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The Evolutionary Trends and Influential Factors Analysis of Agricultural Trade between South Korea and RCEP Member Countries

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ABSTRACT

With the acceleration of regional economic integration, the agricultural trade network within the RCEP region presents new opportunities and challenges for member countries. This study focuses on agricultural trade among RCEP members from 2011 to 2020, utilizing social network analysis to explore the structural characteristics and evolutionary trends of the trade network. Additionally, an extended gravity model is employed to empirically analyze the key factors influencing South Korea's agricultural trade with other member countries. The findings reveal that: (1) Agricultural trade relationships within the RCEP region are stable and mature, with high interconnectivity in the trade network, indicating a trend towards balanced development. (2) The positions of member countries within the agricultural trade network are characterized by both high density and heterogeneity. (3) South Korea's agricultural trade with RCEP member countries is positively influenced by the economic size, population size, and governance level of its trading partners, while South Korea's own indicators show no significant effect. The trade distance between South Korea and member countries also has a positive impact on agricultural trade. By combining social network analysis with an extended gravity model, this study provides a multi-faceted quantitative analysis of the RCEP agricultural trade network, offering new insights into regional agricultural trade. It also provides empirical evidence for agricultural trade cooperation between South Korea and other RCEP countries.

☞ keyword : RCEP, Agricultural Trade, Evolutionary Trends, Social Network Analysis, Extended Gravity Model

1. Introduction

The Regional Comprehensive Economic Partnership (RCEP) unites theeconomic forces of the ten ASEAN countries along with China, Japan, South Korea, Australia, and New Zealand, forming a vast free trade alliance encompassing 15 member countries. The official implementation of RCEP on January 1, 2022, marks not only a new phase in regional economic integration but also signifies a profound transformation in the landscape of free trade cooperation across the Asia-Pacific region.

Currently, RCEP stands as the largest regional free trade agreement globally. The 15 members account for over one-third of the world's population, approximately one-third of the global GDP, and about one-third of the total international trade, showcasing unprecedented breadth and depth of economic integration. The core mission of RCEP focuses on reducing tariff barriers and non-tariff measures, thereby enhancing the liberalization and facilitation of trade in goods and services. This initiative aims to strengthen the economic ties among member states and advance the grand objective of regional economic integration. Within this framework, agricultural trade under RCEP exhibits a series of unique and notable characteristics.

Firstly, the distinctiveness of RCEP lies in the diversity of its members, encompassing nations at various stages of economic development. This structure creates a diversified market ecosystem for agricultural trade within the region. Secondly, with the formal implementation of the RCEP agreement, over 90% of goods trade within the region will progressively benefit from zero-tariff treatment. This will effectively reduce the costs of agricultural trade and enhance the market competitiveness of the products. Lastly, the rules of origin established by RCEP not only facilitate the deep integration of regional industrial and supply chains but also provide a clearer and more predictable trading environment for agricultural trade among member countries.

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Moreover, as economic development and industrialization advance, a slowdown in agricultural growth is inevitable, particularly for countries with high population densities (Anderson, 2010). To sustain economic development in the Asia-Pacific region, agriculture remains one of the most strategically significant sectors for expanding and strengthening cooperation. Most RCEP countries are located in Southeast Asia and possess abundant natural resources, providing a robust foundation for agricultural trade. China, being the world's largest agricultural economy, has seen its agricultural exports to other RCEP members more than triple from 2001 to 2019 (Feng et al., 2022). By around 2020, exports to the other 14 RCEP members accounted for approximately 40% of China's total agricultural exports (Ding et al., 2022). Furthermore, similar to how the United States has sought to diversify its overseas markets beyond China, the signing of RCEP helps mitigate risks for China's agricultural trade amid Sino-American trade tensions.

Similarly, agriculture in South Korea, as a fundamental industry of the national economy, has transitioned from traditional to modern practices, achieving significant advancements in precision farming and mechanization. These developments have effectively enhanced food security and driven economic growth. However, South Korean agriculture still faces challenges such as fragmented land holdings, labor shortages, and high input costs (Yoon et al., 2024). Additionally, income inequality and polarization among farmers are becoming more severe, potentially affecting the future structure of South Korean agriculture (Sung et al., 2017). Research by Lee et al. (2014) has identified structural difficulties in agricultural trade between South Korea and various countries, including consumer preference biases, trade barriers, and policy obstacles.

Under the RCEP framework, how South Korea can leverage its strengths in agricultural trade to further expand international markets and mitigate domestic agricultural risks is a topic worth exploring. In this context, an in-depth study of South Korea's agricultural trade with RCEP members is particularly important. Such research can not only provide a comprehensive understanding of South Korea's agricultural development within the RCEP framework but also offer a scientific basis for formulating sound trade policies, thereby enhancing the competitiveness of South Korean agricultural products in the international market. Furthermore, the study can reveal trade barriers and opportunities among RCEP members, helping South Korean enterprises better adapt to and capitalize on the benefits of regional cooperation, thus increasing the international visibility and market share of South Korean agricultural products.

The subsequent sections of this paper are structured as follows: the second part is a literature review, covering RCEP, agricultural trade, and social network analysis. The third part presents the methodology and construction of the trade network. The fourth part discussesthe characteristics and evolution of the agricultural trade network within the RCEP region. The fifth part investigates the factors influencing South Korea's agricultural trade. The sixth part concludes with a discussion. This study provides crucial empirical evidence for the formulation of trade policies under RCEP, particularly regarding South Korean agricultural trade.

2. Literature review

2.1 Research on RCEP

With the proposal and signing of RCEP, scholars from various fields have conducted in-depth research on this regional agreement. Zainuddin et al. (2020) explored the impact of non-tariff measures on bilateral exports among RCEP member countries and the coverage of bilateral trade among these nations. A comparative analysis of different free tradezones has also been a research focus. Jiang et al. (2021) described the trade relations between China and RCEP and CPTPP member countries, discussing the differences between the two agreements and highlighting the advantages and challenges faced by China. Pomfret (2021) also conducted a comparative analysis of the rise of large regional agreements such as CPTPP and RCEP.

In the field of energy trade, a plethora of studies with rich content and novel perspectives has emerged. These include research on the energy investment layout of RCEP countries by Xia (2020), exploration of implicit energy flows and carbon emissions within RCEP by Ma et al. (2021), a study on regional energy cooperation mechanisms by Xu et al. (2021), an empirical analysis of energy efficiency and its

influencing factors in RCEP countries by Zhang et al. (2022), an investigation into the relationship between economic growth and energy intensity in RCEP countries by Xia et al. (2023), and an examination of the impact of export diversification and the composite risk index of RCEP countries on CO_2 emissions by Khan et al. (2021).

In the realm of agricultural and forestry product research, Simanullang et al. (2022) conducted an analysis of the spatial effects and influencing factors of agricultural product imports within RCEP. Pan et al. (2023) integrated tariff policies to forecast the export potential of forestry products within RCEP. Jin et al. (2024) employed a multi-regional input-output (MRIO) analysis to investigate the relationships among water, energy, and carbon flows in agricultural trade.

2.2 Agricultural Products Trade

Agricultural trade plays a crucial role in ensuring global food security, promoting rural development and economic growth, as well as strengthening economic cooperation and exchange among nations (Kitetu et al., 2020). The academic community maintains a keen interest in the research of agriculture and agricultural products. Anderson (2010), drawing on discussions about past agricultural developments, has proposed potential driving factors and uncertainties in global food and other agricultural product trade trends for the next four decades.

Weinzettel et al. (2019), focusing on specific geographic cropland areas for 236 countries and 186 crops, tracked the final consumption points of each crop through supply networks. Ahmad et al. (2021), with Pakistan as the subject of their study, explored the overall impact of agricultural trade liberalization and protection on agricultural production, trade, income redistribution, and public welfare. Kireyenka (2021) introduced various agricultural types with different levels of social and economic development and diverse land use patterns in different countries, identifying the world's major agricultural food-producing countries, exporters, and importers.

Research on the correlation between agriculture and the environment is also receiving attention. Rega et al. (2019) estimated the trade-off relationships between agricultural output and two key agricultural environmental indicators in Europe for the year 2040 under four different scenarios. Xie et al. (2020) explored the evidence of the impact of climate change on Chinese agriculture. Kitetu et al. (2020) investigated the economic impacts of climate change on agriculture in the year 2050.

Regional agricultural trade is a crucial area of focus for scholars. Numerous researchers have employed the extended gravity model to study the agricultural trade potential of countries along the "Silk Road" economic belt (Wang et al., 2017; Cao et al., 2018; Yang et al., 2020). Research on agricultural products in China, Japan, and South Korea has been a key focus in academia. Eor (2004) conducted an analysis of agricultural production factors, productivity, and trade structure in China, Japan, and South Korea. The study revealed common characteristics in the agriculture of these three countries, suggesting that they could explore various agricultural cooperation measures for mutual development in Northeast Asia.

Subsequent research by Cho et al. (2013) empirically assessed the impact of the China-Korea Free Trade Agreement on the industrial competitiveness and labor markets of both countries, proposing win-win strategies. Moon et al. (2016) identified specific challenges faced by Korean agriculture, particularly the contradiction between diminishing domestic production and societal expectations. The study provided corresponding recommendations to address these issues.

2.3 Social Network Analysis

SNA is a methodology for studying social structures by analyzing the relationships (or "edges") among individuals (or "nodes") to understand the network of social relationships. It focuses on how individuals are connected to each other and how these connections influence the behavior and attributes of individuals and the entire network. Researchers can use various metrics such as degree, network density, centrality, and structural holes to uncover hidden patterns and dynamics within the network (Koschade, 2006), as well as the potential impact of these patterns on economic activities.

In recent years, SNA has found widespread application in trade-related research. Liu et al. (2019) employed SNA methods to study the structure of the global polysilicon trade network from 2006 to 2016, exploring the characteristics of each country within the network. Baek et al. (2019) aimed to understand the current status and issues of the South Korean beauty industry by analyzing the trade network in the cosmetics market, proposing future development directions for K-beauty. Pedroza-Gutiérrez et al. (2020) utilized methods such as semi-structured interviews and social network analysis to analyze the network structure and relationship systems within the seafood supply chain. Wang et al. (2020) used complex network methods and spatial analysis to study the network and spatial characteristics of international natural resource trade from 2000 to 2016.

In summary, SNA has demonstrated clear advantages in various trade studies, contributing significantly to understanding the overall characteristics of trade networks and revealing trade relationships between countries, as well as identifying key trading partners. Now, considering agricultural products as a crucial category of commodities, is their trade network characterized by similar spatial features as other commodity trade networks? As RCEP is a relatively young free trade agreement, what structural patterns emerge in the regional agricultural trade network? This study aims to leverage SNAto deconstruct the network characteristics and evolution of agricultural trade within the RCEP region, with a specific focus on exploring the primary influencing factors of agricultural trade in South Korea.

3. Methodology

3.1 Research Subject and Data Source

This study focuses on the 15 member countries of the RCEP with the aim of exploring the agricultural trade network among these nations from 2011 to 2020. Specifically, this paper conducts a detailed analysis of the overall structural characteristics of the agricultural trade network within this region. It delves into the positions of each member country in the trade network and identifies the key factors influencing agricultural trade between South Korea and other member countries.

To achieve this, our study utilizes the CHRTD (Global Resource Trade Database), which covers bilateral trade data for natural resources among over 200 countries and regions. The database includes the monetary value and trade volume of over 1,350 different types of natural resources and their products. We extracted agricultural trade data between RCEP member countries from 2011 to 2020 and employed the UCINET software to construct annual agricultural trade networks, calculating relevant network metrics. These metrics help us thoroughly analyze the structural characteristics and evolution of the agricultural trade network. Finally, we employed linear regression analysis using SPSS software to systematically analyze the influencing factors of South Korea's agricultural trade relationships.

3.2 Research Method

SNA is an interdisciplinary analytical method for studying relationships among individuals. Through the visualization and analysis of network nodes (such as people, organizations, and countries) and their interconnections (such as social relations, information exchange, and trade relations), SNA reveals the structure of networks, the status of individuals within networks, and their roles. This analysis plays a crucial role in understanding organizational structures, social patterns, information flow, and trade relations. Therefore, the application of SNA is extensive, spanning fields such as economics and trade, organizational management, sociology, computer science, and medicine. In summary, SNA provides a systematic approach to a deep understanding of interactions among individuals, and hidden patterns within network structures, and offers insight for decision-making. Its significance is evident not only in academic research but also in providing essential guidance for optimizing relationships and networks in practical applications.

Building on this foundation, our study employs the extended gravity model to further investigate the key factors influencing agricultural trade between South Korea and other RCEP member countries. For more details, please refer to Chapter 5.

3.3 Construction of Trade Networks

Constructing network models is a crucial method for studying regional trade. A network model consists of nodes and ties between nodes, where nodes represent entities in the network, ties represent relationships between entities, arrows on the ties indicate the direction of the relationships, and the thickness of the ties represent the weight of the relationships.

This study draws inspiration from the approach of Ding et al. (2022) and utilizes social network theory to construct a regional agricultural trade network. Taking the 15 member countries as nodes, the agricultural trade relationships between countries are represented as ties. The direction of the ties indicates the flow of agricultural trade, with the weight of the ties representing the total agricultural trade volume. In theory, this network comprises 15 nodes and 210 ties. The RCEP agricultural trade network is denoted as:

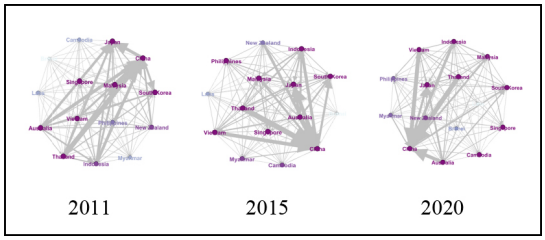
$$Net=(C,R)$$

Where Net represents the agricultural trade network, C represents the 15 member countries $C=(c_1,c_2,\cdots c_{15})$, and R represents the agricultural trade relationships in the network. R_{ij} represents the volume of agricultural trade from country i to country j, reflecting both the presence of trade relationships and the magnitude of trade volume.

4. Characteristics and Evolution of Agricultural Trade between South Korea and Other RCEP Member Countries

4.1 Evolution Trends of Trade Networks

The RCEP agricultural trade network is illustrated in Figure 1. From left to right, it represents the trade networks for the years 2011, 2015, and 2020, respectively. The thickness of the ties is used to emphasize the magnitude of agricultural trade amounts among the 15 RCEP countries—thicker ties indicate larger trade volumes. The size and color of the nodes are indicative of the number of trade partners for each country.



(Figure 1) Agricultural Trade Networks

Based on the RCEP agricultural trade network and its evolutionary trends depicted in Figure 1, we observe the following characteristics. Firstly, there is a significant disparity in the agricultural trade volumes among member countries in this network. Specifically, Brunei, Laos, Cambodia, and Myanmar exhibit relatively low trade volumes, with Brunei and Laos consistently maintaining very low trade volumes throughout the entire observation period, indicating their limited participation in regional agricultural trade.

Secondly, the trade pattern in this network exhibits a certain degree of hub-and-spoke structure, with a few countries such as China, Indonesia, Malaysia, Japan, South Korea, Australia, Thailand, and Vietnam demonstrating high activity and dominant positions in agricultural trade. Particularly noteworthy is China's significant advantageous position in both imports and exports, while South Korea shows a noticeable difference with a stronger demand for imports compared to export capabilities.

Lastly, from a regional perspective, the overall import demand within the RCEP region surpasses export capabilities. This finding points to the degree of dependence on agricultural products by some countries in the region and highlights potential market opportunities. The unbalanced trade pattern has significant implications for regional trade policies and economic cooperation strategies, suggesting the need for further optimization of trade structures within the region to promote trade balance and sustainable development.

4.2 Overall Characteristics and Evolution

Based on constructing the agricultural trade network, this study utilized UCINET 6 to obtain overall network

characteristics such as the number of nodes, number of ties, average degree, network density, and centrality. The results are presented in the table below.

(Table 1) Overall Characteristics of Agricultural Trade Network

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Nodes	15	15	15	15	15	15	15	15	15	15
Ties	201	202	202	203	204	203	204	205	207	203
Avg Degree	13.400	13.467	13.467	13.533	13.600	13.533	13.600	13.667	13.800	13.533
Density	0.957	0.962	0.962	0.967	0.971	0.967	0.971	0.976	0.986	0.967
Deg-Cen	0.050	0.044	0.044	0.039	0.033	0.039	0.033	0.028	0.017	0.039
Out-Cen	0.046	0.041	0.041	0.036	0.031	0.036	0.031	0.026	0.015	0.036
In-Cen	0.046	0.041	0.041	0.036	0.031	0.036	0.031	0.026	0.015	0.036

The number of nodes (Nodes) refers to the number of entities in the network, with nodes representing the countries participating in agricultural trade in this study. From 2011 to 2020, the number of nodes remained constant at 15. This indicates the stability in the number of member countries in the RCEP agricultural trade network.

The number of ties (Ties) represents the number of trade relationships in the network, specifically referring to the agricultural trade relationships among the 15 RCEP countries in this study. Theoretically, the maximum number of ties in the RCEP network is 210. From 2011 to 2020, the actual number of ties in the RCEP network fluctuated slightly between 201 and 207, indicating a stable yet gradually increasing number of trade relationships. This suggests close and progressively expanding trade interactions. However, in 2020, the number of ties dropped to 203, likely due to the sudden impact of the COVID-19 pandemic.

The average degree (Avg Degree), representing the average number of ties per node, reflects how many other countries, on average, each member country engages in trade relationships with. The average degree increased from 13.400 to 13.800, indicating a slight growth in the average number of trading partners for each country. On average, each country maintained a stable number of trading partners throughout the study period.

The network density (Density) is the ratio of the actual number of connections in the network to the total number of possible connections. A higher value indicates a tighter connection among nodes in the network. The maximum value is 1. The density of the RCEP agricultural trade network remained relatively high over the decade, fluctuating between 0.957 and 0.986. This high density indicates a highly interconnected network, where almost all countries have direct trade connections with many other member countries.

Degree Centralization (Deg-Cen) measures the degree to which nodes differ in the number of relationships they possess. It can be divided into Out-degree Centralization (Out-Cen) and In-degree Centralization (In-Cen). High centralization indicates that some nodes in the network have much higher degrees than others, establishing a dominant position in the network. In this study, centrality is low and shows a decreasing trend. It decreases from 0.050 to 0.017, suggesting that there is no clear dominant country in the agricultural trade network, and the roles of member countries in the network are relatively balanced. Both out-degree centralization and in-degree centralization exhibit consistency, indicating balance in regional agricultural trade on both the export and import levels.

In conclusion, the RCEP agricultural trade network demonstrates stability in the number of member countries, a high level of interconnectivity, and a shift towards more closely-knit and balanced trade relationships.

4.3 Individual Characteristics and Evolution

4.3.1 Degree centrality

Degree centrality refers to the number of ties a node has with other nodes in a network. In a directed network, it is further divided into out-degree centrality, which represents the number of ties going from a node to other nodes, and in-degree centrality, which represents the number of ties coming into a node. In this study, these measures indicate the countries to which a specific country exports agricultural products and from which it imports. Degree centrality for the years 2011, 2013, 2015, 2017, and 2019 was calculated for theunweighted directed agricultural trade network, as shown in the table below:

(Table 2) Degree Centrality of Agricultural Trade Network

	Out-Degree centrality					In-Degree centrality				
	2011	2013	2015	2017	2019	2011	2013	2015	2017	2019
Australia	14	14	14	14	14	14	14	14	14	14
Brunei	9	11	10	11	12	14	13	13	13	13
Cambodia	12	13	14	14	14	13	13	13	13	13
China	14	14	14	14	14	14	14	14	14	14
Indonesia	14	14	14	14	14	13	14	14	14	14
Japan	14	14	14	14	14	14	14	14	14	14
Laos	13	11	13	12	13	12	12	12	12	13
Malaysia	14	14	14	14	14	14	14	14	14	14
Myanmar	14	14	14	13	14	11	12	13	12	14
New Zealand	14	14	13	14	14	13	13	13	14	14
Philippines	13	13	14	14	14	13	13	14	14	14
Singapore	14	14	14	14	14	14	14	14	14	14
South Korea	14	14	14	14	14	14	14	14	14	14
Thailand	14	14	14	14	14	14	14	14	14	14
Vietnam	14	14	14	14	14	14	14	14	14	14

The out-degree centrality of most member countries remained at the highest level (14) during the observation period, indicating that they export agricultural products to all other RCEP member countries. Brunei, Cambodia, Laos, Myanmar, New Zealand, and the Philippines had slightly lower out-degree centrality, but most also showed a trend of exporting to the majority of other member countries. Notably, Brunei's out-degree centrality has increased steadily over the years, rising from 9 to 12. This suggests that Brunei is gradually becoming an exporter of agricultural products, increasing its participation in the RCEP regional agricultural trade. In contrast, Myanmar and New Zealand experienced slight decreases in out-degree centrality in 2017 and 2015, respectively, reflecting fluctuations in their trade relationships with specific partners in individual years.

Most countries, including Australia, China, Japan, Malaysia, Singapore, South Korea, Thailand, and Vietnam, maintained the highest in-degree centrality (14) throughout the entire period, indicating that they import agricultural products from all other RCEP member countries. The in-degree centrality of other countries was slightly lower but remained at a relatively high level (12 or 13).

In summary, agricultural trade within the RCEP region is characterized by activity and diversity, showing dynamism over time. Particularly, countries with high out-degree and in-degree centrality, such as Australia, China, Japan, etc., demonstrate their importance and the extensive nature of their trade in the regional agricultural product trading network. In contrast, countries with lower out-degree or in-degree centrality may have relatively smaller agricultural market sizes.

4.3.2 Closeness Centrality

Closeness centrality is a measure of how close a node is to all other nodes in the network. Specifically, the closeness centrality of a node is calculated based on the shortest path lengths between that node and all other nodes in the network. A node with low closeness centrality implies that it can connect more quickly and efficiently with other nodes in the network. In a directed network, closeness centrality can be further divided into out-closeness centrality and in-closeness centrality.

Out-closeness centrality is calculated based on the shortest out-path lengths from a node to all other nodes in the network. In-closeness centrality is calculated based on the shortest in-path lengths from all other nodes to that node. In this study, countries with low out-closeness centrality may be more efficient in exporting agricultural products, and quickly delivering products to other countries. Countries with low in-closeness centrality may be more efficient in importing agricultural products, swiftly obtaining the needed products from multiple countries.

This study calculated the closeness centrality of the unweighted directed agricultural trade network for the years 2011, 2013, 2015, 2017,and 2019, as shown in the table below.

(Table 3) Closeness Centrality of Agricultural Trade Network

	Out-Closeness centrality					In-Closeness centrality				
	2011	2013	2015	2017	2019	2011	2013	2015	2017	2019
Australia	14	14	14	14	14	14	14	14	14	14
Brunei	19	17	18	17	16	14	15	15	15	15
Cambodia	16	15	14	14	14	15	15	15	15	15
China	14	14	14	14	14	14	14	14	14	14
Indonesia	14	14	14	14	14	15	14	14	14	14
Japan	14	14	14	14	14	14	14	14	14	14
Laos	15	17	15	16	15	16	16	16	16	15
Malaysia	14	14	14	14	14	14	14	14	14	14
Myanmar	14	14	14	15	14	17	16	15	16	14
New Zealand	14	14	15	14	14	15	15	15	14	14
Philippines	15	15	14	14	14	15	15	14	14	14
Singapore	14	14	14	14	14	14	14	14	14	14
South Korea	14	14	14	14	14	14	14	14	14	14
Thailand	14	14	14	14	14	14	14	14	14	14
Vietnam	14	14	14	14	14	14	14	14	14	14

Australia, China, Indonesia, Japan, Malaysia, Singapore, South Korea, Thailand, and Vietnam maintained an out-closeness centrality of 14 during the observation period, indicating their ability to swiftly and efficiently export agricultural products to other RCEP countries. Brunei, Cambodia, and Laos had out-closeness centrality slightly higher than 14, suggesting some limitations or lower efficiency in their exports to specific countries.

Australia, China, Japan, Malaysia, Singapore, South Korea, Thailand, and Vietnam consistently maintained an in-closeness centrality of 14. This indicates that these countries can swiftly and efficiently import agricultural products from other countries in the RCEP region. Brunei, Cambodia, Laos, and Myanmar experienced slight fluctuations in their in-closeness centrality, reflecting changes in their agricultural product import relationships in different years.

Overall, these data reveal the efficiency of interaction among RCEP member countries in the agricultural product trade network. Most countries demonstrate high efficiency and diversity in both exports and imports, facilitating more effective agricultural product transactions and reflecting the maturity of the RCEP agricultural product trade network.

4.3.3 Betweenness Centrality

Betweenness Centrality measures the frequency with which a node appears on the shortest paths between all pairs of nodes, indicating the influence and importance of a node as a "broker" in the network. The Betweenness Centrality indicators and trends for the RCEP agricultural product trade network are presented in the table below.

(Table 4) Betweenness Centrality of Agricultural Trade Network

	Betweenness centrality				
	2011	2013	2015	2017	2019
Australia	0.927	0.721	0.560	0.523	0.244
China	0.927	0.721	0.560	0.523	0.244
Japan	0.927	0.721	0.560	0.523	0.244
Malaysia	0.927	0.721	0.560	0.523	0.244
Singapore	0.927	0.721	0.560	0.523	0.244
South Korea	0.927	0.721	0.560	0.523	0.244
Thailand	0.927	0.721	0.560	0.523	0.244
Vietnam	0.927	0.721	0.560	0.523	0.244
Philippines	0.535	0.265	0.560	0.523	0.244
Indonesia	0.358	0.721	0.56	0.523	0.244
New Zealand	0.358	0.449	0.077	0.523	0.244
Cambodia	0.083	0.356	0.160	0.250	0.077
Myanmar	0.083	0.356	0.160	0.000	0.244
Laos	0.083	0.083	0.000	0.000	0.000
Brunei	0.083	0.000	0.000	0.000	0.000

Analyzing the Betweenness Centrality of the 15 RCEP member countries from 2011 to 2019, the following characteristics are observed.

Australia, China, Japan, Malaysia, Singapore, South Korea, Thailand, and Vietnam consistently exhibit high Betweenness Centrality throughout all observed years. This indicates that these countries play crucial intermediary roles in the RCEP agricultural trade network, controlling significant trade flow pathways. They play a key role in facilitating or influencing trade relationships among other countries in the region.

The Philippines, Indonesia, and New Zealand consistently demonstrate a moderate level of Betweenness Centrality throughout the observed period. This suggests that these countries play a significant but not as prominent intermediary role in the network compared to the aforementioned countries.

Countries such as Cambodia, Myanmar, Laos, and Brunei consistently exhibit low or zero Betweenness Centrality. This indicates that these countries have limited intermediary roles in the RCEP agricultural trade network. Particularly, Brunei and Laos demonstrate almost no intermediary significance.

Furthermore, the Betweenness Centrality of almost all countries exhibits a declining trend from 2011 to 2019. This suggests that the trade network within the RCEP region is becoming more balanced, with the intermediary roles of each member country tending to equalize. The diminishing role of specific countries as intermediaries suggests a decreasing reliance on a few key nations, thereby promoting the overall development of agricultural trade within the region.

5. Analysis of Factors Influencing Agricultural Trade between South Korea and Other RCEP Member Countries

5.1 Model Construction and Data Processing

5.1.1 Extended Gravity Model

Gravity models originated in physics, specifically from Newton's law of universal gravitation, and were later extensively applied in economic research. Drawing an analogy from the gravitational force in physics, these models aim to explain and predict the flow of trade between countries. The fundamental idea is based on the assumption that the trade flow between two countries is directly proportional to their economic sizes and inversely proportional to the distance between them. Economic size is typically measured by the Gross Domestic Product (GDP), while distance can encompass factors such as geographic distance, cultural differences, language, policies, or other impediments to trade.

In this study, an extended gravity model is constructed to assess the impact of economic size, trade distance, population size, and governance level on agricultural trade. The model is outlined as follows:

$$\ln T_{ij} = \alpha \ln G_i G_j + \beta \ln D_{ij} + \epsilon_{ij} \quad (1)$$

$$\ln T_{ij} = \alpha \ln G_i G_j + \beta \ln D_{ij} + \gamma \ln P_i P_j + \epsilon_{ij} \quad (2)$$

$$\ln T_{ij} = \alpha \ln G_i G_j + \beta \ln D_{ij} + \gamma \ln P_i P_j + \delta \ln WGI_i \; WGI_j + \epsilon_{ij} \quad (3)$$

In the formula, T_{ij} represents the trade volume between country i and country j, measured by the numberof agricultural exports and imports. G_i and G_j represent the economic sizes of South Korea and the other member countries, measured by their respective GDP. D_{ij} represents the trade distance between South Korea and the other member countries, measured by the distance between their capitals. P_i and P_j represents the population size between South Korea and the other member countries. WGI_i and WGI_j represent the governance levels of South Korea and the other member countries, respectively, measured by the Worldwide Governance Index.

5.1.2 Data Source

In this study, data on economic size, population size, and governance level are sourced from the World Bank Development Indicators Database (http://data. worldbank.org. cn). Capital distance data is obtained from the CEPII database (http://www.cepii.fr). The governance level is normalized using the formula(4), where k represents the six indicators of the Worldwide Governance Index. $I_{(i,k)} - \min I_k$ represents the difference between country i's score on indicator k and the minimum score for k, while $\max I_k - \min I_k$ represents the difference between the maximum and minimum scores for indicator k. This normalization ensures that all values are non-negative. Additionally, to address potential multicollinearity and eliminate the influence of different units of measurement, all data have been log-transformed.

$$\text{WGI} = \frac{1}{6} \sum_k^6 \frac{I_{i,k} - \min I_k}{\max I_k - \min I_k} \quad (4)$$

5.2 Analysis of Factors Influencing Agricultural Trade Based on Export Trade

Table 5 presents the regression results with agricultural export volume as the dependent variable. From the results of Model 1, the coefficient of GDP_i is not significant (p=0.956), indicating that the impact of South Korea's GDP on trade volume is not significant. The coefficient of GDP_j is highly significant (p<0.001), and the β value is high, suggesting that the importing country's economic size significantly influences trade volume, which increases with the growth of the partner country's GDP. The coefficient of D_ij is not significant (p=0.790), indicating that the impact of distance on trade volume is not significant. The R^2 is 0.692, indicating that the model can explain approximately 69.2% of the variability, showing a good fit.

Model 2 results show that, after adding the population size variable for both the exporting and importing countries, the coefficient of GDP_i remains insignificant. Although the coefficient of GDP_j decreases, it is still significant,

indicating that the positive impact of the importing country's GDP on trade volume persists. Trade distance becomes significant ($p<0.01$), and it is positive, contrary to the expectations of the gravity model. This suggests that cost factors are not a primary concern for South Korea when exporting agricultural products within the RCEP region. Among the population size factors, only the population size of the importing country is significantly positive, indicating a significant positive impact of the partner country's market size on trade volume. The R^2 increases to 0.775, indicating an improved explanatory power of the model.

Model 3 further adds governance indicators based on Model 2. Economic size is no longer significant, and trade distance remains significant ($p<0.05$), although the coefficient has decreased. South Korea's population size remains insignificant, while the population size of the importing country is highly significant ($p<0.001$). Similarly, South Korea's governance level is not significant, but the governance level of the importing country is significant ($p<0.01$), indicating that a good governance level is associated with higher trade volume. The R^2 value further increases to 0.790, indicating an enhanced ability of the model to explain variability.

(Table 5) Results of Agricultural Exports Gravity Model for South Korea and RCEP Countries

Variables	Model 1			Model 2			Model 2		
	β	*t*	*p*	*β*	*t*	*p*	*β*	*t*	*p*
GDP_i	0.003	0.055	0.956	0.029	0.195	0.846	0.021	0.148	0.883
GDP_j	0.826	15.971	***	0.530	8.645	***	0.173	1.343	0.182
D_ij	-0.014	-0.266	0.790	0.132	2.682	**	0.098	2.013	*
P_i				-0.021	-0.141	0.888	-0.046	-0.312	0.755
P_j				0.474	7.015	***	0.808	6.455	***
WGI_i							0.018	0.322	0.748
WGI_j							0.287	3.133	**
R^2		0.692			0.775			0.790	
$\triangle R^2$		0.685			0.766			0.779	
F		101.782			92.126			71.052	

Note: *p<0.05, **p<0.01, ***p<0.001

6. Conclusion and Recommendations

6.1 Conclusion

This study, based on agricultural trade data within the RCEP region from 2011 to 2020, employs SNA to construct the agricultural trade network within the RCEP region. Various indicators are utilized to explore the structural characteristics and evolution of the RCEP agricultural trade network, as well as the trading positions of member countries. Furthermore, an extended gravity model is applied for empirical analysis to identify the factors influencing agricultural trade between South Korea and other RCEP member countries. The following conclusions are drawn from the study：

1. From the overall characteristics and evolutionary trends of the agricultural trade network among RCEP countries, it is evident that the agricultural trade relations within the RCEP region are stable, exhibiting a high degree of interconnectedness. Moreover, trade relations are gradually moving towards a more balanced development. This highlights the significant trade potential among RCEP nations.
2. In terms of the individual characteristics and evolution of the agricultural trade network among RCEP countries, each member nation exhibits varying levels of interaction efficiency, activity, and diversity. The majority of countries demonstrate stable and efficient positions, reflecting the maturity and extensive nature of the trade network. However, a few countries, such as Brunei and Laos, display relatively lower levels of participation in the trade network.
3. Through Models 1 to 3, this study examines the factors influencing agricultural trade between SouthKorea and other RCEP members. The results indicate that the economic scale, population size, and governance level of the member countries have a significant positive impact on the volume of both imports and exports. This results is consistent across both import and export trades. However, these indicators within South Korea itself do not show significant effects and have no impact on agricultural trade volumes.

The economic size of the member countries has a significant positive influence on their agricultural trade with South Korea. This implies that the larger the economic scale

of a member country, the greater the volume of agricultural trade with South Korea. This is because countries with larger economies possess more resources and market capacity, enabling them to produce and consume agricultural products more efficiently, thereby fostering increased trade with South Korea.

Population size has also been identified as a crucial factor influencing agricultural trade between South Korea and other RCEP members. The larger the population of a member country, the greater its agricultural trade volume with South Korea. This is because countries with larger populations have higher demand for agricultural products and greater production potential, which in turn fosters trade cooperation with South Korea.

Governance level significantly impacts agricultural trade between South Korea and other RCEP members. Countries with higher governance levels typically have more stable political environments, more efficient government institutions, and more comprehensive legal systems. These factors help reduce trade risks, improve trade efficiency, and thereby attract agricultural trade with South Korea.

Trade distance has a significant positive effect on agricultural trade between South Korea and other RCEP members. Generally, greater trade distance increases trade costs and hinders trade activities. However, within the RCEP region, due to factors such as regional economic integration, complementary resource endowments, and well-developed logistics infrastructure, longer trade distances are actually conducive to trade.

6.2 Discussion

This study highlights the stability and potential of agricultural trade relationships within the RCEP region, revealing the factors influencing agricultural trade between South Korea and other RCEP members. The economic size, population size, and governance level of member countries have significant positive impacts on agricultural trade with South Korea. However, several issues warrant further consideration and research:

Firstly, these indicators within South Korea do not affect its agricultural import and export trade. This may be because South Korea's trade position within the RCEP region is already relatively stable, and the influence of its own economic scale, population size, and governance level on trade volume has reached a saturation point.

Additionally, the individual differences among member countries within the agricultural trade network suggest a need to focus on the roles and contributions of peripheral countries in regional trade. Exploring methods to enhance their participation could lead to more balanced development.

Finally, the unique impact of trade distance on RCEP agricultural trade requires attention. This finding providesa new perspective on the development of regional economic integration. By further improving logistics and infrastructure within the region, the trade barriers posed by distance can be overcome, promoting broader trade cooperation.

6.3 Recommendations

Based on the aforementioned conclusions, this paper presents the following recommendations to further promote the development of regional agricultural trade and offers corresponding policy guidance for South Korea.

Strengthening regional economic integration and cooperation. RCEP boasts significant advantages in terms of economic scale and population size. Our study reveals that the economic and population scales of trade partner countries significantly impact trade volume. Member countries should actively participate in and promote the deep implementation of the RCEP agreement, vigorously enhancing the construction of regional logistics infrastructure. For South Korea, it is crucial to consider these factors when formulating future trade strategies and leverage the market size advantages of major economies to drive trade growth. For instance, developing agricultural export strategies tailored to meet the consumption demands of these large markets.

Promoting balanced development of regional agricultural trade. While the RCEP agricultural trade network is highly concentrated, a few countries lag in development, displaying noticeable individual disparities. Member countries should adjust their trade structures and development strategies based on their resource endowments and regional trade patterns to transform their advantages within the RCEP agricultural trade network. Additionally, regional trade agreement

policies should aim to enhance the participation of peripheral countries to achieve sustainable overall regional development.

Enhancing governance and trade environment. Although South Korea's economic scale, population size, and governance level do not directly significantly impact agricultural trade, continuously optimizing the domestic governance environment—such as strengthening legal and regulatory frameworks, improving government service efficiency, and maintaining political stability—can help enhance international image and build trade partners' confidence.

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