Research on China's Export of Agricultural Products to the U.S.—Based on Trivariate Marginal Analysis

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Abstract. As a major agricultural country and a major agricultural trade country, China and the U.S. are of great significance in strengthening the supply chain of agricultural products, promoting international food security cooperation, and promoting global economic development. China and the U.S. have been important agricultural trade partners of each other for many years, and the two countries have close agricultural trade relations. This paper collects and collates the trade data of 816 agricultural products with six-digit HS codes from 2002 to 2019. Utilizing the cutting-edge research technique of export growth factor analysis, it examines the extensive margin, price margin, and quantity margin of China's agricultural product exports to the U.S. as well as the extent to which these three marginal variables affect export competitiveness. The empirical study demonstrates that the extensive margin is the primary driver of China's increasing agricultural exports to the U.S. The basic mode of China's agricultural products exporting to the U.S. to win by volume has fundamentally changed, and the increase of its export trade volume mainly depends on the continuous increase of the types of agricultural products exported. The price margin can effectively improve the competitiveness of China's agricultural exports to the U.S. in the short term. It has an obvious pulling effect on the export of China's agricultural products to the U.S., and the price margin has the most obvious impact on the competitive advantage.

Keywords: Ternary margin · Export of agricultural products to the U.S. · Export competitiveness

1 Introduction

According to data from the United Nations Office for Trade Statistics, China's import and export of agricultural products will total 304.168 billion U.S. dollars in 2021, up 57.307 billion U.S. dollars from the previous year and growing by 23.2% year over year. Of that amount, exports will total 84.354 billion U.S. dollars, growing by 10.9% year over year, and making up 27.73% of the total import and export of agricultural products. Exports to the U.S. will increase annually by 15.44% in 2021, reaching $7.44 billion. Agricultural exports from China to the U.S. will total $7.44 billion USD during the same time, making up 9% of the total amount of agricultural exports. The total trade

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volume of agricultural products exported from China to the U.S. is growing, despite the fact that there is still a significant gap between China and the U.S. in terms of the total import and export trade of agricultural products. This is due to the deepening of economic globalization and the continuous improvement of China's international trade competitiveness. Although the export of Chinese agricultural products to the U.S. has occasionally faced negative development due to the trade war and tariff obstacles between China and the U.S., it nevertheless exhibits a trend of continuous growth overall. In order to investigate the factors that contribute to the continuous rise and volatility of China's agricultural exports to the U.S., this research analyzes the expansion margin, quantity margin, and price margin of export growth from 2002 to 2019. This research excludes data following the emergence of the pandemic, that is, data for 2020 and later years, in order to more thoroughly assess the major influence of the aforementioned variables on China's agricultural exports to the U.S. In this essay, the agricultural goods trade between China and the U.S. is examined, and appropriate recommendations are made for the trade's future growth. This has significant practical implications for enhancing China's agricultural exports' competitiveness, fostering the growth of the China-US agricultural trade, and fostering world economic prosperity.

2 Literature Review

The research related to this paper mainly includes the following categories.

The first kind of literature is related research on the ternary marginal analysis of China's agricultural exports. On the basis of summing up the characteristics of China's vegetable exports to South Korea, the authors Qiao Wen and Zhu Yinyan applied the ternary marginal decomposition method to analyze the ternary marginal change of China's vegetable exports to South Korea from 1996 to 2017. They concluded that the dominant factor driving China's vegetable export growth to South Korea is the expansion margin, while the intensive margin contributes less to China's vegetable exports to South Korea. Further subdivision of the intensive margin shows that the contribution of the quantity margin to export growth is greater than the price margin [1]. Ye Lei initially examined the general state of China's agricultural commerce with "the Belt and Road" using the HS6 quantile agricultural trade data from 2001 to 2015. On the basis of this, he used the ternary marginal decomposition method to compute the expansion margin, quantity margin, and price margin of China's agricultural export of "the Belt and Road." Then, we thoroughly examine the growth model of China's agricultural exports under "the Belt and Road" Initiative using the techniques of calculating the marginal growth rate of trade, creating a trend chart, and nuclear density simulation. He concluded that, after expanding the range, the quantity range is the key factor affecting the growth of my country's agricultural exports to " the Belt and Road" [2]. These research papers on the ternary marginal analysis objectively and intuitively analyze the impact of each element of the ternary marginal analysis on China's merchandise export trade volume, providing a very important theoretical and methodological basis for the research in this paper.

The second kind of literature is related research on bilateral agricultural trade between China and the U.S. With the increasing trade between China and the U.S., more and more scholars try to study various factors that affect the agricultural trade between the two

countries. As Li Simiao, Guan Jialin, and Li Chao noted in their paper, as trade frictions between China and the U.S. escalate, trade protection measures emerge indefinitely. Tariff increase is one of the most representative means, and its agricultural products are mentioned several times in the list of tariff increase, which will certainly affect China's agricultural trade. Therefore, this paper takes the tariff of agricultural products between China and the U.S. as the starting point, selects the GTAP model, and evaluates the impact of the currently implemented and possibly implemented trade policies on China's agricultural products trade according to the current development of Sino US trade frictions, and puts forward corresponding countermeasures to provide useful reference for the relevant industries [3]. In this paper, Li Siqi and He Haiyan mainly studied the impact of American agricultural technical barriers on China's agricultural exports. They established a vector autoregressive model, and obtained the correlation between China's agricultural exports and foreign technical barriers through impulse response function and variance analysis. The model results show that the US agricultural technical barriers will have a negative impact on China's agricultural exports in the long term, and their impact on China's agricultural exports will gradually decrease over time [4]. These papers on the agricultural trade between China and the U.S. mainly analyze the impact of some factors such as, the U.S. trade policy on China's agricultural exports through some empirical research methods. It can be seen that the implementation and change of some U.S. trade policies and measures will have more or less impact on China's agricultural exports. It is of great significance to use empirical research methods such as ternary marginal analysis to analyze the reasons for the changes and fluctuations of China's agricultural exports to the U.S.

3 Ternary Margin Analysis

3.1 Analysis of Trade Status and Trend

Based on information from Table 1, the total volume of agricultural product trade between China and the U.S. expanded continuously and significantly over the course of the ten years from 2002 to 2012. The volume of trade between China and the US increased quickly, especially when China joined the WTO. The average yearly growth rate of overall trade decreased and stagnated between 2012 and 2019. Even in 2013, 2015, 2016, 2017, and 2018, there was a decline in growth. The entire volume of agricultural product trade between China and the U.S. has been decreasing yearly, particularly in 2016–2018.This is because the U.S.' tariff barriers against China's agricultural exports have been increasing, resulting in a decrease in total trade volume. However, in 2019, the total trade volume has rebounded, and the trade situation of China's agricultural products exported to the U.S. has improved.

To be more precise, the friction in agricultural trade between China and the U.S. stems not only from the exorbitant tariffs but also from the imperceptible non-tariff obstacles. The large trade subsidies for agricultural products are the first. With the 2002 amendment to the US Agricultural Law, the amount of government subsidies for bulk commodities like cotton, soybeans, wheat, and other bulk commodities like peanuts, wool, honey, etc. increased significantly to $190 billion. The second is mandatory technical requirements, which mostly cover transgenic crops, environmental obstacles, green

Table 1. China's total import and export of agricultural products to the United States. Unit: $100 million

Year	Total trade	Import	Export	Deficit
2002	55	38	17	21
2003	87	65	22	43
2004	121	96	25	71
2005	122	91	31	60
2006	145	103	42	61
2007	177	128	49	79
2008	246	190	56	134
2009	229	178	51	127
2010	305	243	62	181
2011	384	311	73	238
2012	438	361	77	284
2013	422	344	78	266
2014	444	366	78	286
2015	392	313	79	234
2016	381	302	79	223
2017	318	241	77	164
2018	253	162	91	71
2019	453	315	138	177

Source: the UN Comtrade database

barriers, and food safety concerns. The Laws on the Safety Management of Agricultural Genetically Modified Organisms and other regulations, which were introduced by China in 2002 and used the technical obstacles permitted by the WTO to limit the export of genetically modified crops to the U.S., angered Americans. Chinese fruits are also commonly hindered by US green obstacles because to their poor quality and low safety, which lowers their competitiveness. In order to reduce environmental damage, the U.S., for instance, mandates degradable packaging for many food items. This requirement raises the cost of commerce while also realizing trade protection in the U.S. The final section discusses anti-dumping and dumping. China routinely experiences agricultural anti-dumping cases. The anti-dumping commodities include honey, garlic, crayfish, concentrated fruit juice, etc. These products are subject to hefty anti-dumping taxes, which reduces the competitiveness of many of China's products with comparative advantages. These elements also played a role in the fall of agricultural commerce between the US and China.

3.2 Determine Marginal Analysis Variables

Based on the binary marginal theory and the decomposition method proposed by Professor Yang Fengmin and his student Li Wenxia in 2015, in this paper, the intensive margin is subdivided into two categories: price margin and quantity margin [5]. The product of the price margin and the quantity margin is the intensive margin. The following analysis involves three dimensions: expansion margin, price margin, and quantity margin.

Suppose that x represents the exporting country, m represents the importing country, and g represents the reference country, where the export of country x. is a subset of the export of country g; i stands for product, I stands for product collection; Z stands for total trade, so the extensive margin is defined as follows:

$$EM_{xm} = \frac{\sum_{i \in I_{xm}} Z_{xm}}{\sum_{i \in I_{gm}} Z_{gm}} \tag{1}$$

Similarly, the intensive margin can be defined as:

$$IM_{xm} = \frac{\sum_{i \in I_{xm}} Z_{xm}}{\sum_{i \in I_{xm}} Z_{gm}} \tag{2}$$

Further divide the intensive margin into price margin and quantity margin, and the relationship between the intensive margin, price margin, and quantity margin is shown in Formula (3):

$$IM_{xm} = P_{xm} Q_{xm} \tag{3}$$

The price margin is defined as:

$$P_{xm} = \prod_{i \in I_{xm}} \left(P_{xmi}/P_{gmi}\right)^{\theta_{xmi}} \tag{4}$$

The quantity margin is defined as:

$$Q_{xm} = \prod_{i \in I_{xm}} \left(Q_{xmi}/Q_{gmi}\right)^{\theta_{xmi}} \tag{5}$$

In Formula (4) and (5), θ represents the weight, which can be obtained by Formula (6):

$$\theta_{xmi} = \frac{\alpha_{xmi} - \alpha_{gmi}}{\ln \alpha_{xmi} - \ln \alpha_{gmi}} \Big/ \sum_{i \in I_{xm}} \frac{\alpha_{xmi} - \alpha_{gmi}}{\ln \alpha_{xmi} - \ln \alpha_{gmi}} \tag{6}$$

In this paper, x represents China, m represents the U.S., and the world is selected by reference to country g. So I_{xm} represents the collection of agricultural products exported from China to USA, and I_{gm} represents the collection of agricultural products exported from the world to the U.S. α_{xmi} refers to the proportion of the trade volume of certain agricultural products exported from China to the U.S. in the total export volume of agricultural products from China to the U.S. α_{gmi} means the proportion of China's export of certain agricultural products to USA in the total export of agricultural products to the U.S.

Table 2. The ternary margin of China's agricultural exports to the U.S.

Year	Extensive margin	Intensive margin	Price margin	Quantity margin
2002	0.9133	0.0364	1.5315	0.0238
2003	0.9107	0.0416	1.3906	0.0299
2004	0.9314	0.0457	1.6481	0.0277
2005	0.9245	0.0541	1.4582	0.0371
2006	0.9319	0.0592	1.4047	0.0433
2007	0.9370	0.0656	1.5150	0.0433
2008	0.9188	0.0828	1.4164	0.0584
2009	0.9314	0.0754	1.2981	0.0581
2010	0.9437	0.0820	1.3845	0.0592
2011	0.9441	0.0849	1.4774	0.0575
2012	0.9307	0.0922	1.5823	0.0583
2013	0.9259	0.0913	1.5277	0.0598
2014	0.9409	0.0905	1.5309	0.0591
2015	0.9420	0.0925	1.3954	0.0663
2016	0.9478	0.0891	1.4827	0.0601
2017	0.9485	0.1033	1.7560	0.0588
2018	0.9692	0.1103	1.6378	0.0673
2019	0.9596	0.0862	1.4529	0.0593

3.3 Ternary Marginal Analysis

On the basis of the above definition of relevant variables, this paper collects and collates HS6 trade data of agricultural products exported from China and the world to the U.S. from 2002 to 2019 through the database of the United Nations Trade Statistics Administration. Each 6-digit code represents a specific agricultural product, and 816 agricultural products are sorted out. Then, according to the above formulas (1), (2), (4), (5) and (6), we can calculate the specific conditions of the extensive margin, intensive margin, price margin, and quantity margin of China's agricultural exports to the U.S. (Table 1).

Table 2 shows that between 2002 and 2019, China's agricultural exports to the U.S. increased due to the combined effects of price margin and extensive margin. The extensive margin of China's agricultural exports to the U.S. has surpassed 90% among them, showing that the extensive margin is increasing overall and that China's agricultural exports are highly diverse. With an average growth rate of 5.78%, intensive margin exhibits a general trend of consistent expansion. The quantity margin had a consistent upward trend from 2002 to 2019, with an average growth rate of 6.35%. This indicates that the improvement of the intensity margin has been more successfully encouraged by the constant rise of the quantity margin and has contributed more to the growth of China's agricultural exports to the U.S. The price margin variation is also evident, with

an average growth rate of −0.74%, which is not substantial for the expansion of China's agricultural exports to the U.S.

4 Analysis on the Competitive Advantage

4.1 Export Competitiveness Index

Revealed Comparative Advantage Index Analysis. The most reliable metric for assessing a nation's export products' competitiveness on the global market is the revealed comparative advantage index (RCA). The RCA index can be used to identify a nation's export-competitive industries, demonstrating that nation's comparative advantage in world commerce [5]. According to the formula, RAC is the proportion of the global export of agricultural products to the importing country to the share of the export of agricultural products from the exporting country to the importing country:

$$RCA_{xm} = \frac{\frac{Z_{xm}}{W_{xm}}}{\frac{Z_{gm}}{W_{gm}}} \tag{7}$$

Consistent with the letter expression used above, RCA_{xm} represents the indicative comparative advantage index of China's agricultural products exported to the U.S.; Z_{xm} refers to the export volume of agricultural products from China to the U.S.; W_{xm} represents China's total exports to the U.S.; Z_{gm} refers to the export volume of agricultural products from the world to the U.S.; W_{gm} refers to the total exports of the world to the U.S.

It can be argued that when the RCA index of a country is greater than 2.5, the international competitiveness of the country's industry is very strong. When a country's RCA is between 2.5 and 1.25, the international competitiveness of the country's industry is strong. And when the RCA is 0.8, the international competitiveness of the country's industry is weak.

International Market Share Index Analysis. The International Market Share (MS) Index measures a country's total exports as a share of global exports. When MS increases, it indicates that the export competitiveness of the country's industry or products has improved. The MS index can reflect changes in the international competitiveness or competitive position of an industry or product of a country [5]. MS index is expressed by formula:

$$MS = \frac{Z_{xm}}{Z_{gm}} \tag{8}$$

In the formula above, Z_{gm} stands for global agricultural exports to the U.S., while Z_{xm} stands for agricultural exports from China to the U.S. The greater the ratio, the greater the proportion of Chinese agricultural products sold in the American market, the greater the industry's ability to compete internationally, and the lesser the effect of the opposite.

Trade Intensive Index Analysis. The relationship between the bilateral trade volume between the two countries and their significance in global trade is shown in the trade intense index (TI). TI index is an indicator reflecting the results [5]. The indicator is typically greater the more complementary the two countries' commerce is. The TI index is expressed by the formula:

$$TI_{xm} = \frac{Z_{xm}/Z_x}{Z_{gm}/Z_g} \tag{9}$$

In the formula above, Z_{xm} stands for China's agricultural exports to the US, Z_x for all of China's exports, Z_{gm} for the entire amount of agricultural exports from around the world to the US, and Z_g for all of the world's exports. In general, if the TI index is larger than 1, it indicates that nation i's export level to country j was higher than country j's share of the global import market for that commodity over the same time period.

4.2 Empirical Conclusion on Export Competitiveness

Calculating the trade intensity index (TI), international market share index (MS), and revealed comparative advantage index (RCA) of China's agricultural exports to the U.S. from 2002 to 2019 yields Table 3. The computation revealed that the RCA index had a general declining trend from 2002 to 2019 with some variations in specific years. The RAC index was less than 0.8 throughout this time period, showing that China's agricultural products had a little competitive advantage in the international market during this time period as far as exports to the U.S. were concerned. The MS index can show how many agricultural products from China are sold on the American market. It can be seen that the MS index is 0.074 on average in these years, indicating that the proportion of Chinese agricultural products in the American market is low, only close to 8%. In addition, we can see from the growth rate of the MS index that the growth rate of the MS index is also increasing year by year. Therefore, it can be predicted that the MS index will gradually increase in the following years without the influence of other external forces or other objective factors. In the TI index, it can be clearly observed that the TI index of each year from 2002 to 2019 fluctuated between 0.9 and 1. In terms of agricultural trade, the relationship between China and the U.S. is very close. From 2003 to 2014, the TI index generally showed an upward trend, and there was a significant decline from 2015 to 2018. However, according to the data of 2018 and 2019, it can be seen that the TI index has a gradual upward trend.

According to the method adopted by Li Gang, Dong Minjie and Jinbei in their analysis of measuring the comparative advantage of China's manufacturing industry's international competitiveness, 1/3 of each of the three competitiveness indicators used are weighted and calculated using the weighted average method [6]. The weighted average value is recorded as the "average competitiveness advantage of agricultural exports" indicator, which is expressed in AC. The calculation results are shown in Table 4.

Table 3. Competitiveness indicators of China's agricultural products exported to the U.S.

Year	RCA	Growth rate	MS	Growth rate	TI	Growth rate
2002	0.731	–	0.043	–	1.033	–
2003	0.657	−0.101	0.047	0.095	0.975	−0.056
2004	0.591	−0.101	0.048	0.038	0.909	−0.068
2005	0.580	−0.019	0.054	0.126	0.915	0.006
2006	0.349	−0.398	0.070	0.280	1.090	0.192
2007	0.658	0.885	0.076	0.086	1.136	0.042
2008	0.838	0.273	0.081	0.065	1.300	0.144
2009	0.548	−0.345	0.075	−0.065	1.156	−0.111
2010	0.569	0.037	0.082	0.085	1.170	0.013
2011	0.408	−0.284	0.082	0.007	1.226	0.048
2012	0.481	0.181	0.086	0.044	1.230	0.003
2013	0.539	0.120	0.088	0.019	1.212	−0.015
2014	0.454	−0.158	0.077	−0.122	1.016	−0.161
2015	0.447	−0.016	0.078	0.020	0.920	−0.095
2016	0.442	−0.010	0.076	−0.035	0.877	−0.046
2017	0.399	−0.098	0.071	−0.060	0.823	−0.062
2018	0.432	0.084	0.079	0.111	0.942	0.144
2019	0.734	0.698	0.120	0.513	1.319	0.400

As shown in Fig. 1, the AC index fluctuated significantly from 2002 to 2019, especially from 2009, indicating that the 2008 financial crisis had a significant and long-term impact on China's agricultural exports to the U.S. In addition, due to the trade war and tariff barriers between China and the U.S., the AC index also declined significantly after 2013, and did not rise significantly until 2019. However, in recent years, the import and export trade has been further affected by the epidemic situation and tariff issues, so it is very likely that there will be substantial fluctuations in the future. According to the data analysis's findings, China must increase the volume of agricultural products exported to the U.S., improve the quality of those products, increase the specialization and technology of agricultural product production, and optimize the structure of its agricultural sector if it wants to reduce the deficit between agricultural product import and export.

Table 4. Average competitive advantage index (AC)

Year	AC	Growth rate
2002	0.602	——
2003	0.560	−0.0706
2004	0.516	−0.0776
2005	0.516	0.0003
2006	0.503	−0.0259
2007	0.623	0.2389
2008	0.739	0.1866
2009	0.593	−0.1976
2010	0.607	0.0232
2011	0.572	−0.0576
2012	0.599	0.0476
2013	0.613	0.0226
2014	0.516	−0.1584
2015	0.482	−0.0659
2016	0.465	−0.0345
2017	0.431	−0.0732
2018	0.484	0.1233
2019	0.724	0.4950

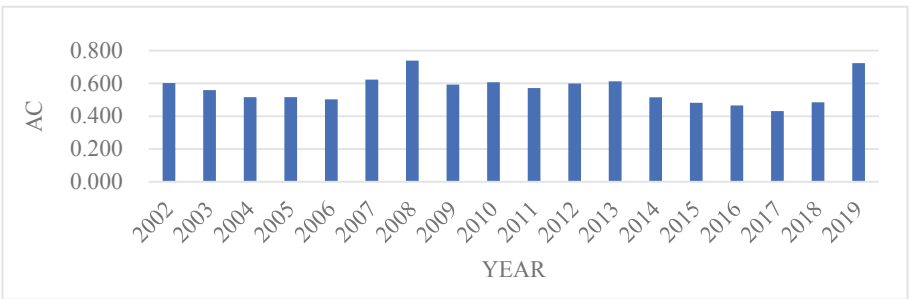

Fig. 1. Average competitiveness index of China's agricultural exports to the U.S. (credit: Original)

5 Conclusion

This study collected the Sino-US agricultural product trade data from 2002 to 2019, and used the triple marginal analysis method to calculate its extensive margin and intensive margin. In this paper, the intensive margin is subdivided into price margin and

quantity margin. According to the analysis of the data from 2002 to 2019, China's agricultural exports to the U.S. have continued to grow on the whole, but the growth rate has slowed down significantly in recent years. The average competitive advantage (AC) of China's agricultural exports fluctuated from 2002 to 2019, and although it had previously decreased, it had clearly recovered by 2019. According to the findings of this study, the expansion range and pricing range have made the most contributions to the growth of China's export trade volume of agricultural products to the United States between 2002 and 2019. China's agricultural exports to the U.S. fluctuate for a variety of reasons, some of which are not all-inclusive. It is anticipated that future research will also be able to analyze the proportion and size of each factor through modeling in the future and provide more detailed recommendations on the trade development between China and the U.S. in order to more thoroughly and concretely study the factors that affect the competitive advantage of China's agricultural exports and the factors that affect changes in the total trade volume of China's agricultural exports to the U.S.

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