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RESEARCH ARTICLE

Research on the export competitiveness of aquatic products and its influencing factors: A case study of Guangdong Province in China

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Abstract: Guangdong Province is a major producer of aquatic products in China, but its export has been lack of competitiveness. Based on data of aquatic products in Guangdong Province from 2009 to 2020, this paper analyzes the export competitiveness and influencing factors of aquatic products in Guangdong Province using an extended gravitational model and result show that production factor input and high-quality production management are the core factors to enhance the export competitiveness of aquatic products. The geographical distance of importing countries and GDP per capita have a significant positive impact; The impact of the fisheries industry and construction industry is significantly positive; Whether the exporting country is an APEC has a significant negative impact, indicating that the previous trade agreements have no effect on the improvement of the export competitiveness of aquatic products in Guangdong Province over time. It has no significant impact on fish breeding area, the number of processing enterprises above designated size and the openness of foreign trade. Reducing the density of aquaculture, increasing innovation, strengthening the supervision of aquatic products and improving the supporting facilities of related industries are important measures to improve the export competitiveness of aquatic products in Guangdong Province.

Keywords: aquatic products, export competitiveness, influencing factors, Gravitational model

1 Introduction

Aquatic products are an important source of food for human beings. In the face of the current Global COVID-19 epidemic and the risk of international trade uncertainty, China's food security problems are becoming increasingly prominent, so aquatic products, as one of the main categories of agricultural products, can not be ignored in China's food security. With the rapid development of the world economy, the scale and quality of people's consumption of aquatic products are also rising, which also promotes the development of trade between aquatic products among countries. Since its accession to the WTO, China has successively ranked first in the world in terms of aquatic products producing and exporting countries, ranking first in the world in terms of production and export scale, and its exports have increased significantly. As of 2020, China's total aquatic product exports reached US$19.041 billion, an average annual increase of 11.24% compared with US$6.07 billion in 2001.

Guangdong Province is rich with water resources and has a long history of aquaculture. In 2020, the total aquatic product value of Guangdong Province reached 160.879 billion yuan, accounting for about 11.90% of the total aquatic product value of the country, ranking second in the country, and the total output scale was also close to 8.76 million tons[data source 2021 China Fishery Statistics Yearbook], and ranked first in the country, it can be said that aquatic products in Guangdong Province occupy an important position in the production of aquatic products in various provinces in China. In addition, Guangdong Province is also the largest province in China's foreign trade, ranking first in the country in terms of total foreign trade over the years. However, in the face of such strong production advantages and geographical advantages, Guangdong aquatic products have not shown corresponding export competitive advantages. In 2020, Guangdong's foreign exports of aquatic products were only 538,000 tons, far less than Shandong (944,300 tons), Fujian (826,100 tons) and Liaoning (709,200 tons) in the same period, and the export value was the same. In addition, in recent years, the export of aquatic products in Guangdong Province has continued to be affected by Sino-US trade frictions. In 2018, the United States publicly imposed a 10% import tariff on tilapia and shrimp imported from China, of which tilapia and shrimp are the top three main varieties of aquatic products production and export in Guangdong Province, and the United States is also the main target market for aquatic products exports in Guangdong Province, thus causing a strong impact on aquaculture and export enterprises in Guangdong Province, coupled with the outbreak of the new crown

epidemic in 2020, the export volume of aquatic products in Guangdong Province continues to decrease, and the export competitiveness of aquatic products in Guangdong Province needs to be improved.

By constructing the panel data of aquatic product exports and their influencing factors in Guangdong Province from 2009 to 2020, this paper uses an extended gravitational model to explore the influence of five major factors in the diamond model, including production factors, demand, corporate strategy and competition, related and supporting industries, government policies and opportunities, on the direction and size of Guangdong Province's aquatic product export competitiveness, and puts forward the specific path of aquatic product export competitiveness improvement.

2 Literature review and research hypotheses

2.1 Research on the influencing factors of the export competitiveness of aquatic products

There are many studies on the influencing factors of aquatic product export competitiveness, including qualitative or quantitative analysis from the aspect of multi-factor influence, as well as detailed research on a specific influencing factor, and from the perspective of various influencing factors, this paper divides the influencing factors of aquatic product export competitiveness into external factors and internal factors.

From the perspective of external factors, Ligeon et al. (1996) [1] analyzed the impact of catfish exported by the United States on the domestic industry from the perspective of the domestic pangasius industry, and found that the impact was not significant. Fontagné et al. (2005) [2] pointed out that the technical trade barriers of importing countries have an important impact on the export trade and international competitiveness of a country's products. Zhang et al. (2018) [3] studied the influencing factors of the "Belt and Road" of aquatic products exports in Shandong Province by constructing a trade gravity model, and concluded that the GDP, per capita consumption expenditure, and whether or not an APEC member of the "Belt and Road" importing member countries had a significant positive impact on the export of aquatic products in Shandong Province, while the factors of import and export logistics time and distance with partner countries were significantly negative, indicating that logistics efficiency and distance cost had a serious inhibitory effect on aquatic product exports. Yang et al. (2021) [4] used the constant market share model to analyze the influencing factors of the export of cephalopod aquatic products, and found that the change in international market demand has an important impact on China's export of cephalopod aquatic products. In addition, international trade frictions, especially the Sino-US trade dispute arising during the Trump administration, have also had a certain negative impact on the export competitiveness of China's aquatic products [5].

From the perspective of internal factors, Wang et al. (2016) [6] analyzed the influencing factors of China's aquatic product export competitiveness from the aspects of aquatic product production, demand, development of related industries, business strategy and competitive pressure, opportunities and government role of aquatic products according to the five elements of the diamond model, and found that the production technology level of fishery, the domestic demand for aquatic product quality, the safety production and cost of fish feed, the degree of brand cultivation of enterprises, Intra-industry competition and some accidental events have a great impact on the export competitiveness of China's aquatic products. There are also many scholars who have studied related and supporting industries based on diamond model theory: for example, the higher the level of deep processing of a product, the higher the added value of its aquatic products, which also has a significant role in promoting the competitiveness of product exports [7]. In addition, Zhang Mei (2008) [8] analyzed the impact of aquatic product processing industry, and found that the improvement of the development scale of aquatic products processing industry can significantly promote the improvement of aquatic product export competitiveness, and the degree of influence is the first, followed by technical education, aquatic product safety testing and industrial agglomeration. In addition, the performance of the logistics sector, the level of brand and processing technology are also key factors affecting the competitiveness of aquatic products exports [9, 10]. In addition, the improvement of labor productivity and the use of agricultural biotechnology are also important factors in improving the competitiveness of product exports [11, 12]. A small number of scholars have proposed the influence of price and quality factors: regarding price factors, the higher the export price of aquatic products, the higher its economic added value and competitiveness can be improved [13]; Regarding quality factors, Wang et al. (2015) [14] found that a series of quality and safety events such as drug residues and heavy metal excesses in aquatic products in China are important factors affecting the export competitiveness of aquatic products.

2.2 Research on strategies for improving the competitiveness of aquatic products

Most of the research on export competitiveness improvement strategies are based on the "diamond" model as the theoretical framework, which is specifically manifested in terms of production factors, demand, corporate strategy and competition, related and supporting industries, government, and opportunities.

2.2.1 Factors of production

Production factors mainly include the natural environment such as geography and climatic conditions required for the production of products, as well as capital, human capital, and production infrastructure. Olin's factor endowment theory points out that when a country produces its products with resource endowment advantages, its production costs are often low, and its products can obtain price competitive advantages in the international market. The richness of resource factors often has an important impact on the competitiveness of products, such as Cai et al. (2018) [15] in the analysis of the influencing factors of China's aquatic products international competitiveness found that abundant labor force and the advantages of output scale can play a significant positive role in the competitiveness of China's aquatic products. In recent years, the impact of production factors on product competitiveness has also attracted much attention from academic circles. Xu et al. (2020) [16] also pointed out when analyzing the export situation of aquatic products in China, which has seriously squeezed the living space of aquatic products due to the decrease in the area of aquatic products year by year, resulting in a serious lack of competitiveness in the development of aquatic industry. In addition, the technical level of aquaculture, the cost of agricultural inputs, and the management aspects also have an important impact on the improvement of aquatic export competitiveness [17]. Teng et al. (2021) [17] believe that technological innovation should drive the development of the aquaculture industry to high quality, so as to increase the technical content of products and maintain competitive advantage. In addition, Shao et al. (2020) [18] also emphasized that improving aquatic infrastructure and improving the quality and technical level of managers are conducive to the improvement of aquatic product competitiveness, based on this, this paper puts forward a research hypothesis 1.

Hypothesis 1: When other conditions remain unchanged, increasing the input of production factors has a positive impact on the export competitiveness of aquatic products.

2.2.2 Demand side

The diamond model points out that demand factors mainly involve two aspects: domestic and foreign. The consumer demand in domestic and foreign markets will stimulate aquatic enterprises to continuously carry out technological innovation and change production methods, thereby improving the competitiveness level of aquatic products in the international market. Jiang et al. (2016) [19] believe that if the overall quality of the product is higher than the average quality of such products in the world, and the quality premium is achieved, it can indicate that the products of the country or region have export competitiveness, so it can improve the quality of domestic aquatic product demand, and then stimulate domestic aquatic production enterprises to improve product quality and improve export competitiveness through technological innovation. In addition, aquatic export enterprises should also get rid of the defect of simplification of export markets, and actively explore foreign markets and expand foreign demand by taking advantage of product diversification, informatization and sales channel diversification [20]. Generally speaking, the higher the level of economic development of a country's domestic and foreign importing countries, the stronger the consumption power of products, which is conducive to the improvement of product export competitiveness [21]. Regarding the impact of consumer demand in the domestic market, some scholars believe that the domestic consumers' demand for product quality will stimulate domestic production enterprises to actively improve product quality, and then promote the improvement of the export competitiveness of their products [22]. In contrast, the quality and safety standards of aquatic products in the international market, especially in developed regions, are often higher than those in China, so its higher quality standards will also affect the export of aquatic products in China and the competitiveness level in the market [23]. Based on this, this paper proposes a research hypothesis 2.

Hypothesis 2: When other conditions remain equal, the expansion of domestic and foreign consumer demand has a positive impact on the improvement of the competitiveness of aquatic exports.

2.2.3 Related and supporting industries

The export trade of aquatic products involves a series of industrial processes, and a perfect industrial chain will not only greatly reduce production costs, but also improve the quality of

aquatic products, thereby enhancing its export competitiveness. For example, fishery insurance and financial services related to aquatic product production will also profoundly affect their export competitive advantage [6]. Some scholars pointed out that the development level of international logistics also has a significant positive impact on the export of aquatic products, and the higher the level of logistics development, the lower the transportation cost, which is more conducive to the improvement of the price competitive advantage of aquatic products in the international market [3]. Based on Han (2014) [24], which believes that vigorous efforts should be made to develop the aquatic product processing industry, improve the level and efficiency of export logistics services, and improve the construction of logistics infrastructure, this paper puts forward a research hypothesis 3.

Hypothesis 3: When other conditions remain unchanged, the improvement of the development level of related and supported industries has a positive effect on the export competitiveness of aquatic products.

2.2.4 Corporate strategy and competition

Porter pointed out that the competition and business strategy of enterprises are important factors affecting the competitiveness of enterprises' products. Regarding corporate strategy, such as the brand strategy of enterprises often plays an important role in the improvement of product export competitiveness, enterprises with brand advantages often give priority to consumers in the international market, may also cause consumer loyalty, so as to have more competitive advantages than other products. Sun (2005) [22] shows that cultivate competitive key aquatic product export enterprises, increase business entities, improve the level of intra-industry competition, and force aquatic products enterprises to increase investment research on production factors, so as to continuously improve the competitiveness level of products. In addition, the competitive pressure from the same industry will continue to motivate enterprises to improve product quality, reduce costs, and thus have greater price competitive advantages in the international market [20], but this is in the long run, in the short term, the greater the competitive pressure of general enterprises, it may weaken the export competition of enterprises. Based on this, this paper proposes a research hypothesis 4.

Hypothesis 4: When other conditions remain unchanged, the competitive pressure of enterprises has a negative effect on the improvement of aquatic product export competitiveness.

2.2.5 Opportunities and government support

According to the theory of competitive advantage, in addition to the above four main factors, the competitive advantage of products is also affected by two auxiliary factors: government and opportunity. Cooperation and exchanges between countries, the signing of trade agreements, and the reduction of tariffs and non-tariff barriers may become competitive factors for the export of products from a country or region [25], including the role of the government. The government is mainly reflected in the policy support, legal protection and information platform construction of production enterprises, which is to assist the external development of enterprises, which is also a major competitive advantage for export enterprises in the international market [26]. The government should increase policy guidance and financial support for aquatic enterprises, cultivate professional aquatic technical personnel, assist enterprises to introduce advanced production and aquaculture technologies, and encourage private financing [26]. At the same time, Chen et al. (2018) [27] pointed out that the government should strengthen the quality supervision of aquatic products, including comprehensive quality control of the production, processing and transportation of aquatic products, and promote the quality of China's aquatic products to meet the testing standards of importing countries, so as to enhance the export competitiveness of aquatic products. Zhang et al. (2020) [13] believe that China's aquatic enterprises should fully seize the opportunity and actively expand exports to countries that have established free trade agreements with China, so as to obtain the competitive advantage of export products. Based on this, this paper proposes a research hypothesis 5.

Hypothesis 5: When other conditions remain equal, enterprises' grasp of opportunities and government support have a positive impact on the improvement of aquatic product export competitiveness.

3 Methodology

3.1 Model construction

The trade gravitational model is derived from the law of universal gravitation in physics, which was proposed by foreign economists Tingbergen and Poyhonen when studying international trade. Subsequently, after a large number of scholars expanded and applied it, and new variables were continuously introduced, the expanded gravitational model was formed, and the

analysis was more comprehensive and detailed, and the accuracy was constantly improving. The dependent variable of the trade gravity model is the total amount of exports, and the export amount can reflect the market share of a country's export of a commodity, which in turn can represent the level of export competitiveness of a country's products. In addition, the export of aquatic products is also greatly related to the export distance and the level of economic development abroad, so it is more appropriate to use the gravitational model. Therefore, this paper draws on Guo (2019) [28] research on the influencing factors of international competitiveness, introduces other factors affecting the export competitiveness of aquatic products on the basis of the gravitational model, and constructs an extended version of the gravitational model to analyze the influencing factors of aquatic product export competitiveness in Guangdong Province. The specific model equation is as follows:

$$\begin{aligned}\mathrm{LnEXP_{ijt}} = \beta_0 + \beta_1 \mathrm{LnSqua_{it}} + \beta_2 \mathrm{LnPri_{jt}} + \beta_3 \mathrm{LnPergdp_{jt}} + \beta_4 \mathrm{LnDis_{jt}} + \\ \beta_5 \mathrm{LnSecon_{it}} + \beta_6 \mathrm{LnNum_{it}} + \beta_7 \mathrm{t} \times \mathrm{APE} + \beta_8 \mathrm{LnOpen_{jt}} + \epsilon_{ij}\end{aligned}$$

Among them, EXPijt represents the total export of aquatic products from Guangdong Province to the export area, i represents Guangdong Province, j represents the export area, t represents the year, and $\beta 0 \sim \beta 8$ is the coefficient of each variable. Squait represents the aquaculture area in Guangdong Province; Priijt indicates the average export price of aquatic products exported by Guangdong Province in the J region; Pergdpjt represents GDP per capita in the T Year j region; Disjt indicates the distance between Guangdong Province and J region; Seconit indicates the output value of the fishery industry and construction industry in Guangdong Province; Numit indicated the number of aquatic product processing enterprises above designated size in Guangdong Province in t; APE indicates whether the exporting country is a member of the Asia-Pacific Economic Cooperation (APEC), and t*APE indicates the interaction of time trends with APE; Openjt indicates the openness of the export region J, and uij is the residual term. Regarding the selection of gravitational model indicators, it should be noted that: according to the research content of this paper, because the trade side is fixed as Guangdong Province, for other regions of export, the GDP value of Guangdong Province is fixed and therefore omitted. By taking the corresponding logarithm of each variable, the data can be smoothed and the situation of large difference in the magnitude of each variable can be eliminated, except for t×APE.

3.2 Sample selection

Based on the completeness and availability of sample data, this paper selects the data of Guangdong Province and its aquatic products exports from 20 major regions from 2009 to 2020, including the United States, Kenya, Canada, Indonesia, Australia, Italy, Mexico, Hong Kong, New Zealand, Japan, Macao, Malaysia,Republic of Côte d'Ivoire,Singapore, Thailand, Russia, Taiwan, Zambia, the Philippines and Chile. The total amount of aquatic products exports in Guangdong Province accounts for more than 85% of the total aquatic products exports of Guangdong Province over the years, and the data of these 20 countries are relatively complete and the sample representation is good.

3.3 Selection of indicators for variable measurement

The indicators of the variables in this paper are selected with reference to the five major influence levels in diamond model theory and the gravitational model. Based on the availability and completeness of the data, the explanatory variable in the empirical model in this paper is the export value of Guangdong Province to various countries, reflecting the size of export competitiveness [29]. A total of eight indicators of the selected influencing factor explanatory variables are shown in Table 1.

3.3.1 Measurement of production factors

In this paper, the aquaculture area (Squa) and the average export price of aquatic products (Pri) in Guangdong Province are selected. First of all, according to the special instructions of the "Central Document No. 1" in 2022: "To stabilize the aquaculture area and improve the quality of fishery development", it can be seen that the increase in aquaculture area will inevitably play a role in stabilizing the production and export of aquatic products, so its export competitiveness tends to be stronger. It is expected that the impact on the competitiveness of aquatic exports will be significantly positive. In addition, the average export price of aquatic products can reflect the technical content and added value of aquatic product production, and the higher the average export price, the higher the added value and better quality of the exported product, and therefore the higher the competitiveness level of the export product [30], and the expected impact is positive.

Table 1 Meaning and expected symbols of explanatory variables

Influencing factors	Indicator selection	Meaning	Theoretical description	Expected impact
Factor of production	$Squa_{it}$	t annual aquaculture area in Guangdong Province	The larger the aquaculture area, the more aquatic products can be exported and the stronger the export competitiveness	+
	Pri_{ijt}	Average price of aquatic products exported in j region of Guangdong Province	The higher the export price of aquatic products, the higher the product quality and the stronger the export competitiveness	+
Demand elements	$Pergdp_{jt}$	Export region j in t annual GDP per capita	The higher the per capita GDP of the exporting area, the better the economic development and the greater the demand for aquatic products	+
	Dis_{ijt}	The distance of Guangdong Province from each export area in t year	The closer the distance, the lower the cost, the more conducive to the export of aquatic products	–
Related and supporting industries	$Secon_{it}$	The output value of fishery industry and construction industry in Guangdong Province t year	The higher the development level of related industries, the more conducive it is to the development of the aquaculture industry and the enhancement of its competitive advantages	+
Competitive pressures on businesses	Num_{it}	The number of aquatic product processing enterprises above designated size in Guangdong Province	The greater the number of enterprises above designated size, the greater the competitive pressure of enterprises, which may improve competitiveness in the long run, but restrict exports in the short term	–

3.3.2 Demand element measurement

In this paper, the per capita GDP (Pergdp) and geographical distance (Dis) of the exporting countries of Guangdong Province reflect the influence of international demand, and these two factors are also the influencing factors included in the gravitational model. The per capita GDP of the exporting country can reflect the consumption capacity and level of the aquatic product exporting country, the higher the economic development level of the exporting country, the stronger the demand for aquatic products, so for the country with the higher the per capita GDP, the greater the competitive advantage of aquatic products export in Guangdong Province. The expected impact is positive. In addition, for the distance factor (Dis), this paper draws on the practice of Jiang et al. (2011) [31], uses the geographical distance between Guangzhou, the capital of Guangdong Province, and the capital of various countries (regions), and adjusts the weight of international crude oil prices. For countries closer to Guangdong Province, the transportation cost and preservation cost of aquatic products are low, so the higher the foreign demand, the stronger the export competitive advantage. The expected impact is negative.

3.3.3 Relevant and supporting industry measurement

This paper selects the Gross Domestic Product of Fishery Industry and Construction Industry (Secon) of Guangdong Province to reflect the development of related industries of the fishery industry, the higher the development level of the fishery industry and the construction industry, the more conducive it is to the production and development of the aquaculture industry, which in turn can enhance the export capacity of products and improve their export competitiveness. The expected impact is positive.

3.3.4 Intra-industry competition measurement

Since the influencing factors at the strategic level of enterprises are difficult to quantify, and based on the principle of data availability, this paper selects the number of processing enterprises above designated size (Num) of aquatic products enterprises in Guangdong Province as the index of enterprise competitive pressure, the main body of aquatic industry mainly includes production and processing industry, the more the number of aquatic product processing enterprises above designated size, the greater the competitive pressure in the same industry, and enterprises will be forced to improve the competitiveness level of products under competitive pressure. It is expected that the impact on the export competitiveness of aquatic products in Guangdong Province will be positive.

3.3.5 Measurement of opportunities and government support

Select whether it is the interaction item of APEC with time trend (t×APE) and the openness (Open) index of aquatic exporting countries. Drawing on the selection criteria of Dong et al. (2002) [31] and Jiang et al. (2011) [32], the product of the selection of APEC members and the time trend reflects the time when the exporting country becomes an APEC member, the longer the time, the closer the trade relationship, the more conducive to the export of products, so for the region that has been a member of the Asia-Pacific Economic Cooperation for a longer time,

Guangdong Province has a higher export competitiveness of aquatic products to the region. The expected impact is positive. In addition, the degree of openness of the importing country also has a greater impact on the export of products, which is equal to the proportion of total imports and exports to GDP. The higher the degree of openness of aquatic product importing countries, the more conducive it is to foreign trade, and the stronger the competitive advantage of products in this country [25]. It is expected that the impact on the export competitiveness of aquatic products in Guangdong Province will be significantly positive.

3.4 Data sources

The data of aquatic product exports, average export prices, per capita GDP of exporting countries, openness of exporting countries, international crude oil prices and whether it is a member of the Asia-Pacific Economic Cooperation in Guangdong Province from 2009 to 2020 are all from the national research network, and the aquaculture area, the number of aquatic product processing enterprises above designated size, fishery industry and construction industry in Guangdong Province over the years are all from the 2009-2020 China Fishery Statistics Yearbook. The geographical distance is calculated based on the distance calculator on the TimeandDate website.

4 Empirical analysis and discussion

4.1 Descriptive statistics, correlation analysis and multicollinearity testing of variables

4.1.1 Descriptive statistics of variables

Table 2 shows the statistical descriptions of the related variables.

Table 2 Statistical descriptions of variables

Variable	Number of Samples	Mean Value	Standard Deviation	Minimum	Maximum
Lnexp	240	17.476	1.937	7.631	20.639
LnSqua	240	13.189	0.082	13.068	13.262
LnPri	240	-0.556	0.725	-5.233	2.480
LnPergdp	240	9.552	1.325	6.879	11.449
LnDis	240	12.463	1.472	8.391	14.534
LnSecon	240	15.091	0.131	14.863	15.295
LnNum	240	4.988	0.082	4.852	5.182
t*APE	240	17.200	11.728	0.000	56.000
LnOpen	240	-0.556	0.724	-1.694	1.435

4.1.2 Correlation analysis

The correlation test of each variable data in this paper (see Table 3) by stata 15.1 shows that the dependent variable has a strong correlation with the selected 8 independent variables, which indicates that the regression in this paper has certain significance and can be further explained by regression.

Table 3 Correlation analysis of variables

Variable	LnExp	LnSqua	LnPri	LnPergdp	LnDis	LnSecon	LnNum	t*APE	LnOpen
LnExp	1.000								
LnSqua	-0.192 ***	1.000							
	0.003								
LnPri	0.378 ***	-0.032	1.000						
	0.000	0.618							
LnPergdp	0.419 ***	-0.033	0.490 ***	1.000					
	0.000	0.608	0.000						
LnDis	-0.285 ***	0.120	-0.026	-0.248***	1.000				
	0.000	0.064	0.685	0.000					
LnSecon	0.248 ***	-0.646 ***	0.202 ***	0.055	-0.075	1.000			
	0.000	0.000	0.002	0.399	0.246				
LnNum	0.200 ***	-0.897 ***	0.039	0.026	-0.152**	0.666 ***	1.000		
	0.002	0.000	0.544	0.686	0.018	0.000			
t*APE	0.493 ***	-0.172 ***	0.464 ***	0.371***	-0.114	0.183***	0.178*	1.000	
	0.000	0.007	0.000	0.000	0.077	0.005	0.086		
Variable	LnExp	LnSqua	LnPri	LnPergdp	LnDis	LnSecon	LnNum	t*APE	LnOpen
LnOpen	0.138 **	0.513	0.023	0.016	-0.334***	-0.032	-0.057	0.246 ***	1.000
	0.033	0.429	0.723	0.805	0.000	0.624	0.377	0.000	

Note: *, **, *** represent significance test levels of 10%, 5% and 1%, respectively

4.1.3 Multicollinearity test

As shown in Table 4, the multicollinearity test results show that the mean variance inflation factor for all independent variables is 2.51, which is much less than 10. Therefore, there is no serious collinearity problem between the independent variables of this model, and further regression analysis can be performed.

Table 4 Multicollinearity test results

Variable	VIF	1/VIF
LnSqua	5.29	0.19
LnNum	5.63	0.18
LnPri	1.62	0.62
LnSecon	1.96	0.51
t*APE	1.50	0.67
LnPergdp	1.51	0.66
LnOpen	1.26	0.79
LnDis	1.28	0.78
Mean VIF	2.51	–

4.2 Analysis of empirical results

The extended gravitational model was tested for F, LM and hausman tests using Stata 15.1 software. For the panel data model, the first is the mixed effects test, and the results show that the model has individual effects, that is, the rejection of mixed regression, and the second step is the individual random effects and mixed regression selection of the model, and the P value is 0.000, which also significantly rejects mixed regression. Further is the random-effects test for individual effects, where the P-value is still 0.000, indicating that the model strongly rejects random effects and should choose fixed effects. Therefore, a fixed effect was selected for final regression of the model, and the results are shown in Table 5.

Table 5 Fixed-effect regression results

Variable	Coefficient	Standard deviation	t-value	P-value
LnSqua	-1.313	1.734	0.760	0.450
LnPri	0.221*	0.128	1.730	0.085
LnPergdp	2.792***	0.657	4.250	0.000
LnDis	-0.939***	0.316	-2.970	0.003
LnSecon	3.264***	0.810	4.030	0.000
LnNum	1.533	1.704	0.900	0.369
t*APE	-0.205***	0.038	-5.470	0.000
LnOpen	0.762	0.753	1.010	0.313

Note: *, **, *** indicate significance test levels of 10%, 5% and 1%, respectively

Based on the above regression results, it can be further explained as follows:

First, the impact of aquaculture area on its export competitiveness is negative and insignificant, which is not in line with theoretical expectations. However, the average export price of aquatic products has a significant positive impact on the export competitiveness of Guangdong Province, and has passed the significance test level of 10%, which is in line with expectations. The possible reason is that the increase in aquaculture area has not changed the production mode of aquatic enterprises in Guangdong Province, and it still maintains an extensive traditional production mode, lacking technology and quality improvement, so its export competitiveness cannot be improved. Specifically: on the one hand, Guangdong Province is also a large consumption province of aquatic products, with a large population, a high demand for aquatic products, and domestic food safety supervision is far less stringent than that exported abroad, so most of the aquatic products produced by local aquatic enterprises tend to be sold to the province or other parts of the country. Due to the low food safety testing standards of aquatic products in the province, the high export costs, insufficient profits, and even the risk of being returned by customs, many aquatic products enterprises in the province are reluctant to export abroad, resulting in the export of aquatic products in Guangdong Province has not made substantial progress. However, for every 1% increase in the average export price of aquatic products, the export value of aquatic products from Guangdong Province also increased by 0.22%. This shows that the higher the export price of aquatic products, the added value and quality of export products can be improved, and then it can occupy more overseas markets, and the export competitive advantage can also be enhanced. At present, Guangdong Province's aquatic products are still dominated by primary production factors, mainly frozen fish and frozen fish fillets with low added value and low price, and the export competitiveness of aquatic products is

gradually decreasing, so Guangdong Province should continuously improve its export added value and cultivate high-level production factors, so as to increase the price of export products and win competitive advantage. Hypothesis 1 is partially validated.

Second, the per capita GDP of the exporting country has a significant positive relationship with the export competitiveness of aquatic products in Guangdong Province, and the geographical distance of the exporting country has a significant inverse relationship with the export competitiveness of aquatic products in Guangdong Province, which is in line with theoretical expectations. Every 1% increase in the per capita GDP value of Guangdong aquatic product exporting countries can increase the export value of aquatic products in Guangdong Province by 2.79%. The higher the economic development level of the aquatic products importing countries in Guangdong Province, the stronger the desire for consumer demand for aquatic products, which will also expand the import value of aquatic products. With the continuous development of the economy, the demand for aquatic products in the international market will be increasing, but at the same time, the quality standards for aquatic products demand are getting higher and higher, therefore, Guangdong Province should actively expand the aquatic products market of overseas developed countries, and at the same time enhance the concept of innovative development and continuously improve product quality, so as to continue to maintain a competitive advantage in the international market. The geographical distance of the exporting country has a significant inverse relationship with the export competitiveness of aquatic products in Guangdong Province, and it has passed the significance test level of 5%. For every 1% increase in geographical distance between Guangdong Province and exporting countries, the level of competitiveness of aquatic products exports decreased by 0.94%. The longer the trade transportation distance means the higher the cost of transportation of the product, the longer the time, and for aquatic products such perishable, deteriorated products, especially the export of aquatic products in Guangdong Province is mostly fresh fish, shrimp-based, the processing industry is underdeveloped, in the long-distance transportation, the higher the requirements for preservation technology, so for countries that are far away, the export competitiveness of aquatic products in Guangdong Province is often low. Hypothesis 2 is validated.

Third, the output value of fishery industry and construction industry has a significant positive impact on the export competitiveness of aquatic products in Guangdong Province, and has passed the significance test level of 1%. The empirical results show that for every 1% increase in the output value of the fishery industry and construction, the export value of Guangdong Province increased by 3.26%. This shows that the development level of fishery-related industries plays an important role in improving the competitiveness of aquatic exports. In addition, Guangdong's fishery industry and construction industry are still far behind other large fishing provinces. Although Guangdong Province ranked first in fishery production in 2020, the output value of its fishery industry and construction industry was only 43.915 billion yuan. Far less than Shandong (140.667 billion yuan) and Fujian (112.787 billion yuan), which shows that the low level of development of relevant industries in Guangdong Province is also an important aspect that restricts its export competition, so Guangdong Province should pay full attention to this factor to improve the development level of its fishery industry and construction industry, so that the export competitiveness of its fishery industry can be improved. Hypothesis 3 is validated.

Fourth, the number of aquatic product processing enterprises above designated size has a positive impact on the export competitiveness of aquatic products in Guangdong Province, but the results are not significant, which may be because the number of aquatic product processing enterprises in Guangdong Province is still small, and the traditional extensive processing mode is still maintained, although there is a slight increase in scale, but it is still unable to enhance the export competitiveness of aquatic products in Guangdong Province as a whole. Specifically, as shown in Table 6, from 2016 to 2020, the average number of aquatic product processing enterprises above designated size in Guangdong Province was only 178, far less than other major fishery provinces in China, although the number of aquatic scale enterprises in Guangdong Province in the past five years has maintained an overall upward trend, but the increase is small, and the average annual increase of only 3 aquatic product scale enterprises, so the improvement of the competitiveness of aquatic products export in Guangdong Province is not significant. Therefore, although the output and output value of aquatic products in Guangdong Province are relatively high, the number of large-scale processing enterprises that can really support their export in the international market is small, and the competitive pressure between the overall enterprises is naturally small, which makes it difficult for Guangdong Province's aquatic products to have strong competitiveness in the international market. Hypothesis 4 is not validated.

Fifth, whether it is a member of the Asia-Pacific Economic Cooperation (APEC) has a significant negative impact on the export competitiveness of aquatic products in Guangdong Province and has passed the significance test of 1%, which is contrary to theoretical expectations.

Table 6 Number of aquatic product processing enterprises above designated size in Guangdong Province and major coastal provinces (units)

Region	2016	2017	2018	2019	2020	Average value
Guangdong	145	163	156	166	178	162
Shandong	657	575	547	548	520	569
Fujian	406	400	401	403	387	399
Zhejiang	281	276	261	247	288	271
Liaoning	375	369	320	335	316	343

Source: China Fishery Statistics Yearbook 2017-2021

The coefficient of whether it is a member of APEC is significantly negative, which means that the role of APEC in promoting bilateral trade will gradually decline over time. The possible reason for this is that regional economic cooperation can indeed achieve trade facilitation and liberalization to a certain extent, but at the same time, with the accumulation of time, the trade potential of the two sides is gradually tapped, so that the space for improvement in aquatic product trade is gradually reduced, and the export competitiveness is gradually weakened. Therefore, Guangdong Province should strengthen its grasp of the latest trade agreement opportunities and proactively adjust its target export markets, so as to play its role in promoting the competitiveness of aquatic products exports. The openness of exporting countries has no significant impact on the export competitiveness of aquatic products in Guangdong Province, which is inconsistent with theoretical expectations. The degree of openness reflects a country's trade policy, the higher the trade volume, the higher its degree of openness, the theoretical more conducive to the export of aquatic products in Guangdong Province, but the empirical results are not consistent, the reason may be that with the rapid development of the world economy, although the degree of openness of the world to the outside world has gradually increased, and aquatic products as a large category of agricultural products, play an important role in their own food security, so countries will also formulate corresponding trade protection measures according to the development of their own aquatic enterprises, etc. Therefore, the more open the country, the stronger the import demand for imported aquatic products. Hypothesis 5 is not validated.

5 Conclusions and recommendations

This study uses the relevant data of aquatic products in Guangdong Province from 2009 to 2020, and uses the extended gravity model to conduct an empirical study on the export competitiveness of aquatic products in Guangdong Province and its influencing factors. The research results show that, first, the average aquaculture area and export. The regression results of prices comprehensively show that the input of modern advanced production factors and high-quality aquatic product production are the core elements to enhance the competitiveness of aquatic product exports in Guangdong Province; second, the geographical distance of importing countries and the regression results of per capita GDP are significant, It shows that countries with closer distances and higher levels of economic development have greater import demand for aquatic products in Guangdong Province. Therefore, the distance and economic level of importing countries are also important factors for the export competitiveness of aquatic products in Guangdong Province; third, fishery industry and The impact of the construction industry is significantly positive, reflecting that the higher the degree of fishery support industry development, the stronger the promotion effect on the competitiveness of aquatic product exports; fourth, the number of processing enterprises above designated size is not significant in the regression results, which may be due to the fact that Guangdong Province has There are few aquatic product processing enterprises with a certain scale in the past, which is not enough to promote the improvement of aquatic product export competitiveness; fifth, the impact of whether the exporting country is Asia-Pacific Economic Cooperation is significantly negative, indicating that over time, previous trade agreements have a negative impact on The improvement of Guangdong's aquatic product export competitiveness has no effect; sixth, the trade openness of importing countries has no significant impact on the improvement of Guangdong's aquatic product export competitiveness. Based on the above research conclusions, this paper puts forward the following countermeasures and suggestions.

First, reduce the breeding density, increase innovation and improve the quality of aquatic products. The empirical results show that the traditional primary production factors are no longer enough to support the further improvement of the export competitiveness of aquatic products in Guangdong Province. Only by producing high-quality products can the core competitiveness of aquatic product exports be re-established. Over the years, the export of aquatic products in Guangdong Province is still mainly based on the production of primary factors. Although the

production and export scale advantages are large, the quality of exported aquatic products is low and insufficient, which leads to its low level of competitiveness in the international market. Therefore, aquatic products enterprises in Guangdong Province should optimize the input of production factors, reduce the density of aquaculture, and increase the development space of aquatic products.

Second, strengthen the safety supervision of aquatic products and enhance consumers' food safety awareness. Improving the production quality of aquatic products is inseparable from the guidance and supervision of the government and relevant departments. Due to the current domestic food safety testing standards for aquatic products are generally low, and consumers do not pay enough attention to the consumption safety of aquatic products, resulting in irregular farming in most aquatic enterprises in Guangdong Province, and fishery drugs often exceed the standard. In contrast, foreign countries, especially the developed regions where Guangdong's aquatic products are mainly exported, have extremely strict safety testing standards for aquatic products, which also makes it difficult for most aquatic products in Guangdong to pass customs and cause losses. Therefore, the Guangdong provincial government should increase the safety supervision of the entire aquatic industry, actively call on consumers to enhance their awareness of aquatic product safety consumption, and improve the demand quality of aquatic products in the province. its market competitiveness.

Third, improve related industrial facilities and promote the upgrading of the aquatic industry chain. The empirical analysis shows that the improvement of the development level of related industries in the aquatic industry has a significant role in promoting the export competitiveness of aquatic products in Guangdong Province. Through the improvement of supporting industries related to aquatic products, the upgrading of the entire upstream, midstream and downstream industrial chains of the entire aquatic industry will be promoted, which will play an important role in promoting the production, export and competitiveness of aquatic products. First, innovate fishery insurance related to aquatic products. As an important supporting industry for aquatic product production, fishery insurance also plays an important role in improving its export competitiveness, such as climate index insurance, cost index insurance and fish feed price index insurance for aquatic products. In particular, fishery feed price index insurance, whose feed ingredients mainly include corn and soybean meal, has a relatively high risk for its frequent price fluctuations, and fishery insurance can effectively reduce production risks. Secondly, vigorously develop the aquatic product processing industry and support leading processing enterprises to become bigger and stronger. Guangdong Province should increase investment in research and development, actively explore deep processing technologies, and increase the long-term transportation and preservation period and added value of aquatic products, thereby enhancing its export competitiveness. At the same time, the government should actively help aquatic enterprises to expand financing channels, guide various types of capital to invest in the fishery industry, and adopt favorable policies to lower interest rates for enterprises and loans, so as to promote enterprises to expand their operations, gradually get rid of government financial subsidies and policy dependence, and then promote the export of aquatic products high-quality development. Finally, actively promote the construction of fishery industry and construction industry. Based on the analysis of empirical results, it can be seen that the development level of fishery industry and construction industry in Guangdong Province is low, and it has a significant positive impact on the competitiveness of aquatic product exports. Therefore, Guangdong Province should increase investment in fishery industry and construction industry, including The investment in fishing equipment, fishery medicine and fishery feed will comprehensively improve its industrial development level, which in turn is conducive to the improvement of Guangdong's fishery competitiveness.

Fourth, actively integrate into regional free trade zones and expand market space. Although the empirical results show that opening to the outside world and joining the OECD did not improve the export competitiveness of Guangdong's aquatic products, but with the full implementation of RCEP, it will greatly promote the trade of countries in the region. Guangdong Province must actively take advantage of its endowment advantages of a large aquatic province and rich water resources, actively expand the regional market to continuously improve the competitiveness of aquatic products.

Author contributions

Conceptualization: Li Huang and Youdong Chen;
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Conflicts of Interest

The authors declare no conflict of interest.

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Data availability statement

The data used by this study are publicly available at https://www.drcnet.com.cn/www/int were accessed and downloaded in December 2021.

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