Analysis on the Import Quality of China's Agricultural Products

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Authors' contributions

This work was carried out in collaboration among all authors. Author DY designed the study, wrote the protocol and rectified the manuscript. Author SY managed the literature searches and wrote the first draft of the manuscript. Author CJ performed the statistical analysis and managed the analyses of the study. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Since China's accession to WTO, the agricultural imports have been growing considerably, but China has also met various concerns with the safety of imported agri-food. Therefore, enhancing the quality of imported agricultural products has become an imperative problem in China. Based on the HS6-digit data from 2002 to 2017, this paper uses the nested logit model to construct the comparable quality indicators of imported agricultural products. The paper found that the quality of imported agricultural products has been steadily improving. By 2017, the relative weighted quality of importing countries had mainly settled in the range of 0.6-0.9. It is worth noting that the quality of agricultural products from Brazil and America was greater than 0.9. In terms of product quality, vegetable products have the highest relative weighted quality, followed by live animals, animal products, prepared foodstuffs, beverage and other products.

1. INTRODUCTION

China has been actively engaged in international agriculture trade since WTO accession. Therefore, China's agricultural trade has grown dramatically, with significant increases in the scope and volume of agricultural imports. With an average annual growth rate of 17.2%, China's

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agricultural imports climbed from US$12.42 billion in 2002 to US$149.88 billion in 2019. China has surpassed the United States as the world's largest agricultural importer and second-largest agricultural trader. China's agricultural products, on the other hand, are facing a massive trade deficit. The agriculture trade surplus was US$5.7 billion at the time of China's WTO accession, but the trade deficit began to manifest in 2004 and reached US$71.31 billion in 2019[1]. As a result, imported agricultural products are gaining a competitive edge in the Chinese market, and Chinese consumers have been increasingly dependent on imported agricultural products.

On one hand, world trade enriches Chinese consumers' choices of agri-food. On the other hand, as agricultural trade grows, so does the risk of encountering toxic and deadly germs, as well as foreign epidemics. In contrast to 339,000 batches of harmful creature intercepted in 2010, China intercepted 685,000 batches of harmful creature in the process of import quarantine in 2018, according to the data released by General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (AQSIQ). Therefore, the quality and safety of imported agricultural products has been highly regarded.

The term "quality" used in this paper is to describe the vertical difference between two products after taking into account product pricing and horizontal variations such as variety and specification. The paper aims to investigate the quality of China's imported agricultural products and to determine which importing countries have better product quality. Hence, assessing the quality of agricultural imports serves as a foundation for identifying safe and high-quality importing suppliers.

The impact of export quality on trade volume has increasingly become a contemporary research hotspot as product quality measurement technologies have improved. Dong and Huang (2016) evaluated the quality of HS9-digit agricultural products exported to Japan from 2005 to 2012, and discovered that the quality of China's exported agri-food firstly increased followed by a decline, and finally rebounded,

fluctuating in a N-shaped pattern [1]. Chen and Xu [2] used the product-level regression and back-induction method to calculate the quality of China's imported agricultural products from 2000 to 2013, and found that the quality of China's imported agricultural products shows an obvious upward inverted U-shaped trend from 2010 to 2012 [2]. Jiang and Yao [3] pointed out that the EU Maximal residual limits (MRLs) standard not only slowed the rate of quality improvement of imported fresh fruits, but also had a nonlinear effect on the quality improvement [3]. Liu and Zhao [4] investigated the theoretical mechanism of the impact of the export quality of agricultural products on the upgrading of agricultural sector through the transmission paths of material capital, human capital, science and technology and institutional quality. They came to the conclusion that improving the export quality of agricultural products has a direct impact on the agricultural industry's overall upgrading, and the most noticeable influence on upgrading is seen in central China [4].

The current study focuses mostly on agricultural product export quality, with less discussion on agricultural product import quality. What's more, there are few research based on the nested logit model on the quality of imported agricultural products. As a result, the paper seeks to use Khandelwal (2009)'s nested logit model to estimate the quality of China's imported agricultural products, elucidating the quality disparity between Chinese and foreign items. In addition, to augment the current literature, heterogeneity analysis will be undertaken from the dimension of importing nations and classification of imported agricultural products.

2. METHODOLOGY

The technological sophistication index (TSI) and export unit value are currently the most extensively utilized methodologies for determining quality. TSI was first proposed by Michaely (1984) and improved by Hausman et al. (2006). Its primary premise is that product quality can be estimated by multiplying the weight of a product's fraction of total exports in the world by the country's GDP per capita. The technical complexity displays the difference in technical substance between different items, which is a fundamental flaw with this method. Obviously, the cultivation technology of aquatic products is different from that of cultivated crops. The difference of technical content cannot be simply used to determine the quality of the two products.

The export unit value technique (Schott, 2004) holds that the greater the product quality, the more satisfied customers are, and they are prepared to pay a higher reservation price, resulting in an increase in the product's unit value. This method is extensively utilized in empirical research since it relies on readily available micro data such as product value and export quantities. Unfortunately, the unit value technique is unable to eliminate the cost of manufacturing information (especially the different wage levels in various countries). Since high price is only a necessary condition for high quality, the unit value is also affected by factor price distortion, transportation costs, trade barriers and government subsidies. Therefore, it is possible to overestimate or underestimate quality. At present, the most cutting-edge method is the nested logit model constructed by Khandelwal [5] based on the product price and import quantity. Its core idea is that, for a given unit price, the bigger the market share of the product, the higher the quality. It regards the market share of an export product in the target market as a function of the product price, horizontal difference preference and product quality (vertical difference preference) [6].

According to Khandelwal (2009), the discrete demand function is obtained as follows:

$$\ln(S_{iht}) - \ln(S_{0t}) = \lambda_{1,ih} + \lambda_{2,t} - a\ln p_{iht} + \sigma\ln(ns_{iht}) + \gamma\ln Market_{it} + \lambda_{3,iht} \qquad (1)$$

where the left-hand side of the equation is the relative market share of imported product *h* at time *t*. On the right-hand side of the equation, ns_{iht} denotes the nested market share, while p_{iht} denotes the price level of product *h* imported from country *i* at time *t*. $Market_{it}$ means the market size of importing country *i* at time *t*. The expression for quality can then be derived backwards as follows.

$$\lambda_{iht} \equiv \hat{\lambda}_{1,ih} + \hat{\lambda}_{2,t} + \hat{\lambda}_{3,iht} \qquad (2)$$

where $\lambda_{1,ih}$ is the individual fixed effect of country *c*'s export of product *h* that does not vary over time (excluding non-quality effects on the importing country's product such as bilateral trade relations, trade barriers, etc.). $\lambda_{2,t}$ is the time fixed effect and $\lambda_{3,iht}$ is the unobservable error term indicating the component that deviates from the time and product fixed effects.

The existing literature also exhibits the way to measure the relative market share s_{iht} in equation

(1). Firstly, regard the overall market of agricultural products as 1 and use q_{iht} to refer to the quantity of agricultural products *h* imported from country *i*. After that, the sub-industry scale MKT_t is measured by using the import volume *q* of agricultural products and its market share of imported agricultural products (1-external market share s_{0t}) as shown in equation (3):

$$MKT_t = \frac{\sum_{ih \neq 0} q_{iht}}{1 - s_{0t}} \qquad (3)$$

Then the market share of imported agricultural products *h* is presented as follows:

$$s_{iht} = {}^{q_{iht}}\!/\!{}_{MKT_t} \qquad (4)$$

Nevertheless, there are significant issues with utilizing equation (1) to assess product quality. To begin with, most existing literature assesses the price level of imported products using the ratio of total import value to import quantity, which is bound to be influenced by factors such as transportation distance and cost between trading countries. However, it is difficult to eliminate the impact of uncountable transportation costs in one of the quality components, $\lambda_{3,iht}$, which is related to the price level. Secondly, there may exists endogeneity in $\lambda_{3,iht}$, which indicates the deviation in addition to the time and product fixed effects, and the nested market share.

Considering that the data required by some models are difficult to obtain, the paper will simplify equation (5) by referring to the research method of Shi [7] as follows:

$$\ln\frac{S_{iht}}{1 - S_{0t}} = \lambda_{1,ih} + \lambda'_{2,t} - \alpha\ln p_{iht} + \sigma\ln\left(\frac{ns_{iht}}{1 - S_{0t}}\right) + \gamma\ln Market_{it} + \rho\ln cost + \lambda_{3,iht} \qquad (5)$$

where $\lambda'_{2,t} = \lambda_{2,t} + \ln(S_{0t}) + (\sigma - 1)\ln(1 - S_{0t}$ and $\ln\frac{S_{iht}}{1-S_{0t}}$ represents the proportion of agricultural products in the total imported agricultural products of importing countries. $\frac{ns_{iht}}{1 - S_{0t}}$ stands for the share of the number of agricultural products subdivided on the HS6-digit level at time t in the corresponding total value of imported agricultural products of the same group. lncost is the transportation cost as the instrumental variable. The quality measurement is expressed as follows:

$$\lambda_{iht} = \hat{\lambda}_{1,ih} + \hat{\lambda}_{2,t} + \hat{\lambda}_{3,iht} = \hat{\lambda}_{1,ch} + \hat{\lambda}_{2,t} + \ln S_{0t} + (\sigma - 1)\ln(1 - S_{0t}) + \hat{\lambda}_{3,iht} \qquad (6)$$

The quality can be standardized with reference to Chen and Xu (2018) as follows, given that it is constant when the time is fixed, in order to eliminate the effect of non-quality components, $\ln S_{0t} + (\sigma - 1)\ln(1 - S_{0t})$.

$$\lambda'_{iht} = \frac{\lambda_{iht} - \min\lambda_{ht}}{\max\lambda_{ht} - \min\lambda_{ht}} \qquad (7)$$

3. DATA DESCRIPTION AND EMPIRICAL RESULTS

3.1 Data Description

The paper selects HS6-digit agricultural products exported by 156 countries to China from UN Comtrade in 2002-2017, including the import scale and volume of agricultural products with different digits. The World Bank provided the population and GDP per capita figures used to measure the market size of importing countries. Crude oil price and geographic distance are available from the IMF[2] and CEPII[3] databases respectively. After missing or duplicate data was removed, 134,260 groups of valid data were obtained. The descriptive statistics of relevant variables are shown in Table 1.

Table 1 illustrates that China's agricultural import trading partners have an average relative market share of 0.000187 and a nested market share of 0.763. The importing country's GDP per capita is US$26,200, and its average population is 91 million. The average unit value of imported agricultural products is US$32.35 per kilogram, according to panel statistics.

3.2 Analysis of Empirical Results

In the paper, the population of importing countries (pop) and its GDP per capita (perGDP) are used to represent the market scale $Market_{it}$. The fixed effect and random effect regression are carried out based on the panel data, with Hausman test being done. In Table 2, Columns (1) and (3) stand for fixed effects, while Columns (2) and (4) represent random effects. The results of each column demonstrates that most variables are significant at the level of 1%. However, the population in Column (2) is not significant under random effects. In addition, the Hausman test results reveal that the null hypothesis is rejected at a significance level of 1%, regardless of

whether population or GDP per capita are employed to describe the market scale. In general, the fixed effect is preferable, and thus the fixed effect is used to estimate the model in this paper.

According to the research results of Hummels and Skiba [8] on the "Washington apple" effect, the transportation cost is related with $\lambda_{1,iht}$ and time fixed effect $\lambda_{2,t}$, but unrelated with the error term $\lambda_{3,iht}$ [8]. In order to minimize the endogeneity problem between $\lambda_{3,iht}$, nested market share and unit price, the paper introduces the transportation cost, lncost, as the instrumental variable, that is, the product of crude oil price and distance between countries, with reference to the Pula and Santabarbara [9].

In Table 3, Columns (1) and (3) are estimated for IV, while Columns (2) and (4) are estimated for OLS. The proxy variable for the economic scale in the model is the population in Columns (1) and (2), whereas GDP per capita in Columns (3) and (4).

According to Table 3, almost all the variables are statistically significant at 1% level. To begin with, the coefficients of nested market share in all the four models appear positive, it means that the more agricultural products a country exports, the more quantitative advantages it has in a group of competitive items, and hence the bigger its relative market share. However, the coefficients in IV models are less than those in OLS models, which indicates that the coefficients are overestimated in OLS models due to the endogeneity. The P values for Durbin-Wu Hausman test show that the null hypothesis should be rejected at 1% level, which further proves that OLS regression does lead to endogenous problems.

Moreover, the coefficient of unit value is negative, implying that the unit price has a negative impact on the relative market share, which is consistent with practical logic and previous research. In terms of the choice of market scale variables, the coefficient of population of importing countries (pop) is negative. However, according to Krugman's (1980) standard model, types of products will increase as a country's population grows, resulting in a rise in relative market share to some extent, which is obviously in conflict with the regression results. As a result, the paper will use GDP per capita (perGDP) as an index to

determine the market size of importing countries. Specifically, holding other variables constant, the transportation cost increases 1%, the relative market share will decrease 1.247% on average in Column (3). Empirically, if the transportation cost rises, the price will increase as well. Based on the principle of economics, the relative market share will go down accordingly.

Table 1. Descriptive statistics

Index	Relative market share	Nested market share	Population (10,000)	GDP per capita (USD)	Unit value (USD / kg)	Oil price (USD / barrel)	Distance (km)
Mean	1.19E-04	0.076281	9100	26175.49	32.34517	67.526	8709.619
Minimum	4.52E-13	7.18E-11	1.1099	111.9272	4.05E-07	24.412	1156.57
Maximum	0.851475	1	1.34E+05	102913.5	57980.15	111.959	18765.08
25% Quantile	3.37E-08	0.00066	1030	5587.026	1.132308	44.545	5239.905
75% Quantile	2.27E-06	0.045652	8210	42431.89	6.794693	98.59	10777.59

*Source: Stata14

Table 2. Regression results of fixed effect and random effect

Variables	(1) FE	(2) RE	(3) FE	(4) RE
lnpop	0.023***	-0.003		
	(3.98)	(-0.55)		
lnns	0.817***	0.760***	0.812***	0.758***
	(477.03)	(461.06)	(482.88)	(463.53)
lnp	-0.194***	-0.307***	-0.260***	-0.337***
	(-53.70)	(-89.14)	(-70.53)	(-95.70)
lnperGDP			0.600**	0.255***
			(66.28)	(40.13)
cons	-10.829***	-11.028***	-16.128***	-13.412***
	(-109.01)	(-132.97)	(-128.43)	(-222.21)
Hausman test				
χ^2	5790.35		8229.49	
Prob>χ^2	0.0000		0.0000	
R^2	0.81	0.81	0.81	0.80
N	134270	134270	134270	134270

*Note: t statistics in parentheses, *p< 0.1, **p< 0.05, ***p< 0.01

Table 3. Comparative analysis of different groups of regression estimation results

Variables	(1) IV	(2) OLS	(3) IV	(4) OLS
lnns	0.364***	0.598***	0.286***	0.560***
	(25.71)	(304.47)	(20.24)	(307.39)
lnp		-0.780***		-0.787***
		(-198.40)		(-195.18)
lnpop	0.003**	-0.012***		
	(1.25)	(-3.23)		
lnperGDP			0.004***	0.031**
			(3.82)	(7.60)
lncost	-1.026***		-1.247***	
	(-18.21)		(-15.41)	
_cons	-8.694***	-10.753***	-9.008	-11.255***
	(-70.61)	(-161.00)	(-67.73)	(-283.91)

Variables	(1)	(2)	(3)	(4)
	IV	OLS	IV	OLS
Individual fixed effect	Controlled	Controlled	Controlled	Controlled
Time fixed effect	Controlled	Controlled	Controlled	Controlled
Durbin-Wu-Hausman P value	0.0000		0.0000	
R^2	0.82	0.83	0.83	0.83
N	115460	115460	115460	115460

*Note: t statistics in parentheses, *p< 0.1, **p< 0.05, ***p< 0.01*

4. QUALITY ANALYSIS OF CHINA's IMPORTED AGRICULTURAL PRODUCTS

4.1 The Overall Quality Stays Relatively Stable

Fig. 1 (left), which illustrates the overall import quality in different years based on the standardized relative quality under the weighted average at the HS6-digit level, shows that the overall quality of imported agricultural products improved with a noticeable increase from 2002 to 2003. There are mainly two reasons for the surge. On one hand, China's WTO accession paved the path to cooperate with the world agricultural powers. On the other hand, China started to notified Sanitary and Phytosanitary (SPS) measures and established its own system for quality supervision, inspection and quarantine. The relative quality rose steadily from 2006 to 2008, peaking in 2008, but quickly declined, which is likely due to the worldwide economic collapse brought on by the global financial crisis. The relative weighted quality changed after 2008, but stayed around 0.9.

Fig. 1 (right) displays the distribution of importing countries' quality metrics at the HS6-digit level through time. Agricultural products exported to China by most countries have a relative quality of 0.4 to 0.7 at various times. Overall, the quality of agricultural products imported by China fluctuates less and grows consistently, which is related to the world economy's slow recovery, ongoing international trade frictions, China's economic slowdown, and so on.

4.2 The Quality Exported by Traditional Agricultural Powers Is More Superior

There are differences in the quality of agricultural products from different importing countries or regions, although the overall quality dwells in the range of 0.6 to 0.8.

In general, the larger the importing country's relative market share, the higher the quality of agricultural products, which enhances the overall quality of agricultural products. The average relative quality of agricultural imports is high, as indicated in the box diagram of individual quality distribution in Fig. 2, with minimal variation from 2002 to 2017. Specifically, the relative quality of products improved noticeably from 2002 to 2003. As a result, the lowest quality level of agricultural products of the same type is largely concentrated in 2002. The total quality difference of imported agricultural products between 2002 and other years is amplified after standardization.
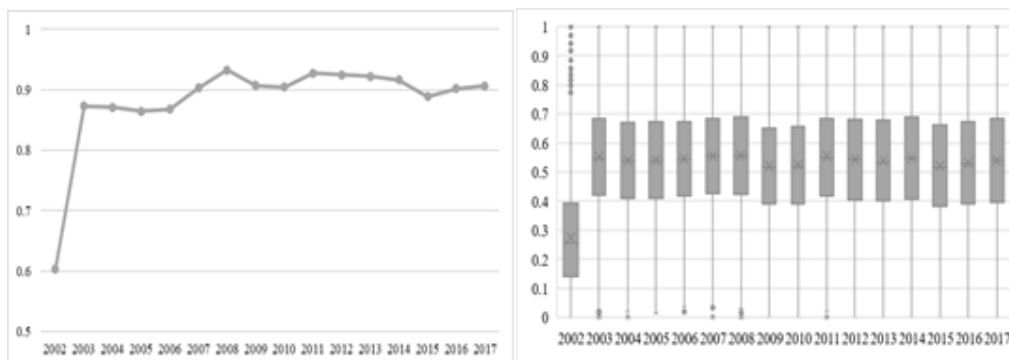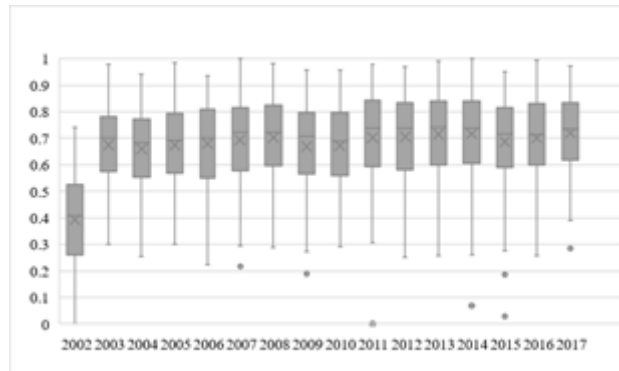

Fig. 1. Overall import quality of China's agricultural products from 2002 to 2017
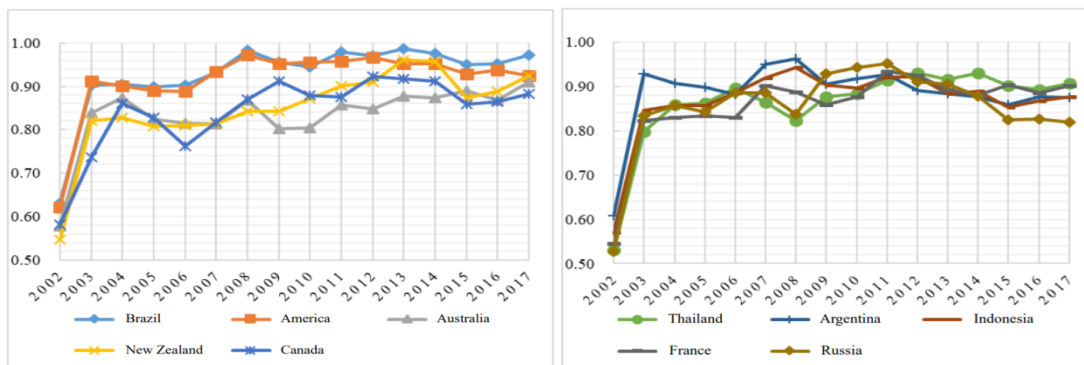*Source: calculated by the author*

Fig. 2. Box diagram of the relative quality of agricultural products from different countries from 2002 to 2017
*Source: calculated by the author

Because of the vast number of importing nations, the paper compares the top 10 trading partners by import share in 2019 (Brazil, America, Australia, New Zealand, Canada, Thailand, Argentina, Indonesia, France, and Russia). Fig. 3 shows that, in terms of overall quality of imported agricultural products, the top 10 countries improved dramatically from 2002 to 2003, but fluctuated slightly after that. Quality of agricultural products imported from Brazil and the United States has been above 0.9 in recent years, whereas quality fluctuation of agricultural products imported from Canada, New Zealand, Russia, and Argentina has been quite substantial.

Developed countries such as the United States and Canada are agricultural exporters with a high degree of agricultural modernization and a comprehensive regulatory framework for agricultural products, and thus the quality of agricultural product has been placed in a leading position. It's worth noting that the quality of agricultural products in significant agricultural countries like Brazil and Chile in South America, where the overall quality of agricultural products has been above 0.9 in recent years, is greater than in European and American countries. The first reason is that these countries are superior in geographical location and rich in agricultural natural resources. Secondly, there are also some external factors. The Brazilian government, for example, has offered agricultural financing and other support measures for agricultural development, resulting in a positive agricultural development trend in Brazil [10]. It is also possible that, due to prices after the exchange rate, Brazil also exported high-quality products, such as organic food, to China. In addition, the demand transformation of world agricultural product market, to some extent, plays a role in boosting Brazil's agricultural exports [11]. Thailand and Indonesia, as traditional agricultural countries, have abundant natural resources and low labor costs, giving their land and labor-intensive products a competitive advantage in the market.

Fig. 3. The quality of imports from top10 countries during 2002 to 2017
*Source: the relative quality data at the national level is obtained by the data of the weighted average of the quality at the national and product level
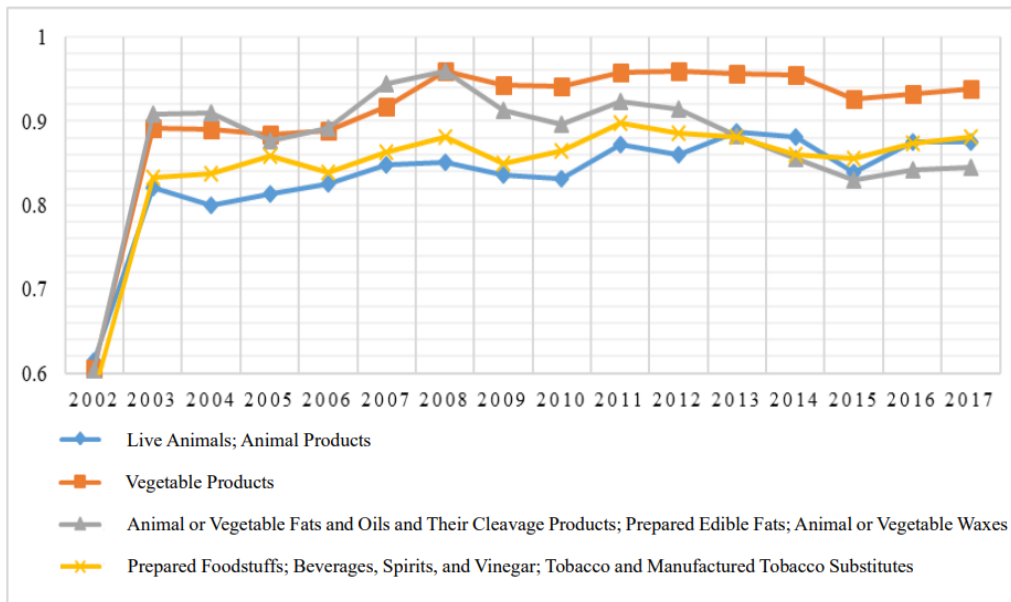
Fig. 4. Quality of the four major categories of imported agricultural products from 2002 to 2017
Source: calculated by the author

4.3 The Quality Level of Vegetable Products is the Highest

The number of imported agricultural products grew from 608 to 611 at the 6-digit level of the HS agricultural commodity classification from 2002 to 2017, and there were some variations in the distribution of import quality of agricultural products. The proportion of types of agricultural products with relative quality greater than 0.8 has climbed from 2.4% to 43.2%, indicating that the overall quality of agricultural products is improving dramatically.

Agricultural products are classified into four categories according to HS code, including Live Animals and Animal Products (HS01-HS05); Vegetable Products (HS06-HS14); Animal or Vegetable Fats and Oils and Their Cleavage Products, Prepared Edible Fats, Animal or Vegetable Waxes (HS15); Prepared Foodstuffs, Beverages, Spirits, and Vinegar, Tobacco and Manufactured Tobacco Substitutes (HS16-HS24).

As shown in Fig. 4, the relative weighted quality of vegetable products is the highest, which is higher than 0.9 in recent years. The quality of HS01-HS05 and HS16-HS24 have risen steadily, but the increase is not distinct. In contrast, the quality of HS15 fluctuated significantly, with an obvious decrease compared with the peak in 2008.

5. CONCLUSIONS AND IMPLICATIONS

The paper uses the nested logit model to measure the quality of China's imported agricultural products on the whole scale as well as country and product-based scale. The paper found that the overall quality improved steadily from 2002 to 2017, with most agricultural products maintaining a relative quality of 0.5-0.8. At the national level, the relative weighted quality of imported agricultural products is high, while the relative average quality still has sufficient space for upgrading. The quality of agri-products imported from different countries varies significantly. Agricultural products that have a competitive edge can often occupy a larger relative market share in China. From the perspective of products, the overall quality of vegetable products is better than that of live animals, animal products, foodstuffs, beverages and other products.

Based on the above conclusions, it is suggested that the quality control of China's agricultural products should be strengthened to further improve the quality. Health and safety should always be taken as top priority for China's quarantine and market control departments. Moreover, appropriate management and prosecution measures, as well as foreign sophisticated prosecution methods, should be implemented. Additionally, businesses are

supposed to be advised on how to select higher-quality international agricultural items.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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