“Competitiveness or complementarity: Analysis of agricultural trade between China and Brazil”

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COMPETITIVENESS OR COMPLEMENTARITY: ANALYSIS OF AGRICULTURAL TRADE BETWEEN CHINA AND BRAZIL

Abstract

The competitiveness and complementarity of trade reflect the advantages and disadvantages of exports and future trade trends. After China joined the WTO, the import and export volume of agricultural products has increased significantly, but the import volume and import growth rate have greatly exceeded the export volume and export growth rate. China is the world's largest importer of agricultural products, and Brazil has become the world's largest exporter of agricultural products. As a country with the largest increase in agricultural exports, China and Brazil have close agricultural trade exchanges. China has become Brazil's largest importer of agricultural products for four consecutive years. In addition, both China and Brazil are BRIC countries; therefore, the establishment of a cooperation mechanism is more conducive to the development of agricultural trade. This study uses quantitative research methods to investigate the agricultural trade between China and Brazil by calculating the revealed comparative advantage index, trade complementarity index, and trade intensity index. The study found that due to the different endowments of agricultural resources and the significant differences in agricultural structure, China and Brazil's agricultural trade competitiveness is weak and they are highly complementary. The main agricultural products exported by China are labor-intensive processed products (pulp and waste paper, textile fibers, vegetables and fruits), and the main agricultural products exported by Brazil are land-intensive products (oilseeds and oily fruits, vegetable oils, raw hides and furs). Complementary advantages in agricultural trade were analyzed. In the future, the two countries have huge potential for cooperation and development.

Keywords agricultural exports, agricultural imports, influencing factors, competitiveness, complementarity, growth potential

JEL Classification D41, F14, Q13

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INTRODUCTION

After China joined the World Trade Organization, trade in agricultural products has developed rapidly, but imports have grown faster than exports, and the trade has turned from a surplus to a deficit. In 2020, imports of agricultural products amount to US$170.8 billion, exports – US$76 billion, and a trade deficit – US$94.8 billion, with an average annual growth rate of 21%. China has become the world's largest importer of agricultural products. However, as a major agricultural producer with considerable development potential in the world, Brazil's agricultural exports have achieved substantial growth in recent years. Since 2015, Brazil has become the country with the largest increase in agricultural exports in the world. China and Brazil are important agricultural countries in the world. Due to the differences in the endowment of agricultural resources and the growth conditions of agricultural products between the two countries, agri-

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cultural product trade is an important part of the foreign trade exchanges between the two countries. At the same time, China and Brazil are members of the "BRIC countries", and the two sides are important trading partners to each other. China is currently the world's largest market for Brazilian agricultural exports, and it is also the second largest source of Brazilian import trade. China and Brazil are highly complementary in agricultural products trade, and their respective advantageous agricultural products are very different. This paper uses the trade data of the United Nations Commodity Trade Statistics Database to conduct an empirical analysis of the competitiveness, complementarity and development potential of China and Brazil's agricultural trade by calculating the trade intensity index, the comparative advantage index and the trade complementarity index, and examine its development trends. This is of great significance to strengthen bilateral agricultural trade cooperation and promote agricultural development.

1. LITERATURE REVIEW

China and Brazil have close agricultural trade relations, and bilateral trade volume has increased substantially. The research on the trade of agricultural products between the two countries has become the focus of attention of scholars.

Zeng (2020) studied the foreign trade of Chinese agricultural products under the "Belt and Road" initiative and believed that the "Belt and Road" initiative can promote the development of China's agricultural exports and create favorable conditions. However, it has also had a negative impact on China's agricultural exports, such as high export risks, a single agricultural export structure, and an imperfect trade circulation system. Therefore, to promote the development of foreign trade in agricultural products, China should optimize the export structure and foreign trade methods of agricultural products, improve the trade circulation system, and further reduce export risks.

Based on Novy's improved gravity model, Zhenjun (2020) calculated the trade cost of agricultural products after China joined the WTO. It turns out that China's agricultural trade costs have shown a rapid decline, as well as a certain competitive advantage in exports. The main reason is that China has actively adopted modern agricultural production methods and built a sound agricultural infrastructure. The industrial technology spillover effect is caused by the rapid development of manufacturing and service industries. In the next step, China should build and rely on a modern agricultural trade information platform to reduce trade costs and cultivate China's new competitive advantage in agricultural trade.

Meng et al. (2018) studied trade flows and analyzed the heterogeneity of China's agricultural trade cost elasticity among different types of trading partners. The results show that there is an obvious negative correlation between the import share of Chinese agricultural products by trading partners and the corresponding trade cost elasticity. Specifically, the higher the import share of trading partners in China's agricultural products, the lower the weighted average trade cost elasticity. The measure of trade cost elasticity shows significant heterogeneity among various fields.

Jing et al. (2018) believe that as China's agriculture continues to open up to the outside world, the degree of integration with the world market will increase significantly. Thus, agricultural trade can adjust surplus and shortages, ensure supply, exert comparative advantages, and optimize domestic resource allocation. Having played an important role, China has become the world's most important agricultural trading country. However, China's agricultural trade deficit is becoming more and more normal. The bulk of agricultural products is showing a situation of full net imports. The competitiveness of traditionally advantageous agricultural products has declined. This has brought severe challenges to national food security, domestic agricultural production, and agricultural industry security, as well as agricultural employment. In addition, the income of farmers is suffering greater pressure. To reverse this situation, choosing a more reasonable import and export trade strategy, and formulating a more effective agricultural

domestic support and trade policy will become particularly important in the future as China's agriculture is more fully integrated into the world economy.

Stosic et al. (2020) investigated the overall characteristics of the Brazilian agricultural market and the complex effects of political and economic instability. The multifractal trend fluctuation analysis (MFDFA) was used to analyze Brazil's daily prices of twelve agricultural products; the time dependence of four commodities (sugar, soybeans, coffee, and cattle) are subjected to MFDFA to address the impact of specific political and economic instability events. All commodities exhibit multifractal characteristics, which are then used to evaluate market efficiency. It was found that all commodities except coffee showed low market efficiency in Brazilian prices, such as the minimum price policy. From the time-related MFDFA, it is found that after the 2007/2008 food crisis, market efficiency has increased, as indicated by price dynamics towards lower persistence and weaker multifractal changes, where small fluctuations dominate.

Martha and Alves (2018) believe that the public sector has played a key role in transforming Brazil's traditional agriculture into modern agriculture by leading Brazil's agricultural R&D and providing most of the funding for R&D activities. The spillover effects of modern agriculture are not limited to the agricultural industry, but will also create considerable markets for industry and service industries. The success of science-based agriculture in Brazil has provided a guarantee for substantial improvements in food and nutrition security, expansion of employment and income-generating opportunities in the value chain of agriculture and related industries, a more positive trade balance, and a significant reduction in inflationary pressures. Therefore, in the coming decades, it is important for Brazil to strengthen knowledge exchange, capacity development, technology transfer, extension services, and well-functioning input and market chains, and minimize the adverse effects of market imperfections on technology adoption. Brazil's agriculture can bring greater value to the society.

Liu and Xiao (2017) used UN Comtrade database data to analyze the export trade status of Brazilian agricultural products from the three aspects of trade scale, product structure, and market distribution, and applied a constant market share model to Brazil. The influencing factors of agricultural export volatility were studied. The results found that Brazilian agricultural product export fluctuations mainly depend on changes in world agricultural product market demand. Export competitive advantages, especially overall export competitive advantages, are important factors that promote the growth of Brazilian agricultural exports, while export product structure has a relatively small impact on export fluctuations.

Capitani and Mattos (2017) focused on the Brazilian agricultural product market, using five research methods including volatility, coefficient of variation, lower partial moment, value-at-risk, and value-at-risk. The price is evaluated for diversification and downside risk analysis. The results of the study found that although some commodities have relatively high price volatility, their downside risks are relatively small; while the price volatility of other commodities is relatively small, but their downside risks are relatively high. Therefore, there is no single answer to the question of which commodity exhibits greater price risk, but different answers to different individuals' perceptions of risk. These findings are relevant to agents in the agricultural industry because they influence marketing and risk management decisions, and they may be policy makers involved in agricultural support programs.

You and Huang (2020) studied the scale of agricultural trade and commodity structure between China and Brazil and other BRICS countries, discovering the economic scale of China and the BRICS countries, establishing free trade zones, and joining the BRICS organizations, etc. Some factors can significantly promote the trade of agricultural products between the two sides; while the distance between trading countries, the total population of the two sides, and the difference in per capita income have a negative effect on agricultural trade. The exchange rate level and participation in the World Trade

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Organization and other factors have no significant impact. As far as China and Brazil are concerned, China's trade deficit with Brazil's agricultural products is obvious, and the structure of trade products is relatively concentrated. According to the current model, the potential for future development of agricultural trade between the two countries is small.

Zhang (2019) measured the comprehensive efficiency, pure technical efficiency, and scale efficiency of China and Brazil's agricultural trade from 2006 to 2016, and analyzed its driving factors. The results show that China's agricultural trade is relatively safe, and the international environment for agricultural product trade is generally stable and developing. Brazil's agricultural trade has comprehensive efficiency, pure technical efficiency, and scale efficiency that are fluctuating and rising. Agricultural trade security is gradually improving. The overall efficiency of trade is closely related to the increase in jobs in foreign trade, the trade relationship with trading partners, the degree of dependence on foreign trade, and the contribution of foreign trade to GDP. The above four elements constitute an important driving force for the security of agricultural trade between China and Brazil.

Wang et al. (2018) studied the current situation of agricultural trade between China and Brazil. The result is that the trade relationship between the two countries is getting closer. China has become Brazil's largest agricultural product export market, and Brazil is China's second-largest agricultural importer. The complementarity of the two countries' agricultural trade is greater than the competition. China has a huge trade deficit with Brazil's agricultural products, and the product structure of bilateral trade is seriously simplistic. Therefore, the two countries should continue to deepen cooperation in the agricultural field. While the scale of bilateral trade expands, the product structure should be further optimized.

Tian and Zhang (2017) analyzed the current status and growth prospects of agricultural trade between China and Brazil based on relevant trade data from 2002 to 2015. The categories of agricultural products that China and Brazil have comparative advantages in export are quite different. China's agricultural exports and Brazil's agricultural imports show relatively weak complementarity. Brazil's agricultural exports and China's agricultural imports are highly complementary. China's overall competitive advantage of agricultural products is weaker. The agricultural product export market structure of the two countries is similar to a certain extent, but the main products exported by each are different. The development of agricultural product trade between the two countries has growth potential.

2. AIMS

This paper aims to analyze the trade data on import and export of agricultural products between China and Brazil from 2010 to 2019, to study the current situation of the two countries' trade in the international agricultural product market, and to find the advantages and disadvantages of agricultural export. In addition, the paper investigates the existing problems and provides suggestions to promote the agricultural trade between the two countries.

3. METHODS

This paper uses comparative advantage theory, factor endowment theory, and national competitive advantage theory. The study uses the 2010–2019 China and Brazil's agricultural import and export trade data coded by the SITC Rev.3 in the United Nations Commodity Trade Statistics database to measure the revealed comparative advantage index, trade complementarity index, and product export similarity index. The results judged the competitiveness and complementarity of agricultural trade between China and Brazil and studied the status quo of agricultural trade development in terms of trade policy, trade dependence, and trade structure. The trade intensity index is used as an explanatory variable to measure the trade potential index and analyze the development potential of agricultural trade between the two countries. Table 1 shows the SITC Rev.3 code in the United Nations Commodity Trade Statistics Database.

Table 1. SITC classification of agricultural products

Code	Meaning	Code	Meaning
SITC00	Live animals	SITC12	Tobacco and its products
SITC01	Meat and meat products	SITC21	Rawhides and raw furs
SITC02	Dairy and egg products	SITC22	Oilseeds and oleaginous fruits
SITC03	Fish, crustaceans, mollusks, and their products	SITC23	Raw rubber
SITC04	Cereals and their products	SITC24	Cork and wood
SITC05	Vegetables and fruits	SITC25	Pulp and waste paper
SITC06	Sugar, sugar products, and honey	SITC26	Textile fiber and its waste
SITC07	Coffee, tea, cocoa, condiments, and their products	SITC29	Other animal and plant raw products
SITC08	Forage excluding unmilled grains	SITC41	Animal oils and fats
SITC09	Miscellaneous food	SITC42	Vegetable oils and fats
SITC11	Beverage	SITC43	Processed animal and vegetable oils, fats, and animal and vegetable waxes

4. RESULTS

4.1. Complementarity of agricultural trade between China and Brazil

Due to the differences in agricultural technology and industrial structure between China and Brazil, the two countries have their own comparative advantages in agricultural exports. To analyze the comparative advantages of the export of agricultural products between the two countries, the revealed comparative advantage index is used (Balassa, 1965) and is calculated by:

$$RCA_{ij}^{k} = \frac{X_{ij}^{k} / X_{ij}^{t}}{X_{i\omega}^{k} / X_{i\omega}^{t}}, \quad (1)$$

where RCA_{ij}^{k} is a revealed comparative advantage index, $RCA_{ij}^{k} \geq 2.5$ means the *k*-th commodity in country *i* has a strong competitive advantage; $1.25 \leq RCA_{ij}^{k} > 2.5$ means the *k*-th commodity in country *i* has a strong competitive advantage; $0.8 \leq RCA_{ij}^{k} > 1.25$ means the *k*-*h* commodity in country *i* has a certain competitive advantage; $RCA_{ij}^{k} < 0.8$ means that the *k*-th commodity in country *i* does not have a competitive advantage. X_{ij}^{k} and X_{ij}^{t} respectively refer to the export value of country *i* to country *j* of *k* commodities and the total export value of country *i* to country *j* of all commodities. $X_{i\omega}^{k}$ and $X_{i\omega}^{t}$ respectively represent the export value of country *i* to the *k*-th commodity on the world market and the total export value of all commodities in country *i* to the world market.

It can be seen from Table 2 that both China and Brazil have comparative advantages in exporting agricultural products, and the categories of agricultural products in the two countries with export comparative advantages are more balanced. Specific analysis shows that China's comparative advantage in agricultural products exported to Brazil has 7 items, namely item 25 (pulp and waste paper), 26 (textile fiber and its waste), 29 (other animal and plant raw materials), 08 (forage excluding unmilled grains), 05 (vegetables and fruits), 41 (animal oils and fats), and 23 (raw rubber). China has a strong export comparative advantage in item 25 (pulp and waste paper), 26 (textile fibers and its waste), 29 (other animal and plant raw materials), 08 (forage excluding unmilled grains), and 05 (vegetables and fruits). The agricultural products that Brazil exports to China with comparative advantages include 7 items, namely item 22 (oilseeds and oleaginous fruits), 25 (pulp and waste paper), 42 (vegetable oils and fats), and 21 (rawhides and raw furs). Item 26 (textile fiber and its waste), 12 (tobacco and its products), and 01 (meat and meat products) have a strong export comparative advantage, in addition to item 22 (oilseeds and oleaginous fruits), 25 (pulp and waste paper), 42 (vegetable oils and fat), and 21 (rawhides and raw furs). Among the agricultural products that the two countries share the comparative advantage in the export, China has stronger export comparative advantages in item 25 (pulp and waste paper) and 26 (textile fiber and its waste). Item 06 (sugar, sugar products, and honey) has the same value for the two countries. Among the agricultural products that only one country has a comparative advantage in the export, China only has strong exports in item 29 (other animal and plant raw materials), 08 (forage excluding unmilled grains), and 05 (vegetables and fruits). Brazil has a strong export comparative advantage in item 22 (oilseeds and oleaginous fruits), 42 (vegetable oils and fats), and 21 (rawhides and raw furs).

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Table 2. Revealed comparative advantage index of China and Brazil's agricultural exports

RCA Index of Chinese agricultural products exported to Brazil						RCA index of Brazilian agricultural products exported to China				
SITC	2010	2013	2015	2017	2019	2010	2013	2015	2017	2019
00	–	–	–	–	–	0.000	–	–	–	–
01	–	–	–	0.006	0.004	0.111	0.144	0.408	0.543	0.990
02	–	–	–	–	–	–	–	–	0.000	0.001
03	0.663	0.757	0.720	0.675	0.356	0.180	0.151	0.211	0.185	0.434
04	0.128	0.136	0.124	0.160	0.135	0.019	0.008	0.028	0.003	0.005
05	1.078	1.300	0.906	0.634	0.422	0.178	0.123	0.101	0.093	0.089
06	0.155	0.407	0.238	0.313	0.268	0.260	0.624	0.522	0.053	0.257
07	0.255	0.081	0.089	0.093	0.080	0.005	0.007	0.011	0.010	0.015
08	0.922	0.920	0.891	0.956	0.773	0.040	0.018	0.022	0.031	0.025
09	0.431	0.440	0.613	0.534	0.329	0.071	0.126	0.093	0.083	0.043
11	0.082	0.113	0.192	0.028	0.008	0.012	0.017	0.018	0.018	0.018
12	0.015	0.050	0.025	0.152	0.008	0.815	0.729	0.648	0.605	0.640
21	0.018	–	0.000	–	0.115	2.098	1.275	1.167	–	0.124
22	0.003	0.005	0.016	0.011	0.014	4.216	3.933	4.011	3.593	2.761
23	0.877	0.650	0.799	0.677	0.659	0.281	0.247	0.164	0.306	0.211
24	0.034	0.123	0.119	0.044	0.047	0.413	0.294	0.284	0.490	0.347
25	0.923	1.934	1.966	2.070	1.443	1.551	1.604	1.784	1.856	1.546
26	0.821	1.182	1.699	1.807	1.718	0.981	0.834	0.724	0.453	1.096
29	0.714	0.929	1.438	1.568	1.021	0.129	0.147	0.083	0.129	0.187
41	0.440	1.116	0.673	1.264	0.737	0.001	–	0.000	–	0.602
42	0.015	0.003	0.048	0.046	0.045	3.589	1.861	0.739	1.025	0.831
43	0.113	0.277	0.040	0.006	0.003	0.217	0.385	0.505	0.522	0.540
total	7.685	10.424	10.595	11.042	8.186	15.167	12.529	11.523	9.997	10.704

Note: "–" indicates that the data for the year is not available, so there is no calculated value; "0" indicates that the value is very small, due to the retention of decimal places.

At the same time, according to Table 3, the top agricultural exports of China and Brazil from 2010 to 2019 are all agricultural products with comparative advantages. Therefore, in general, China and Brazil have different types of agricultural products and their comparative advantages. It laid the foundation for the development of complementary trade in agricultural products between the two countries.

Table 3. Top ten agricultural products traded between China and Brazil from 2010 to 2019

Rank	Agricultural products exported from China to Brazil	Agricultural products exported from Brazil to China
1	25	22
2	26	25
3	29	42
4	08	21
5	05	26
6	41	12
7	23	01
8	03	43
9	09	24
10	06	06

The next step is to measure the complementarity of agricultural trade between China and Brazil based on the explicit comparative advantage index:

$$rca_{ji}^{k} = \frac{Y_{ji}^{k} / Y_{ji}^{t}}{Y_{j\omega}^{k} / Y_{j\omega}^{t}}. \quad (2)$$

$$C_{ij}^{k} = RCA_{ij}^{k} \cdot rca_{ji}^{k}. \quad (3)$$

rca_{ji}^{k} refers to the comparative disadvantage index of country j's imports of category k commodities from country i. The larger the number, the greater the disadvantage; Y_{ji}^{k} refers to the import value of country j's imports of category k commodities from country i; Y_{ji}^{t}. Refers to country j's total imports from country i; $Y_{j\omega}^{k}$ refers to country j's imports of category k goods from the world; $Y_{j\omega}^{t}$ refers to country j's total imports from the world; C_{ij}^{k} refers to country i's exports to country j. The trade complementarity coefficient of category k commodities; the larger the number, the stronger the complementarity.

It can be seen from Table 4 that China's agricultural exports and Brazil's agricultural imports are relatively weakly complementary. From the perspective of specific types of agricultural products, China's agricultural exports and Brazil's imports of agricultural products are complementary mainly to item 08 (forage excluding unmilled grains), 26 (textile fibers and its waste), and 29 (other animal and plant raw products). However, Brazil's agricultural exports and China's imports of agricultural products are highly complementary. Specific categories of agricultural products include item 01 (meat and meat products), 06 (sugar, sugar products, and honey), 12 (tobacco and its products), 22 (oilseeds and oleaginous fruits), 25 (pulp and waste paper), and 43 (processed animal and vegetable oils, fats, and animal and vegetable waxes). The main reason is that China and Brazil are geographically different, so the resource endowment of agriculture is quite different. At the same time, China is the most populous country in the world. In addition, with the rapid economic development in recent years, people have higher requirements for agricultural products. Therefore, agricultural trade is highly relevant for China and Brazil holding a very important position and showing a trend of rapid growth year by year.

4.2. Competitiveness of agricultural trade between China and Brazil

The revised product export similarity index proposed by Glick and Rose (1999) is used to analyze the competition between China and Brazil's agricultural exports in the world market. It is calculated by:

$$S_{ij}^{p}=\left\{\sum_{k}\left[\frac{\left(\frac{x_{i\omega}^{k}}{x_{i\omega}^{t}}\right)+\left(\frac{x_{j\omega}^{k}}{x_{j\omega}^{t}}\right)}{2}\right]\cdot\left[1-\frac{\left(\frac{x_{i\omega}^{k}}{x_{i\omega}^{t}}\right)-\left(\frac{x_{j\omega}^{k}}{x_{j\omega}^{t}}\right)}{\left(\frac{x_{i\omega}^{k}}{x_{i\omega}^{t}}\right)+\left(\frac{x_{j\omega}^{k}}{x_{j\omega}^{t}}\right)}\right]\right\}\cdot 100. \quad (4)$$

where $x_{i\omega}^{k}$ and $x_{i\omega}^{t}$ respectively refer to the export value of country i to world k commodities and the total export value of country i to all commodities in the world; $x_{i\omega}^{k}$ and $x_{j\omega}^{t}$ refer to the export value of country j to world k commodities and the total export value of country j to all commodities in the world. S_{ij}^{p} refers to the product export similarity

Table 4. China and Brazil's agricultural trade complementarity index

	China's exports and Brazil's imports					Brazil's exports and China's imports				
SITC	**2010**	**2013**	**2015**	**2017**	**2019**	**2010**	**2013**	**2015**	**2017**	**2019**
00	–	–	–	–	–	–	–	–	–	–
01	–	–	–	–	–	9.034	2.967	5.575	6.161	5.610
02	0.300	–	0.290	–	–	–	–	–	–	0.001
03	0.988	1.360	1.286	0.959	0.704	0.002	0.013	0.021	0.028	0.065
04	0.303	0.304	0.295	0.296	0.296	0.004	0.002	0.001	0.001	0.001
05	1.300	1.452	0.868	0.810	0.662	0.981	0.478	0.373	0.344	0.243
06	0.577	0.818	0.723	0.876	0.897	17.628	21.322	16.577	7.650	6.583
07	0.503	0.411	0.372	0.350	0.365	0.291	0.275	0.378	0.385	0.378
08	2.200	1.838	1.939	1.429	1.446	0.134	0.045	0.062	0.118	0.104
09	0.520	0.583	0.553	0.571	0.565	0.317	0.310	0.149	0.057	0.035
11	0.300	0.301	0.291	0.291	0.292	0.005	0.008	0.006	0.006	0.003
12	0.332	0.418	0.513	0.538	0.291	15.468	9.879	5.805	4.736	6.914
21	–	–	–	–	0.377	0.002	0.001	–	–	0.001
22	0.336	0.340	0.361	0.346	0.383	11.249	16.591	16.769	15.221	15.653
23	0.330	0.348	0.333	0.321	0.328	0.069	0.073	0.035	0.067	0.018
24	0.508	0.813	0.581	0.633	1.077	0.252	0.096	0.153	0.258	0.266
25	0.342	0.374	0.334	0.411	0.356	4.260	3.671	5.188	4.952	5.380
26	1.231	1.798	2.059	1.832	1.875	0.674	0.842	1.244	0.573	2.887
29	1.221	1.444	1.465	1.616	1.436	0.304	0.145	0.141	0.328	0.439
41	0.498	0.902	0.468	0.431	0.370	–	–	–	–	0.094
42	0.305	0.304	0.293	0.293	0.293	3.613	1.837	1.072	1.270	0.616
43	0.304	0.443	0.426	0.323	0.317	1.251	2.081	3.230	2.155	2.585

Note: "–" indicates that the data for the year is not available, so there is no calculated value; "0" indicates that the value is very small, due to the retention of decimal places.

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index of countries *i* and *j* exported to the world market. The index varies from 0 to 100. The larger value indicates that the export structure of the two countries tends to be similar, and the competition between the two countries in the world market is stronger; otherwise, the competition tends to be flat.

It can be seen from Table 5 that the S_{ij}^{p} index of agricultural products of China and Brazil from 2010 to 2019 showed a wave trend of rising-falling-rising-falling, with the index fluctuating from 31 to 36. The agricultural products of the two countries are on the world market. The competition is relatively flat.

Further analysis of the main export markets of China and Brazil for agricultural products in 2019 shows that China is Brazil's largest agricultural product export market, accounting for 34.24% of Brazil's share of world agricultural exports, which is higher than the second-largest country (the US with 5.48%). There is a strong complementarity between Brazil's agricultural exports and China's agricultural imports. The categories of agricultural products that Brazil exports to the Chinese market are mainly item 22 (oilseeds and oleaginous fruits), 01 (meat and meat products), 25 (pulp and waste paper), 26 (textile fiber and its waste), etc. Item 22 (oilseeds and oleaginous fruits) is the most important agricultural product exported from Brazil to China, accounting for 67.05% of the total agricultural export in 2019. Both China and Brazil are large exporters of agricultural products. There is a certain degree of competitiveness in the world market for agricultural exports from China and Brazil, but the competitiveness is relatively weak. The United States, Japan, Hong Kong, South Korea, and Germany are the common important agricultural export markets of the two countries. However, the two countries have major differences in the structure of agricultural export. For the US market, China mainly exports such agricultural products as item 03 (fish, crustaceans, mollusks, and their products), 05 (vegetables and fruits), 09 (miscellaneous food), 29 (other animal and plant raw materials), etc. Brazil mainly exports item 25 (pulp and waste paper), 07 (coffee, tea, cocoa, condiments, and their products), 05 (vegetables and fruits), 24 (cork and wood), etc. The two countries have the same competitiveness in item 05 (vegetables and fruits). For the Japanese market, the main categories of agricultural products exported by China are item 03 (fish, crustaceans, mollusks, and their products), 05 (vegetables and fruits), 01 (meat and meat products), 29 (other animal and plant raw materials), etc. The categories of agricultural products exported by Brazil are mainly item 04 (cereals and their products), 01 (meat and meat products), 07 (coffee, tea, cocoa, condiments, and their products), 22 (oilseeds and oleaginous fruits), etc. The two countries are only competitive in item 01 (meat and meat products). For Hong Kong of China, the main categories of agricultural products exported by China are item 05

Table 5. Similarity index of agricultural export between China and Brazil and their main export markets

China and Brazil's agricultural export similarity index		Major export markets of Chinese and Brazilian agricultural products in 2019			
Year	S_{ij}^{p}	China's main export markets	Percentage of China's total agricultural exports (%)	Brazil's main export markets	Percentage of Brazil's total agricultural exports (%)
2010	32.686	Japan	12.96%	China	34.24%
2011	34.012	Hong Kong of China	11.73%	USA	5.48%
2012	32.280	USA	8.15%	Netherlands	4.25%
2013	31.740	Vietnam	6.98%	Japan	3.62%
2014	31.773	Korea	6.23%	Iran	2.46%
2015	31.947	Thailand	4.59%	Spain	2.38%
2016	35.955	Malaysia	3.67%	Hong Kong of China	2.31%
2017	34.633	Indonesia	3.19%	Germany	2.18%
2018	33.178	Germany	2.65%	Belgium	2.15%
2019	32.699	Philippines	2.54%	Korea	1.98%

(vegetables and fruits), 03 (fish, crustaceans, mollusks, and their products), 09 (miscellaneous food), 11 (beverage), etc. The main categories of agricultural products exported by Brazil are item 01 (meat and meat products), 29 (other animal and plant raw products), 03 (fish, crustaceans, mollusks, and their products), 12 (tobacco and their products), etc. The two countries are only competitive in item 03 (fish, crustaceans, mollusks, and their products). For the Korean market, the main categories of agricultural products exported by China are item 03 (fish, crustaceans, mollusks, and their products), 05 (vegetables and fruits), 09 (miscellaneous food), and 08 (forage excluding unmilled grains). The main categories of agricultural products exported by Brazil are item 04 (cereals and their products), 08 (forage excluding unmilled grains), 01 (meat and meat products), 25 (pulp and waste paper), etc. The two countries are only competitive in item 08 (forage excluding unmilled grains). For the German market, the main categories of agricultural products exported by China are item 03 (fish, crustaceans, mollusks, and their products), 05 (vegetables and fruits), 29 (other animal and plant raw materials), 08 (forage excluding unmilled grains), etc. Brazil mainly exports item 07 (coffee, tea, cocoa, condiments, and their products), 08 (forage excluding unmilled grains), 25 (pulp and waste paper), 01 (meat and meat products), etc. The two countries are only competitive in item 08 (forage excluding unmilled grains).

4.3. Growth potential of agricultural trade between China and Brazil

The Kojima trade intensity index is used to analyze the growth potential of agricultural trade between China and Brazil. It is calculated by:

$$I_{ij}^{k} = \frac{x_{ij}^{k} / x_{i\omega}^{k}}{Y_{j\omega}^{k} / \left(Y_{\omega\omega}^{k} - Y_{i\omega}^{k}\right)}. \quad (5)$$

where I_{ij}^{k} refers to the trade intensity index of country *i* to country *j*. The larger the index, the closer the trade ties between the two countries; $Y_{\omega\omega}^{k}$ and $Y_{i\omega}^{k}$ refer to the world's *k*-th commodity imports and country *i*'s *k*-th world x_{ij}^{k} represents the export value of country *i* to country *j*'s k commodities, and $x_{i\omega}^{k}$ represents the export value of country *i* to the *k*-th commodity in the world market.

Table 6. China and Brazil's agricultural trade intensity index

SITC	China's agricultural trade intensity index					Brazil's agricultural trade intensity index				
	2010	2013	2015	2017	2019	2010	2013	2015	2017	2019
00	–	–	–	–	–	0.012	–	–	–	–
01	–	–	–	0.295	0.271	9.546	5.917	14.389	16.084	19.080
02	–	–	–	–	–	–	–	–	–	0.042
03	13.048	10.754	9.314	7.949	5.022	7.918	5.922	7.663	6.215	9.886
04	1.109	0.885	1.055	1.281	1.026	2.649	0.437	0.793	0.117	0.348
05	23.008	21.523	14.650	9.960	7.894	15.129	7.296	4.529	4.822	3.888
06	17.737	26.632	14.554	23.288	23.603	17.385	22.611	20.588	3.503	19.130
07	11.365	4.068	2.642	2.378	2.446	1.251	1.311	1.345	1.619	2.165
08	54.376	41.114	28.322	33.163	28.597	1.395	0.645	0.621	1.306	1.156
09	14.667	8.830	9.672	9.389	6.103	4.797	5.346	2.744	1.871	0.904
11	2,837	3.100	4.122	0.572	0.170	1.067	1.062	0.837	0.735	0.858
12	1.346	6.558	2.642	13.318	0.965	65.857	39.814	27.145	31.353	39.571
21	3.777	–	0.003	–	6.076	13.438	5.609	5.516	1.084	0.971
22	0.489	0.354	0.997	0.860	1.830	19.529	14.551	15.703	14.675	16.252
23	4.399	3.496	5.629	4.019	4.999	1.986	1.977	1.800	2.298	2.703
24	11.056	40.541	20.441	9.411	9.810	4.130	2.200	2.132	3.401	3.316
25	20.209	47.192	35.340	73.028	53.905	8.718	9.214	9.629	9.976	11.811
26	22.515	30.668	41.459	34.838	35.404	6.289	4.718	7.394	5.581	15.356
29	14.482	15.283	18.145	20.755	12.105	8.185	7.151	4.106	6.540	10.052
41	12.007	19.620	8.796	13.322	8.709	0.021	–	0.007	–	17.164
42	0.271	0.047	0.645	0.504	0.635	49.871	26.737	14.610	23.372	20.112
43	3.075	4.116	0.842	0.077	0.048	17.711	38.537	45.272	43.221	59.815
average	10.535	12.945	9.967	11.746	9.528	11.677	9.140	8.492	8.081	11.572

Note: "–" indicates that the data for the year is not available, so there is no calculated value.

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It can be seen from Table 6 that China's export level of agricultural products to Brazil and Brazil's export level of agricultural products to China are higher than Brazil's average import share from the world market and China's average import share from the world market during the same period. The agricultural trade intensity index for both countries is greater than 1. China and Brazil are closely linked in agricultural trade. From 2010 to 2019, China's agricultural trade intensity index with Brazil showed a wave pattern of rising-declining-rising-declining trend; while Brazil's agricultural trade intensity index with China showed a downward-rising U-shaped trend. Thus, there is huge potential for the development of agricultural trade between the two countries.

From the analysis of various agricultural products, China and Brazil have a high trade intensity index in item 03 (fish, crustaceans, mollusks, and their products), 05 (vegetables and fruits), 06 (sugar, sugar products, and honey), 07 (coffee, tea, cocoa, condiments, and their products), 09 (miscellaneous food), 12 (tobacco and its products), 23 (raw rubber), 24 (cork and wood), 25 (pulp and waste paper), 26 (textile fibers and its waste), 29 (other animal and plant raw materials), etc. The export level of one country to another country is higher than that of another country in the same period. The share of imports from the world market shows that China and Brazil have close two-way trade ties in these 11 types of agricultural products. In addition, China has a close trade relationship with Brazilian agricultural products in item 08 (forage excluding unmilled grains), 41 (animal oils and fats), and 04 (cereals and their products). Brazil mainly imports such Chinese agricultural products as item 01 (meat and meat products), 21 (rawhides and raw furs), 22 (oilseeds and oleaginous fruit), 42 (vegetable oils and fats), and 43 (processed animal and vegetable oils, fats, and animal and vegetable waxes). According to Table 6, the trade intensity index of agricultural products shows that China and Brazil have a relatively high trade complementarity and close trade relationship. Although some agricultural products are not highly complementary, the trade intensity index is relatively high, indicating a greater potential for trade development.

5. DISCUSSION

Both China and Brazil have comparative advantages in exporting agricultural products. Compared with the comparative advantage of Chinese agricultural products exported to Brazil, the comparative advantage of Brazilian agricultural products exported to China is stronger, and the types of agricultural products with comparative advantages exported by both sides are quite different. Brazil's agricultural exports and China's imported agricultural products are highly complementary, while China's agricultural exports and Brazil's imported agricultural products show relatively weak complementarity. China is Brazil's largest export market for agricultural products. The agricultural products of the two countries differ greatly in their main export markets, and only a few agricultural products compete. The trade intensity index of agricultural trade between China and Brazil is basically in growth or stable states. The agricultural trade of the two countries has great potential for development, laying a foundation for better cooperation and development in the future.

It is vital to strengthen and promote the complementary advantages of China and Brazil in agricultural resources. Combining with China's actual needs, it is important to further strengthen bilateral agricultural trade and expand the types and quantities of imported agricultural products. At the same time, China should actively seek import substitution, reduce the cost of importing related agricultural products from Brazil, increase corporate profits and protect residents' demand, and avoid excessive dependence on the Brazilian market. In addition, it is important to gradually improve the agricultural trade protection system that is compatible with the level of openness of the Brazilian agricultural market, make full use of the rights granted by WTO rules, further improve the agricultural support and protection policy, and provide economic compensation to the affected agricultural production areas and agricultural trade operators, as well as strengthen trade negotiations and trade remedies. The two sides should strengthen communication, establish a negotiation mechanism for agricultural trade, and jointly participate in the formulation of trade rules. China should insist on taking agriculture as the focus of protection, expand the export of superior agricultural products, and maintain the healthy development of agricultural trade between the two sides; establish an agri-

cultural trade remedy system, agricultural trade dispute resolution, and trade remedy agencies, personnel systems, resolve trade frictions between the two countries, conduct industrial damage investigations, and understand whether there are anti-dumping, countervailing and other violations in the import of agricultural products from Brazil. Implementation of trade remedy measures for over-imported agricultural products in trade with Brazil is also important, as well as strengthening bilateral agricultural technology cooperation and exchanges.

China and Brazil should strengthen cooperation in agricultural development and jointly research agricultural varieties and technologies, especially in the fields of organic agriculture and low-carbon agriculture. This will help China effectively reduce the pressure on energy production and promote the development of a friendly and healthy social environment. At present, China has established about 20 economic and trade cooperation zones abroad. The Chinese government can use the established foreign economic and trade cooperation zones and increase the construction of foreign trade cooperation zones to actively promote agricultural cooperation with Brazil and realize the mutual promotion of agricultural trade between the two countries.

CONCLUSION

This study aimed to analyze the complementarity, competitiveness, and trade development potential of China and Brazil's agricultural trade. On this basis, the purpose is to provide policy influence, expand agricultural economic and trade cooperation between China and Brazil, and accelerate the optimization and upgrading of agricultural trade. The research results show that bilateral agricultural trade is more complementary and less competitive in the world agricultural export market. This study also provides practical evidence for this important result. The difference in agricultural resource endowment and agricultural structure directly affects the trade of agricultural products between the two countries.

At the same time, this study has certain limitations. First, due to the limitations of research conditions, this study only selected trade data over 10 years as the research object. Future studies can select a longer and updated data period for analysis, reflecting a more comprehensive trade relationship. Secondly, natural factors or major emergencies, such as the global spread of the COVID-19, are not included in this study. Therefore, this can be analyzed as a major factor affecting trade changes in further studies. Third, this study is only a demonstration and analysis of selected trade data using mathematical models. However, traditional culture and political factors of specific regions can also have a significant impact on bilateral trade exchanges and promote or hinder trade cooperation. The establishment of friendly and equal diplomatic relations between the two countries is the basis for resolving trade issues.

AUTHOR CONTRIBUTIONS

Conceptualization: Fenghe Zhang.
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Investigation: Fenghe Zhang.
Methodology: Fenghe Zhang.
Project administration: Fenghe Zhang.
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Supervision: Fenghe Zhang.
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