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Factors Influencing Agricultural Products Trade between China and Africa

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Abstract: Studies on the factors affecting agricultural trade between China and Africa are of practical significance to ensure the healthy and sustainable development of their agricultural cooperation and to strengthen the strategic outcome of China's "one belt, one road" strategy. Firstly, this paper posits research hypotheses considering six aspects—economic scale, geographical and demographic factors, natural resource endowment, the level of agricultural science and technology, political factors, and exchange rate factors—and then performs an empirical analysis based on an extended gravity model by using data on China from the UN COMTRADE and other data on 58 Africa countries from 2010 to 2019. The results indicate that China's GDP, African countries' GDP, the years of education of the African population, the average arable land per capita of African countries and the renewable water resources per capita in Africa have positive effects on the trade flow of agricultural products between China and Africa. Geographical distance and China's exchange rate have a negative impact on trade flow. The impact of the human capital index of China and the "one belt, one road" policy are not significant. Next, in order to analyze the impact of these factors on different regions of Africa, this paper uses sub samples to test the regional heterogeneity and discusses the relevant issues. Finally, some countermeasures are put forward: the top-level design and overall layout of bilateral cooperation should be consolidated, the stereoscopic traffic network construction of bilateral trade should be accelerated, and the upgrading of agricultural technology should also be accelerated.

Keywords: Africa; agricultural product trade; gravity model; influence factor

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1. Introduction

In September 2013, President Xi Jinping proposed the "one belt, one road" strategy. Until October 2021, China has signed 206 "one belt, one road" cooperation documents with 140 countries and 32 international organizations, and has established more than 90 bilateral cooperation mechanisms, which has provided experience and reference for exploring global economic growth and creating new regional cooperation models and has set an excellent example for building a mutually beneficial community and achieving a rational allocation of global economic resources [1]. It has also effectively driven the economic development of other countries along the way. Agricultural development is the important foundation of national economic development for countries involved with the "one belt, one road" strategy, and the development of agricultural cooperation is a common demand. Agricultural product trade plays an irreplaceable role in economic development, employment, and food security of these countries. It is important component in "one belt, one road" agricultural cooperation.

This paper considers the agricultural trade between China and Africa as the study target. First, China is the largest developing country, and Africa is the continent with the largest concentration of developing countries. The two regions have similar historical experiences, face common economic development tasks, and have broad common economic interests in international affairs. Secondly, the coordinated development of bilateral

agricultural trade between China and Africa, as important members of developing countries, is of far-reaching significance for promoting cross-regional agricultural cooperation. China has successively established trade relations with more than 50 African countries and regions, signed bilateral trade agreements with more than 40 countries, established a bilateral economic and trade mixed (joint) committee mechanism with 35 countries, signed bilateral agreements on encouraging and safeguarding investments with 28 African countries, and signed agreements on avoiding double taxation with 8 African countries. China–Africa agricultural cooperation is an important topic of China's global economic and trade cooperation, and agricultural product trade is an important channel of China–Africa agricultural cooperation. Thirdly, since China has implemented the "one belt, one road" strategy, China–Africa trade relations have been developing continuously and have entered a new stage. The trade volume of agricultural products has increased gradually every year. This benign development is in line with the economic interests and needs of both regions and has created a cooperative environment and growth momentum towards continuing to deepen economic and trade ties. Therefore, considering the agricultural trade between China and Africa as a research target can provide theoretical or practical support for the agricultural trade cooperation between China and other countries.

Domestic and foreign scholars have conducted relevant research on the current situation and influencing factors of agricultural trade between China and Africa. Yang Jun et al. (2019) [2] found that the overall trade of agricultural products between China and Africa showed an increasing trend but faced prominent structural problems and reduced complementarity. Luan Yi-Bo et al. (2018) [3] studied the evolution process of trade intensity and international status of agricultural product trade between China and Africa and found that most African countries have a low trade frequency and a small trade volume with China. Li Hao and Huang Ji-Kun (2016) [4] found that the growth of China's demand for agricultural products and the production capacity of African agricultural products are important factors affecting bilateral trade. Yu Feng-Ren et al. (2020) [5] built a food self-sufficiency rate and food security cooperation potential index to quantitatively analyze the cooperation effectiveness and future trends of China and countries in Southern Africa. Dimpho Malebogomatlhola and Ruishan Chen (2020) [6] applied a telecoupling framework and used data extracted from media reports and FAO to understand the scale and impacts of donkey-hide trade from Botswana to China. However, by looking at the literature, it is not difficult to find that most scholars use the traditional gravity model. The research target is also a "single country model", the comparison and analysis of which is more common than a "multi country model". Therefore, this paper plans to analyze its affecting factors and conduct empirical research, so as to provide suggestions for the development of agricultural trade between China and Africa.

"Africa" in this article refers to 58 countries, including 10 East African countries (Ethiopia, Eritrea, Somalia, Djibouti, Kenya, Tanzania, Uganda, Seychelles, Rwanda, and Burundi), 15 countries of Southern Africa (Botswana, Namibia, Angola, the Republic of South Africa, Eswatini, Lesotho, Madagascar, Malawi, Comoros, Mauritius, Mozambique, Zambia, Zambia, Ma Yue Island, and Reunion Island), 17 West African countries (Mauritania, Senegal, Gambia, Mali, Burkina Faso, Guinea, Guinea Bissau, Cape Verde, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, Niger, Western Sahara, and Nigeria), 8 North African countries (Egypt, Sudan, South Sudan, Libya, Tunisia, Algeria, Morocco, and Melilla), and 8 Central African countries (Chad, the Central African Republic, Cameroon, Equatorial Guinea, Gabon, Congo (cloth), Congo (gold), Sao Tome, and Principe).

2. Theoretical Foundation and Research Hypothesis

2.1. Theoretical Foundation

This paper is based on the theory of factor endowment, new trade theory, and universal gravitation theory. According to the theory of factor endowment, a country should produce and export products by intensively using its abundant production factors, and should import products produced by intensively using its scarce factors, so as to reduce

production costs and enable both countries to benefit from international trade. China is rich in tropical, subtropical, and temperate climate resources, which makes it suitable for vegetable crops and food crops. Most countries in Africa have a tropical desert climate, a tropical grassland climate, or a tropical rainforest climate. A climate resource endowment provides a comparative advantage in the production of cash crops, such as coffee and rubber; food crops, such as rice; and oil crops, such as nuts. The difference in these factor endowments leads to a difference in the supply capacity of two regions regarding a certain agricultural product, as well as a difference in relative price, resulting in the international trade of agricultural products between those two regions. The new trade theory emphasizes the heterogeneity of economic subjects. Africa is a very diverse continent in geography, climate, economy, and politics. Due to different geographical regions and climates, African countries cannot be perfectly classified into one category. Therefore, on the basis of benchmark regression, Africa is divided into five regions for regional heterogeneity analysis, to draw more scientific and applicable conclusions and suggestions. According to the theory of universal gravitation, the gravitation between two objects is directly proportional to their mass, and the trade relationship and trade flow will occur between two trading subjects because of the existence of gravitation. By applying the theory of universal gravitation to the field of economics, the gravity model (which initially reflects the scale of tourism) and the subsequent core model (which includes economic scale and geographical distance) were born. Based on the core model, combined with the situation of China and Africa, and the results of previous studies, this paper analyzes the specific factors affecting the bilateral trade volume.

2.2. Research Hypothesis

After China put forward the "one belt, one road" strategy, foreign trade has been an important driving force for economic growth. Trade between China and Africa has been developing rapidly, and the bilateral trade has reached a higher level. International trade has become an important force to promote the development of Sino-African cooperation, and related industries are also booming. What factors affect the trade volume between different countries? The gravity model (GM) is the most commonly used and empirically successful model in the field of international trade. Starting from the gravity model, this paper collects data from the UN COMTRADE of China and 58 Africa countries from 2010 to 2019, hypothesizes the factors affecting the trade flow of agricultural products between China and Africa, and expands the hypothesis on the basis of the basic model and devises an empirical test.

2.2.1. Economic Scale

According to the law of universal gravitation, trade relations will occur between two trade subjects because of the existence of gravitation. Thus, trade flow appears. The main factors affecting bilateral trade are the potential supply capacity of exporting countries and the potential demand capacity of importing countries. Supply capacity reflects the production capacity of exporting countries, and demand capacity reflects the consumption capacity of importing countries. These two capacities are related to their economic scale. In other words, the larger the economic scale, the more output the country has, and the greater its potential export capacity. Similarly, the potential import capacity of importing countries is also directly proportional to their economic scale. The larger the economic scale, the greater the import demand.

In many studies, economic scale is often expressed by gross domestic product (GDP), which has been used by scholars at home and abroad to perform a wealth of empirical research. Song Ya-Dong and Li Cui-Xia (2021) [7] found that China's GDP has a significant negative correlation with the import and export of dairy products, while foreign GDP has a positive impact. Cao Fang-Fang and Sun Zhi-Lu (2021) [8] found that the per capita GDP and the population size of China and Latin America have a significant positive impact on the import of agricultural products. Zeng Xing (2021) [9] pointed out that China's GDP

has an impact on China's trade flow with South Asia. Cui Ri-Ming and Huang Ying-Wan (2017) [10] found that GDP plays a great role in promoting China's export of trade.

Therefore, it is hypothesized here that the GDP of China and African countries is a factor affecting the bilateral agricultural trade flow and that its impact is positive.

2.2.2. Geographical and Demographic Factors

① Geographical Factors

As mentioned earlier, the gravity model is the mainstream method used to analyze the influencing factors of trade flow [11]. In the description of the theorem, the gravity between two stars is inversely proportional to the square of their distance. When this is applied to trade flow, the geographical distance between two trade subjects is the factor affecting the trade flow.

There are different ways to determine geographical distance in the industry. One is the straight-line distance and actual distance. Straight-line distance refers to the shortest spherical distance between two points on the earth's surface. In the empirical study of trade flow, it is generally expressed by the straight-line distance between the economic centers or capitals of two countries [12]. However, in practice, constrained by various geographical conditions, the transportation distance of products between two countries is generally greater than its straight-line distance. If distance is used as an indicator affecting trade flow, straight-line distance is obviously less accurate than actual distance. Therefore, many scholars tend to use the sailing distance or transportation mileage between the main ports of two countries as the actual distance instead of the straight distance. Another one is the absolute distance and relative distance. The above straight-line distance and actual distance are the absolute distance between two points in the importing and exporting countries. In practice, some scholars incorporate GDP, population, and other components affecting transportation costs into the model for adjustment, and the adjusted distance is the relative distance. Considering that the relative distance may not fully capture the distance effect or transportation cost and the considerable amount of agricultural trade between China and Africa, this paper considers the transportation mileage of major ports between China and African countries as the variable to measure geographical factors.

Therefore, this paper hypothesizes that geographical distance is a repulsive factor of trade flow, i.e., that the distance between China and African countries is an influencing factor of bilateral agricultural trade flow, and its influence is hypothesized to be negative.

② Demographic Factors

Scholars have studied the impact of population on trade flow from different perspectives of population. Firstly, Linnemann (1966), Bergstrand (1985, 1989), Soloaga et al. (2001), and Li Wenxia et al. (2019) [13] believed that the population scale of importing and exporting countries is negatively correlated with trade flows. The larger the population scale of the exporting country, the less products are used for export after meeting the needs of its own market. The larger the population scale of the importing country, the stronger its self-sufficiency and the fewer products it imports from abroad. Brada (1985) [14], Li Xiaozhong, Du Tianhao (2019) [15], Liao Jia, and Shang Yuhong (2021) [16] hold the opposite view, believing that population size has a positive impact on trade flow. The increase in the population scale of exporting countries will increase production and supply and improve export capacity. The larger the population scale of the importing country, the greater the demand for products, and the more inclined it is to increase the import of products.

Secondly, many scholars have paid attention to the impact of population education and population structure on trade flows. In terms of population education, scholars basically agree: the number of years of population education has a positive impact on trade flows. Shi Xinping (2020), Yao Yaojun (2010), Li Wei (2010), Xu Qiongxia (2009), and other scholars have found that the increase in the years of education will play a positive role in promoting the transformation of the growth mode of the commercial circulation industry, the expansion of the scale of foreign exports, and the optimization of the structure of export commodities. In terms of population structure, scholars who have subdivided

it into age structures, gender structures, urban–rural structures, etc., and have studied its impact on trade flow and trade structure, have drawn some conclusions: that changes in the population structure have a significant impact on trade structure (Lin yanru, 2016), and that the aging population hinders the development of China's export trade (Zhu Feng, 2021; Xu Guoyuan, 2017) but will alleviate the imbalance between China and the United States (Yang Qing, 2012) and promote the transformation of China's trade from "quantity expansion" to "connotation improvement" (Liu xueshuai, 2019; Qian Hui, 2020).

In view of the limited impact of a simple population size on trade flows, from the perspective of productivity, this paper selects the education years of the population of African countries as an influencing factor of agricultural trade flows between China and Africa, and its impact is expected to be positive.

2.2.3. Natural Resource Endowment

A difference in natural resource endowment is an important explanation for comparative advantage, and differences in comparative advantage will lead to international trade. The trade of agricultural products is closely related to its output, and the output is also greatly affected by the endowment of agricultural resources. Natural resources include land resources, water resources, climate resources, etc.

An abundance of land resources will affect the scale of agricultural production and then affect the quantity of agricultural products. Planting, forestry, animal husbandry, and fisheries are all developed on the basis of land resources. Only when it is suitable for agriculture, forestry, and animal husbandry can we give full play to the potential of land resources. In terms of the impact of water resources on trade flows, Han Dong et al. (2021) [17] found that water resources are the main factor affecting the trade pattern among countries. The smaller the difference in water resources, the easier it is to maintain a close agricultural trade relationship. The impact of climate resources on agricultural trade is twofold. In terms of positive impact first, the heat-rich climate resources make characteristic agricultural products more popular and provide a greater market growth space (Fan Li, 2019 [18]). At the same time, due to climate warming, the urban heat island effect, and other factors, there is more market demand for trees and flowers that can afforest the city, purify the air, and beautify houses (Yu Miao-Jie, 2019 [19]). Secondly, agriculture is a low-carbon industry. Agricultural products have product advantages and can yield more development opportunities because of their "low-carbon nature" (Cao Bang-Ying, Hu Shi-Yu, 2016 [20]). In terms of negative effects, climate change leads to instability in agricultural production, and declines in yield and quality. Climate warming will also increase agricultural water demand and regional differences in the water supply. Climate change makes agricultural products more perishable, especially for products with strong seasonal characteristics, which increases the trade cost to a certain extent (Peng Shui-Jun, Zhang Wen-Cheng, 2016 [21]; Yang Zhan-Hong, 2015 [22].) In addition, relevant scholars have also studied the reaction of trade to "macro-environment" factors including water, soil, and climate. Hong Chen and Wenzhe Hu (2020) [23] found that trade development reduces regional environmental pollution through a scale effect, and an increase in service trade helps to reduce the growth rate of pollution emission.

Therefore, this paper hypothesizes that natural resource endowment is an influencing factor of agricultural trade flow between China and Africa. Since there are many kinds of natural resource endowments and the impact of each resource on agriculture is different, it is hypothesized that its impact is uncertain.

2.2.4. Agricultural Science and Technology Level

The macro impact of the level of agricultural science and technology on trade is reflected in the following: First, the level of agricultural science and technology has accelerated the development of economic integration and the international division of labor and has stimulated the growth of national agricultural trade. Secondly, the level of agricultural science and technology has greatly changed the commodity structure of agricultural

trade. The status of primary agricultural product trade in world commodity trade is declining; however, the trade of high-tech agricultural products is developing rapidly, and the progress of science and technology has yielded a series of agricultural products that tend to be miniaturized and light. Moreover, the unbalanced development of agricultural science and technology has led to differences in the competitiveness of different countries and regions in international trade, thus changing the pattern of international agricultural trade. The micro impact of the level of agricultural science and technology on trade is reflected in the following: First, the advanced level of agricultural science and technology has yielded advanced technical equipment for agricultural product production and has improved labor productivity. Second, it has also improved the technological progress of land productivity and the quality of agricultural products, providing high-quality means of production, chemical fertilizers, and plastic films for continuous agricultural development, providing new varieties of animals and plants for agricultural cultivation, and improving the input–output ratio.

Domestic scholars have researched the impact of the level of agricultural technology on trade. Zhai Tao et al. (2020) [24] found that the interregional differences in the development of China's foreign trade of agricultural products are affected by the level of science and technology investment, the level of regional economic development, the level of foreign investment, and other factors. Qu Ru-Xiao (2019) [25] analyzed the data of 23 sub-sectors and concluded that scientific and technological innovation cooperation significantly promoted the growth of export trade, and this promotion effect was mainly reflected by expanding the margin. Zhang Yu-Qu et al. (2020) [26] found that scientific and technological innovation can promote the development of productivity, promote changes in international trade infrastructure and transaction mode, promote changes in the international trade commodity structure, and determine the geographical pattern of international trade.

Therefore, this paper hypothesizes that the level of agricultural science and technology is an influencing factor of agricultural trade flow between China and Africa and that its influence is positive.

2.2.5. Political Factors

Scholars at home and abroad generally believe that political factors will have an impact on the international trade of both regions. Among them, institutional economics holds that the improvement of a system can reduce transaction costs and promote the development of trade. Dong Gui-Cai and Wang Ming-Xia (2018) [27] found that international political relations have a significant impact on China's high-end equipment manufacturing trade. Muhammad Ridwan (2020) [28] pointed out that the implementation of the China-ASEAN Free Trade Agreement has a positive impact on the palm oil trade between Indonesia and China and improves their bilateral trade. Wang Jue et al. (2019) [29] found that good bilateral political relations can create good external conditions for China's exports and effectively expand exports. Xie Jian-Guo and XU Ping-Ping (2019) [30] found that the boycott of Chinese consumers, triggered by the Sade incident, caused a loss of nearly 30% of South Korea's exports to China. Zhou Yong-Hong and Wang Lu (2019) [31] pointed out that the Sino-Japanese political conflict has a negative impact on Japan's exports to China, and the short-term effect is relatively significant.

The "one belt, one road" strategy has played a strong role in promoting the development of agricultural trade between China and Africa. Since the strategy was put forward in 2013, trade ties between China and African countries have become stronger. Mutually beneficial cooperation has moved to record heights. At present, 49 countries in Africa have signed a "one belt, one road" cooperation plan with China. Therefore, this paper hypothesizes that the "one belt, one road" strategy is a factor that influences the trade flow between China and Africa and that its influence is positive.

2.2.6. Exchange Rate Factors

First, exchange rate changes have an impact on trade flows. The price of a country's export products is mainly affected by the demand of the international market and the production cost of products, and production cost is restricted by the price of raw materials and workers' wages. Under a direct pricing method, if the exchange rate rises, the local currency is devalued, which will increase the export trade flow of domestic products. On the contrary, a decline in the exchange rate will promote an increase in the import flow of domestic products. Secondly, a change in the exchange rate will also cause a change in the trade flow. Trade flow refers to the product flow of a country or region to other countries, which can be understood as the national structure of a country's product trade region or market distribution. The impact of exchange rate changes on the flow of product trade occurs because, within a certain period of time, exchange rate changes the distribution of the trade market of a country or a region. Under the joint interaction of transaction costs, transaction methods, international demand, and other factors, the proportion of a country's trade with other countries changes, thus forming a new market structure. Moreover, changes in exchange rates will also have an impact on the commodity structure of trade.

Therefore, this paper hypothesizes that the exchange rate has an uncertain impact on the trade flow of agricultural products between China and Africa.

3. Materials and Methods

3.1. Model Construction and Data Source

The idea and concept of the gravity model originated from Newton's law of universal gravitation, which holds that the gravity between two objects is directly proportional to their mass. According to this law, the astronomer Stewart (1947) and sociologist Zipf (1949) first extended the application of the gravity model to the field of social science and constructed a gravity model reflecting the scale of tourism, namely,

$$I_{ij} = (Pop_i Pop_j)/D_\beta \quad (1)$$

where I_{ij} is the number of travelers between cities, Pop is the number of cities, D is the distance between cities, and β is the parameter.

After that, Tinbergen (1962) [32] used the model to study international trade. After innovatively adding the variable of preferential trade arrangement to the original econometric model, he found that the scale of bilateral trade was positively correlated with the total economy and negatively correlated with geographical distance. He extended the model to:

$$X_{ij} = \beta_0 Y_i \beta_1 Y_i \beta_2 D_{ij} \beta_3 E \beta_4 P \quad (2)$$

where X_{ij} is the trade volume between country i and country j, Y_i is the gross national product of country i, Y_j is the gross national product of country j, D_{ij} is the distance between the two countries, and P is a virtual variable reflecting regional preferential trade arrangements.

Due to the differences between countries in geographical factors, historical relations, exchange rate risk, and trade policies, scholars have innovated the model according to their own research fields and needs. For example, Linnermann (1966) [11] and Berstrand (1985) [12] introduced factors such as population, per capita income, exchange rates, and common languages and borders and calculated the trade potential. Frankel (2002) [33] believed that real GDP and distance constitute the standard form of the gravity model. Factors such as a common border and a common language were added, and a complete gravity model was finally formed. In addition to the variables mentioned above, Zimmer (2003) [34] continued to add eight variables and comprehensively summarize the various factors that may affect trade. The gravity model has been successfully verified in research on international trade. It is widely used in measuring trade flow, identifying the effect of

trade groups, analyzing trade patterns, and estimating the border cost of trade barriers, and it better explains the economic phenomena observed in reality.

This paper uses the panel data of agricultural trade between China and 58 African countries in the United Nations trade database (UN COMTRADE) from 2010 to 2019. The term "agricultural products" is defined here based on the statistical classification standard of the Ministry of Agriculture of China. Stata16.0 software was used for analysis.

3.2. Selection and Description of Indicators

3.2.1. Selection of Indicators

① Gross domestic product

Tinbergen (1962), the initiator of the gravity model, believed that economic scale is the main factor affecting trade flow, because it can affect both the potential supply capacity of exporting countries and the potential demand capacity of importing countries, and economic scale is directly proportional to these two capacities. Scholars at home and abroad have reached consistent conclusions (Linnermann, 1966 [11]; Cui Ri-Ming, 2017 [10]; CAO Fang-Fang, Sun Zhi-Lu and LI Xian-De, 2021 [8]). In international trade, nominal gross domestic product (GDP) is generally used to express the trade capability of both regions. Therefore, this paper uses the GDP of China and African countries to characterize the influencing factors of economic scale on bilateral trade flows and expects its impact to be positive.

② Transportation mileage of major ports

The distance between importing and exporting countries represents the level of transportation costs and is an important factor in hindering trade. In empirical studies, scholars concluded that, under the same conditions, the farther the distance between importing and exporting countries, the more obstacles that need to be overcome, and the smaller the trade volume. This is because distance not only reflects the transportation cost, but also represents other barrier factors caused by distance between countries, such as differences in language and culture.

In view of the classification of different geographical distances proposed earlier, considering the fact that the relative distance may not fully capture the distance effect or transportation cost and the considerable amount of agricultural trade between China and Africa, this paper considers the transportation mileage of major ports between China and African countries as a variable to measure geographical factors and expects its impact to be negative.

③ Years of education

The original trade gravity model contained only the economic scale of the importing country, the economic scale of the exporting country, and the distance between the two countries. Later, economists carried out extensive research on various exogenous variables set in the construction of the trade gravity model. The introduction of population as a variable into the model is a prominent example of this kind of research. The size of the population, the number of years of education, and the population structure will have an impact on the trade flow and trade structure. In view of China's agricultural trade with Africa, from the perspective of population size alone, we cannot clearly explain the impact of population factors on trade flows. Therefore, this paper selects the years of education in African countries as the demographic factor affecting China–Africa agricultural trade flows and expects its impact to be positive.

④ Per capita arable land area

Compared with other natural resource endowments, it is obvious that agricultural production relies on land. The amount of cultivated land per capita in a country represents an important part of natural resource endowments, affects the production quantity of agricultural products in the country, and affects the trade flow of agricultural products together with the demand. The increase and decrease of cultivated land area and its

composition, the different production capacity of cultivated land, and the changes in cultivated land quantity will all have an impact on the total output capacity. Song Hai-Ying (2013) [35] found that factors such as land resource endowment promote the agricultural trade between China and Latin American countries. Maynur and Zhao Jun (2019) [36] found that per capita cultivated land area has a positive effect on bilateral trade between China and Brazil. In view of the small scale of agriculture in most African countries, agricultural production basically depends on rainfall and soil fertility, and the degree of mechanization and the adoption rate of agricultural technology are relatively low, so the per capita arable land area will well represent original agricultural production. Therefore, this paper considers the per capita arable land area of African countries as one of the factors affecting the natural resource endowment of China–Africa agricultural trade flow and expects its impact to be positive.

⑤ Renewable water resources per capita

With the development of human economy and society, water resource management has become a primary problem of global resources and the environment in the 21st century. Due to the uneven distribution and large consumption of water resources, the shortage of water resources has become a constraint on the economic and social development of many countries and regions (Zeng Xian-Gang et al., 2021) [37]. Most agricultural products are water resource-intensive, and the abundance of agricultural water resources will have an important impact on trade flow and trade structure and thus affect regional economic growth. In terms of China's specific national conditions, China has few water resources per capita, and the food security problem caused by resource shortage is an important factor affecting China's sustainable development and has an adverse impact on China's food production. Domestic scholars have calculated the water resources contained in China's agricultural trade and have affirmed that the import of agricultural products can effectively alleviate the pressure on China's water resources, which has played a certain role in ensuring food security. Han Dong and Li Guang-Si (2020) [17] have found that water resources and the economic volume and system are main factors affecting the trade pattern between countries.

Therefore, this paper considers renewable water resources per capita of Africa countries as an influencing factor affecting the trade flow of agricultural products between China and Africa, and the impact is expected to be positive.

⑥ Human capital index

Human capital has always been an important input factor of various economic activities concerned by scholars. It is "the knowledge, skills, ability and quality owned by individuals that can create personal, social and economic well-being", and it is an important part of social wealth. In agricultural production, the improvement of farmers' human capital is the material basis for agricultural scientific research and extension activities. It is conducive to the production and promotion of agricultural scientific research achievements and can impact the agricultural means of production, and thus improve the production efficiency of agricultural products. The improvement of production efficiency will lead to an increase in output, which will make the supply of agricultural products more sufficient and have a positive impact on the trade volume of agricultural products between China and Africa. Compared with African countries, China's agricultural science and technology has improved faster in recent years, which exemplifies the leading scientific and technological force affecting the trade flow of agricultural products between them, taking into account the availability and convenience of data. Therefore, this paper calculates China's human capital index based on the international mainstream human capital calculation method and Jorgenson Fraumeni's lifelong income method (hereinafter referred to as the j-f method) to measure the agricultural science and technology level as it pertains to China–Africa agricultural product trade, and the impact is expected to be positive.

⑦ The "one belt, one road" strategy

System economics posits that the improvement of a system can reduce transaction costs and promote the development of trade. Backward systems will hinder the development of trade and become an "important informal barrier". Thanks to the implementation of the "one belt, one road" strategy, China and Africa are gradually moving towards the goal of "five links", especially in the field of trade and infrastructure. Many projects and policies have effectively promoted the development of trade facilitation of agricultural products between China and Africa. Relevant domestic scholars have also conducted research on the impact of policies and trade flows. Therefore, this paper considers the "one belt, one road" strategy as a virtual variable that affects the trade flow of agricultural products between China and Africa, and it is expected to have a positive impact.

⑧ Exchange rate

The exchange rate will have an impact on agricultural trade. Relevant studies show that the price of agricultural products, compared to that of non-agricultural products, is more affected by exchange rate fluctuations. The relevant literature also shows that developing countries (like most African countries) are more adversely affected by exchange rate fluctuations than developed countries. Dengjun Zhang (2014) developed a risk-enhanced differential demand system to test the impact of exchange rate fluctuations on trade. Using data on salmon imported by the United States from Chile, Canada, Norway, the United Kingdom, and other regions, the results show that exchange rate fluctuations reduce imports. Mohsen Bahmani Oskooee (2013) used data on the trade between the United States and Brazil from 1971 to 2010 to investigate the risks of exchange rate fluctuations on trade and found that the degree of damage to Brazil's agricultural exports was obvious. The exchange rate will affect the market structure and product structure of agricultural trade between China and Africa. In view of the large number of African countries and the lack of a unified currency and exchange rate system across the continent, this paper considers China's RMB exchange rate as a factor affecting China–Africa agricultural trade, and it is expected to be negative.

Based on the present situation of Chinese agricultural trade and the characteristics of China–Africa agricultural trade, nine variables were finally added to the model: the GDP of China, the GDP of Africa, the transportation mileage of major ports, the years of education of the African population, the average arable land per capita of African countries, the renewable water resources per capita in Africa, the human capital index of China, the "one belt, one way" strategy, and China's exchange rate to build an extended trade gravity model. At the same time, in order to reduce the heteroscedasticity of the panel data and facilitate linear analysis, the variables of the gravity model are considered as a logarithm. The expanded model is as follows:

$$\begin{aligned} LnTRA_{ijt} = {} & \beta_0 + \beta_1 LnGDP_{it} + \beta_2 LnGDP_{jt} + \beta_3 LnDIS_{ij} + \beta_4 LnEDU_{jt} + \beta_5 LnLAND_{jt} \\ & + \beta_6 LnWAT_{jt} + \beta_7 LnHUM_{it} + \beta_8 LnBELT_{jt} + \beta_9 LnEXC_{it} + U_{ij} \end{aligned} \quad (3)$$

TRA_{ijt} represents the total trade volume of agricultural products between country i and country j in year t; GDP_{it} and GDP_{jt}, respectively, represent the GDP of country i and country j in year t; DIS_{ij} represents the distance between major ports from country i to country j; EDU_{jt} represents the years of education of country j in year t; $LAND_{jt}$ refers to the per capita arable land area of country j in year t; WAT_{jt} represents the amount of renewable water resources available to people in country j in t year; HUM_{it} represents the human capital index in country i in year t; $BELT_{jt}$ represents the joining of the "one belt, one road" strategy of j in year t; EXC_{it} represents the exchange rate of country i against the US dollar in year t; β0 is a constant term; β1–β9 are the regression coefficients; U_{ij} is the random error term.

3.2.2. Index Description

The expected outcomes, theoretical descriptions, and data sources of each explanatory variable are shown in Table 1.

Table 1. Explanatory variables, expected outcomes, and data sources.

Explanatory Variables	Variable Name	Expected Outcome	Theoretical Explanation	Data Resource
TRA_{ijt}	Trade volume between China and Africa	—	Trade volume between China and Africa	UNCOMTRADE (Unit:dollar)
GDP_{it}	GDP of i	Positive	The economic scale of exporting countries reflects the potential trade Supply.	World bank database (Unit:dollar)
DP_{jt}	GDP of j	Positive	The economic scale of importing countries reflects the potential trade Demand.	World bank database (Unit:dollar)
DIS_{ij}	Transportation mileage of major ports	Negative	The greater the distance, the more it hinders the trade.	CEPII database
EDU_{jt}	Years of education of j	Positive	The longer the years of education, the stronger the trade demand, or the stronger the self-sufficiency.	World Union database (Unit:year)
$LAND_{jt}$	Per capita arable land of j	Positive	The more arable land per capita, the greater the output.	World bank database (Unit:hectare)
WAT_{jt}	Per capital renewable water resources of j	Positive	The more abundant water resources are, the richer production of agriculture products.	FAO website (Unit:cubic meter)
HUM_{it}	Human capital index of i	Positive	The higher human capital index, the higher agricultural productivity and the more sufficient supply of agriculture products.	Statistical year book of province
$BELT_{it}$	"One belt, one road"strategy	Positive	After implementation of strategy, the less trade obstacle.	Official website of "One belt, one road"
EXC_{it}	Exchange rate of i	Negative	Exchange rate changes affect trade flow, market structure and product structure.	WDI database

4. Results

4.1. Empirical Result

Stata16.0 was used to convert the data of the selected variables into logarithms, the relevant commands were used for regression analysis, and the Hausman test command was used to judge whether the expanded trade gravity model is a fixed effect model or a random effect model. If the *p* value of the test result was less than 0.05, the fixed effect model was selected; if it was greater than 0.05, the random effect model was selected. Table 2 reveals the specific regression analysis results. The test results show that the *p* value was equal to 0.039 and less than 0.05, so the fixed effect model was selected. According to the regression results of the fixed effect model, the final trade gravity model equation was obtained:

$$\begin{aligned} LnTRAijt = &-22.883 + 0.900LnGDPit + 0.637LnGDPjt - 0.572DISij + 0.073EDUjt + \\ &0.986LANDjt + 0.349WATjt - 0.091EXCit + Uij \end{aligned} \quad (4)$$

Table 2. Regression result of gravity model based on full sample about the factors affecting the. trade volume of agriculture products between China and Africa.

Explanatory Variables	Fixed Effect Model	Random Effect Model
C	−22.883 (−1.74)	−21.839 (−1.40)
$LnGDP_{it}$	0.900 ** (6.56)	0.771 * (5.73)
$LnGDP_{jt}$	0.637 * (7.44)	0.545 * (6.20)
$LnDIS_{ij}$	−0.572 *** (−1.75)	−0.626 *** (−1.56)
EDU_{jt}	0.073 * (2.04)	0.047 * (1.42)
$LnLAND_{jt}$	0.986 ** (1.75)	0.990 ** (1.88)
WAT_{jt}	0.349 * (2.31)	0.350 * (2.60)
$LnHUM_{it}$	0.620 (2.56)	0.594 (3.86)
$BELT_{it}$	0.316 (0.80)	0.348 (0.91)
EXC_{it}	−0.091 ** (−0.51)	−0.079 ** (−0.64)
R^2	0.952	0.927
Prob(F-statistic)	0.00	0.00

Note: *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

4.2. Robustness Test

There are differences in different agricultural products, and the production of agricultural products in different years is different. Therefore, there may be errors in simple linear regression. In order to investigate the robustness and reliability of the measurement results in this paper, we reduced the number of research countries to regress the panel data of 50 African countries, as well as shortening the sample space from 2010 to 2018 to eliminate the influence of COVID-19 and obtain more stable variable data. The results show that the regression coefficient symbol and the significance level of nine variables are basically consistent. Therefore, both the reduction of research targets and the shortening of the sample interval have little impact on the empirical results of this paper. The empirical results in this paper are robust and reliable. The estimation results of the robustness test are shown in Table 3. According to this table, whether the impact of various factors on China–Africa trade flow in the benchmark model has been accurately estimated can be evaluated.

Table 3. Estimation results of the robustness test.

Variables	Coefficient	Z Value
C	−23.41	−1.5963
$LnGDP_{it}$	4.2432 **	3.3343
$LnGDP_{jt}$	0.5480 *	5.8476
$LnDIS_{ij}$	−0.4048 ***	−1.5021
EDU_{jt}	0.0448 *	2.0391
$LnLAND_{jt}$	−1.1253 **	−3.1439
WAT_{jt}	1.031 *	3.1482
$LnHUM_{it}$	0.5094	1.5121
$BELT_{it}$	0.3192	1.1532
EXC_{it}	−0.116 **	−1.2539
Loglikehood	132.3348	
LR 检验 LR Test	149.36	

Note: *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

The results of the robustness test show that the goodness of fit of the model is good. The coefficients of China's GDP, Africa's GDP, the number of years of education of Africa's population, Africa's per capita arable land area, and the amount of renewable water resources available to Africans are still positive, indicating that they have a positive impact on the trade flow of agricultural products between China and Africa. The coefficients of geographical distance and China's exchange rate are negative, indicating that they have a negative impact, which is significant at the statistical level of less than 10%, indicating that the model passes the robustness test. Compared with the benchmark regression results, the coefficients of African GDP, the transportation distance of major ports, and the years of education of the African population all decreased. In the benchmark regression, the variable coefficient of African GDP was 0.637, the distance coefficient of major ports was −0.572, and the years of education of the African population was 0.073. In the robustness test, the coefficients of these three variables were 0.5480, −0.4048, and 0.0448, respectively. The benchmark regression overestimates the impact of Africa's GDP, the distance between ports, and the number of years of education of the African population on the trade volume of agricultural products. On the contrary, the coefficients of China's GDP, the per capita arable land area in Africa, the amount of renewable water resources available to Africans, and China's exchange rate have increased, which shows that the benchmark regression underestimates their impact on China–Africa agriculturatrade.

4.3. Regional Heterogeneity Analysis

Theoretically, a variety of factors may lead to regional heterogeneity in the impact of the above factors on the trade volume of agricultural products between China and Africa. First, the level of economic development, institutional and cultural traditions, and the resource endowment conditions of African countries are uneven, and there are differences in the basis of mutual political trust and trade development between China and different countries, which makes the willingness, ability, and intensity of bilateral cooperation different. Secondly, the policy system of cooperation between China and African countries is mainly constructed by bilateral cooperation agreements. The content and signing time of the agreements are different, and the influencing factors will naturally produce regional differences. Third, although China's trade capacity has been expanding, its trade resources are limited, which means that China's trade with different African countries also has an ebb-and-flow relationship to a certain extent, resulting in a differential impact on trade.

Based on the geographical differences of African countries, in this paper, they were divided into five regions: East, Southern, West, North, and Central. After the Hausman test, the fixed effect model was selected to investigate the regional differences of the above nine factors on the five regions. The result is as follows in Table 4.

Table 4. Regression result of gravity model based on regional sample about the factors affecting the trade volume of agriculture products between China and Africa.

	East Africa	**Southern Africa**	**West Africa**	**North Africa**	**Central Africa**
$LnGDP_{it}$	0.913 **	0.921 **	0.920 **	0.911 *	0.905 *
	(6.89)	(6.60)	(5.19)	(5.38)	(5.24)
$LnGDP_{jt}$	1.000 *	1.008 **	1.002 *	0.988 **	0.982 *
	(7.91)	(7.53)	(6.55)	(6.13)	(6.24)
$LnDIS_{ij}$	−0.591 ***	−0.660 **	−0.722 ***	−0.617 *	−0.544 **
	(−1.64)	(−1.60)	(−1.61)	(−1.58)	(−1.56)
EDU_{jt}	0.069 *	0.085 *	0.072 *	0.078 *	0.055 *
	(1.41)	(1.32)	(1.46)	(1.35)	(1.36)
$LnLAND_{jt}$	0.966 **	0.968 **	0.992 **	0.852 **	0.876 **
	(1.97)	(1.89)	(1.95)	(1.87)	(1.72)

Table 4. *Cont.*

	East Africa	Southern Africa	West Africa	North Africa	Central Africa
WAT_{jt}	0.392 **	0.362 *	0.356 **	0.268 *	0.248 *
	(2.32)	(2.54)	(2.32)	(2.52)	(2.48)
$LnHUM_{it}$	0.591	0.633	0.585	0.687	0.602
	(3.96)	(4.18)	(3.97)	(4.19)	(3.45)
$BELT_{it}$	0.277	0.279	0.278	0.275	0.277
	(0.86)	(0.75)	(0.89)	(0.67)	(0.79)
EXC_{it}	−0.096 *	−0.102 **	−0.085 *	−0.080 **	−0.061 *
	(−0.59)	(−0.53)	(−0.60)	(−0.54)	(−0.62)

Note: *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

5. Discussion and Countermeasures

5.1. Discussion

According to the analysis of the full sample results of Table 2, the following conclusions can be drawn:

Firstly, it can be seen that the economic scale of both regions, the transportation distance of major ports, the number of years of education of the African population, the per capita arable land area of Africa, the amount of renewable water resources available to Africans, and China's exchange rate have a significant impact on the trade volume of agricultural products between China and Africa. The economic scale of China and Africa is one of the factors affecting trade. The potential demand capacity of importing countries and the potential supply capacity of exporting countries affect the comparative advantage of bilateral trade. The transportation distance of major ports is a repulsive factor of trade, which is because China and Africa must travel long distances. The trade of agricultural products involves the multiple entry and exit of raw materials and semi-finished products, which is sensitive to the impact of transportation distance. The farther the distance, the higher the transportation cost of trade. The more educated the African population is, the greater the reduction in the opportunity costs and transaction costs of agricultural trade, and the greater the promotion of its scale and quality. African education trains its citizens to become engaged in agricultural production, which is conducive to the accumulation of human capital and the optimization of the market environment, so it has a positive impact on the trade of agricultural products. Migration agriculture is prevalent in most African countries. The farming methods and technologies are backward, and the level of modernization is low. Therefore, the production of agricultural products mainly depends on the natural resources, and the biodiversity and the length of a crop's growth season are affected by the amount of arable land and water resources. The appreciation of RMB will benefit China's imports but not its exports, and the depreciation of RMB will benefit Africa's imports but not its exports. Generally speaking, due to the difference between the import and export trade volume of the two regions, the rise in the RMB exchange rate will reduce their trade volume and have a negative impact on it.

The Chinese human capital index and the "one belt, one road" strategy have no significant impact on the trade volume of China–Africa agricultural products. This is because the investment of human capital has a lag effect, and it will take a long time to fully highlight the role of human capital in promoting agricultural growth and agricultural trade flow. The "one belt, one road" strategy has only been implemented for a short time since 2013, and the relevant trade promotion policies are still being implemented step by step. The infrastructure for promoting trade facilitation is still in development.

According to the analysis of the regional sample results of Table 3, the following conclusions can be drawn:

The impact of GDP on the trade volume of agricultural products between China and the five African regions is relatively obvious. When the economic scale of GDP is large and relatively stable, in terms of exports, agricultural enterprises are more likely to expand production scale and reduce production costs. Industries that gain development

advantages gain more advantages in resource allocation, thereby creating a virtuous circle. This international competitive advantage has a positive impact on the growth of agricultural trade with China. In terms of imports, a large and stable economic scale of GDP sends a positive signal to domestic agricultural producers. They increase the import of raw materials and primary agricultural products from abroad, stimulating the demand for more agricultural products in China.

The transportation distance of major ports has the most obvious impact on the trade volume of agricultural products between China and West Africa. Ghana, Guinea, Nigeria, and other countries have excellent geographical conditions. West Africa has the only deep-water port in the Gulf of Guinea, LOM é port of Togo, which is mainly where Africa and China import and export grain and other agricultural products. There is also the Lagos port, with a warehouse area of 240,000 square meters, which provides convenient conditions for both regions to import and export textiles, flour, wine, candy, food, etc. In addition, the coastline of the Abidjan port in Côte d'Ivoire is about 6085 m long, and there are offshore oil berths. It exports cocoa, coffee, bananas, cotton, food, and other agricultural products to China. Due to the inland location of China and Africa and the lack of port conditions bordering the outside world, the impact of port transportation distance is not significant.

The terrain of West Africa is relatively low and flat. Niger, Sudan, and other countries are rich in per capita arable land resources, and the output of oil palm, cocoa, palm kernels, peanuts, coffee, rubber, and other agricultural products is large. In addition, Nigeria has 340,000 square kilometers of arable land, accounting for more than one third of the land area. It grows cotton, peanuts, rice, cassava, and other crops. In addition, it has a sufficient labor force and is conducive to intensive cultivation, so the region makes full use of cultivated land and other natural resources and thus contributes to the agricultural trade between China and Africa.

Africa is generally rich in water resources, but the amount of renewable water resources per capita is extremely poor, and those that can be used for agricultural production are even scarcer, which has become one of the main bottlenecks hindering the development of agricultural trade between China and Africa, which is exemplified by East Africa. For example, Tanzania sits on Lake Victoria, the world's second largest freshwater lake, and includes Tanganyika Lake, Malawi Lake, the Rufiji River, and the Pangani River. However, due to the shortage of funds, insufficient investment, a lack of basic irrigation data, among other factors, the country's farmland water conservancy facilities are lacking and are developing slowly, and the rich water resources are difficult to use for agricultural production.

In recent years, countries in Southern Africa have taken a series of strong measures to improve the education level of their nation. The length of the education of their nationals has had a significant impact on the trade of agricultural products between China and Africa. By paying attention to the relationship between education quality and economic development, school education can more accurately reflect the elements and needs of a modern agricultural economy and can even promote the allocation of educational resources to backward agricultural producing countries through legislation. Education should be strengthened, so a cooperation mechanism for sharing economic interests with countries exporting educational services should be established.

Furthermore, China's exchange rate has a negative impact on China–Africa agricultural trade between the five regions. The impacts of China's human capital index and the "one belt, one road" strategy are not obvious. These conclusions are consistent with the regression of the whole sample.

5.2. Countermeasures

In order to vigorously develop the trade of agricultural products, China and African countries have taken a series of effective measures. For example, in terms of governmental cooperation, China and 49 African countries have signed "one belt, one road" cooperation agreements, laying a solid foundation for the further development of agricultural trade. In 2019, the Foreign Liaison Department of the CPC Central Committee and the Ministry

of Agriculture of the People's Republic of China jointly hosted the first China–Africa agricultural cooperation forum, launched eight new measures for cooperation, advocated the establishment of a fair, just, inclusive, and orderly international agricultural trade system, and improved the external environment for agricultural development in developing countries. In terms of trade tariffs, China has established a "green channel" for the export of African agricultural products to China and provided zero tariff treatment for 97% of the products exported to China from 33 developing countries in Africa, and many of these products are agricultural. In terms of trade facilitation, China has assisted Africa by means of investment and cooperation in building railways in Addis Ababa in Ethiopia, Djibouti, Tanzania, and Mombasa Nairobi in Kenya and ports such as Suez in Sudan, which has shortened the distance of agricultural trade.

In the future, China and Africa can also continue to strengthen cooperation and mutually beneficial results by optimizing the top-level design and the overall layout of bilateral cooperation. The long-term friendly cooperation and mutual political trust between China and Africa have laid a good foundation for the development of bilateral agricultural trade. Therefore, in the future, the governments of these two regions should strengthen exchanges and interaction and deepen economic and trade cooperation. China should strive to sign more "one belt, one road" cooperation agreements with more African countries, promote free trade negotiations with more African countries, and improve policy guarantees for bilateral cooperation. Second, the three-dimensional transportation network construction of bilateral trade should be accelerated. Both parties should start from the three aspects of "ocean, land, air" to shorten the geographical distance. The coastal areas should actively ensure that certain agricultural products enter and exit specially designated ports. For example, eastern and coastal ports in East Africa can be designated for vegetables, fruit, or other trade products. The China–Africa railway transportation system on land can be consolidated and improved, and the risks of railway construction can be reduced by signing memoranda, refining and dividing up projects, and learning from the experience of successful projects. In the air field, government subsidies and supporting policies can be increased, as can the kinds and scope of tax waivers in China's air transport industry, and a "one belt, one road" air bridge can be constructed. Third, the upgrading of agricultural technology can be accelerated, and the development of trade modernization can be ensured. Agricultural technologies that can be embedded into the existing farming and livelihood systems of African farmers can be promoted. Precision agriculture can be promoted, agricultural productivity can be improved, more farmers can be incentivized to participate, and technology can be made to produce scale and diffusion effects.

6. Paper Limitations and Prospective Future Research

The limitation of this paper is that it involves an application and data analysis of a quantitative model, but it has not carried out any in-depth mining and processing of a specific problem, and there are still deficiencies in the depth of problem analysis. In terms of analysis and conclusion, we pay more attention to data, and the connection with actual cases is not close enough.

In the future, research on the dynamic influencing factors affecting trade potential, such as the institutional design of free trade zones as well as improvements in investment and financing conditions, such as infrastructure investment banks, needs to be more extensively conducted. Cross research on the trade competitiveness of agricultural products and benefit distribution can also be further explored.

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