Original Research Article

Quality of Chinese Agricultural Products Exported to Japan 2001-2017: Econometric Descriptive Nested Logit Analysis

Abstract: Improving the quality of agricultural products is a key issue that needs to be urgently addressed in China's agricultural development. The top market for China's agricultural exports is Japan, so the quality of agricultural products exported to Japan is directly related to the overall trend of China's agricultural exports. Therefore, this study examined the spatial and temporal evolution of the quality level of China's agricultural exports to Japan based on HS 9-digit coded data on Japan's imports of agricultural products from 158 countries around the world from 2001 to 2017, using the Nested Logit Method. The results indicate that the quality of China's agricultural products exported to Japan during the data period generally shows a fluctuating downward trend. And, the overall quality of China's agricultural products is in the middle level of the world, but there is a large gap between the quality levels of different categories. Low-quality varieties of agricultural products account for nearly 50 percent of the total, while high-quality agricultural products account for less. In terms of quality, China’s agricultural products lack competitiveness in Japan. To this end, China should vigorously improve the pesticide regulatory policy, implement standardized production, and establish production advantage zones for special agricultural products.

Keywords: Agricultural Exports, Quality, Nested Logit Method

1. Introduction

Nowadays, the global dietary structure tends to be diversified and balanced, and international consumers pay more attention to food quality and safety [1]. As the world's largest producer of agricultural products and an important agricultural trading country, China's exports of agricultural products have been growing rapidly since it acceded to the WTO. The value of exports grew from $16.626 billion in 2001 to $96.372 billion in 2022, at an average annual rate of 8.73%, and its share of the international market has been maintained at around 4%[1].

However, constrained by basic agricultural conditions such as low per capita water and soil resources, low productivity of agricultural enterprises, and the continuous growth of the trade deficit in agricultural products, there is insufficient impetus to upgrade the quality of China's exported agricultural products [2]. Japan, as the largest market for China's agricultural exports, has shown a relative shrinkage. Regarding the total volume of agricultural products, exports to Japan only grew from US$5.648 billion in 2001 to US$10.453 billion in 2022, an increase of 0.85 times, while China's exports of agricultural products grew 4.8 times during the same period. In terms of market share, the share of exports to Japan in China's exports of agricultural products declined from 33.97 percent in 2001 to 10.85 percent in 2022. Similarly, the share of Japan's agricultural imports and the share of Chinese agricultural products declined from 16.01 percent in 2006 to 11.27 percent in 2022[2]. Regarding export varieties, the types of

[1] Data source: WTO database.

[2] Data source: WTO database and wind database.

Chinese agricultural products exported to Japan at the HS 9-digit code level declined from 895 in 2006 to 794 in 2017[3].

The main reason for China's agricultural exports to Japan to be hindered is that the Japanese market is constantly raising the quality threshold for agricultural products. In 2006, the Japanese government implemented the world's most stringent Positive List System, comprehensively raised the pesticide residue limits in food, and strengthened the quality and safety of imported agricultural products supervision. After the "poisoned dumplings" incident in 2008, Japan even implemented a mandatory inspection order for Chinese agricultural products, making China's exports tougher. Data shows that a total of 1,581 batches of Chinese agricultural and food exports were blocked in 2022, the total number of which was reduced compared to 2020, but the number of unqualified agricultural and food products that were detained or recalled by Japan increased by 19 batches compared to 2020[4].

Currently, China's economic development has entered a new era, and its trade growth model also urgently needs to be transformed around improving the quality of its export products. This study therefore explores the following questions: what is the quality level of Chinese agricultural products in the Japanese market? Where do they stand compared to other competitors? Is quality the main reason for the gradual withdrawal of Chinese agricultural products from the Japanese market?

[3] Data source: calculated based on the authors of Japan's Ministry of Finance and Trade (MOFTEC) database.

[4] Data source: China's technical trade measures website (http://www.tbtsps.cn/page/tradez/IndexTrade.action).

Two categories of literature are closely related to this study. The first body of literature concerns theoretical and empirical studies on the quality of export products. Research on product quality first appeared in the paper of Linder [3], who put forward the theory of overlapping demand, which states that the income level of consumers determines the demand. Consumers with different incomes have different preferences, so the income level of consumers increases, the level of consumption will be raised, and they will pursue higher-quality products and give up the consumption of lower-quality products, which will have a particular guiding effect on the formation of the industrial structure of the exporting countries. This will have a particular guiding effect on the industrial structure of the exporting countries. Since then, theoretical studies have expanded on this concept. In the vertical type intra-industry trade model proposed by Falvey and Kierzkowski [4], it is assumed that consumers have the same preferences between two countries so that consumers will choose products of different quality according to their incomes at constant relative prices. Flam and Helpman [5] introduced the vertical intra-industry trade theory by incorporating the North-South quality differences. Grossman and Helpman [6] further proposed the endogenous growth theory of quality upgrading. In a novel trade theory pioneered by Melitz [7], the assumption of homogeneity among producers was questioned for the first time. Since then, the academic community has begun to emphasize the heterogeneity of production efficiency among enterprises, and exploring the heterogeneity of product quality of enterprises has gradually become a hot issue in domestic and international research.

In terms of empirical research, there are several main measures of quality. Firstly, the technical complexity method [8-12] is built on the theory of comparative advantage and includes measures such as the indicative comparative advantage index [13]. However, the export product's complexity is positively correlated with the level of economic development of the exporting country, so considering product technological complexity alone underestimates the impact of small exporting countries [8]. The unit value method [14-18] obtains the export product by calculating the value of the export product divided by the export quantity unit value of export products. However, the export price per product unit contains information on product quality cost fluctuations, and demand shocks, so this method is unreliable. Some scholars use the rating indicator method [19-21] to measure the quality of products, but this only applies to some specific products. Because of the shortcomings of the above quality measurement methods, Khandelwal [22] based on the discrete choice model proposed by Berry [23], used a nested logit model to measure the quality of each country's exports to the U.S. The product quality of the segmented products was measured through regression analysis and backcasting method, which breaks the assumption that the unit price of a product is equivalent to its quality. The internal logic of the backcasting method is that product price and market performance information measure product quality, and if the price is the same, the market performance is better. The higher the product quality, the more the product quality can be obtained by removing the price factor from the market performance. This method is a more cutting-edge method in measuring quality at present and is widely used by Pula and Santabarbara [24], Shi et al. [25], Dong and Huang [26], Liu [27], Li and Peng[28], and others.

The second body of literature studies the quality of China's agricultural exports. For example, Dong and Huang [29], based on the quality of the HS9 quintile data of agricultural products imported from Japan from 2005 to 2012 and adopting the nested logit methodology, found that the quality of China's agricultural products exported to Japan has shown a "positive N-type" movement of increasing, then decreasing, and then increasing since 2005. Chen and Xu [30], based on the data from the China Customs Trade Database from 2000 to 2013 and the demand framework method, found that the quality of China's agricultural products exported to Japan showed an upward trend in general, and there was a noticeable "U" shape change during 2007-2012. Wang and Xiao [31], based on the HS 10-digit code data of agricultural products imported from the world by the United States from 2005 to 2014, found that the quality of agricultural products exported from China to the United States showed a fluctuating trend of decreasing and then increasing with the fluctuation of the quality ladder. Dong and Liu [32] used a demand structure model to measure the quality of world agricultural exports to the United States from 2000-2017. They found that the quality of China's agricultural products showed a fluctuating upward trend and that consumer-oriented agricultural products were in line with the trend of agricultural products as a whole. Li et al. [33] analyzed the scale and quality of China's exported agricultural products, in general, showed an upward trend based on the CEPII database of world agricultural export data from 1998-2018 and the backward extrapolation method of demand information, but the quality of exported agricultural products declined and then increased during 2012-2018. There is still a particular gap between it and the major agricultural exporting countries. In the existing literature, the demand structure approach does not consider the effect of nested market shares on product market shares and artificially sets product elasticity of substitution data, which may deviate from the reality of China's agricultural market. In addition, the studies using nested logit do not consider the possible endogeneity between unit product price and agricultural product quality and, therefore, may overestimate the quality level.

2. Modelling and data

2.1 Modelling

The Nested Logit Method proposed by Khandelwal [22] assumes that consumers' choice preferences can be categorized into horizontally and vertically differentiated preferences. Price reflects consumers' horizontal difference preferences, and quality reflects consumers' vertical difference preferences. High-quality agricultural products will gain a higher market share at the same price level. Therefore, the utility function of consumers can be expressed as:

$$V_{ncht} = \lambda_{1,ch} + \lambda_{2,t} + \lambda_{3,cht} - \alpha p_{cht} + \sum_{h=1}^{H} \mu_{nht} d_{ch} + (1-\sigma)\varepsilon_{ncht} \tag{1}$$

Equation (1) represents the maximum indirect utility function that a Japanese consumer *n* prefers for an agricultural product *h* (hereafter referred to as agricultural product *ch*) imported from country *c* in year *t* and obtained by purchasing the agricultural product ch[5]. $\lambda_{1,ch}$ reflects the individual fixed effects of agricultural product ch. $\lambda_{2,t}$ is used to control for the time trend of all agricultural product classes. $\lambda_{3,cht}$ reflects specific components that deviate from the time-fixed effects and product fixed effects, and p_{cht} represents the product unit price. And in term $(\sum_{h=1}^{H}\mu_{nht}d_{ch}+\varepsilon_{ncht})$, ε_{ncht} is assumed to follow an extreme I-type distribution, which is used to explain the extreme case if a low-quality product will still be exported at a high price. And $\sum_{h=1}^{H}\mu_{nht}d_{ch}$ is the focal part of the nested model for this purpose, while μ_{nht} reflects consistent consumer preferences within agricultural product *h*. For example, if consumers prefer Chinese apples, then they will also be willing to choose apples imported from other countries over Chinese pears, and the Nested Logit Method is used to capture this part of the preference structure. d_{ch} is a dummy variable that takes the value of 1 when Japanese imports of agricultural product *h* are exported from country *c*.

In addition, Japanese consumers can purchase domestic agricultural products as a substitute for imported agricultural products. Japanese consumers will choose to purchase domestic agricultural products if they get more utility by purchasing domestic agricultural products than by purchasing foreign agricultural products. The utility obtained by purchasing domestic agricultural products is expressed by the following function:

5 This paper draws on the Japanese Ministry of Finance and Trade database and Dong Yinguo et al.'s (2016) subindustry categorization, where each HS 9-digit code is treated as a product and the HS 6-digit code is treated as a subindustry. For example, HS070490010 is broccoli and HS070490030 is Chinese cabbage, and all HS070490010 and HS070490030 imported by Japan are categorized into HS070490 and viewed as a sub-industry. As can be seen, the nested Logit approach places more emphasis on vertical product differences than on inter-product differences.

$$u_{n0t} = \lambda_{1,0} + \lambda_{2,t} + \lambda_{3,0t} - \alpha p_{0t} + u_{n0t} + (1-\sigma)\varepsilon_{n0t} \quad (2)$$

Where the market share of imported agricultural products is (1 - external market share) if the overall market share of agricultural products is 1. The external market share is the share of Japanese consumers purchasing domestic agricultural products. Thus, once the external market share s_{0t} is known, the size of the subsector can be found by the following equation:

$$MKT_t = \sum\nolimits_{ch\neq 0} q_{cht} \big/ (1 - s_{0t}) \quad (3)$$

In equation (3), q_{cht} denotes the quantity of agricultural products *ch* imported, so the market share of imported agricultural products can be found by the following equation:

$$s_{cht} = q_{cht} \big/ MKT_t \quad (4)$$

Consumers will choose the agricultural product that maximizes their utility. Therefore, based on the fact that the differential preferences of consumers in terms of utility levels satisfy an extreme I-type distribution, Berry [23] derives the following demand curve:

$$\ln(S_{cht}) - \ln(S_{0t}) = \lambda_{1,ch} + \lambda_{2,t} + \lambda_{3,cht} - \alpha p_{cht} + \sigma \ln(vS_{cht}) \quad (5)$$

where vS_{cht} denotes the nested market share of product *ch* in product *h* at time *t*. Differences in relative market shares, after controlling for product quality and price, may also be caused by differences in the level of consumers within the sub-industry, which may overestimate product quality if this variable is not controlled for. Therefore, Khandelwal [22] introduces the concept of nested market shares by grouping similar products within the same sub-industry, allowing for products within the same sub-industry to have related performance and characteristics and for consumers to receive the same utility from the same sub-industry. Instead, market share differences in products within the same subsector arise from consumers' horizontally differentiated preferences rather than vertically differentiated preferences. Since $\lambda_{3,cht}$ and agricultural unit product prices are potentially correlated, instrumental variables need to be introduced to redefine and replace product prices. Prices that include transport costs may be related to quality, because firms may choose to export high-quality products to reduce transport costs per unit of product [16], but as long as transport costs are not correlated with $\lambda_{3,cht}$, there is no endogeneity problem. Therefore, this paper introduces the product of the distance from each exporting country to Japan and the oil price as instrumental variables.

In addition, according to the standard model theory of Krugman [34], product variety increases with a country's population. In order to control the level difference of products, the model introduces the variable of economic size of the exporting country, which is generally expressed by the population or GDP of the exporting country. The size of the economy is temporarily represented by the population size in Eq. Therefore, the demand curve formula controlling for the hidden variety problem is as follows:

$$\ln(S_{cht}) - \ln(S_{0t}) = \lambda_{1,ch} + \lambda_{2,t} + \lambda_{3,cht} - \alpha p_{cht} + \sigma \ln(vS_{cht}) + \gamma \ln pop_{ct} \tag{6}$$

where pop_{ct} is the population of the exporting country at time t. And the parameters being estimated and the residual values obtained from the regression constitute the quality of the product class ch at time t in the following form:

$$\lambda_{cht} \equiv \hat{\lambda}_{1,ch} + \hat{\lambda}_{2,t} + \hat{\lambda}_{3,cht} \tag{7}$$

Another issue of concern in this model is that many factors unrelated to quality can also affect market share and thus impact the estimation of quality. Controlling for the price factor in the model makes its effect small.

Based on the availability of data, the above equation is obtained by simplified deformation:

$$\ln(s_{cht}/(1-s_{0t})) = \lambda_{1,ch} + \lambda_{2,t} + \lambda_{3,cht} - \alpha \ln p_{cht} + \sigma \ln(ns_{cht}/(1-s_{0t})) + \gamma \ln pop_{ct} \quad (8)$$

Where relative market share is represented by the share of an HS9-digit agricultural product in Japan's imports of the same product, and nested market share is represented by the share of that HS9-digit agricultural product in Japan's imports of the corresponding HS6-digit agricultural product. In addition, $\lambda'_{2,t} = \lambda_{2,t} + \ln S_{0t} + (\sigma-1)\ln(1-s_{0t})$ is a fixed effect that varies only with time. Therefore, the mass result should be:

$$\lambda_{cht} = \hat{\lambda}_{1,ch} + \hat{\lambda}'_{2,t} + \hat{\lambda}_{3,cht} = \hat{\lambda}_{1,ch} + \hat{\lambda}_{2,t} + \hat{\lambda}_{3,cht} + \ln S_{0t} + (\sigma-1)\ln(1-S_{0t}) \quad (9)$$

In equation (9), $\ln S_{0t} + (\sigma-1)\ln(1-S_{0t})$ is not a product quality component, but it is constant for a given product and a given year, and in order to remove its effect, this paper introduces the normalization formula:

$$\lambda'_{cht} = (\lambda_{cht} - \min \lambda_{ht})/(\max \lambda_{ht} - \min \lambda_{ht}) \quad (10)$$

2.2 Data description

In this paper, data on HS 9-digit coded agricultural products imported by Japan from all over the world (158 countries in total) during the period 2001-2017 from the Ministry of Finance and Trade of Japan database were selected, totaling 2,298 species. Each data entry contains the value volume of the imported products, the import quantity, and the

HS9-digit code of the product. The country-level data representing the size of the economy are the country's population and GDP per capita, which are obtained from the World Bank[6], where GDP per capita is expressed in current US dollars. The world price of Brut crude oil as an instrumental variable is from the International Monetary Fund (IMF)[7]. Based on the need to calculate the nested market share, the product quantity unit needs to be consistent; this paper selects the unit of measurement of agricultural products as kg as the object of study. In addition, samples with extreme values of 5% at each end of the unit product price and samples with quantities less than or equal to 1 are excluded. In order to ensure the comparability of instrumental variable regression and ordinary least squares regression, samples without instrumental variable data are excluded, and finally, 151,717 samples remain. Descriptive statistics of the variables are shown in Table I.

Based on the above model, and in order to avoid the problems of model heteroskedasticity and non-normal distribution of data residuals, this paper takes logarithms of the variables of relative market portion (*S*), nested market portion (*ns*), population (*pop*), GDP per capita (*GDP per*), unit value (*price*), and the product of the price of oil and distance (*dcr*) to analyze and discuss them in the empirical evidence.

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[6] Data source: https://data.worldbank.org/indicator

[7] Data source: http://data.imf.org/?sk=388DFA60-1D26-4ADE-B505-A05A558D9A42

Table I. Descriptive statistics of variables[8]

Norm	Relative market portion	Nested market portion	Population (millions)	GDP per capita ($10,000)	Unit value (1,000 yen/kg)	Oil price ($/barrel)	Distance (kilometres)
Mean	8.92E-5	0.669	188.347	2.569	4.529	66.164	8504.914
Min.	5.69E-11	9.73E-08	.00995	0.0498	0.0406	24.412	1156.57
Max.	7.61E-2	1	1386.395	13.774	761.543	111.959	18587.08
25% quartile	1.43E-07	0.171	16.865	1.0335	2.78E-01	44.0473	5329.095
75% quartile	1.45E-5	1	113.662	3.813	1.409	97.66	10777.42
Expected Symbol	---	+	+	+	-	-	-

3. Analysis of empirical results

3.1 Regression results

The Hausman test is first performed on the panel data to determine whether the model selects fixed or random effects for the regression. In this paper, the following four sets of regressions were conducted using population size and GDP per capita to measure market size, respectively, and the results are shown in Table II. Among them, (1) (3) uses a fixed effect model, and (2) (4) uses a random effect model. According to the results, the Hausman test rejects the original hypothesis at the 1% significance level for both population size and GDP per capita as market size. Therefore, this paper chooses the fixed effect approach for model estimation.

[8] Source: Calculations based on Stata14.

Table II. Fixed effects and random effects regression results[9]

	(1)	(2)	(3)	(4)
	FE	RE	FE	RE
lnpop	0.505***	0.390***		
	(64.55)	(67.48)		
lnns	0.532***	0.455***	0.507***	0.426***
	(156.75)	(149.22)	(147.47)	(138.99)
lnprice	-0.943***	-1.037***	-0.978***	-1.082***
	(-172.50)	(-215.02)	(-172.25)	(-218.54)
lngdpper			0.0238**	0.110***
			(2.26)	(12.45)
_cons	-22.03***	-21.01***	-13.37***	-15.30***
	(-159.82)	(-207.09)	(-128.43)	(-175.11)
N	151717	151717	150861	150861
χ^2	3390.41		3138.15	
Prob> χ^2	0.0000		0.0000	

In addition, prices that include transportation costs may be related to quality as there may be firms that choose to export high-quality products in order to reduce transportation costs per unit of product [16]. The resulting endogeneity problem can bias the OLS estimation results, so this paper introduces IV estimation to further test the model. Thus, the endogeneity problem is solved as long as transportation costs are uncorrelated with $\lambda_{3,cht}$. Therefore, this paper refers to Khandelwal [22] and Pula and Santabarbara [24] and uses the product of geographic distance between the two countries and the price of crude oil as instrumental variables to obtain consistent and unbiased estimates of the coefficients of price. Meanwhile, the paper uses a two-way fixed effects

[9] t statistics in parentheses， * $P < .1$, ** $P < .05$, *** $P < .01$

approach to control for individual fixed effects and time fixed effects of the product to obtain the results in Table III. The results of the Durbin-Wu-Hausman test show that the OLS regression has an endogeneity problem, so it is essential to use instrumental variables for estimation in this paper.

Table III. Comparison of IV and OLS regression results[10]

	(1)	(2)	(3)	(4)
	IV	OLS	IV	OLS
lnprice		-0.994***		-1.025***
		(-176.15)		(-179.42)
lnpop	0.128***	0.482***		
	(6.97)	(61.53)		
lnns	0.275***	0.526***	0.187***	0.504***
	(24.27)	(155.47)	(17.51)	(148.00)
lndcr	-3.113***		-3.825***	
	(-35.91)		(-47.81)	
lngdpper			0.433***	-0.278***
			(13.76)	(-19.64)
_cons	-16.93***	-21.72***	-19.26***	-10.63***
	(-60.51)	(-157.44)	(-57.34)	(-78.65)
Individual fixed effect	Controlled	Controlled	Controlled	Controlled
Time fixed effect	Controlled	Controlled	Controlled	Controlled
Durbin-Wu-Hausman-p value	0.0000		0.0000	
N	151717	151717	150861	150861

The results show that all the explanatory variables are significant at the 1% statistical level and that the coefficients obtained using OLS regression are almost always higher than those obtained using IV estimation, except for the instrumental variables. This shows that the use of OLS estimation overestimates the impact of some

[10] t statistics in parentheses, * $P < .1$, ** $P < .05$, *** $P < .01$

of the explanatory variables on the relative market shares of the explanatory variables. The negative coefficients on price per unit of product, with or without instrumental variables, suggest that consumer utility decreases as the price paid increases, and therefore, relative market share decreases. The coefficients on the nested market shares in the above regressions are all positive, indicating that the more varieties of agricultural products a country exports, the larger its share in the group and the higher its relative market share of Japanese agricultural products. Moreover, the population size used to measure market size has a positive effect on relative market share in both (1) (2), and the effect of using it to represent market size is significantly better than the effect of GDP per capita. To summarize the analysis, this paper will use the estimation results of (1) in Table III to calculate the quality.

To ensure the robustness of the conclusions, this paper uses different regression methods to re-measure the quality level of China's agricultural exports to Japan. Based on the results of previous empirical analyses, we re-estimate the quality of exported agricultural products by using the population number to represent the size of the economy, and by using OLS estimation. The OLS regression results are similar to the IV estimation results[11], both results show that the quality of China's exported agricultural products shows a fluctuating downward trend, although the OLS estimation results are high, but in the absolute value of the quality basically stays between 0.6-0.7, the fluctuation trend is similar. Therefore, the conclusion that the quality of Chinese agricultural products declines in the Japanese market is robust under different

[11] The large difference between the two in 2017 may be related to the large fluctuations in international oil prices.

measurement methods.

3.2 Dynamic evolution of the quality level of agricultural products in China

Based on the results of (1) in Table III and Equation (10), the quality levels of agricultural products exported to Japan by China and each country are calculated and summed up to calculate their trends. The results (as shown in Figure I) show that the quality of China's agricultural exports to Japan has fluctuated and declined overall since WTO accession, with the average quality level improving in the post-financial crisis period 2008-2016, basically remaining at around 0.65. However, there was another significant decline in 2017 due to a significant drop in the quality of products in the broad export category of edible vegetables in 2017, thus pulling down the overall quality of agricultural products.

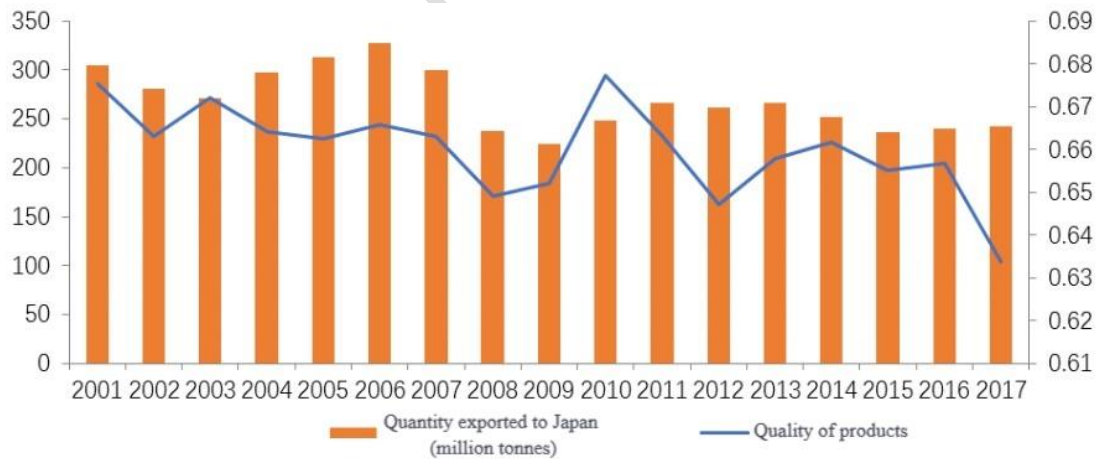

Figure I. Quality and quantity of China's agricultural exports to Japan, 2001-2017[12]

In terms of the relationship between the quantity and quality of exported

[12] Figure 1 illustrates that the quality of China's agricultural exports to Japan has fluctuated and declined on the whole since WTO accession, improved after the financial crisis and basically stayed around 0.65, but then showed a significant decline in 2017.

agricultural products, before 2005, the quantity and quality of China's agricultural products exported to Japan showed an inverse trend, with low product quality but high quantity. The reason for this phenomenon may be that in the early years of China's accession to the WTO, due to the geographic proximity between China and Japan, Japan had a high demand for agricultural imports, and its early import requirements were relatively lax, with more emphasis on food hygiene than on product quality and safety, so that Chinese agricultural products were able to be exported in large quantities to Japan on the basis of their price advantage. However, Japan implemented the *Positive List System* in 2006, which comprehensively limits the pesticide content of agricultural products and raises requirements for the quality of imported agricultural products, resulting in some low-quality Chinese agricultural products being unable to be exported to Japan. The inverse relationship has weakened, and there is more of a situation where the quality of exported products is high (low), and the quantity of exported products is also high (low).

Furthermore, the research in this paper shows that the quality of Chinese agricultural products increased significantly between 2009 and 2010, but the export volume increased only slightly. This means that after the implementation of the *Positive List System*, Chinese firms need to upgrade technology to continue exporting agricultural products to the Japanese market, which will take some time to improve quality. However, it is evident that the strict SPS measures of importing countries have pushed China to upgrade the quality of its agricultural exports [29][30].

The trend in the quality of China's agricultural products exported to Japan from

2005 to 2013 measured in this paper is similar to the results of Dong and Huang [29]. However, the overall trend is relatively lagging behind. The reason may be that the samples selected for this paper are different. Due to the large scale of production of the four major categories of agricultural products exported by China, enterprises were able to respond to Japan's positive list system promptly. However, other niche specialty agricultural products have had relatively slow adjustments to their production technologies due to changes in the export environment. So, from a general point of view, the overall quality trend is similar but lagging behind the conclusions of previous authors.

Moreover, from the whole period of 2001-2017, the results obtained in this paper are entirely different from the conclusion of Chen and Xu [30] that the quality of China's agricultural products exported to Japan has been increasing year by year. Instead, it has shown a fluctuating downward trend. In addition, the quantity of China's agricultural exports to Japan has also begun to decline sharply since the implementation of the positive list system in 2006 and reached the lowest in 2019, which implies that the advantage of relying on quantity growth to drive export growth has been weakened.

3.3 International comparison of the quality of agricultural products

In this paper, the top 10 source countries of Japan's imported agricultural products (China, the United States, Brazil, Chile, Australia, Canada, Thailand, Italy, France, and South Korea) were first selected for quality comparison. The results show that the overall quality of China's agricultural products stays between 0.6 and 0.7[13], which is only higher than that of South Korea, in the penultimate position. The overall quality of Korea's agricultural products is on an upward trend, but the value is only between 0.4 and 0.5, which may be related to the Korean government's long-term policy of protecting the domestic market and small farmers [35]. The quality of agricultural products exported by the other eight countries stays above 0.8. Among them, developed countries such as the United States and the European Union have a higher degree of agricultural modernization. Hence, the quality of agricultural products is generally higher than that of China. Thailand, which is also in Asia, as a traditional agricultural country, has the advantage of resource endowment that makes its land-intensive and labor-intensive products more competitive in the market.

Unlike the previous stereotypes, Brazil, Chile, and other large agricultural countries in South America have higher quality agricultural products than the developed countries in Europe and the United States; the main reasons are as follows. Firstly, these countries are rich in agricultural, natural resources and labor resources have a large supply of organic agricultural products, and are among the world's top exporters, meeting Japan's high demand for organic agricultural products. Meanwhile, the United States produces more varieties with high yields, good appearance and high energy content, without considering quality, taste and health. Secondly, external factors have increased the international competitiveness of agricultural products in these countries. For example, the Brazilian Government has provided exporters with supportive policies

[13] The quality measured in this paper is relative quality, i.e., the value of the quality level relative to that of Japan.

such as agricultural credit to expand agricultural exports[14]. In contrast, the agricultural products of the European Union, protected by the Common Agricultural Policy, have been negatively affected.

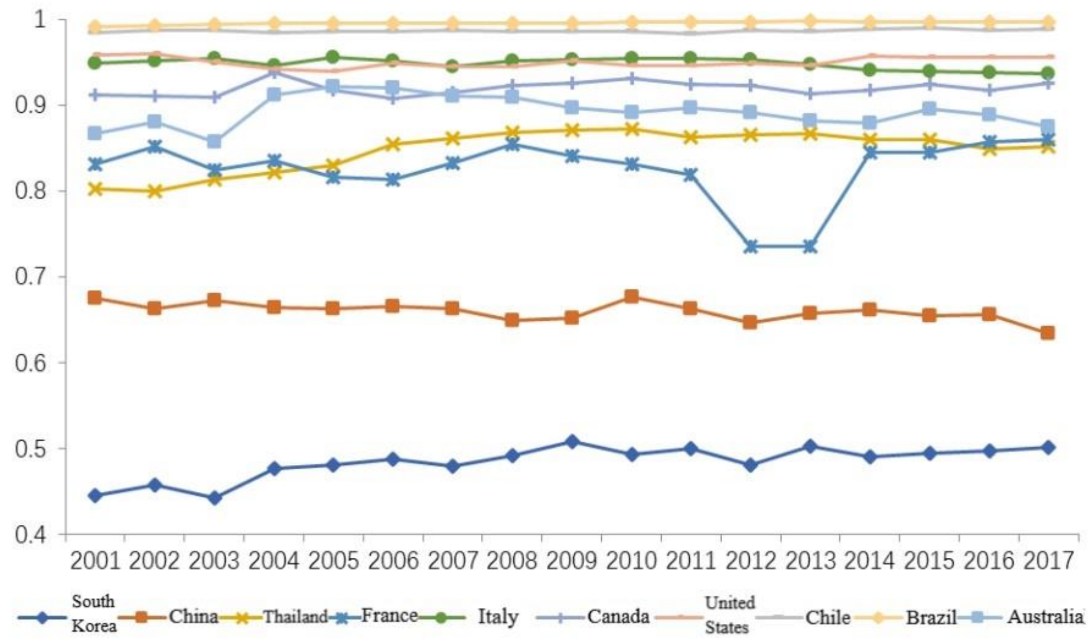

Figure II. Comparison of quality levels of agricultural products imported from Japan[15]

The quality data at the HS2-digit product level can be obtained by weighted averaging the resulting relative quality data. At the HS2-digit product level, the relative quality of the four categories of agricultural products with the largest value of China's agricultural exports to Japan is shown in Figure III. These four categories of agricultural products account for 66.32% of China's total agricultural exports to Japan. They are the main products exported by China to Japan, which are labor-intensive products. Their average quality is basically above 0.5, with different trends. For example, the quality of

[14] Source: WTO Trade Policy Review: Brazil, 2017.

[15] Figure II compares the quality of the top 10 source countries (China, the United States, Brazil, Chile, Australia, Canada, Thailand, Italy, France, and South Korea) of Japan's imported agricultural products, selected.

two categories of agricultural products, HS07 (edible vegetables, roots, and tubers) and HS20 (products of vegetables, fruits, nuts, or other parts of plants), has fluctuated downward.

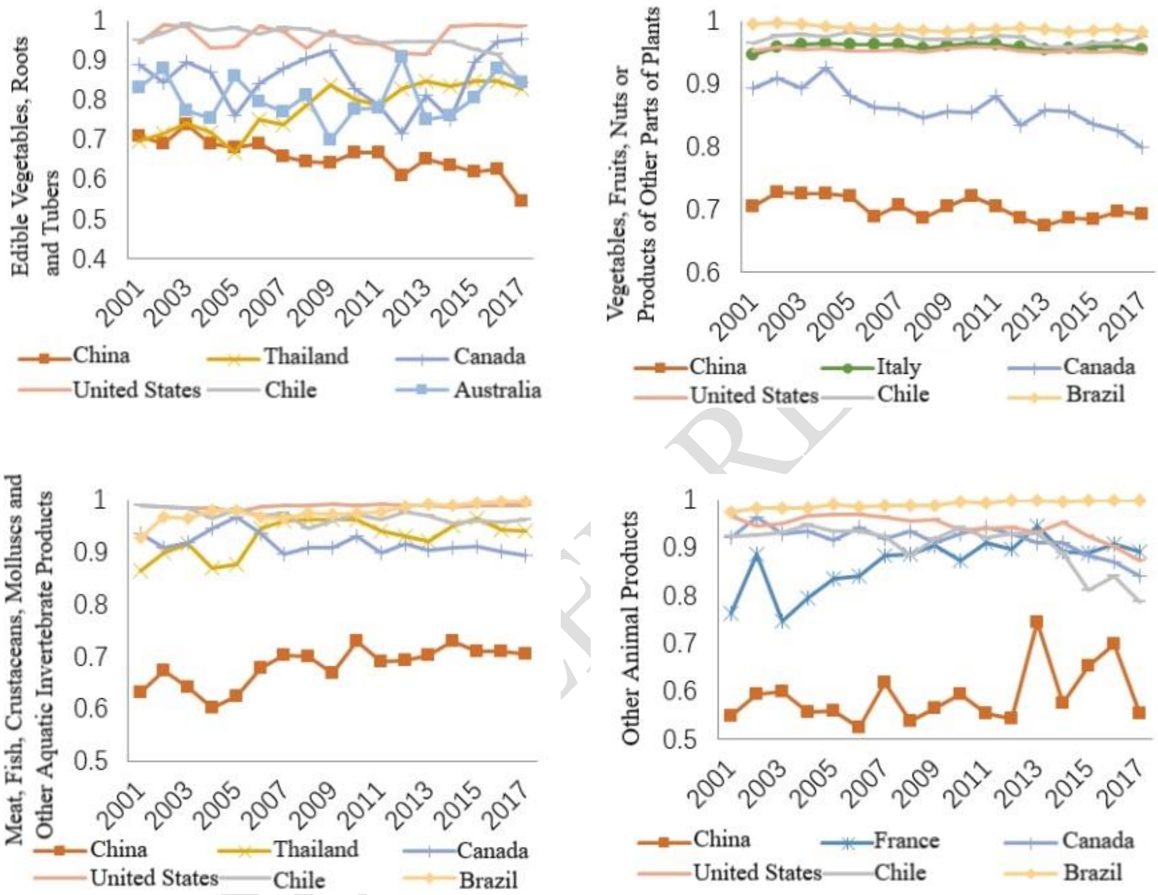

Figure III. Comparison of the quality of four major categories of agricultural products between China and competitors[16]

The quality level of the HS07 category was similar to the level of Thailand in 2001, but since then it has been declining year by year, and the gap between it and the same kind of agricultural products from Thailand has widened. In the absence of significant changes in the structure of basic export agricultural products, the quality of

[16] Figure III shows the relative quality of the four largest categories of Chinese agricultural exports to Japan at the HS2-digit product level.

major export agricultural products has failed to improve or even continued to decline, partly explaining that China's agricultural exports to Japan have declined. After the implementation of Japan's positive list system in 2006, the restrictions on pesticide residues have been further improved, especially the implementation of the "uniform standard," which has dramatically impacted the export of Chinese agricultural products.

Next, this paper compares the quality level of agricultural products in China with that of countries worldwide[17] in terms of the quality level of agricultural products. According to equation (10), it can be seen that when calculating the relative quality in each agricultural product subsector, there is a minimum value, which is set to 0, and a maximum value, which is set to 1. Therefore, this paper divides the quality of agricultural products exported to Japan from all countries in the world in the HS9 quartile into eleven quality tiers (including a category of relative quality 0) and finds that, among all the agricultural product types in the HS9 quartile exported by China to Japan, the quality of 72.37 percent of them has a quality level is below 0.5, with 25.18 percent of the agricultural product categories having a quality below 0.1 (Table IV). In contrast, only 7.54 percent of the agricultural products have a quality above 0.7. Combined with the fact that the quality of China's agricultural products as a whole is at the level of 0.6-0.7 (Figure II), it can be assumed that fewer high-quality agricultural products and four major categories of relatively high-quality agricultural products have contributed to the overall quality of China's agricultural products exported to Japan. The quality of niche agricultural products is at a low level because most of them are

[17] Countries that export agricultural products to Japan.

specialty products with a small production volume, so their standardized production and large-scale cultivation and other quality-enhancing standard systems have not yet been perfected, thus forming a vicious circle, which has led to China's exports of agricultural products to Japan in general to the status quo of low quality has not yet changed.

Horizontally, agricultural products with relative quality levels in the 0, 0-0.1, and 0.1-0.2 ranges accounted for 24.76 percent, 5.91 percent, and 19.59 percent, respectively, of the world's exports of the same type to Japan during the same period. Only 1.59 percent of the world's exports were in the 0.9-1 relative quality range[18]. This is not a significant competitive advantage at the world level. Although the pass rate of Chinese agricultural products was above 96 percent both before and after 2018, China's standards on pesticide residues, excessive heavy metals, and illegal additives are far worse than those of developed countries. Furthermore, consumer confidence in purchasing comes more from the standards and regulatory systems hidden behind the products as incomes continue to rise. Therefore, in the Japanese market, without significant quality improvement, Chinese agricultural products will become less competitive than other European and American products.

[18] The percentage here is the average of the percentage for each year of the 17-year period.

Table IV. Number of types and annual changes in China's HS9-digit coded agricultural products at different quality levels[19]

	0	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	0.4-0.5	0.5-0.6	0.6-0.7	0.7-0.8	0.8-0.9	0.9-1
2001	118	47	61	98	102	90	88	54	26	12	13
2002	122	44	83	80	109	99	84	54	30	14	18
2003	135	49	79	77	95	96	101	48	24	9	17
2004	142	51	71	75	100	99	98	63	23	11	17
2005	132	56	60	88	98	91	107	60	28	11	18
2006	145	45	62	80	97	108	91	70	30	10	15
2007	141	55	61	91	101	109	82	54	33	12	14
2008	121	41	62	83	105	97	79	53	26	8	13
2009	127	46	64	78	81	103	85	57	25	8	12
2010	133	30	54	84	76	104	93	53	26	13	13
2011	130	31	56	82	102	85	91	47	34	7	12
2012	143	49	66	83	88	97	82	54	28	8	18
2013	127	39	72	83	60	114	88	54	29	14	17
2014	127	31	66	70	97	99	79	57	25	12	16
2015	135	42	64	75	81	99	80	41	25	11	20
2016	146	50	49	75	78	101	80	58	20	7	23
2017	147	60	58	77	77	86	91	48	22	10	21
Average share of China's agricultural products (%)	18.85	6.33	9.02	11.44	12.81	13.92	12.43	7.66	3.77	1.47	2.30
World average of similar agricultural products (%)	24.76	5.91	19.59	16.14	12.32	9.67	6.98	4.06	2.19	1.17	1.59

[19] Source: Calculations based on the authors.

From a dynamic point of view, the variety of products in the middle part of the quality range of agricultural products has been decreasing from 2001-2017, and the variety at both ends has been increasing. The types of products with a quality level of 0.3-0.8 decreased from 360 types in 2001 to 324 types in 2017, which included the four major categories of agricultural products for export, while the types with a quality level of 0-0.3 increased from 324 to 342 types, and the types with a quality level of 0.8-1 increased from 21 to 31 types. This suggests that the heterogeneity of the quality of China's agricultural exports has increased after WTO accession. At the same time, the fact that the quality of midstream products has not increased significantly while the quality of overall products has declined may partly explain the decline in China's agricultural exports to Japan and the relative shrinkage of its market share after WTO accession.

4. Conclusions and recommendations

In this study, we adopted the Nested Logit Method to examine the spatial and temporal evolution of the quality level of China's agricultural products exported to Japan, based on HS9-digit coded agricultural products import data from 2001-2017 in Japan's Ministry of Finance and Trade database.

The study shows that the quality of China's exported agricultural products is still significantly different from that of developed countries and traditional agricultural powerhouses, leading to a lack of export competitiveness. The reasons for the low quality of Chinese agricultural products are mainly as follows. *(i)* Given China's large population and relative shortage of agricultural resources, the main objective of agricultural production has long been to increase yields. As a result, the problem of the over-application of pesticides in agricultural production has arisen, leading to excessive residue limits in agricultural exports. They even exceeded the access criteria of the Japanese positive list system and therefore had to be phased out of the Japanese market. *(ii)* China lacks a sound pesticide regulatory policy, with a small regulatory scope and little practical experience. Although the standards are constantly being updated, there is still a large gap compared to the European Union (more than 500 pesticides and more than 14,000 standards) and Japan (more than 50,000 standards under the positive list system). *(iii)* Characteristic agricultural products, which occupy an important position in China's agricultural exports, are mostly produced by specific regions, with a small scale of production and a low degree of standardization, so the level of product quality is also relatively low.

Three main policy insights can be drawn from the findings of the study. *(i)* China's agricultural sector should pay attention to the management of pesticide residues, and actively promote the standardization of pesticide residue limits in line with international standards. *(ii)* For large categories of agricultural products, agribusinesses should combine their strengths to form large-scale production and reduce costs. Deep-processing technology for agricultural products should be upgraded through increased investment in science and technology. *(iii)* For existing high-quality but low-yield characteristics of agricultural products, it is possible to build a special agricultural products advantage zone, to achieve standardization and large-scale planting, and to improve its quality, so that the resource advantage can be sustainably transformed into a realistic competitive advantage in exports.

Data Availability Statement

The authors confirm that the data supporting the findings of this study are available from the corresponding author, D, upon reasonable request.

Conflict of Interest Disclosure

None of the authors have a conflict of interest to disclose.

Disclaimer

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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