The Impact of RCEP on China's Agricultural Import and Export Trade Based on the GTAP Model for Sustainability

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Abstract

This paper analyses the impact of RCEP on China's import and export of agricultural products and makes an in-depth study on the post-pandemic trade scale and structure of agricultural products between China and other RCEP member countries after RCEP takes effect. The GTAP model empirically simulates the RCEP effects on China's agricultural trade. The simulation results show that RCEP has expanded the scale of China's agricultural trade and further promoted the export trade. Implementing RCEP will positively impact China's GDP growth and overall welfare level while increasing the total scale of imports and exports. The total trade volume and trade deficit of agricultural products are growing, and the trade volume between China and other RCEP members will continue to rise. In the end, according to the simulation results of empirical analysis, combined with the relevant analysis of the current situation of agricultural trade, this paper puts forward countermeasures and suggestions for policy-makers, major enterprises, and professionals related to agriculture to promote the development of our country's agricultural trade import and export, and further promoting regional agricultural cooperation and development.

Keywords: RCEP, Agriculture, Import and Export, GTAP, Sustainability

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Introduction

In recent years, due to the COVID-19 pandemic, the world economy has been affected, and countries are seeking ways to revive the economies. Accelerating regional cooperation and advancing the development process of regional integration has also become one of the methods. The Regional Comprehensive Economic Partnership Agreement, the world's largest free trade zone, was officially signed on 15th November 2020 and took effect on 1st January 2022. As the most significant free trade agreement in East Asia, the entry into force of RCEP possibly has a profound impact on the import and export trade pattern of China's agricultural products.

As a global agricultural power, China occupies a significant share of its agricultural products in international trade. As one of the pillars of the national economy in China, agriculture is of great significance to the study of the import and export of agricultural products. In the study, the definition of agricultural ·products is based on Chinese customs. This generally includes food products from agriculture and fishery, as well as agricultural raw materials and sideline products such as starch, skins and hides, or fur, but does not include products from forestry or processed raw materials such as biofuels. With improving living standards, the public's demand for food safety and quality is increasing, and the demand for farm products in overseas markets continues to rise. Based on the General Administration of Customs statistics, in 2023, China's imports and exports to the other 14 RCEP member states totaled 1.74 trillion USD, an increase of 5.3 percent compared with 2021 before the agreement came into effect. China’s exports to other RCEP member states reached 0.89 trillion USD, accounting for the proportion of China's exports increased by 1.1 percent over 2021, reaching 27 percent.

Figure 1 shows that from 2005 to 2023, China's agricultural imports jumped from $ 28.65 billion to $ 234.11 billion, with an average annual growth rate of 11.41%, indicating an overall upward trend. During the same period, the export value of agricultural products increased from $27.18 billion to $98.93 billion, with an annual growth rate of 3.99 percent. Regarding import and export volume, the proportion of agricultural trade volume between China and RCEP members remains relatively high. From the perspective of import and export volume, since 2008, China's total import of agricultural products has been higher than the total export volume, showing a significant trade deficit, and this gap has gradually increased. By 2023, China's trade deficit in agricultural products had reached $135.18 billion. Compared with 2008, the trade deficit has widened nearly seven times. Meanwhile, according to the data of the China Customs database, in the past five years, the major agricultural exporters of China, except the United States, the rest countries are members of RCEP, including Japan, South Korea, Vietnam, and Thailand.

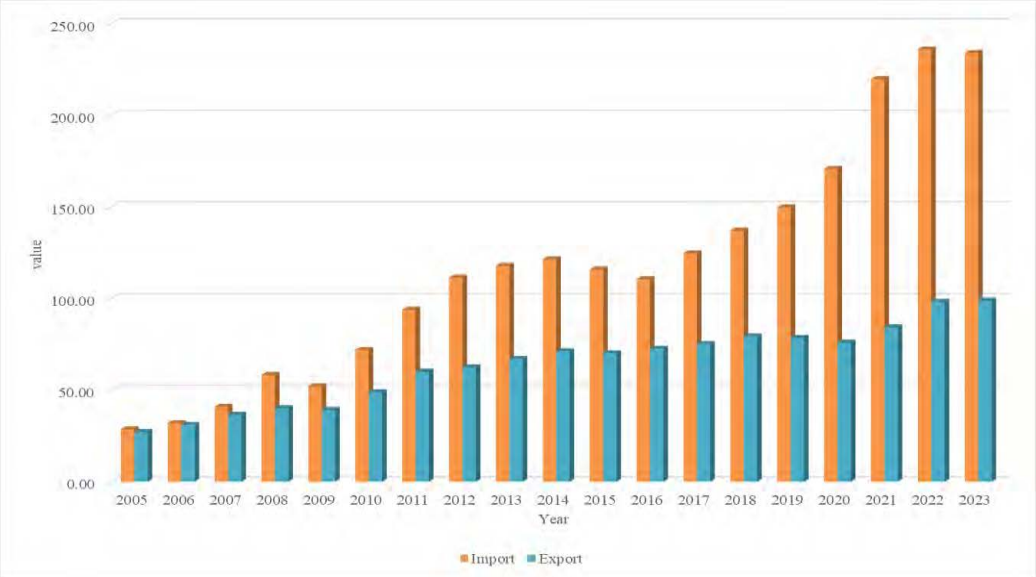

Figure 1: China's import and export of agricultural products (in billion U.S. dollars)

Data source: China Customs database

Based on the RCEP policy, the import and export tariff systems show diversified arrangements, which triggered the adjustment of the industrial structure of agricultural products. As a significant trade component, the supply and demand situation of the agricultural products trade market possibly also changed. In China, agriculture is related to the employment security of farmers, the improvement of rural economic vitality, and the critical area to ensure national food security management. Therefore, an in-depth analysis of the impact of RCEP on China's import and export trade of agricultural products is vital for promoting the healthy development of China's international trade of agricultural products, which helps the transformation of farm modernization and realize the strategy of rural revitalization.

Table1 indicates that 26.86 percent of China's agricultural export trade was exported to RCEP countries in 2021. It accounts for the largest share of the world's total trade, with a total export value of $44.311 billion. In contrast, 43.94 percent of China's agricultural imports are from RCEP countries, totalling $58.655 billion. It was found that China's agricultural products are highly competitive in the international market. However, there is still a significant gap compared with the world average level, especially with other countries. Meanwhile, China's main imports of agricultural products in the RCEP region are from ASEAN, Japan, and South Korea. In 2021, these three major markets accounted for 25.86 percent, 10.83 percent, and 5.72 percent of China's total agricultural exports. It shows that Japan, South Korea, and ASEAN countries highly depend on China's agricultural trade. ASEAN, Australia, and New Zealand export Chinese agricultural products, accounting for 15.40%, 4.87%, and 4.03% of China's total agricultural exports in 2021. Among them, the import of agricultural products exported to ASEAN accounts for the most. The trade between China and ASEAN countries has a long history, and relatively stable bilateral relations have been formed in long-term trade exchanges. China has maintained sizable agricultural trade surpluses with Japan and South Korea, at $8.621 billion and $4.521 billion. China's net import of agricultural products from Australia,

ASEAN, and New Zealand reached $7.954 billion, $8.857 billion, and $10.675 billion, and there was a significant trade deficit with these countries.

Table 1: China's agricultural trade with RCEP members in 2021 (USD 100 million)

Countries	Export		Import		Trade deficit
ASEAN	260.7	15.40%	349.27	25.86%	88.57
Japan	109.2	1.01%	22.99	10.83%	-86.21
South Korea	57.7	0.55%	12.49	5.72%	-45.21
New Zealand	11.86	4.03%	91.4	1.17%	79.54
Australia	3.65	4.87%	110.4	0.86%	106.75
RCEP	443.11	26.86%	586.55	43.94%	143.44

Data source: World Integrated Trade Solution (WITS) database

This paper aims to analyze the overall scale and competitiveness of agricultural products import and export trade of RCEP member states, the interaction relationship of agricultural products trade among member states, and the potential of China's agricultural products trade with RCEP member states. The Global Trade Analysis Project (GTAP)is used to simulate and forecast the possible impact of RCEP on the import and export of agricultural products to provide more detailed theoretical supplement and empirical support for the effects of the import and export trade of agricultural products in specific industries under the framework of RCEP. It probably helps deeply clear the potential advantages of RCEP on agricultural products in China and provides decision-making reference for relevant agricultural products enterprises, agricultural operators, and policy-makers to promote the development of international trade of agricultural products and the agricultural transformation and upgrading so that achieve rural revitalization and sustainable development of rural economy.

This paper mainly focuses on five parts. The first part is an introduction that discusses the paper's research background, significance, and aims. The second part is a literature review to set the theoretical foundation of the research. The third part is a methodology to introduce the GTAP model and conduct an empirical analysis. The fourth part is the results, and the fifth is the conclusion and discussion.

Literature Review

RCEP

The Regional Comprehensive Economic Partnership Agreement (RCEP) was formally signed after an extensive eight-year negotiation process, encompassing Australia, China, Japan, New Zealand, South Korea, and the ten member states of the Association of Southeast Asian Nations (ASEAN), among them the Philippines and Indonesia. This monumental partnership boasts a combined GDP of $26.2 trillion, equivalent to 30% of the global total, and contributes 28% to the world's economic output. Furthermore, the 15 signatories collectively represent a population of 2.2 billion people. This is an essential step towards regional integration in the Asia-Pacific region. Analyzing the structure of trade among member countries is crucial for understanding the path of regional integration and the policy implications of regional cooperation under the RCEP framework. Table 2 shows China's tax reduction commitments under RCEP, which indicates that China has reduced tariffs on 86% of Japanese and South Korean products to zero, and the proportion of tariffs on ASEAN, Australia, and New Zealand products to zero has reached more than 90%, 90.5%, 90%, and 90%. Based on Table 3, the proportion of other contracting parties' tariffs on Chinese products eventually reduced to zero and reached more than 85%, including 98.2% for Australia.

Table 2: List of Tax Reductions Imposed by China on Other RCEP Members

Tax Reduction Mode		Japan	South Korea	ASEAN	Australia	New Zealand
Reduce to 0		25%	38.6%	67.9%	65.8%	66.1%
Interim Period Reduce to 0	10 years Reduce to 0	46.5%	41%	12.7%	14.2%	13.9%
	15 years Reduce to 0	11.5%	3.1%	3%	0%	0%
	20 years Reduce to 0	3%	3.2%	6.9%	10%	10%
0 Tariff Ratio		86%	86%	90.5%	90%	90%
Partial Tax Reduction		0.4%	1%	5.4%	5.5%	5.6%
Exceptional Product		13.6%	13%	4.1%	4.5%	4.4%

Data source: Author collated from China Free Trade Network

Table 3: List of Tax Reductions Imposed on China by Other RCEP Members

Tax Reduction Mode	Japan	South Korea	ASEAN		Australia	New Zealand
			Malaysia, Vietnam Singapore, Thailand Indonesia, Philippines Brunei	Laos, Cambodia Myanmar		
Reduce to 0	57%	50.4%	74.9%	29.9%	75.3%	65.4%
0 Tariff Ratio	88%	86%	90.5%	86.3%	98.2%	91.8%
Partial Tax Reduction	0%	1.1%	5.5%	0%	1.1%	8.2%
Exceptional Product	12%	12.9%	4%	13.7%	0.7%	0%

Data source: Author collated from China Free Trade Network

RCEP and Economic Consequences

The RCEP is the first Grand Free Trade Area in East Asia and of great significance in ASEAN and East Asia. ASEAN has secured centrality in East Asia's economic integration, and the AEC and RCEP will become even more critical amid rising protectionism, as well as during the pandemic and post-era (Shimizu, 2021). Preferential tariff provisions relating to agricultural products formulated by RCEP

China must participate in higher-level FTAs to push reforms in some areas and industries. The construction of free trade zones will inject a strong impetus into regional and global economic growth and further accelerate the implementation of the dual circular economy strategy (Jiang & Yu, 2021). (Chen, Yuan, & Song, 2023) investigated the current RCEP trade structure based on segmented commodity data, highlighting the relative importance of intra-versus extra-regional interdependence and the trade asymmetry among regional members. RCEP benefits most member countries, with South Korea receiving the most significant benefits, followed by Australia, Japan, New Zealand, and ASEAN. At the same time, China has the most minor improvements in trade and welfare.

RCEP mainly stems from the increase in trade volume, while the terms of trade tend to deteriorate. As a free trade port, Singapore's welfare has not improved significantly. Computers, electronic and optical products, and electrical equipment contribute the most to China's trade scale effect. (Lin, Lv, Yang, & Li, 2024). (Peng, Fan, Hu, & Yuan, 2024) Quantifying the trade and welfare effects of the RCEP using a quantitative multi-country and multi-sector trade model to distinguish between critical features of intermediate and final goods, we illustrate the heterogeneous effects of the RCEP on trade and welfare. RCEP has a trade-creating effect on members but a trade-diverting effect on non-members. The Regional Comprehensive Economic Partnership (RCEP) has come into force in Vietnam in 2022, easing trade between the country and member states. This has led to expansion opportunities and intense competition for Vietnam's seafood business, especially the import and export business. (Tran & Tran, 2023).

GTAP Model

Based on the GTAP model, (Nina Zhu, Lixing Lv, Siyi Huang, & Gong, 2022) concluded that the reduction of tariffs will increase the export volume of China's high-quality manufacturing industry, and the trade complementarity between China and some ASEAN countries will decline in the short term and rise in the medium and long term. Meanwhile, the trade complementarity between China, Japan, and South Korea will continue to increase. Using a dynamic GTAP model to measure the potential impact of the Japan-U.S. Free Trade Agreement on Japan, it is found that when tariffs are removed between Japan, the United States, and China, the GDP of all three countries will increase. Still, static and dynamic models have less than 1% impact. (Akahori, Hasegawa, Sawauchi, & Yamamoto, 2021). Through the GTAP-E model, the simulation results of the economic effects of the BRICS free trade area under zero tariff and exceptional sector scenarios show that the construction of the BRICS free trade area has a differentiated impact on different industries of the member countries, and the overall optimization adjustment is made in the direction of their comparative advantages. It has also been found that resource integration in the industrial field can improve the productivity of BRICS countries. (Nie, 2023).

Above all, many scholars have adopted GTAP in their research on the economic effect of RCEP. The model conducts quantitative simulation, but many studies are performed in the background before the RCEP takes effect. This paper turns to the perspective of the signing of the RCEP. It predicts the impact of the establishment of RCEP on China's import and export

of agricultural products through the value of import and export of farm products, which has sure accuracy. In addition, this paper covers the impact of the time node of COVID-19, which has a certain timeliness.

Methodology

Global Tade Analysis Project (GTAP) is a computable general equilibrium model for multi-country and multi-sector applications based on neoclassical economic theory. (Hertel & Tsigas, 1997). The GTAP model assumes that the market is perfectly competitive, the returns to scale of production are constant, producers minimize production costs, consumers maximize utility, and all product and input factor markets are cleared. Elastic properties were replaced by fixed properties (CES):

$$X = A\left[a_L L^{\rho} + a_K K^{\rho}\right]^{\frac{1}{\rho}} \qquad (3.1)$$

Where, X represents the product; A stands for technical parameter; L and K are input labor force and capital elements; $aL$and aKseparately indicating the share of labor force element and capital element in the production of M products, and meet aL+aK=1, ρ is the alternative parameter.

In the meantime, each country has only one account into which all taxes, financial assets, income from capital, and labor are accumulated. The income in the account is divided into private consumption, savings, and government consumption. The private expenditure equation uses the constant difference of elasticity (CDE) utility equation. The utility equation of the government takes the form of the Cobb-Douglas equation:

$$U = AX^{a}Y^{1-a} \qquad (3.2)$$

Where U is the utility, A is the technical parameter, X and Y are the product, α represents the share of X in U. The share of product Y in U is represented by 1-a. International trade can be added based on a single-country model to form a multinational model. There is a substitution relationship between imported products and domestic products, but it is not entirely substituting for each other, which is expressed here by the constant elasticity of substitution (CES):

$$(X_i, X_d) = \left[a_L X_i^{\rho} + a_K X_d^{\rho}\right]^{\frac{1}{\rho}} \qquad (3.3)$$

Where, $\rho \leq 1$and $\rho \neq 0$, $X_i$and X_d are import products and domestic products, $a_L$and a_K are the shares of the factors of labor and capital in the production of $X_i$and X_d.

The GTAP model involves two separate government departments, the National Bank and the International Transport Department. Through this model, each country's corresponding tariff and subsidy data in import and export trade can be effectively reflected. The formula for calculating import and export prices using this model is as follows:

$$P^{FOB} = P^{EX}(1 + T^{EX}) \quad (3.4)$$

$$P^{CIF} = P^{FOB}(1 + F) \quad (3.5)$$

$$P^{IM} = P^{CIF}(1 + T^{IM}) \quad (3.6)$$

Where, export and import port prices are P^FOB and P^CIF, the domestic prices of exports and imports are P^EXand P^IM, Fis the commodity transportation expense, while export and import duties are represented by T^EXand T^IM .

In the study, we choose the number of tariff and non-tariff barriers as the impact variable and use the GTAP model to analyze the impact of short – term and long-term RCEP on China's agricultural products and explain through the social welfare, agricultural product output, agricultural product import, and export changes. Based on the import and export ratio between China's agricultural products and its major trading partners, 141 countries or regions in the GTAP10.0 database are classified into nine regional groups: China, Japan, South Korea, Australia, New Zealand, ASEAN, the European, the United States and the rest of the world.

Considering the definition of the simulation sector, this study referred to the classification methods of past scholars. It carried out ten major reclassifications of agricultural products in GTAPAgg2: cereal products, fruit and vegetable products, sugar products, oils and fats, plant fibers, animal products, milk and its products, aquatic products, beverages and tobacco, and other agricultural products.

During the short-term analysis, it is necessary to calculate the baseline tax rate and the tax rate data for the first year of the RCEP tariff commitment table. This paper introduces a simple and feasible calculation method, which can be used to determine the introductory tax rate of countries in the region and the trend of the change of the introductory tax rate between different years. First, the base tax rate under the HS 8-digit code and the tax rate in the first year of the member countries in the region are arithmetically averaged to obtain the HS 6-digit code. Then, using the corresponding import amount of each agricultural product in 2021 as the weight, the benchmark tax rate of each farm product under the HS 2-digit code between countries and the tax rate in the first year is calculated. Since the base year in the GTAP 10 database is 2014, and the adequate time of RCEP is 2,022 years, to make the simulation results more consistent with reality, In this paper, the critical indicators in the GTAP database are updated to 2022 by dynamic recursion method. In the long-term analysis, both tariff and non-tariff scenarios must be weighed. Based on the cost of trade in various cases, the benchmark price of agricultural products in each country can be calculated to judge the extent of its impact on domestic agricultural production. Considering the tariff fluctuations, we use a short-term approach to measure the essential tax rates of various agricultural products in each country under the HS 2-digit code and the tax rates for 20 years. Analysis of farm products over different periods provides insight into how trade patterns have changed. Regarding non-tariff changes, first, within the RCEP region, we set a 100% reduction in agricultural export subsidies, a 100% reduction in quantitative restrictions, a 10% increase in sanitary and phytosanitary measures, a 10% reduction in technical trade barriers, and a 10% increase in safeguard measures, while anti-dumping, countervailing and tariff quotas remain.

Results and Discussion

Analyzing the short-term and long-term impact through GTAP, it is possible to predict the effects of reductions in short-term and long-term tariff and non-tariff barriers on the economic indicators of regional countries, including China. The study results reveal that RCEP has a positive financial impact on China's agricultural trade. Still, there are some differences in the direction of this impact in different subdivided agricultural sectors.

Impact on China's social welfare

As shown in Table 2, reducing tariffs and non-tariff barriers is expected to improve the overall welfare status of member countries except New Zealand and ASEAN. For different countries, the stage of economic development is an essential factor in determining the choice of their welfare policies, and the economic structure of different countries is different. Therefore, there will be a widening or even declining welfare gap among members. Among these countries, Japan and South Korea showed the most significant improvement in the short- and long-term welfare. However, the short- and long-term welfare growth showed similar trends. China's welfare has changed to major trading partners heavily, and the gap is more comprehensive compared with other countries. Through the observation of its tariff commitments, it is found that during Japan's tax reduction period, many agricultural products did not participate in the tax reduction commitments, which may harm the growth of welfare.

Table 2: GTAP simulation results of overall social welfare change

Observations	Terms of trade (%)		Welfare (Millions of dollars)		import (%)		export (%)	
	short-term	long-term	short-term	long-term	short-term	long-term	short-term	long-term
China	-0.42	-0.18	2097.7	2624.44	2.04	2.63	2.12	3.49
Japan	1.51	1.31	197695.7	22424.55	6.87	7.93	8.03	8.67
South Korea	1.33	1.25	10414.18	9126.36	6.52	6.19	4.43	4.93
Australia	-0.39	0.05	623.06	921.41	3.11	3.53	0.52	0.74
New Zealand	-1.5	0.51	-472.02	166.28	-1.87	1.24	-0.17	1.24
ASEAN	-0.43	-0.63	-3249.22	3598.70	-0.02	0.76	-0.03	1.02
America	-0.16	-0.18	-5374.16	-5846.03	-0.42	-0.43	-0.16	-0.54
European	-0.05	-0.06	-2089.42	-2025.13	-0.30	-0.42	-0.13	-0.16
Others	-0.13	-0.15	-8247.43	-8524.01	-0.43	-0.44	-0.22	-0.34

Data source: Author's analysis by GTAP simulation

Impact on China's agricultural output

When RCEP came into force, China showed relative advantages in agricultural products, primarily sugar and plant fiber, in both the short and long run. Milk and its related products have clear advantages in the short term, while in the long term, this advantage is gradually weakening. With the implementation of the RCEP agreement, all member countries are working hard to fulfill their responsibilities of reducing taxes and non-tariff barriers. In this context, the greater the degree of intra-regional trade liberalization, the more significant the decline in the output of agricultural products without comparative advantage, while the output growth of farm products with more significant comparative advantage will gradually slow down.

Table 3: GTAP simulation results of China's agricultural output change (%)

Product	Short-term	Long-term
cereal product	-0.54	-0.33
Fruits and vegetables	-3.34	0.62
Sugar	3.27	0.31
oil and grease	-10.32	0.56
Plant fibers	0.62	0.82
Animal products	-0.46	-0.43
Milk and dairy products	0.65	-0.65
Aquatic products	0.01	0.16
Beverages & Tobacco	0.05	0.04
Other agricultural products	0.02	0.73

Data source: Author's analysis by GTAP simulation

The impact on China's agricultural imports and exports

The GTAP model calculates the scale changes of the classified agricultural products that China imports and exports from various countries under the dual impact of tariff and non-tariff cuts in RCEP. By comparing the changes in the trade scale of different agricultural products, the conclusion shows that the import and export of cereal products are the most severely impacted, mainly reflected in the reduction of the trade scale. From the perspective of imports, China's exports of grain products to member countries generally show a slight reduction trend. In addition to the 2.59 percent increase in the volume of imports from ASEAN, China reduced the size of imports from other countries in the region and increased the size of imports from countries outside the area, thus causing trade diversion.

Table 4: GTAP simulation results of China's import and export of agricultural products (%)

Product	Short-term		Long-term	
	Export	Import	Export	Import
cereal product	38.3	87.48	-100.78	-20.54
Fruits and vegetables	-10.13	7.61	60.62	1.42
Sugar	4.27	16.54	55.31	-24.12
oil and grease	-30.32	-0.14	87.56	112.12
Plant fibers	-1.62	3.72	6.82	-35.13
Animal products	4.46	15.37	-2.42	35.82
Milk and dairy products	8.65	6.73	-34.65	72.17
Aquatic products	5.01	-40.12	-16.16	49.45
Beverages & Tobacco	-8.05	10.09	24.04	-29.04
Other agricultural products	-13.02	4.76	55.73	-28.46

Data source: Author's analysis by GTAP simulation

Conclusion and Discussion

Based on the agricultural trade between China and RCEP countries, this study uses the GTAP model to simulate the impact of RCEP on the agricultural trade of China and other RCEP members after it takes effect.

First of all, from the perspective of the whole social welfare, the RCEP policy has come into effect, China has received positive feedback regarding imports and exports, and social welfare has also improved. In the long run, the welfare of RCEP member countries has increased, although, in the short term, New Zealand and ASEAN have shown some negative feedback. However, the import and export trade of them showed a positive effect over time. What we can also see is that the entry into force of RCEP shows that the structure of international trade will change over time, and the social welfare based on the import and export of other countries, such as the United States and Europe, will be negatively affected.

From the perspective of the impact on the output of China's agricultural products, there will be changes in the production of different products over time. For example, the output of oil and grease will decrease in the short term but increase in the long term. Over time, the milk and dairy products first increased and then reduced. These changes in output, to some extent, also explained the changes in the demand for agricultural products in international trade.

Regarding the impact on China's import and export of agricultural products, the implementation of RCEP policy makes the import and export quantity of various agricultural products change over time. For example, cereal products' import and export volume will rise and decline. In contrast, the export volume of fruits and vegetables will decrease and then rise, gradually becoming an exporting country. The import demand for milk and dairy products will increase over time. In general, the entry into force of RCEP has adjusted the type structure of China's import and export of agricultural products, and the dynamic changes can reduce the dependence on the import or export of a specific product to a certain extent.

About China's trade development, the total trade volume and trade deficit of agricultural products are proliferating, among which the main export direction is fruit, vegetable, and aquatic products. At the same time, the import is grease and oil. Then, in the next decade, the trade of agricultural products between China and RCEP member countries continued to rise, and the trade volume between China and ASEAN increased the most rapidly and significantly. The implementation of RCEP will positively impact China's GDP growth and welfare while also increasing the total volume of imports and exports. However, this may lead to a decline in China's agricultural output. In terms of agricultural trade, although the overall import and export scale is expected to expand, in terms of details, the implementation and upgrading of RCEP may adversely affect the import of cereals, fruits and vegetables, animal products, dairy products, and other agricultural products, as well as the export of fruits and vegetables, oils and fats, plant fibers and other agricultural products.

According to the conclusion, the provisions of RCEP on agricultural products will create broader development prospects and more growth opportunities for China's agricultural products. Therefore, policymakers, major enterprises, and professionals related to agriculture should take the initiative to learn and study the RCEP rules. Policymakers need to refine the rules further and formally explain and promote the provisions on trade in goods and services, investment, and origin in the RCEP. This can help agricultural-related businesses and producers better understand the rules and lay a solid foundation for their wide application in the future.

In addition, the corresponding supporting policies should be formulated to regulate and guide agricultural production, promote the growth of agricultural exports, and improve our country's competitiveness. Therefore, it is suggested that the structural reform of the supply side of agricultural products be continued, the modernization process of primary agricultural production areas should be promoted, financial support for agriculture should be increased, and all participants should be encouraged to innovate farm production and operation methods. New production factors should be integrated into agricultural production and circulation to improve the quality, technical content, and economic added value of agricultural products and enhance the comprehensive competitiveness of the international market.

Moreover, the GTAP simulation data reveal that the output of agricultural products, such as cereals, will be reduced, and both imports and exports will be hit hard. This contradicts the actual situation and reflects that our country's grain production is putting us in bigger trouble. The yield of cereals is directly related to food security, a key issue closely related to the national economy and people's lives. Food supply security is affected by national policy, economic development level, international politics, and other factors. Therefore, to ensure food safety, increasing the monitoring and support of such agricultural products is necessary.

Limitations

Using simulation to study the impact of policy on import and export trade has limitations. The GTAP model has certain restrictions based on the computable general equilibrium model. This prediction is not unconditional but more like an experiment to determine the consequences of changing policy in a hypothetical environment, which will undoubtedly differ from the real world. Secondly, the GTAP model is a quantitative study based on theory, which is not an empirical study in the context of an econometric model but a strict test of experience under restricted conditions. This paper uses the arithmetical equation to calculate the target tariffs of various industries at different times through the Tariff Commitment Table, so there may be differences between the average method and the actual result.

This paper gives a brief conclusion, and does not deeply discuss the import and export changes of each RCEP member country and each agricultural product, which is a limitation of this paper and needs to be further studied. Besides, due to the author's ability, the research has limitations, but it is also hoped to be the direction of further study.

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The Impact of Inward Sectoral FDI in Agricultural and Food on Food Security

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Abstract

The purpose of this paper is to investigate the impact of inward primary-sector foreign direct investment and inward secondary-sector foreign direct investment in agriculture and food on food security and its four pillars, including food affordability, food availability, food quality and safety, and food sustainability and adaptation. This study focuses on 21 high-income countries and 17 middle-income countries from 2012 to 2021. For the methodology, this paper employs panel regressions. The results manifest that inward sectoral FDI differently impacts each food security pillar for each country group. For high-income country group, both inward primary-sector FDI and inward secondary-sector FDI negatively impact food security, reflecting that inward FDI is unrequired for high-income country group to improve food security. However, in the context of the middle-income country group, inward primary-sector FDI has positive impacts on some food security pillars, indicating that inward primary-sector FDI has the potential to support a nation's food security. Nonetheless, inward secondary-sector FDI adversely affects the food security of this group, revealing that inward secondary-sector FDI is not a potential instrument for middle-income countries to enhance food security. The results can lead to specific policy implications. Governments of high-income countries should emphasize policies that encourage trade openness in agricultural and food sectors, while governments of middle-income countries should prioritize policies that support inward-primary FDI to improve food security.

Keywords: Food Security, Inward Primary-Sector Foreign Direct Investment, Inward Secondary-Sector Foreign Direct Investment, Agricultural and Food Industries

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Introduction

It is undeniable that food has been considered one of the fundamental needs of human beings, becoming a considerable global issue. Nevertheless, it is reported by the Food and Agriculture Organization of the United Nations (FAO) that in 2022, approximately 735 million people in the world have encountered hunger and food insecurity, especially in the developing countries (FAO, 2006). This manifests the suffering of massive people caused by hunger and undernourishment. As a result, the United Nations has prioritized responding the food security issue through the creation of the sustainable development goals (SGDs) with Goal number 2 focusing on "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" (United Nations, 2023).

Even though the urgency of food security has globally distressed, the globalization of the 21st century has interweaved the interdependence of nations, performing positive and negative effects on food security. Especially, the incident of inward foreign direct investment has appeared as crucial factor impacting food security. However, the effect of inward foreign direct investment on continues a subject of argument, because inward foreign direct investment is categorized into 2 important sectors: inward primary-sector foreign direct investment, regarding investment in natural resources and export to developed countries, and inward secondary-sector foreign direct investment, involving investment in manufacturing. Moreover, the results of previous studies investigating the impacts of each inward sectoral foreign direct investment on food security have been arguable consequences.

To illustrate, for inward primary-sector foreign direct investment, Mihalache-O' Keef and Li (2011) suggested that inward primary-sector foreign direct investment adversely impacts on food security. One of the main reasons is the destruction of downstream industries of in host countries because of misdistribution of host country's resource toward foreign countries. Nevertheless, Santangelo (2018) argued that the inward primary-sector foreign direct investment can positively impact on food security of the host countries, especially regarding inward foreign direct investment in land by the developed countries. In perspective of inward secondary-sector foreign direct investment, its effect on food security is a subject of controversy. On the positive side, Mihalache-O' Keef and Li (2011), also Slimane et al. (2016), concluded in their research that inward secondary-sector foreign direct investment could upgrade upstream and downstream industries through know-how spillover and modern technology from foreign countries. As a result, these positive effects contribute to increased increasing income, employment, and market competition in the host countries. Nonetheless, Slimane et al. (2016) concerned about the adverse impacts of inward secondary-sector foreign direct investment, especially in the aspect of environment, focusing pollution issues connected with the inward secondary-sector foreign direct investment process.

In addition, massive previous researches have investigated the impacts of inward foreign direct investment on food security. However, most of previous empirical studies commonly measured food security through daily per capita calories and protein consumption. Moreover, in the context of inward foreign direct investment, many empirical studies examined both primary-sectoral and secondary-sectoral inward foreign direct investment across diverse sectors, rather than specially concentrating on the agricultural and food sector. Besides, most of the relevant previous research concentrated only on studying the effects of inward sectoral foreign direct investment of agricultural and food sector on food security within the context of developing countries, neglecting a comprehensive investigating of every country worldwide. However, the Economist Intelligence Unit reports values for each food security index within different income-level country groups that are obviously different (The Economist Intelligence Unit, 2021), as shown in the figure 1.

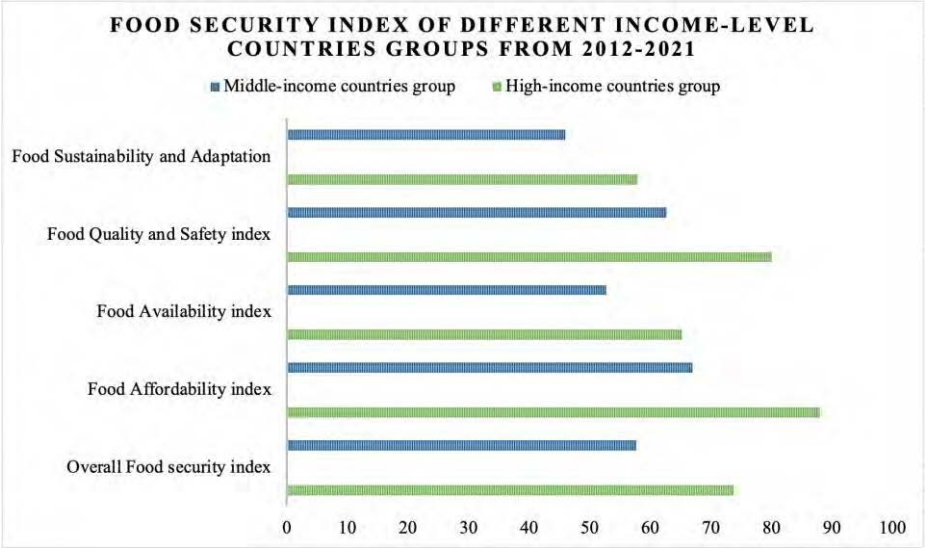

Figure 1: The summary data of each food security index of high-income and middle-income country groups in 2012-2022. Adapted from The Economist Intelligence Unit (2021).

Additionally, the figure 1 reveals the average values of the overall food security index and the four key pillars of food security including food affordability index, food availability index, food quality and safety index, and food sustainability and adaptation index for 38 countries worldwide from 2012 to 2021. These countries are categorized into two groups: middle-income countries (17 countries), and high-income countries (21 countries); see Table A1 in the appendix for the list of countries.

From the figure 1, it clearly demonstrates values for each food security index: overall food security index, food affordability index, food availability index, food quality and safety index, and food sustainability and adaptation index. Noticeably, these indices are totally different among different income-level country groups. Obviously, the high-income country group shows the highest values of all food security indexes while the middle-income country group ranking second. As a result, when investigating the impacts of inward sectoral FDI of agricultural and food sector on food security of each income-level country group, the results of study may be significantly different for each country group.

Therefore, there are some noticeable research gaps comprising of third aspects. First, even though many previous empirical studies widely measured food security through calories and protein intake, this approach has crucial problems. Determining the proper or minimum calories consumption is controversial issue as it depends on individual characteristics, and the demand for calories intake expresses the problem regarding income elasticity; they tend to select satisfying food rather than focusing on enough calories of food when people have higher income (Jensen & Miller, 2010). Therefore, protein and calories intake may not be appropriate representatives of food security, especially for high-income countries. On the other hand, the measurement of food security and its four pillars would provide a comprehensive representative.

Second, there are few previous researches investigating inward sectoral foreign direct investment exclusively in agricultural and food sector. Nevertheless, concentrating on inward primary-sectoral foreign direct investment and inward secondary-sectoral foreign direct investment in agricultural and food sectors can demonstrate the detailed impact of sectoral

inward foreign direct investment on food security (Djokoto, 2012). Besides, inward sectoral foreign direct investment in agricultural sector would more manifest its direct impacts on food security when considered based on the key four pillars of food security. Lastly, few researches have investigated the impacts of inward sectoral FDI in the agricultural and food sectors on food security across countries with different income levels. Most researches focus on developing countries. From all the above, this study aims to investigate the impact of inward primary-sector FDI and inward primary-sector FDI in the agricultural and food sectors on each food security index across countries with different income levels.

Literature Review

According to review the literature on the impacts of inward sectoral FDI in agriculture and food on food security, the analysis is categorized into three crucial sections. These sections comprise of the definition and measurement of food security, the inward foreign direct investment and food security, and trade openness and food security. In addition, for the trade openness and food security section, it is inevitable the interweave between FDI and trade openness therefore, trade openness should be considered in this section especially in the context of export dependency.

Food security (Definition and measurement)

The concept of food security is based on the 1996 World Food Summit that "Food security exists when all people, at all time, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). Because of this food security concept, the FAO identified four important pillars of food security. First of all, 'food availability' pillar mentions about the sufficient supply side of basic foodstuffs through both domestic production and international trade. Secondly, the FAO has also concerned 'food access or food affordability' pillar. This pillar emphasizes the individual's capability to access adequate food for living since only the sufficient food supply at both international and national levels is insufficient for assurance individual food security. Furthermore, 'food utilization or food quality and safety' pillar is considered focusing on individual's nutritional and energy adequacy. Lastly, 'food stability or food sustainability and adaptation' pillar is examined concentrating on the individual need to access sufficient basic foodstuffs all the time, regardless concerning economic factors, natural disasters, political instability, and other threats. All of these four pillars completely reflect the concept of food security following the FAO.

For food security measuring, previous studies commonly employ either traditional or modern approaches. To begin with the traditional approach, food security is mainly measured by energy consumption. To illustrate, there were measurements with daily per capita energy consumption (Dithmer & Abudulai, 2017; Santangelo, 2018), calories and protein daily intake per capita consumption (Mihalache-O' Keef & Li, 2011; Wimberly & Bello, 1992), and the average five-year calorie and protein per capita consumption (Jenkins & Scanlan, 2001). Nevertheless, the traditional approach has three crucial problems (Jensen & Miller, 2010). Firstly, the appropriate calories consumption remains a controversy issue as it depends on individual characteristics such as sex, age, daily physical activity, and weight. Secondly, the problem focuses on absorption since it is very difficult to confirm whether all nutrients consumed by humans are completely absorbed by the body. Lastly, it involves income elasticity because people with higher income tend to select satisfying food based on taste rather than focusing on completing sufficient calories intake. From all these issues, the traditional approach might not be appropriate representative of food security.

On the other hand, the modern approach offers a different method for food security measurement by five indexes: including the overall food security index, food availability index, the natural resources and resilience index, the food affordability index, and the quality and safety index (Saboori et al., 2022). Obviously, all the indexes of food security provide a comprehensive elucidation of all four pillars of food security according to the FAO.

Determining the aforementioned limitation regarding the traditional approach and seeking to contain the four important pillars of food security, it is reasonable that this paper employs a modern approach measuring food security with five crucial perspectives: overall food security index, food availability index, food affordability index, food quality and safety index, and food sustainability and adaptation index. The figure 2 demonstrates the criteria for each index of food security based on its four keys pillars by FAO.

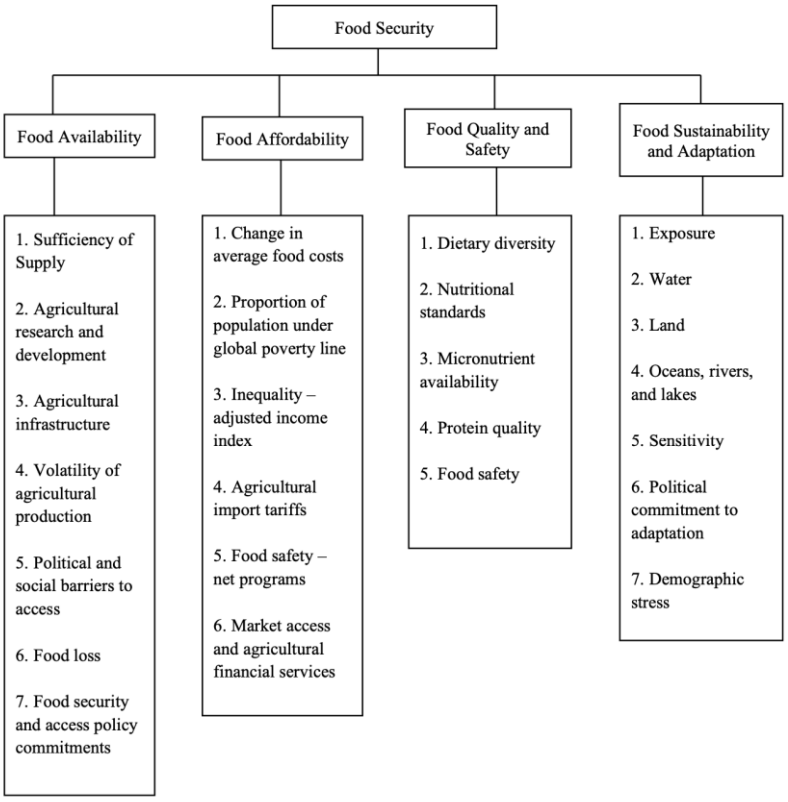

Figure 2: The four indexes of food security. Adapted from the Economist Intelligence Unit. (2021).

Inward Foreign Direct Investment (IFDI) & Food security

Based on the empirical studies relating the impacts of inward sectoral FDI (IFDI) on food security, the conclusions remain controvertible until the present day. Principally, IFDI is classified into two main sectors: inward primary-sector foreign direct investment (IPFDI), and inward secondary-sector foreign direct investment (ISFDI). First of all, 'inward primary-sector foreign direct investment or IPFDI' is defined as foreign investment in the natural resources of host countries. After that, the products are produced in host countries and exported to developed countries. Mostly, the effects of IPFDI are adverse direction. According to the character of IPFDI relies on the interdependence on other countries, the principal spillover from developed to developing countries is not occurred by this type. Instead, downstream industries

of host countries can be destroyed, as misdistribution deflecting the host country's resource to foreign countries and unfavorable labor market (Mihalache-O' Keef & Li, 2011). Although IPFDI and primary export may not disturb domestic agricultural production, the long-term adverse disruption in food consumption can happen through primary exporting to foreign market (Wimberley & Bello, 1992). Besides, IPFDI can destroyed food security in host countries through environmental deterioration, land grabbing, and resource misallocation. Domestic development is obstacle by foreign investors, acting as land grabbers. This leads to the intensive use of chemicals in primary resources, emphasizing commercial farming rather than sustainable practices. Moreover, primary resources of host countries are exported to investor's home countries more than being used locally (Cotula et al., 2009). Nonetheless, IPFDI can establish a positive impact on food security when it relates to IFDI in land of developed countries. The reason is IFDI in land of developed countries can result in rising in cropland, and beneficial spillover in technology and environment. This is because developed countries investors inclined to comply with responsible farmland investment processes and human rights (Santangelo, 2018). It is apparent that under the same inward primary-sector foreign investment, the results of each empirical study are disputable and can be analyzed from many perspectives. These results are summarized in figure 3.

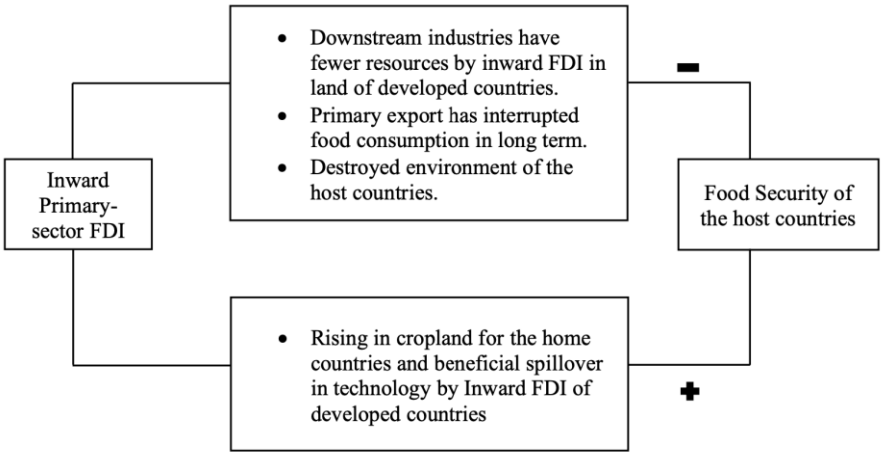

Figure 3: The impact of inward primary-sector FDI on Food security. Adapted from "Modernization VS. Dependency Revisited: Effected of foreign direct investment on food security in less developed countries," by Mihalache and Li, 2011, International Studies Quarterly, 55, 71-93.

Secondly, another type of IFDI is 'inward secondary-sector foreign direct investment (ISFDI)'. ISFDI is defined as the direct investment of foreigners in manufacturing sector of host countries. Similar to IPFDI, the influences of ISFDI on food security are contentious. For positive side, ISFDI has ability to improve agricultural production, resulting in enhancing food supply. This implies that ISFDI effectively supports two of the four key pillars of food security including food utilization and food availability. Furthermore, technology and know-how spillover have potential to upgrade both downstream industries and the upstream industries, resulting in increasing in employment, income and market competition in the host countries. On the other hand, the negative effects of ISFDI on food security are a concern from environment aspect, as ISFDI may lead to pollution (Slimane et al., 2016; Mihalache-O' Keef & Li, 2011). These results are summarized in figure 4.

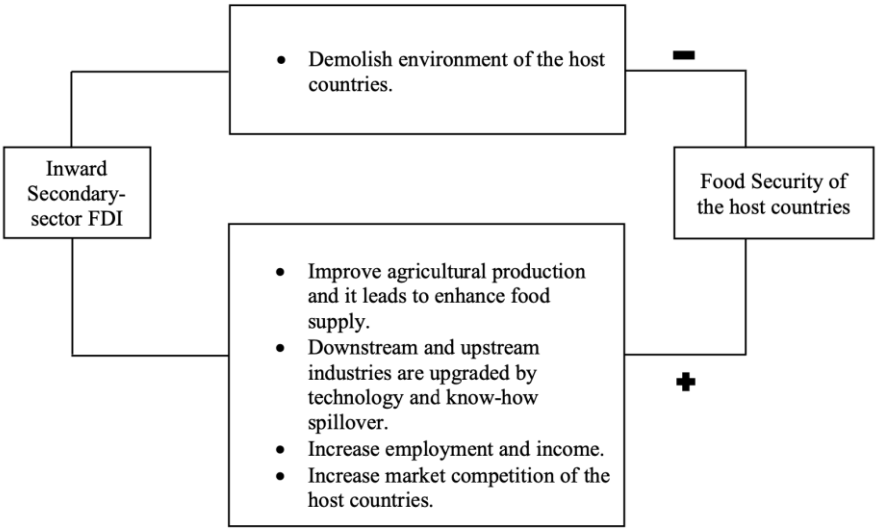

Figure 4: The impact of inward secondary-sector FDI on Food security. Adapted from "Modernization VS. Dependency Revisited: Effected of foreign direct investment on food security in less developed countries," by Mihalache and Li, 2011, International Studies Quarterly, 55, 71-93.

In spite of few researches on inward sectoral FDI especially in agricultural and food sector, the results of inward sectoral FDI in agricultural and food sectors manifest direct impacts on food security while inward sectoral FDI in other sectors express indirect impacts on food security, considering the key four pillars of food security. For example, the "food availability" pillar considers average food supply as a criterion, implying changes in agricultural sector's products directly affect food security in terms of the availability pillar. To illustrate some research studying the impacts of the inward sectoral FDI in agricultural and food sector on food security, Djokoto (2012) found the negative effects of the agricultural inward primary-sectoral FDI on food security in Ghana because of the destroying of the host country's environment and decreased resources for downstream industries. Nevertheless, Skoet et al. (2004) found that agricultural inward primary-sector FDI positively impacts food security and poverty reduction in the Africa, Caribbean, and Pacific countries (ACP) region by providing sufficient food supply and creating employment opportunities for the labor force. It is obvious that the effects of inward primary-sectoral FDI on food security are controversial, even within agricultural sector. Besides, there are studying only inward primary-sectoral FDI in agricultural sector, it still lacks investigating the agricultural inward secondary-sectoral FDI.

Trade openness and Food Security

From the literature review, most results of empirical studies manifested positive impacts of trade openness on food security. Generally, the trade openness improved food security by assuring the sufficient supply of dietary energy, presenting the positive impact of trade openness on national food security (Dithmer & Abdulai, 2017; Pyakuryal et al., 2010). To illustrate empirical studies, Brewer et al. (2023) suggested that Pacific Island Countries and

Territories (PICTs) were able to decrease vulnerabilities connected with insufficient food security by rising dependency on imported food and beverage from other regions. This revealed economic development that sometimes, imported food achieves cheaper price than local food. This caused physical improvement that local people can access the adequate food, and social development of people in the region that they choose their preferred food more than local food by importing food (Brewer et al., 2023). As a result, in this case, the trade openness completely positively enhanced the food security in the PICTs region be it in aspect of economic, social, physical advancement. Similarly, Dorosh et al. (2016), which especially explored the influence of trade openness on food security in cereal markets of South Sudan, the reduced domestic agricultural production resulted in the insufficient food supply and this was effectively solved by importing agricultural products. It is obviously, in the case of South Sudan, trade openness also plays an important role in improving food security by assuring adequate food supplies for population. From these results of many empirical studies, it is conspicuous that trade openness has significantly positively affected both national and regional food security.

Theoretical Framework

It is incontrovertible that inward foreign direct investment (IFDI) has significantly influenced on food security. The previous studies regarding the impacts of inward FDI on food security have outlined two significant controversial theories explaining the relationship between IFDI and food security: including the dependency theory and the modernization theory. However, this paper will consider both theories and evaluate their rationality based on the results gained.

Dependency theory or World System theory

The dependency theory usually emphasizes foreign direct investment and export dependency. Generally, the dependency supporters are concerned that foreign investment and international trade might result in inequality, unfairness, and growth disparities between developed and developing countries through globalization. The developing country's economies could encounter exploitation by the foreign direct investment with many reasons. First, FDI can cause repatriation of profits by foreign corporations to their home countries and this practice extremely hinders economic development of host countries. Second, FDI often relies on technology therefore, it results in a decrease in the employment rate in host countries. Third, foreign corporations often ignore social programs that promote the social welfare of the people, leading to greater responsibility from host country's governments. Last but not least, the concentration on the export sector of foreign corporations can hurt domestic markets of the host countries, as the domestic sector of the host countries may be ignored (Jenkins & Scanlan, 2001).

Applying the dependency theory to food security, previous studies argued that IFDI and export dependency have been significantly perilous to food security (Mihalache-O'Keef & Li, 2011; Wimberley & Bello, 1992; Jenkins & Scanlan, 2001). According to inward FDI and international trade are harm to economic development and social welfare, it negatively leads to food security. Moreover, IFDI is connected to higher unemployment rates, causing the reduction of people's capacity to access adequate food. Finally, due to export dependency and

FDI chiefly concentrate on the export sector and neglect the social development in the host countries, these cause the necessary rising governments expenditure on social program, including enhancing food security. This expresses that if there is an increase in government expenditure in agriculture, it contributes to better food security.

Modernization theory

On the controversy with the dependency theory, the modernization theory generally concentrates on economic structure. Basically, the modernization defenders debate that FDI and international trade can establish benefits for both developed and developing countries. For the developed countries, investors are able to attain benefit in terms of accessing cheap labor, raw materials, and new markets in the host countries. At the same time, the developing countries can gain advantage from the FDI and the international trade through advantageous knowledge and technology spillover, leading to improvement in domestic markets. As a result, these effects could effectively cause equality between developed and developing countries in long term such as equal product prices and real wages worldwide. Furthermore, the modernization theory importantly believes in human capital investment that it definitely supports economic growth and quality of life through developing labor skills and add adaptability to modern technology. Lastly, the modernization theory also suggests that political democracy is a crucial factor affecting economic and social development. This because political democracy provides opportunities for all classes, especially lower class, to express their interests and help restrain corruption. Therefore, these actions totally result in overall improvement in life and economy of a country.

Applying the modernization theory to food security, the impacts of FDI and international trade based on this theory completely cause economic development in both developed and developing countries. This economic development is an important factor that enhances food security. Moreover, education and political democracy also influence the food security as these factors are able to improve both economy and social welfare. When individual can access to higher education and more stability of political democracy, they can elevate their economic status, absolutely resulting in increased level of food security.

Crucially, the dependency theory and the modernization theory play an important role in this study as they specifically focus on the impacts of inward foreign direct investment and international trade on development of nation, including national food security. Therefore, these two theories are commonly referenced in literature related to inward foreign direct investment and food security. However, these two theories provide different conclusions regarding the effects of inward foreign direct investment on food security: the dependency theory suggests that the inward foreign direct investment can jeopardize national food security, while the modernization theory argues that the inward foreign direct investment can enhance national food security. As a result, this study investigates both the dependency theory and the modernization theory.

Methodology

For the methodology of this study, it utilizes the panel regression model to synthesize the dataset, which comprises of the same cross-section unit measured at different time point (Zulfikar & MM, n.d.). For the initial step, the impacts of inward primary-sector FDI and inward secondary-sector FDI on the food security of each country group are investigated using five model specifications. These models examine overall food security and its four pillars. Specifically, the model I focuses on the overall food security pillar (OFS), the model II concentrates on the food affordability pillar (FAF), the model III gives importance to the food availability pillar (FAV), the model IV pays attention to the food quality and safety pillar (FQS), and the model V revolves about the food sustainability and adaptation pillar (FSA). In each model specification, the dependent variable changes, but the other variables remain the same across all models. However, the panel regressions can be performed utilizing either the fixed effect or random effect approach. To determine the suitable approach, the Hausman test is employed, where the null hypothesis suggests the random effect model and the alternative hypothesis recommends the fixed effect model (Wooldrige, 2013). Consequently, for the high-income country group, the Hausman test reveals that the fixed effect model is proper for the overall food security, food affordability, and food sustainability and adaptation pillars. However, the random effect model is appropriate for food availability and food quality and safety models. On the other hand, for the middle-income country group, the Hausman test suggests the random effect models for all food security models, except for the food sustainability and adaptation model, which is better suited to the fixed effect model.

The model specification

$$FSI_{it} = \beta_0 + \beta_1 IPFDI_{it} + \beta_2 ISFDI_{it} + \beta_3 ln\_GDPpercapita_{it} + \beta_4 TO_{it} + \beta_5 ln\_Educ_{it} + \beta_6 ln\_GEagri_{it} + \beta_7 ln\_NR_{it} + \beta_8 COVID_{it} + \varphi_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Where FSI, IPFDI, ISFDI, ln_GDPpercapita, TO, ln_Educ, ln_GEagri, ln_NR, and COVID represent the food security index, inward primary-sector FDI, inward secondary-sector FDI, the logarithm of GDP per capita, trade openness, the logarithm of education, the logarithm of government expenditure in agriculture and food, the logarithm of natural resources, and COVID-19, respectively. φ_i stands for the unit-specific random or fixed effects. λ_t indicates the time-specific random or fixed effects. In this model, t denotes countries, i denotes year, and ε is the error term. Most of the data used in this paper are derived from the Food and Agricultural Organization of the United Nations (FAOSTAT). Other data are accumulated from the International Monetary Fund (IMF), the UN Comtrade Database, the World Bank, and Our World in Data (for the data source, see Table A2 in the appendix).

In the model specification, inward primary-sector FDI in agricultural and food, and inward secondary-sector FDI in agricultural and food, may have either positive or negative impacts on food security. Due to the dependency theory, the inward FDI can destroy food security by decreasing economic development and resources for host countries. In contrast, the

modernization theory argues that inward FDI can enhance food security by increasing economic development and technology spillovers. To analyze these contrasting aspects, the model specification of this study controls for six factors, including GDP per capita, trade openness, education, government expenditure in agricultural and food, natural resources, and COVID-19 pandemic. For the GDP per capita, both the dependency theory and the modernization theory suggest that GDP per capita can impact food security as a representative of economic development. Moreover, GDP per capita has the capacity to help this study control for indirect influence of FDI on food security, with its impact expected to be positive as both theories suggest that economic development effectively promotes national food security.

Next, trade openness is also controlled for this study, measured by the volume of trade (real exports plus imports) in agricultural and food sector relative to real GDP (Dithmer & Abudulai, 2017). The dependency theory believes that trade openness negatively impacts food security by decreasing national food supply sufficiency. On the other hand, the modernization theory argues the opposite, suggesting trade openness positively affects food security, increasing national food supply through export and import. Therefore, the expected result could be either positive (following modernization theory) or negative (following dependency theory). Third, government expenditure in agricultural and food sector is a crucial factor, as both theories suggest that this spending captures national resources and state ability to directly address national food insecurity. As a result, the expected effect of government expenditure in agricultural and food sector on food security is positive; the more government expenditure spends in agricultural and food sector, the higher lever of food security.

At the same time, this study controls education, as a representative of human capital investment. Both important theories propose that human capital investment rises access to basic foodstuffs by establishing labor force with better skills, which should promote national food security in turn. Therefore, its impact of education on food security is expected to be positive. Furthermore, it is necessary to control natural resources, measured by a nation's arable land. It is an important for agricultural production and thus affects a nation's food supply. Lastly, this study includes COVID-19 pandemic to assess the impact of global shock on food security, investigated by stringency COVID index. The impact of the COVID-19 on food security is expected to be negative.

Since the panel regression models in this study are derived from both cross-sectional and time series data, they face heteroskedasticity and autocorrelation problems. To solve these issues, the study employs Huber-White robust standard error technique. The models are also scrutinized for multicollinearity problem using Variance Inflation Factor (VIF) and this issue is not present in these models. Furthermore, the models are examined endogenous problem using Durbin-Wu Hausman test and the results illustrate some endogenous problems. Therefore, this study also utilizes the Two-Stage Least Squares (2SLS) and the Instrumental Variables techniques (IV) to solve the endogenous problems. Since GDP per capita, which is the main endogenous variable and correlate with inward FDI, this study utilizes the first-order lag of GDP per capita as an instrumental variable. This process is explained in the equation 2-5.

Two-Stage Least Squares (2SLS)

To begin with the first-stage regression of the Two-Stage Least Squares method, if the equation is given by

$$FSI_{it} = \beta_0 + \beta_1 IPFDI_{it} + \beta_2 ISFDI_{it} + \beta_3 ln\_GDPpercapita_{it} + \beta_4 TO_{it} + \beta_5 ln\_Educ_{it} + \beta_6 ln\_GEagri_{it} + \beta_7 ln\_NR_{it} + \beta_8 COVID_{it} + \varphi_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where FSI or food security index can refer to overall food security, food affordability, food availability, food quality and safety, or food sustainability and adaptation, depending on the specific model.

After that, the endogenous variable or ln_GDPpercapita for this model is regressed on the instrumented variable and the exogenous variables, as demonstrated in the equation 3.

$$ln\_GDPpercapita_{it} = \pi_1 + \pi_2 lag1\_ln\_GDPpercapita_{it} + \pi_3 IPFDI_{it} + \pi_4 ISFDI_{it} + \varphi_i + \lambda_t + \upsilon_{it} \quad (3)$$

where ln GDPpercapita is the endogenous variable of this model, lag1_ln_GDPpercapita represents the first-order lag of GDP per capita or the instrumented variable of this model, and υ_{it} is the error term of the first-stage regression.

Following this, the predicted value is obtained from the first-stage regression, as shown in the equation 4.

$$\widehat{ln\_GDPpercapita}_{it} = \hat{\pi}_1 + \hat{\pi}_2 lag1\_ln\_GDPpercapita_{it} + \hat{\pi}_3 IPFDI_{it} + \hat{\pi}_4 ISFDI_{it} + \varphi_i + \lambda_t \quad (4)$$

where $\widehat{ln\_GDPpercapita}$ is the predicted value.

After receiving the predicted value, the endogenous variable is substituted by the predicted value, resulting in the second-stage regression, as illustrated in the equation 5.

$$FSI_{it} = \beta_0 + \beta_1 IPFDI_{it} + \beta_2 ISFDI_{it} + \beta_3 \widehat{ln\_GDPpercapita}_{it} + \beta_4 TO_{it} + \beta_5 ln\_Educ_{it} + \beta_6 ln\_GEagri_{it} + \beta_7 ln\_NR_{it} + \beta_8 COVID_{it} + \varphi_i + \lambda_t + \mu_{it} \quad (5)$$

where μ_{it} is the error term of the second-stage regression. Therefore, all the models solve problems related to heteroscedasticity, autocorrelation, and endogeneity. The results of all models are shown in the next section.

Empirical Results

The results of this study are separated into 2 groups: high-income country group, and middle-income country group. For each group, the results are manifested across five models, including the overall food security pillar, the food affordability pillar, the food availability pillar, the food quality and safety pillar, and the food sustainability and adaptation pillar.

Table 1: The results of high-income country group

Results of High-income country group

	Model I	Model II	Model III	Model IV	Model V
	Overall FS	Food affordability	Food Availability	Food Quality and Safety	Food Sustainability and Adaptation
IPFDI	-0.001273**	-0.0025101***	-0.0026382***	-0.0016168	0.0022652
	(0.0005896)	(0.0008676)	(0.0008559)	(0.0010058)	(0.0020425)
ISFDI	-0.0000835***	0.0000174	-0.0000669***	-0.0000801***	-0.0002408***
	(0.0000266)	(0.0000181)	(0.0000237)	(0.000024)	(0.0000907)
TO	0.0000354**	0.0000907***	-0.0000168	0.0000668***	-0.0000129
	(0.000015)	(0.0000181)	(0.0000138)	(0.0000214)	(0.0000342)
Ln_GDP	8.319715***	1.686874**	3.178333***	10.52536***	20.68946***
	(0.7986904)	(0.8501398)	(1.068725)	(0.8719468)	(2.014693)
Ln_GOV	-1.326737***	0.2098116	2.21126***	-3.459172***	-5.177016***
	(0.4010195)	(0.473226)	(0.5889504)	(0.5122578)	0.8495483
Ln_NR	0.8647048***	-1.138811***	-0.7371231	1.743189***	4.454438***
	(0.287555)	(0.3143511)	(0.4799258)	(0.3621304)	0.817723
Ln_EDUC	-4.477171	1.428409	18.28357***	-22.13652***	-19.85177
	(4.583046)	(4.972369)	6.495982	(7.012388)	(11.80704)
COVID	0.0009368	-0.0160745	-0.0152124	-0.0076173	0.0501114**
	(0.0087032)	(0.0113302)	(0.0141595)	(0.0137636)	(0.0250724)
Constant	15.04539	71.80902***	-69.25201***	96.07781***	-48.93137
	(18.19275)	(20.26751)	(26.23165)	(30.13738)	(45.5155)
Observation	189	189	189	189	189
Countries	21	21	21	21	21
R-Squared	0.9804	0.3054	0.4986	0.3500	0.4761

Note. robust standard errors in parentheses
*Significant at 10%
**Significant at 5%
***Significant at 1%

For the table 1, it reports the impact of inward primary-sector FDI and inward secondary-sector FDI on the five food security pillars for high-income country group. In model I, it demonstrates that both inward primary-sector FDI and inward secondary-sector FDI negatively impact overall food security, with significance level of 5% and 1%, respectively. Also, trade openness, GDP per capita, and natural resource are significant with positive impacts. In model II, only inward primary-sector FDI negatively impacts the food affordability pillar at 1% significance level. However, trade openness and GDP positively affect the food affordability. In model III, both inward primary-sector FDI and inward secondary-sector FDI adversely impact the food availability pillar, with 1% significant. Nevertheless, GDP per capita and education reveal positive effects. In model IV, only inward secondary-sector FDI negatively influences the food quality and safety pillar at 1% significance level. Nonetheless, trade openness, GDP per capita, and natural resource demonstrate positive effects. In model V, only inward secondary-sector FDI negatively impacts the food sustainability and adaptation

pillar at 1% significant. On the other hand, GDP per capita and natural resource show positive influence.

To summarize, the inward primary-sector FDI contributes negative effects on food security in high-income countries across the overall food security, food affordability, and food availability pillars. This shows that the foreign investment in the natural resources may destroy food security by decreasing domestic production potential and limiting access to basic foodstuffs. In the perspective of inward secondary-sector FDI, this FDI also negatively impacts food security of high-income countries across the overall food security, food affordability, food quality and safety, and food sustainability and adaptation pillars. It demonstrates that the foreign investment in manufacturing can harm food security by declining individual's access to basic foodstuffs, individual's nutritious adequacy, and hindering individual access to basic foodstuffs all the time without concerning any threats.

Moreover, trade openness positively affects food security in high-income countries, promoting overall food security, food affordability, food quality and safety. It reveals that export and import support food security by enhancing individual's ability to afford food and access sufficient nutrition. GDP per capita also positively impacts all five food security pillars. For the natural resources, it manifests the positive impacts on overall food security, food quality and safety, and food sustainability and adaptation. Lastly, the education has a positive impact only on food availability pillar. These findings apparently highlight the importance of GDP per capita, natural resources, and education as crucial instruments in enhancing food security.

Table 2: The results of middle-income country group

Results of Middle-income country group

	Model I	Model II	Model III	Model IV	Model V
	Overall FS	Food affordability	Food Availability	Food Quality and Safety	Food Sustainability and Adaptation
IPFDI	0.0030954***	0.0048011***	0.0080472***	0.0009085	-0.0025175*
	(0.0006766)	(0.0018468)	(0.0014685)	(0.0019906)	(0.0014066)
ISFDI	-0.0004035***	-0.0008273**	-0.0006217***	0.0005363	-0.0005338**
	(0.0001194)	(0.0003734)	(0.0002018)	(0.000477)	(0.000259)
TO	-1.62e-06**	-8.57e-06***	6.38e-06**	-6.42e-07	-2.25e-06*
	(7.63e-07)	(1.82e-06)	(2.59e-06)	(2.46e-06)	(1.22e-06)
Ln_GDP	5.976791***	12.30546***	-1.473728	9.830971***	1.970903**
	(0.6103221)	(1.251716)	(1.381941)	(0.8963138)	(0.9580382)
Ln_GOV	0.4488503	-1.883057***	3.5348***	-1.374468**	1.977776***
	(0.3351672)	(0.6208131)	(0.674058)	(0.6708362)	(0.6926517)
Ln_NR	0.2530304	-0.4233788	-1.392444**	1.874534***	1.352024**
	(0.2941758)	(0.4316668)	(0.6311049)	(0.4633521)	(0.6137145)
Ln_EDUC	-5.728154	-22.67661*	24.72436**	-6.89779	6.806939
	(5.583996)	(12.13187)	(11.506)	(8.338673)	(8.316456)
COVID	0.0393575***	-0.0009694	0.0510347**	0.0435794**	0.0758321***
	(0.0105598)	(0.0216682)	(0.0234324	(0.0215275)	(0.021982)
Constant	4.47969	99.90848	-70.33171	6.293845	-40.24442
	(28.1777)	(61.53612)	(57.47079)	(42.14655)	(40.17142)
Observation	153	153	153	153	153
Countries	17	17	17	17	17
R-Squared	0.7059	0.6023	0.4814	0.6012	0.3984

Note. robust standard errors in parentheses
*Significant at 10%
**Significant at 5%
***Significant at 1%

For the table 2, it reports the impact of inward primary-sector FDI and inward secondary-sector FDI on the five food security pillars for middle-income countries. In model I, inward primary-sector FDI positively impacts the overall food security pillar at 1% significance level, while inward secondary-sector FDI adversely affects this pillar at the same significance level. Trade openness demonstrates negative impact, while GDP per capita and COVID-19 have positive impacts at 1% significance level. In model II, inward primary-sector FDI positively affects food affordability pillar at 1% significance level, whereas inward secondary-sector FDI negatively impacts this food pillar at 5% significance level. Trade openness adversely impacts food affordability, while GDP per capita provides positive effect.

In model III, inward primary-sector FDI has a positive effect on the food availability pillar, while inward secondary-sector FDI negatively impacts it at 1% significance level, similar to the model I and II. Nevertheless, trade openness, government expenditure on agriculture and food, education, and COVID-19 contribute positive impacts on food availability pillar. In model IV, the result reveals that neither inward primary-sector FDI nor inward secondary-sector FDI are significant for food quality and safety pillar. Nonetheless, GPD per capita, natural resources, and COVID-19 positively affect this pillar. In model V, both inward primary-sector FDI and inward secondary-sector FDI adversely impacts food sustainability and adaptation pillar at 10% and 5% significance level, respectively. Trade openness demonstrates negative effect on this pillar, while GDP per capita, government expenditure on agriculture and food, natural resources, and COVID-19 provide positive effects on food sustainability and adaptation.

To summarize, the inward primary-sector FDI displays the positive impacts on food security through the overall food security, food affordability, food availability pillars, aligning with the modernization theory. This shows that the foreign investment in a country's natural resources can promote food security by increasing individual's access to basic foodstuffs and enhancing domestic production. However, the inward primary-sector FDI adversely affects food sustainability and adaptation pillar, aligning with the dependency theory. This reflects the harm caused by a focus on commercial farming over sustainable practices, leading to deplete primary resources in the long term.

In contrast, inward secondary-sector FDI negatively impacts food security in middle-income countries across the overall food security, food affordability, food availability, and food sustainability and adaptation pillars, supporting the dependency theory. It demonstrates that the foreign investment in manufacturing causes harms to food security by decreasing domestic production, limiting individual's access to food, and impeding individual's ability to access food without concerning any threats.

For trade openness, it has both positive and negative influences on food security in middle-income countries. On the positive impacts, it promotes food availability by enhancing the supply of basic foodstuff through international trade. However, trade openness negatively impacts overall food security, and food affordability, decreasing individual's ability to access food. GDP per capita positively impacts the overall food security, food affordability, food quality and safety, and food sustainability and adaptation pillars. This reflects that GDP per capita is one of crucial factors supporting food security. Government expenditure on agriculture and food positively affects the food availability and food sustainability and adaptation pillars.

For natural resources, it positively affects the food availability, food quality and safety, and food sustainability and adaptation pillars. It manifests that arable lands of nations cause escalating in basic foodstuff that individual can access all the time without concerning any threats and supporting individual's nutrition and energy. Education positively impacts only the food availability, highlighting its potential to enhance food security. Finally, COVID-19

positively impacts the overall food security, food availability, food quality and safety, and food sustainability and adaptation pillars. Despite restriction during COVID-19 pandemic, middle-income countries, where are extensively agricultural, can maintain their potential to produce their own food and agricultural products.

Conclusion and Policy Implication

Food security remains a global issue that every country pays attention to eliminate this problem. Globalization, especially through inward FDI, has interweaved the interdependence of nations, affecting food security both positively and negatively. With this reason, this study aims to examine the effects of inward primary-sector FDI and inward secondary-sector FDI in the agricultural and food sectors on diverse food security indices across countries with different income levels. The dataset of this study covers 38 countries, comprising of 21 high-income countries and 17 middle-income countries, from 2012 to 2021. For methodology, this paper employs fixed and random effect regressions to achieve the objectives. The results manifest that the inward primary-sector FDI has negative impacts on the food security of high-income countries. Moreover, it adversely affects food sustainability and adaptation pillar of middle-income countries group. Nonetheless, this type of FDI positively impacts food security of middle-income countries group in perspective of overall food security, food affordability, and food availability pillars.

In terms of inward secondary-sector FDI, this FDI negatively impacts food security in both high-income and middle-income countries. Moreover, trade openness appears as an important factor for food security. This factor establishes positive impact on food security in high-income countries. Nevertheless, in middle-income countries, trade openness reveals both positive and negative impacts on food security. It positively affects food availability, while it negatively influences the overall food security, and food affordability. Moreover, this study also considers the impact of COVID-19 on food security, as a representative of global shocks. The results suggest that in the aspect of food security, middle-income countries are less vulnerable to shocks or external threats compared to countries with different income levels.

These results lead to specific policy implications for each income country group. For high-income countries, governments should emphasize policies that encourage trade openness in agricultural and food sectors, as expanding exports and imports in these sectors is a powerful channel to improve nation's food security. On the other hand, inward FDI might not be an effective instrument for enhancing food security in high-income countries. For middle-income countries, governments should prioritize policies that support inward-primary FDI to improve food security. Conversely, trade openness in the agricultural and food sectors might not be an effective strategy to enhance food security in these countries, as expanding international trade in these sectors could potentially harm food security in certain perspectives.

Lastly, this study still has some limitations. First of all, the data availability poses challenges especially in middle-income countries. For example, the datasets regarding the inward sectoral FDI in each industry are very limited. Second, this study leaves some gaps. One of the fascinating research gaps is investigating the impacts of outward FDI on food security because it could provide valuable insights for higher-income countries in the context of FDI and food security. Therefore, exploring this area in the future research could provide crucial policy implications.

Appendix A

See appendix table A1-A2

Table A1

List of countries

High-income countries		Middle-income countries	
Austria	Norway	Argentina	Paraguay
Belgium	Poland	Bangladesh	Russia
Finland	Romania	Brazil	Serbia
France	Slovakia	Bulgaria	Thailand
Germany	South Korea	Cambodia	Tunisia
Greece	Spain	China	Turkey
Hungary	Sweden	Kazakhstan	Ukraine
Israel	United Kingdom	Malaysia	
Italy	United States	Mexico	
Japan	Uruguay	Morocco	
Netherlands			

Table A2

Variables definitions and source

Variable	Definition	Source
FSI	Food security index that can be overall food security, food affordability, food availability, food quality and safety, and food sustainability and adaptation, depending on which model it is	Food and Agricultural Organization of the United Nations (FAOSTAT)
IPFDI	Inward primary-sector FDI in agriculture and food	Food and Agricultural Organization of the United Nations (FAOSTAT)
ISFDI	Inward secondary-sector FDI in agriculture and food	Food and Agricultural Organization of the United Nations (FAOSTAT)
ln_GDPpercapita	The natural logarithm of GDP per capita (representing economic development)	International Monetary Fund (IMF)
TO	Trade openness: measured by the volume of trade in agriculture and food industries (real export plus import) over real GDP	UN Comtrade Database
ln_Educ	The natural logarithm of education: measured by school enrollment, primary (% gross) (representing investment in human capital)	The World bank
ln_Geagri	The natural logarithm of government expenditure in agricultural and food industries	Food and Agricultural Organization of the United Nations (FAOSTAT)
ln_NR	The natural logarithm of natural resource: measured by the arable land	The World bank
COVID	COVID-19 pandemic: measured by COVID-19 Stringency Index	Our World in Data

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