)	0.212** (2.50)
Hausman	55.62***		61.38***		58.89***	
Adjusted R2	0.812	0.807	0.851	0.856	0.849	0.851
LMlag			35.267***			
LMerr			3.265*			

Table 4 shows the estimation results of the ordinary panel data model, the panel spatial lag model (SAR), and the spatial error autocorrelation model (SEM). The spatial autoregressive coefficient ρ and the standard deviation of the disturbance term are both positive and significant at the significance level of 1%, indicating that there are spatial trade complementary effects and spatial spillover. That is, the increase in trade volume caused by the improvement of the trading environment in neighboring countries has led to the increase in the intra-industry trade of agricultural products between South Korea and its trading partners. The regression coefficient of the spatial measurement model is significantly different from the coefficient of the ordinary panel model, which means that ignoring the promotional role in trade played by interactive effects between neighboring countries may lead to an overestimation of the effects of other factors.

The estimation results of the spatial autoregressive model (SAR) show that the elastic coefficients and signs of AFDIijt, HUMjt, DEjt,,ESjt, DPGjt, OPjt, DIjt, and TCjt are basically consistent with the expected results. Among them, the coefficients of AFDIijt and HUMjt are positive and pass the 1% significance test, indicating that the foreign direct investment in agriculture and the difference in human capital between Korea and its trading partners have promoted the expansion of bilateral agricultural trade. The stage of economic development, DEjt, and the economic scale, ESjt have significant positive impacts on the volume of intra-industry trade of agricultural products, while the differences in demand structure DPGjt have a significant negative impact. Therefore, we can conclude that the larger the economic scale gap and the greater the differences in stages of economic development between South Korea and its partners, the smaller the scale of possible intra-industry trade of agricultural products. On the other hand, a greater difference in the demand structure does not facilitate the development of intra-industry trade of agricultural products. The trade openness level OPjt is significantly positive at the level of 1%, indicating that this factor plays a role in promoting the development of intra-industry trade of agricultural products. The degree of trade imbalance, DIjt, and the agricultural product trade competitiveness, TCjt, are negatively correlated with the volume of intra-industry trade, denoting that the greater the trade imbalance between South Korea and its trading partners and the stronger the international competitiveness of agricultural products in its trading partners, the lower the development of intra-industry trade of agricultural products for both parties. The coefficients of geographical distance, DISjt, and the external shock of the dummy variable, ECt, are not significant, showing that the European sovereign debt crisis and the trade war between the United States and China have not had a significant impact (at least for now) on Korean intra-industry trade of agricultural products. Although there exists a spatial spillover effect, the geographical distance is not a determinant factor of the total intra-industry trade of agricultural products.

5.3. Research on the Classification of Agricultural Products

Since the overall regression results support the spatial autoregressive model rather than the spatial error autocorrelation model, in this section we will only refer to the estimated results of the first model (SAR). The null hypothesis of the Hausman test statistics is rejected for textile raw materials but it is not rejected for animal products, cereals and oilseeds and plant products. Therefore, we report the results of the random-effect model except for textile raw materials, for which we show the results of the fixed-effect model. The model estimation results are shown in Table 5.

Table 5. Estimation results of sub-category SAR model

Variables	Animal products	Processed agricultural products	Plant products	Cereals and oilseeds	Textile raw materials
$\ln AFDI_{ijt}$	0.112*** (3.04)	0.123*** (5.14)	0.131*** (4.80)	0.181*** (3.16)	-0.552*** (-2.83)
HUM_{jt}	0.016*** (3.66)	0.047*** (10.75)	0.039*** (6.78)	0.022*** (3.82)	0.008*** (2.53)
DE_{jt}	0.057*** (3.09)	0.060*** (4.48)	0.073*** (5.17)	0.112*** (4.36)	-0.416** (-2.06)
$\ln EG_{jt}$	0.255*** (2.81)	0.116* (2.09)	0.116* (1.73)	0.138 (0.88)	-0.128 (-0.26)
DPG_{jt}	-2.511*** (-3.35)	-0.831* (-1.86)	-1.557*** (-3.06)	0.753 (0.66)	-8.252** (-2.07)
OP_{jt}	0.581*** (2.72)	0.653*** (5.09)	0.387** (2.51)	1.316*** (3.68)	6.105*** (5.19)
DI_{jt}	-1.510*** (-7.91)	-1.132*** (-9.78)	-0.359*** (-2.57)	-0.391 (-1.15)	-0.385 (-0.36)
TC_{jt}	-1.101*** (-2.33)	0.295 (0.99)	0.112 (0.315)	0.486 (0.66)	-12.360*** (-4.05)
$\ln DIS_j$	0.183 (0.37)	0.126 (0.35)	-0.509 (-1.37)	-1.258*** (-2.01)	0.375 (0.98)
EC_t	-0.037 (-0.42)	-0.012 (-0.23)	-0.031 (0.47)	0.032 (0.20)	-1.580*** (-3.24)
β_0	-2.163 (-0.81)	-5.717** (-2.26)	-3.761* (-1.66)	-5.076 (-0.96)	-5.962 (-1.16)
ρ	0.112* (1.80)	0.581*** (11.89)	0.517*** (9.29)	0.077 (1.37)	0.089 (1.38)
Adjusted R^2	0.611	0.805	0.669	0.385	0.307

(1) Spatial effect: The spatial autoregressive coefficients ρ of animal products, processed agricultural products, and plants products are all significantly positive, showing an obvious spatial effect. The spatial autoregressive coefficients of cereals and oilseeds, and textile raw materials are not significant. One of the possible reasons explaining this fact is that labor-intensive agricultural products are more processable and more diversified than land-intensive agricultural products. The difference in agricultural product trade structure promotes product diversification, which is conducive to expanding the volume of intra-industry trade of agricultural products, thereby promoting trade spillover effects. The second possible reason is that technology spillovers are often considered to be one of the factors of economic dependence between countries. Compared with labor-intensive agricultural products, land-intensive products show a lower technical level, leading to lower possibilities of technology spillovers. Therefore, there exists a significant spatial correlation between volumes of intra-industry trade of labor-intensive agricultural products. The spatial correlation between land-intensive agricultural products is not significant.

(2) Impact of factor endowments: The coefficients of $AFDI_{ijt}$ in the regression results of animal products, processed agricultural products, cereals and oilseeds, and plant products are all positive, and all of them pass the significance test with a significance level of 1%, denoting that the foreign investment in these types of agricultural products is efficiency-driven. Among the four products, the elasticity coefficient of grain and oilseeds was significantly higher than that of other agricultural products, followed by horticultural products and animal products. The possible reason is that animal products tend not to require much reprocessing compared to other types of products, thus the impact of outward direct investment on animal products through technology spillovers is the weakest. Textile raw materials require simple technology and relatively small scale of equipment, and foreign direct investment in them is mainly market-oriented. Therefore, the coefficient of foreign direct investment in the textile raw materials model is significantly negative, indicating that foreign direct investment in such products will hinder the development of intra-industry trade. The regression coefficients of the differences in human capital in all kinds of agricultural products are positive and pass the 1% significance test, showing that the differences in human capital have a positive impact on the intra-industry trade of all kinds of products. This verifies the previous conjecture that the differences in human capital cause the differences in product quality and promote the occurrence of intra-industry trade.

(3) Influence of economic development level: The regression coefficients of all types of agricultural products in the stage of economic development pass the significance test at the level above 5%. The regression coefficient of four kinds of agricultural products, such as cereals and oilseeds, is positive, while the regression coefficient of the textile raw materials model is negative. This indicates that the evolution of the economic development stage has an inhibitory effect on the intra-industry trade scale of textile raw materials, while it has a promoting effect on the intra-industry trade scale of grain, oilseeds and other products. The economic scale (EG) has a positive impact on animal products, processed agricultural products and plant products, and passes the significance test at the 1% level. However, the impact on cereals and oilseeds and textile raw materials is not significant. This shows that intra-industry trade of land-intensive agricultural products may not be affected by the economic scale. The possible reason is that South Korea's land-intensive agricultural products lack comparative advantages, but its labor-intensive agricultural products feature strong international competitiveness and are more susceptible to the economic scale of its trading partners. Except for cereals and oilseeds, the coefficients of difference in per capita income (DPG) of other products are all significantly negative. The greater the difference in per capita income, the smaller the intra-industry trade volume of other types of agricultural products. The coefficient of the difference in per capita income between cereals and oilseeds is not significant. The possible reason is that cereals and oilseeds are necessary goods, and changes in their supply and demand have little effect on them.

(4) Impact of the trade environment: The coefficient of trade openness (OP) level is positive and passes the 1% significance test. Prior literature generally agrees that the development of intra-industry trade is positively related to the degree of trade openness. Textile raw materials have the largest trade openness coefficient, followed by cereals and oilseeds, indicating that intra-industry trade of land-intensive agricultural products is more affected by trade openness than that of labor-intensive agricultural products. The degree of trade imbalance (DI) has a negative impact on all five categories of agricultural products, but has no significant impact on cereals and oilseeds and textile raw materials. Labor-intensive agricultural products are more vulnerable to trade protection, and in recent years, developed countries have implemented technical barriers to trade. Consequently, the degree of trade imbalance

cannot truly reflect the actual trade situation, resulting in an illusion that the intra-industry trade of labor-intensive agricultural products is not affected by the degree of trade imbalance.

The coefficient of agricultural product competitiveness (TC) is significantly negative in the regression results of animal products and textile raw materials. Moreover, in terms of textile raw materials, trade is most negatively affected by the competitiveness of agricultural products. The reason for this is the lack of comparative advantages for textile raw materials because such products have a low degree of product differentiation. Compared with other types of products, textile raw materials are more dependent on intra-industry trade.

(5) Other factors: Geographical distance (DIS) only has a significant negative impact on the intra-industry trade of cereals and oilseeds. The intra-industry trade of other types of agricultural products are not significantly impacted. The possible reason is that cereals and oilseeds are easily affected by transportation, storage and preservation restrictions, causing geographical distance to have a negative impact on them.

The estimated coefficient of the external shock (EC) in the textile raw materials model is negative, and it passes the 1% significance test, indicating that the intra-industry trade of textile raw materials is most affected by the European sovereign debt crisis and the trade war between the United States and China. The intra-industry trade of textile raw materials is generally a vertical intra-industry trade, which is more dependent on the international market in terms of raw materials quality and high-end equipment, and thus more vulnerable to the negative impact of external shocks in the international market.

5.4. Robustness Test

The spatial weight matrix is highly sensitive to the estimation results of the spatial econometric model. In view of the fact that the spatial weight matrix in the previous model was constructed using the geographical distance weighting method, however, intra-agricultural trade may be more affected by the level of agricultural development and the difference of agricultural products. Therefore, based on the characteristics of agricultural products, the distance weight matrix of agricultural products industry was constructed according to the construction method of spatial weight matrix to test the robustness of the above model. The definition method of agricultural-product-industry distance followed Jaffe (1986)'s definition of technical distance. The specific process was as follows:

The five categories of agricultural products selected in this paper (animal products, processed agricultural products, cereals and oilseeds, plant products and textile raw materials) are considered into a five-dimensional agricultural-product-industry space, and the decentralized correlation coefficient of the agricultural product industry vectors A_i and A_j between the two countries is used to measure the proximity of the agricultural product industries of trading partners i and j. The calculation formula is:

$$w_{ij} = A_i A_j ' / [(A_i A_j ')\bullet(A_i A_j ')]^{\frac{1}{2}}$$

When the industry vectors of the two countries are equal, its value is 1. When the two countries' industry vectors are orthogonal, its value is 0. In the above formula, the weight matrix is the distance weight matrix of agricultural products industry, and the value between all trading partners is between 0 and 1. To test the robustness of the model, the SAR model was still selected for the LMlag and Lmerr tests, and the spatial autoregressive coefficient is significant. The signs of coefficients' estimator, and the significance test results of LnAFDI, lnEG, lnDPG, lnAD, OP, DI, TC, lnDIS, and EC are not much different.

6. Conclusions and Recommendations

6.1. Conclusion

The scale of Intra-industry trade of Korea's agricultural products keeps increasing, but the regional differences are obvious. The intra-industry trade volume between Korea and Asia and America is higher than that of other regions, and the intra-industry trade distribution of different categories of agricultural products is different in each region. Based on the panel data from 2010 to 2019, a spatial autoregression model was established to analyze the influencing factors of intra-industry trade of agricultural products, and the degree and direction of the influencing factors were investigated from the perspective of the categories of agricultural products.

The study found that, firstly, with the deepening of globalization, intra-industry trade of agricultural products between Korea and its trading partners presents spatial effects, and ignoring these spatial correlations can lead to deviation in the estimation of the effects of various factors.

Secondly, from the point of influence factors, Input factors, including outward direct investment and human capital differences between Korea and the trading partners have significant promoting effects on the scale of intra-industry trade of Korean agricultural products. In economic development factors, the stage and scale of economic development have significant promoting effects on the scale of intra-industry trade of agricultural products, while demand structure in per capita income level differences have inhibitory effect. The degree of trade openness has a positive influence on the intra-industry trade of agricultural products, while the degree of trade imbalance and the competitiveness of agricultural products trade have a negative influence on the intra-industry trade of agricultural products. Geographical distance and external shocks have no obvious effect on the overall intra-industry trade of agricultural products in South Korea.

Finally, from the perspective of trade structure of agricultural products, intra-industry trade spillover effect of land-intensive agricultural products (cereals and oilseeds, textile raw materials) is not significant, while intra-industry trade of labor-intensive agricultural products (animal products, processed agricultural products and horticultural products) shows significant and positive spatial spillover effect. The main form of intra-industry trade of labor-intensive agricultural products is that relatively developed countries invest in and build factories in relatively less developed countries, export raw materials or intermediate products to them, assemble and ship them back to their home countries, and most of such types of trade belong to vertical intra-industry trade. But as each country's industrial structure is upgrading, the proportion of horizontal intra-industry trade between Korea and its Asian neighbours is increasing.

6.2. Policy Suggestions and Inspirations

(1) Improve international coordination mechanisms and strengthen cooperation in the regional economy and trade. The obvious spatial spillover effect indicates that intra-industry trade of agricultural products in Korea is significantly affected by neighboring countries. Based on this, and in relation to the development of this type of trade, South Korea should replace bilateral relations with multilateral relations, strengthen exchanges and cooperation with neighboring countries, and promote the development of multilateral intra-industry trade.

(2) Differentiated policies should be adopted for different types of agricultural products. Differentiated production strategies should be formulated and implemented according to the characteristics of each product, and "differentiated targeted" trade policies should be formulated to meet the international demand for agricultural products of different qualities. The formation of closer multilateral trade links with other countries should also be promoted. For labor-intensive agricultural products, attention should be paid to the external effect of neighboring countries' development, regional trade cooperation should be strengthened, and brands of agricultural products with Korean characteristics should be promoted to participate in international competition. For land-intensive agricultural products, attention should be paid to quality and core value.

(3) Increase cooperation and direct investment in efficiency-driven agricultural products in China, Southeast Asia and other regions. The intra-industry trade index between Korea and Asia is the highest one. Compared with Korea, ASEAN is an underdeveloped region. China, despite its growing economic strength, is South Korea's second largest trading partner. However, it is undeniable that it is still at a relatively backward stage in the processing of many agricultural products, and its agricultural industry still contains a large number of processing business of intermediate agricultural products. To strengthen the investment with China and Southeast Asia in the establishment of plants in the cereals and oilseeds, horticultural products and other agricultural products, the industry can play the comparative advantage of this kind of product in Korea. The textile industry is obviously affected negatively by the sudden external shocks. In view of the current turbulent international situation, reducing the textile industry's foreign investment is beneficial to the intra-industry trade.

(4) Maintain technological and capital advantages, and promote the coordinated development of vertical and horizontal intra-industry trade of agricultural products. Asia has been the region with the largest intra-industry trade in agricultural products with South Korea. As a developed country, South Korea has advantages over its Asian neighbors, including China, in terms of capital and technology, but disadvantages in terms of natural resource endowment and labor force. Before 2015, the intra-industry trade of agricultural products between South Korea and its Asian neighbors was mainly vertical intra-industry trade. However, with the development of science and technology in China, Vietnam and other countries, the technological gap between the Asian neighbors and South Korea is narrowing, and the proportion of vertical intra-industry trade is declining. In order to maintain the balance of agricultural trade with its Asian neighbors, South Korea must constantly improve the level of science and technology in its agricultural industry, develop technology-based and differentiated agricultural products, and maintain the stability of vertical intra-industrial trade. At the same time, the capital advantage must be used to form the industrial chain of technology-based agricultural products, to realize the scale economy of some technology-based agricultural industries, and to maintain the diversification of agricultural products export and domestic agricultural products supply in the horizontal intra-industry trade.

References

Fertő, I. (2007), “Intra-industry trade in horizontally and vertically differentiated agri-food products between Hungary and the EU”, *Acta Oeconomica,* 57(2), 191-208.

Gong, Xin-Shu and Ning Liu (2015), “A Positive Study of the Level and the Structure of Intra-industry Trade in Sino-Russian Produce Based on Silk Road Economic Zone as Strategic Background”, *Asia-pacific Economic Review,* 2, 50-54.

Grubel, H. G. and P. J. LLOYD (1975), "Intra-industry Trade: the Theory and Measurement of International Trade in Differentiated Products", *The Economic Journal,* 85(339), 646-648.

Hoang, V. (2019), "The Dynamics of Agricultural Intra-Industry Trade: A Comprehensive Case Study in Vietnam", *Structural Change and Economic Dynamics,* 49, 74-82.

Liao, Dong-Sheng and Yuan Zhou (2014), "Comparative Analysis of Agricultural Trade between China and Thailand", *Academic Forum,* 3, 76-80.

Liu, Yi-Zhuo, Chang-Sheng Zuo and Hong-Yuan Xu (2006), "Analysis of Intra-industry Trade of Forest Products in China", *Chinese Rural Economy,* 9, 38-44.

Lu, Wen-Cong and Yan Mei (2005), "An Empirical Analysis of Agricultural Intra- industry Trade between China and EU", *Journal of International Trade,* 12, 41-47.

McCorriston, S. and I. M. Sheldon (1991), "Intra-Industry Trade and Specialization in Processed Agricultural Products: The Case of the US and the EC", *Applied Economic Perspectives and Policy,* 13(2), 173-184.

Rasekhi, S. and S. S. Shojaee (2012), "Determinant Factors of The Vertical Intra-industry Trade in Agricultural Sector: A Study of Iran and Its Main Trading Partnersc Agricultural Economics, 58, (4), 180-190.

Sun, Jiang-Ming and Xin-Yi Chu (2019), "Analysis of Intra-industry Trade between China and Its Trading Partners -- SAR Model based on classified Agricultural Products", *World Agriculture,* 10, 61-70+104.

Yang, Yue-Hui and Jian-Zhou Yang (2012), "Empirical Study on the Dominant International Competitiveness of China Main Flower Products", *Journal of Fujian Forestry Science and Technology,* 4, 57-61+68.

Yong, Chen-Chen, Siew-Yong Yew and Mui-Yin Chin (2019), "Spatial Panel Analysis on Asean-China Trade Links", *The Singapore Economic Review,* 64(3), 709-726.