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Three-Margin Analysis of China's Animal-Derived Food Import

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Abstract

Aggregate import of China's animal-derived food increased remarkably and has been on a continuous upward trend. This paper uses import data at the Harmonized System (HS) six-digit level from 2002 to 2018 to explore the growth driver of China's animal derived food imports. It is found that: (1) China's animal-derived food import growth is mainly driven by rapid quantity growth, which contributes up to 70.12%; (2) Although China's animal-derived food import market is highly concentrated, it exhibits a tendency toward diversification; (3) There is an enormous difference between developed and developing countries in terms of exporting at the bilateral level, at which the degree of product variety differs with the particular type of trading partners, although variety generally increases.

Keywords

Animal-Derived Food, Import Growth, Three-Margin Analysis

1. INTRODUCTION

China is a major producer, consumer and trading country of animal-derived food[①], and aggregate import has been on a continuous upward trajectory, driven by the combined effects of strong domestic demand, rapid economic development and the domestic food safety incidents. However, domestic production is unable to meet consumers growing demand for high-quality and wide variety of animal-derived food, thus leading to the dramatic increase in the scale of imports. The total import volume has exceeded 20 billion US dollars, accounting for more than 20% of China's total imports of agricultural products. Moreover, China's animal-derived food import sources are highly concentrated, still dominated by developed countries, which account for 58.2% of overall imports. However, as illustrated in Figure 1, there is a trend that developing countries' share continues to grow, and import sources are more diverse.

[①]Animal-derived food refers to all edible animal tissues as well as eggs and milk, including meat and its products (including animal organs), aquatic animal products, etc. This paper links "animal-derived food" to the relevant products in HS02 (meat and edible mince), HS03 (fish, crustaceans, mollusks and other aquatic invertebrates), HS04 (dairy products; eggs; natural honey; other food animal products) and HS16 (meat, fish, mollusks and other aquatic invertebrates) of the HS (2002 version) at 6-digit-code level. See WCOTradeTools.org for more details on the higher-level codes.

Meanwhile, China's animal-derived food categories structure has changed (Figure 1. China's Import Share Of Developed Countries And Developing Countries

Source: CEPII BACI database.

Figure 2). The total share of the top 10 products in total import value fell from 93.20% to 83.17%, implying higher diversification and lower concentration of animal-derived food. For example, HS03 took a large share before 2008 but has started to decline steadily since 2014. On the other hand, the share of HS02 grew from 25.43% to 38.72% gradually, and now has overtaken HS03 to rank first.

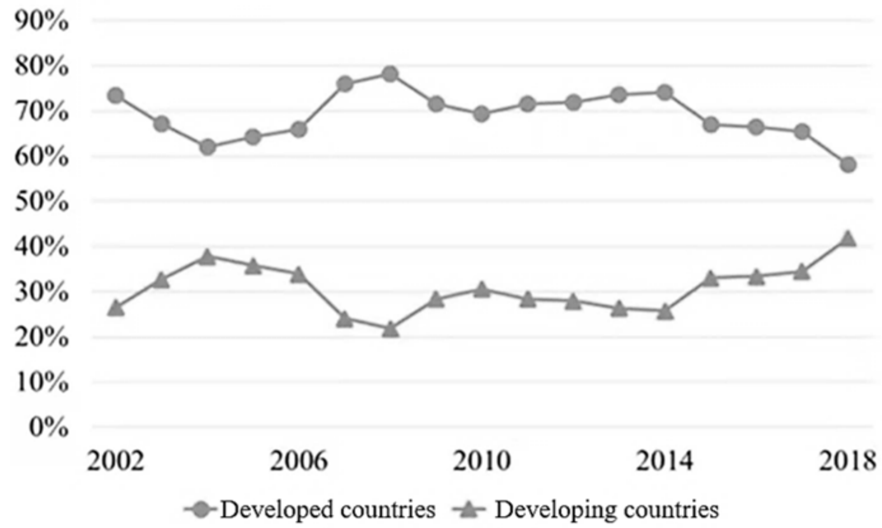

Figure 1. China's Import Share Of Developed Countries And Developing Countries

Source: CEPII BACI database.

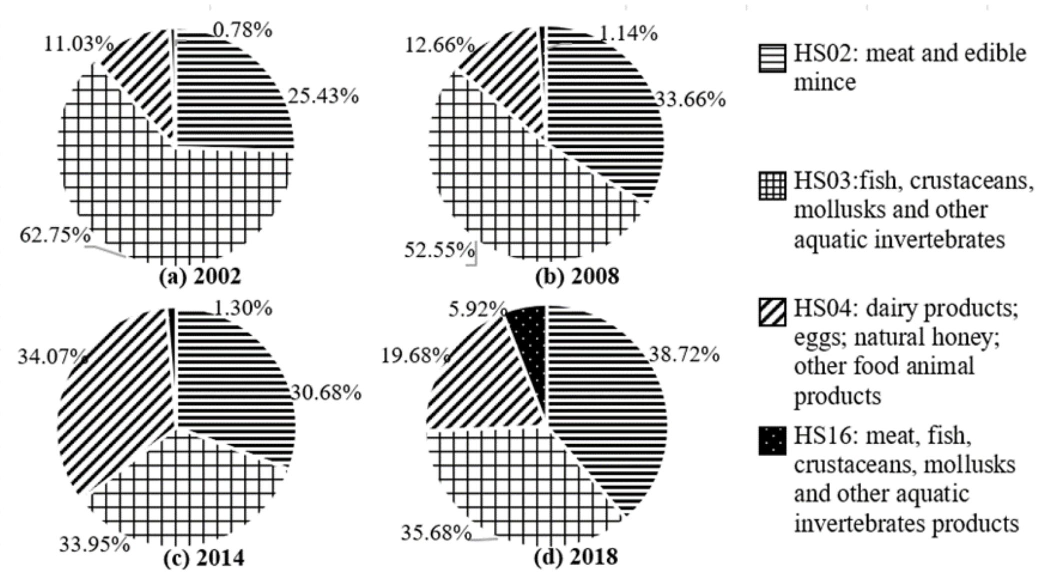

Figure 2. Product Composition of the Import Trade in Some Years

Source: CEPII BACI database.

What we concentrate on in this paper is that what exactly the driving forces behind the growth of China's animal-derived food imports is and whether it is mainly driven by rapid price growth, quantity growth, or extensive margin growth. To obtain more insights, we use the three-margin analysis methodology to systematically analyze the driving forces of China's animal-derived food imports from both static and dynamic perspectives, and empirically explore the contribution ratio changes of China's animal-derived food import growth after the accession of WTO. By this means, it offers practical implications for the import trade and domestic industry on a theoretical basis.

2. LITERATURE REVIEW

A significant number of literatures examines the impact of SPS measures on trade margins. Bao and Yan (2014) measured the binary margins of China's agricultural exports, arguing that SPS measures have a significant dampening effect mainly at the level of the intensive margin. Using an HMR model based on firm heterogeneity, Qin and Ni (2014) found that the trade effects of SPS measures took effect through the export costs of firms and contributed to increase in the expansion margin and decrease in the intensification margin of trade. Fontagné et al. (2015) studied the impact of product standards on trade margins at the firm level and found that the imposition of restrictive SPS measures generates additional fixed and variable costs that affect the trade expansion margin and the agglomeration margin across firm heterogeneity effects. As a result, SPS measures would lead to a decrease in firms' export participation rate and a greater fall in the value of exports at the agglomeration margin, with negative effects even exceeding those associated with a 10% increase in tariffs. A study by Beestermöller et al. (2018) on Chinese firms exporting agricultural products to the EU through a binary margin approach also shows that EU health standards exclude small firms from the market on the expansion margin and promote the export size of incumbent exporters on the intensification margin.

Ferro et al. (2015) introduced the Heterogeneity in Trade Index (HIT) to analyse the impact of food safety standards on international agricultural exporters and found that exporters were more likely to export to low-standard countries due to increased fixed costs. If developed and developing countries were to further harmonize and comply with established international standards, this would reduce fixed costs and thus increase exports from developing countries, as firms would then only need to comply with one international standard rather than several different importing countries' standards. It is worth noting that safety standards have a negative but statistically insignificant effect on the margin of aggregation in the case of low-income importers-high-income exporters if the importing country has stricter safety standards compared to the exporting country.

Furthermore, Fernandes et al. (2019) innovatively assessed the impact of product standards on firms' export decisions, covering all exporting firms in 42 developing countries and pesticide standards for 243 agricultural and food products in 63 importing countries over the period 2006-2012, elaborating on the impact of product standards on heterogeneous firms. Zhang and Wang (2020) analyzed the impact of importing countries' food safety standards on Chinese micro-firms' export behavior and technological innovation from 2000-2007 and found that although higher technical standards in importing countries force firms to exit in the short run, with negative effects on the expansion and intensification margins, they have a positive effect on disadvantaged exporters in terms of promoting technological innovation and are conducive to exporters' trade growth in the long run.

Therefore, a large number of studies in China and abroad have studied the trade impact of SPS measures on exporting countries through binary margin analysis. To be theoretically valuable, this paper contributes to the existing literature by exploring the impact of SPS measures on import trade flows and ternary margins from the perspective of importing countries.

3. METHODOLOGY

As already noted, we aim to assess the three margins of China's animal-derived food import and analyze its growth structure and main driving forces. Here, we outline our methods for achieving these empirical tasks. Following the three-margin decomposition methodology proposed by Shi (2010), we decompose the total value of China's animal-derived food imports into extensive, price and quantity margin at the HS six-digit code level.

First, the import value is decomposed into the extensive margin (EM) and the intensive margin (IM). The extensive margin is appropriately weights categories of goods by their overall importance in exports to a given country, and it is the ratio of a particular country's animal-derived food exports to the world within categories it has exported to China, compared to animal-derived food it has exported worldwide. It reflects the variety of products China has covered. The intensive margin is the ratio of a country's animal-derived food exports to China compared to that to the world inside the categories it has exported to China. It reflects China's share in the markets of these categories. Then, the intensive margin is further decomposed into quantity margin (*Q*) and price margin (*P*).

The extensive margin and intensive margin are defined as:

$$EM_{jk} = \frac{\sum_{i \in I_{jk}} p_{ki} q_{ki}}{\sum_{i \in I_k} p_{ki} q_{ki}}, IM_{jm} = \frac{\sum_{i \in I_{jk}} p_{jki} q_{jki}}{\sum_{i \in I_k} p_{ki} q_{ki}} \quad (1)$$

where j is used to represent China, and k is the trading partner. m will be rest-of-world (*ROW*), while i is the product category. p_{jki} and q_{jki} denote the average price and quantity of product i imported by China from country k. p_{ki} and q_{ki} denote the average price and quantity of product i exported by country k in the world market. I_{jk} denotes the set of products imported by China from country k, and I_k is the full set of products exported by country k in the world market, and thus there is $I_{jk} \subseteq I_k$.

Furthermore, the intensive margin can be decomposed into price margin P and quantity margin Q as in Eq. (2):

$$IM_{jk} = P_{jk} \times Q_{jk}, P_{jk} = \prod_{i \in I_{jk}} \left(\frac{p_{jki}}{p_{ki}} \right)^{w_{jki}}, Q_{jk} = \prod_{i \in I_{jk}} \left(\frac{q_{jki}}{q_{ki}} \right)^{w_{jki}} \quad (2)$$

The weights w_{jki} can be calculated by the following formula, where ln denotes the natural logarithm, s_{jki} is the proportion of commodity i in China's import from country k, and s_{ki} is the proportion of commodity i in world's export to country k, that is:

$$s_{jki} = \frac{p_{jki}q_{jki}}{\sum_{i \in I_{jk}} p_{jki}q_{jki}}, s_{ki} = \frac{p_{ki}q_{ki}}{\sum_{i \in I_{jk}} p_{ki}q_{ki}}, w_{jki} = \frac{\frac{s_{jki} - s_{ki}}{\ln s_{jki} - \ln s_{ki}}}{\sum_{i \in I_{jk}} \frac{s_{jki} - s_{ki}}{\ln s_{jki} - \ln s_{ki}}} \quad (3)$$

The price margin stands for the weighted product of the ratio of China's animal-derived food import price to that of the world. If the value is greater than 1, it indicates that China's import price is higher than the world average import price. The quantity margin stands for the weighted product of the ratio of China's animal-derived quantity to that of the world.

We summarized each exporter's margins across all the markets as follows. We first decompose China's imports from each market $k \subseteq K_j$, where K is the set of countries for which export data are available. We then take the geometric average of China's decompositions across the K_j markets to get:

$$EM_j = \prod_{k \in K} EM_{jk}^{\alpha_{jk}}, IM_j = \prod_{k \in K} IM_{jk}^{\alpha_{jk}}, P_j = \prod_{k \in K} P_{jk}^{\alpha_{jk}}, Q_j = \prod_{k \in K} Q_{jk}^{\alpha_{jk}} \quad (4)$$

where weight α_{jk} is the logarithmic mean of the shares of k in the overall imports of j. Thus, the aggregated three-margin decomposition result of China's animal-derived food imports in year t can be obtained as in Eq. (5).

$$S_{jt} = EM_{jt} \times IM_{jt} = EM_{jt} \times P_{jt} \times Q_{jt} \quad (5)$$

In order to compare the contribution ratio of each margin on import growth, we calculate the growth rates of the three margins and the import share S, and calculate the contribution of the three margins to the growth of the import share.

4. EMPIRICAL RESULTS

We utilize the HS six-digit code data of China's animal-derived food import from CEPII BACI database from 2002 to 2018, and the corresponding export data of all exporters. It should be noted that though the trade data in the database has been updated to 2020, considering the huge impact of the African swine fever epidemic in 2019, we set the time limit for research data to 2018. Since China's import sources market are not exactly the same in different years, we take all countries (regions)that are available in each year as samples.

The empirical analyses are in three parts. First, we study the overall characteristics and changes in the three margins of China's import growth. Second, we divide the period into three phases, and study the dynamic roles of the three margins; and lastly, by using a kernel distribution graph to simulate China's import growth.

4.1 Overall Analysis

The decomposition results of China's animal-derived food import growth from 2002 to 2018 are shown in Table 1.

We find that: (1) China's animal-derived food import growth depends more and more on quantity and price growth, which contribute up to 70.12% and 22.51% respectively, and less on extensive margin, with the smallest contribution of 7.36%. (2) The extensive margin constantly decreases from 2006, indicating that the varieties of animal-derived food imported by China gradually decreased, probably due to the impact of international animal epidemics during this period, and then rebound above the starting level afterward. (3) China's import price of animal-derived food has been lower than the average international market price for a long time, but it continues to increase, especially the faster growth rate after 2009, which is related to the growth of China's per capita GDP greatly enhanced consumption of residents, and the demand for higher-quality import products (Wei, 2016). Besides, China has set up higher tariffs, and took a series of non-tariff measures in order to protect domestic agriculture, which also drives up the import prices consequently (Zhu and Wu, 2012; Liu et al., 2016). As a result, China's import price is above international market average price.

Table 1. Decomposition Results of Three Margins of China's Animal-Derived Food Imports

Year	*K*	*Import Share*	*EM*	*IM*	
				P	*Q*
2002	98	0.0805	0.8284	0.8943	0.1086
2003	102	0.0536	0.7937	0.9254	0.0730
2004	103	0.0460	0.7840	0.9013	0.0651
2005	107	0.0412	0.7896	0.8656	0.0603
2006	107	0.0477	0.7623	0.8408	0.0744
2007	118	0.0531	0.7979	0.8727	0.0763
2008	108	0.0492	0.7965	0.9323	0.0663
2009	121	0.0668	0.8181	0.9064	0.0901
2010	126	0.0689	0.8243	0.9292	0.0900
2011	131	0.0725	0.8092	0.9179	0.0976
2012	127	0.0743	0.8250	0.9714	0.0928
2013	120	0.0964	0.8216	0.9733	0.1205
2014	123	0.0924	0.8343	0.9841	0.1125
2015	121	0.0850	0.8117	0.9859	0.1062
2016	125	0.0986	0.8229	1.0162	0.1178
2017	125	0.1014	0.8574	0.9758	0.1212
2018	111	0.1197	0.8554	0.9833	0.1423
Average annual growth rate（%）		2.51	0.20	0.59	1.70
Import growth contribution rate（%		100.00	7.36	22.51	70.12

Source: Calculated by the authors based on data from the CEPII BACI databases.

4.2 Sub Periods Analysis

Considering the historical stages of China's animal-derived food import growth and the impact of the world financial crisis that breakout in 2008, we divide the period from 2002 to 2018 into three sub-periods, 2002-2008, 2009-2014, and 2015-2018, respectively. The results are shown in Table **2**.

Table 2. Changes and Contribution Rates of Three Margin by Period

Stages	Indicators	S	EM	P	Q
2002—2008	Growth rate (%)	-7.86	-0.65	0.70	-7.89
	Contribution rate (%)	100.00	10.01	-11.03	101.01
2009—2014	Growth rate (%)	6.70	0.39	1.66	4.55
	Contribution rate (%)	100.00	5.56	24.17	70.27
2015—2018	Growth rate (%)	12.10	1.76	-0.09	10.25
	Contribution rate (%)	100.00	13.76	-0.67	86.91

Source: Calculated by the authors based on data from the CEPII BACI databases.

From 2002 to 2008, the share of China's animal-derived food import trade showed a downward trend with an average annual growth rate of -7.86%. The price margin increased relatively slow with an average annual growth rate of 0.70%, as domestic consumption was not that strong, and most of the products were imported at a low price. The decrease in quantity margin was the determining factor of the slow growth of animal-derived food import, with an average annual growth rate of -7.89%. During this period, farming industry in some areas hit hard by animal diseases, such as Mad Cow Disease (BSE) and avian influenza. Thus, China's imports from the US, Japan, Korea and Western Europe were restricted to a considerable degree. For example, as early as 2001, due to the outbreak of BSE in Japan, the General Administration of Customs of the People's Republic of China (GACC) prohibited the import of related products from Japan, and the lifting of the ban was not announced until the end of 2019 (GACC, 2019).

From 2009 to 2014, China's animal-derived food import experienced rapid growth, quantity and price margins growth serving as determined forces. That is because the robust domestic demand simulates import quantities, and there have been a number of incidents here in domestic market, such as the poisoned milk powder incident in 2008 and lean meat powder incident in 2011. There incidents dented consumers' confidence badly, and more consumers turned to products imported from developed countries (Xie and Yang, 2013; Li et al., 2019). Wealthier countries export higher-quality products at moderately higher prices, driving up the growth of price margin (Lai et al., 2018; Aiginger, 2019).

After 2015, the growth of China's animal-derived food import has accelerated remarkably, with a slight decrease in the price margin. The average annual growth rate of the extensive margin reached 1.76%, contributing 13.76% to the import growth, indicating the expansion of new trading relationships and product varieties.

4.3 Bilateral Trade Analysis

We select the top 20 countries whose trade volume accounts for 86.28% of China's total animal-derived food imports for three-margin analysis, which probably reflects the overall situation. The results are shown in Table 3.

Table 3. Decomposition Results of Three Margin of Bilateral Trades

Import source countries	2002			2008			2018		
	EM	*P*	*Q*	*EM*	*P*	*Q*	*EM*	*P*	*Q*
New Zealand	0.8809	0.9112	0.0537	0.9001	0.8860	0.0554	0.9897	0.9595	0.2941
Brazil	0.7704	0.7129	0.0056	0.5184	0.8370	0.0011	0.8957	1.1283	0.1715
Australia	0.9234	0.9352	0.0177	0.9288	0.9502	0.0276	0.9683	1.0061	0.1940
US	0.8508	0.7890	0.0891	0.9373	0.9320	0.0903	0.9558	1.0566	0.0670
Russia	0.8274	0.6178	0.2481	0.7779	0.6527	0.1950	0.9113	1.0012	0.2846
Argentina	0.3592	0.8067	0.0701	0.5071	0.8546	0.0655	0.7498	0.9923	0.3329
Canada	0.7522	0.7134	0.0639	0.7489	1.0234	0.0443	0.9098	0.8384	0.1539
Uruguay	0.8419	0.8763	0.0217	0.6172	0.7507	0.0309	0.9407	0.9367	0.3685
Germany	0.6033	1.0235	0.0036	0.6559	1.3793	0.0023	0.6554	1.1256	0.0498
Denmark	0.5428	0.7132	0.0228	0.5609	1.0854	0.0366	0.7662	0.9930	0.0810
Spain	0.4039	1.0889	0.0161	0.5108	1.0940	0.0089	0.7635	0.9935	0.0635
Indonesia	0.7245	0.5134	0.0240	0.7898	0.7303	0.0222	0.9733	0.6678	0.1159
Netherlands	0.5005	0.6111	0.0082	0.5262	0.9491	0.0171	0.6518	0.9571	0.0417
Ecuador	0.3452	0.9825	0.0087	0.1321	1.2574	0.0006	0.7007	0.9356	0.1863
France	0.6191	1.2361	0.0074	0.7392	1.2986	0.0156	0.7868	1.0297	0.0527
Chile	0.5983	1.2247	0.0219	0.6413	2.4867	0.0082	0.9536	1.0535	0.0741
Vietnam	0.7965	0.3816	0.0250	0.9490	0.7095	0.0210	0.9314	0.9306	0.0821
Norway	0.8824	0.9167	0.0239	0.8996	0.9674	0.0336	0.9080	1.1899	0.0402
India	0.8132	0.5033	0.0817	0.8464	0.7919	0.0535	0.6218	0.6985	0.0968
Japan	0.9153	0.7323	0.1737	0.9409	0.7779	0.1596	0.8346	0.9168	0.1826

Source: Calculated by the authors based on data from the CEPII BACI databases.

Overall, China's animal-derived food import grows mainly along the quantity margin and price margin, with several countries' price margin exceeding one in 2018, indicating the average price of China's animal-derived food has exceeded the world's average price, while the contribution of the extensive margin is relatively small.

In addition, it can be found that the three margin of China's animal-derived food import growth is significantly heterogeneous between developed and developing countries. Therefore, we use kernel density distribution analysis to compare the three margins distribution of developed and developing countries in 2018. It should be noted that the results in **Hata! Başvuru kaynağı bulunamadı.** include all China's 111 trading partners in 2018 more than just the top 20 listed in Table 3.

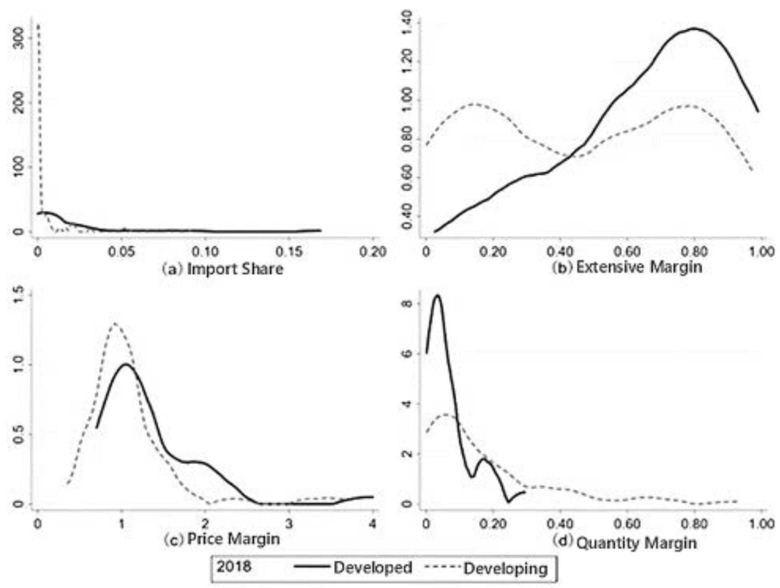

Figure 3. Comparisons of Three-Margin Shares Between Developed And Developing Countries In 2018

Hata! Başvuru kaynağı bulunamadı. reports the kernel density distribution analysis results: **Hata! Başvuru kaynağı bulunamadı.**The peak of the developed countries' share curve is on the right of developing countries', and the density closed to zero of developing countries' curve is higher. (b)Extensive margin distribution of developed countries' right tail is thicker, while developing countries' distribution curve is more dispersed, which means developed countries export a wider range of products to China. (c)Price margin distribution of developed countries is thicker and denser, indicating their prices are generally higher than those of developing countries. (d)Quantity margin distribution of developing countries is more skewed to right and the right tail is thicker, indicating that developing countries' animal-derived food export to China accounts for a higher proportion of their total exports in the world market. Obviously, it is because developed countries usually have more trading partners and a larger export scale.

4.4 Dynamic Analysis

In order to further identify the dynamic characteristics of the import growth on three margins and to check the robustness of our conclusions, we use a kernel density distribution method to analyze the data in 2002, 2008, 2014 and 2018, and the results are shown in Figure 4.

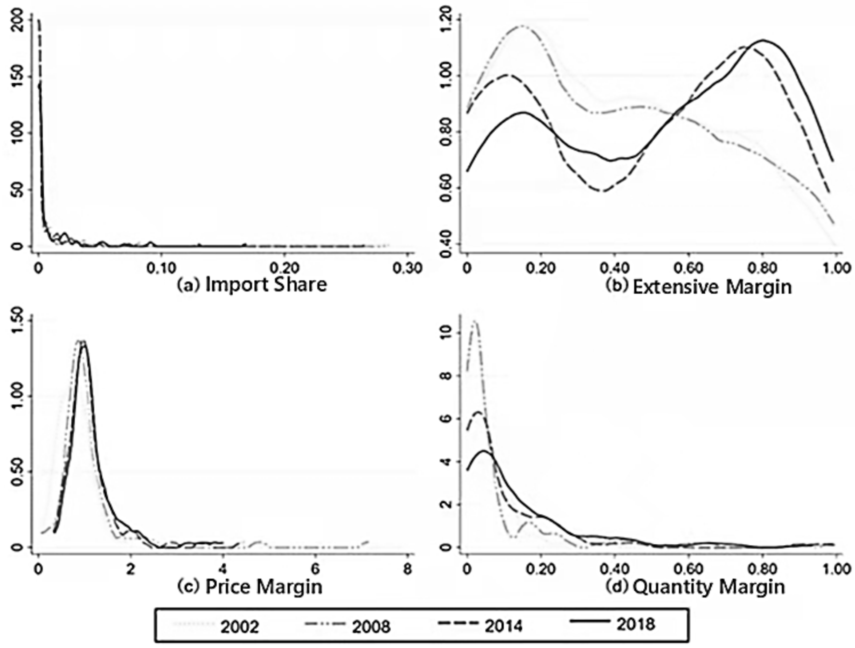

Figure 4. Kernel Density Distributions of China's Imports And Three Margins In Specific Years

The results show that: (a)From 2002 to 2018, the density of share distribution around the peak has reduced, the right tail slightly has thickened, and the density closed zero has increased significantly, implying that China's import share from each trading partner has increased, and the import sources have been more diversified. (b)The density on the right side of the extensive margin distribution has gradually increased, the right tail has become thicker, and the peak has shifted to right, indicating that China's import varieties from most trading partners have increased; meanwhile, the density on the left side of the distribution has decreased significantly after 2008. Combined with the previous analysis of the three-margin decomposition result on the bilateral trade level, there are good reasons to believe that the categories of products exported by developed countries to China still have great growth potential, and the density between 0 and 0.40 is still dense. (c)The peak of the price distribution has been constantly higher, but the density on both sides of the distribution curve has decreased and the right tail has been thicker, indicating that the price margin distribution curve has had an obvious upward trend from 2002 to 2014, with a slight decline in 2018. The price margin between China and some trading partners have exceeded the world average price level after 2008, though the proportion has been decreasing. (d)The right tail of the quantity margin distribution has become significantly thicker, suggesting that China's import of animal-derived food has been showing a trend of diversification.

Combining Figure 4 (a) and Figure 4 (d), it is found that quantity margin and import share's distribution characteristics and trends of the growth are consistent and almost perfectly overlap, thus it can be concluded that China's animal-derived food import is mainly driven by quantity margin, which is consistent with the analysis results in Table 1 and Table 2.

5. DISCUSSION AND CONCLUSION

China has experienced rapid trade growth since China joined the WTO in 2001. The paper has identified the main driving forces and characteristics of China's animal-derived food import growth. We follow the three-margin methodology to decompose the import growth into extensive, price and quantity margin, and present a series of empirical analyses using China's animal-derived food import data at the HS six-digit level from 2002 to 2018. It is found that: (1) China's animal-derived food import has expanded rapidly, and is mainly driven by quantity growth, which accounts for 70.12% of overall growth. (2) China's animal-derived food import sources have been highly concentrated, but there shows a trend of diversification. (3) Consumers' growing demand for variety, high quality and food safety is widening the gap between food supply and demand, which has contributed to driving the constantly growth of import trade. (4) There are huge differences between the bilateral-level three margins of developed and developing countries' export to China, which requires more attention in the follow-up studies. For these significant findings, the study, by establishing a three-margin framework, has enriched and elaborated the analysis in the role SPS measures play in animal-derived imports.

These conclusions have important policy implications for China. First, since quantity is the main driving factor for China's animal-derived food import growth, it requires China to produce large quantities to satisfy the domestic market's ever-growing demand. Second, the lack of growth in extensive margin means that China's import concentration has not fundamentally changed. Therefore, China's imports are overly dependent on specific products or partners, which are easily affected by external factors and are highly volatile. Promoting import diversification is critical to China's future import growth. Third, since price can substitute for quality to a certain extent in empirical work, it can be seen from these data that the rapid increase in China's import prices means that the demand for high-quality products is rising. Product quality is critical to competitiveness, and China should also improve its own product quality if it is to reduce its reliance on imports. How to improve product quality is also important for China's import security and endogenous economic growth. To conclude, China should transform from a quantity-driven to an extensive marginal-driven import, and at the same time vigorously develop high-tech agriculture, improve productivity, reduce agricultural risks, and ensure the quality and quantity of product supply. This is a task that poses a major challenge to both the government and companies.

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