Analysis on Factors Affecting the Aquatic Product Price based on Stepwise Multiple Linear Regression Model

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Abstract—Based on the panel data of 29 provinces in China from 2017 to 2019, a multiple linear regression model is established. It uses the stepwise regression method to analyze the factors that affect aquatic product price. The result shows that the refrigeration capacity of aquatic cold storage, the number of cold chain logistics enterprises and vehicles, the number of aquatic seedlings, the output of aquatic products, the processing capacity of aquatic products, the price of substitutes and coastal factors have a positive correlation with aquatic price. The negative correlation variables include cold storage capacity, ice-making capacity, freezing capacity, urbanization level and residents' income level. The study is meaningful to balance between the supply and demand of aquatic products and promote the construction of cold chain infrastructure.

Keywords-Aquatic product price; Cold chain infrastructure; Factors analysis.

1 INTRODUCTION

China is rich in fishery resources, and the output of aquatic products is the first in the world for 32 consecutive years. In recent years, with the rapid development of Chinese economy, resident's food consumption demand is developing towards the stage of personalized demand. At the same time, the level of urbanization and the fresh e-commerce have grown rapidly in China. Compared with general food, the spatial distribution of aquatic products varies greatly and the demand for freshness is high, so the requirements for cold chain logistics are also higher. In recent years, due to the huge market demand and strong government support, the construction of cold chain infrastructure in China has developed rapidly. The report of China Cold Chain Logistics Association shows that China's cold chain logistics market grows at a rate of 15% every year, and it is expected that the cold chain logistics market will reach 550 billion yuan in 2024. [1] China's per capita cold storage capacity rose from 272.08 to 432.31 tons per million between 2015 and 2019, according to the *China Cold Chain Logistics Development Report (2020)*. Although Chinese cold chain infrastructure has been greatly improved, there are still many problems such as prominent structural contradictions.

Under the rapid growth of aquatic products production and consumer demand, it's vital to explore the influencing factors of aquatic price for promoting supply and demand balance of them, building a better cold chain infrastructure and realizing the optimal allocation of fishery resources.

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At present, domestic scholars, mainly focus on the research and analysis of aquatic price from a macro perspective. Wang and Tian (2009) used the elasticity model to measure the income elasticity of demand for aquatic products, and concluded that with the increase of disposable income, the demand for them in the urban area is strong. [2] Zhu Jianzhen and Liu Hanbin (2012) used ARCH model to analyze the price fluctuation of aquatic products in China market, and found that the price fluctuation of them had leverage effect. [3] Duan Qingling and Zhang Lei (2017) proposed a prediction model based on time series GA-SVR, which realized a more accurate prediction of aquatic price. [4] Based on the panel data of 30 provinces in China from 1995 to 2014, Huang Qiaolong et al. (2018) used Moran's I index and Moran scatter plot to analyze the spatial and temporal characteristics of price fluctuations in the Chinese market and concluded that there was a diffusion effect in the regional aquatic product price market. [5] Yang Chenxing et al. (2021) predicted Chinese aquatic product consumption price index based on SARIMA model and better revealed the seasonality and trend of it. [6]

After reviewing the existing studies, it's found that there have been abundant achievements on the influencing factors of aquatic price, but the relevant research still has some shortcomings: they mainly focus on the consumption side, and ignore the production and circulation links; they mainly focus on macro indicators, ignoring the impact of micro factors aquatic price. Therefore, the paper will quantitatively analyze the influencing factors of aquatic price by constructing a multiple linear regression model and using the panel data of 29 provinces in China to further explore the specific transmission mechanism of each factor.

2 THEORETICAL ANALYSIS

Based on the existing research results and combined with development of aquatic products in recent years, the study will mainly discuss the impact of cold chain infrastructure on aquatic price, and control it from two aspects of supply and demand. The main factors are as follows (see Figure 1.).

From the cold chain infrastructure construction situation. Cold storage mainly provides ultra-low temperature environment to store products, breaks the time limit, and promotes the supply and demand balance in off-peak season. By speeding up the circulation of products, cold chain vehicles have realized cross-regional sales, broken space constraints and promoted regional supply and demand

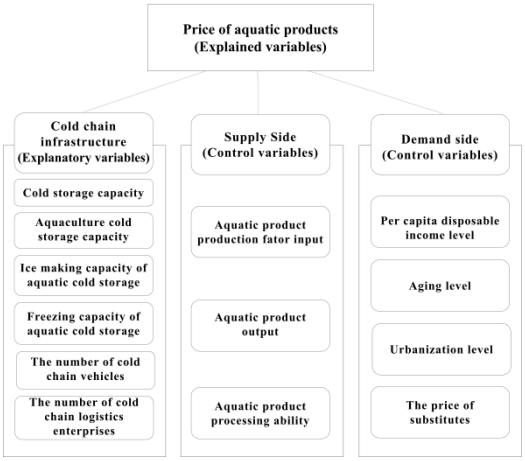

Figure 1. Relationship diagram of factors affecting aquatic product price

balance of products. Cold chain logistics enterprises have laid a vital foundation for the ultimate value appreciation of products by providing more perfect sales services and wider radiation range.

From the supply side of aquatic products. Product supply is closely related to product production factor input status, processing capacity and output. The number of aquatic seedlings and aquaculture area are key indicators for the input of production factors. The more inputs for both, the greater the yield, thereby increasing the market supply of products and ultimately transferring it to the price. The added value of products is improved by processing, which can directly improve the price. The yield of products is a key factor affecting aquatic price.

From the demand side of aquatic products. The impact of socio-economic environment of aquatic price are mainly income level, population structure, urbanization level and the price of substitutes. The consumption of aquatic products is in the middle and high level. With the improvement of residents' consumption level, the share of aquatic consumption expenditure in total household consumption food expenditure has increased. [7] Population aging has become the China's basic national condition. The elderly will become a vital group of aquatic product consumption. A series of measures such as the improvement of social security system are helpful to accelerate the level of urbanization and promote consumption demand of aquatic products in China. Besides, livestock and poultry meat as a substitute for aquatic products, its price will affect aquatic price.

3 VARIABLE SELECTION

According to the above brief analysis, the paper believes that the factors affect aquatic price may include: cold storage capacity (sc), aquaculture cold storage capacity (csc), ice making capacity (imc), freezing capacity (fc), the number of cold chain vehicles (nv) and cold chain logistics enterprises (nc), number of aquatic seedlings (ns), aquaculture area (fa), processing capacity of aquatic products (pap), output of aquatic products (oap), per capita disposable

income (pcdi), aging level (pep), urbanization level (ul), price of substitutes (pm) and coastal factors (wco).

Aquatic price is affected by many factors and the influence mechanism of each factor is also different. The paper mainly establishes a multiple linear regression model to analyze the influencing factors of price. The price index in 2019 is used as the explained variable, select the following indicators (see TABLE 1) as explanatory variables to analyze the impact of aquatic price. In order to test the robustness of the model, the CPI of aquatic products is calculated with 2017 and 2016 as the base periods.

The data selected in this paper are mainly cross-sectional data, it's easy to find that heteroscedasticity causes the model results to be unreliable. So, in addition to retaining the original data, the paper also takes the above variables logarithmic regression analysis. Besides, considering the calculation method of CPI value, this paper also takes the ratio of each variable in 2019 to 2018.

4 MODEL BUILDING AND EMPIRICAL ANALYSIS

4.1Model form

Multivariate linear regression analysis is a classical method of statistical analysis, which uses the method of quantitative statistics to study multivariate (multi-index) problems. The paper selects appropriate variables to construct multiple linear regression model to analyze the influencing factors and influencing mechanism of price. Selected provinces (Xinjiang, Tibet, Hong Kong, Taiwan, Macao, not included for missing data) respectively aquatic price index as explained variable, select 15 factors as explanatory variables to build the model:

$$Y_i = X_i\beta + \varepsilon_i$$

The models containing all variables are M1, M2 and M3. In order to weaken the influence of heteroscedasticity on the model, the paper also selects all variables except pep, ul, pm and wco in 2019 as explanatory variables to construct logarithmic models M4, M5 and M6. The product price index is the explanatory variable, and the ratio of 2019 to 2018 data of all explanatory variables except the variable wco are selected as the explanatory variable to construct the ratio model M7.

4.2Model estimation and test

With the aquatic product price index in 2019 as the dependent variable, the original value of the independent variable is used for regression analysis to obtain M1, the logarithm of the independent variable is used to obtain M2, and the ratio of the independent variable is used to obtain M3. In order to test the robustness of the model, the CPI base period of aquatic products in 2018 is adjusted to 2017 (that is, the price index of aquatic products in 2017 is 100) to replace the dependent variable. The original value and ratio of independent variables are used to obtain M4 and M5, respectively. The base period of aquatic products in 2017 is adjusted to 2016. The original value and ratio of independent variables are used to obtain M6 and M7. All models use "stepwise regression" to select variables. Finally, the model M1, M2, M3, M4, M5, M6, M7 heteroscedasticity test, the results are shown in TABLE 1.

TABLE 1. SUMMARY OF MODEL RESULTS

		M1	M2	M3	M4	M5	M6	M7
Nobs		29	29	29	29	29	29	26
Adjusted R^2		0.367	0.265	0.351	0.21	0.162	0.323	0.631
AIC		113.402	143.809	140.859	117.113	147.632	142.109	88.472
P-value		0.021	0.031	0.009	0.046	0.105	0.014	<0.001
Intercept		102.835*** (-2.950)	105.951*** (1.837)	101.942*** (1.975)	92.881*** (-4.196)	85.588*** (7.542)	90.973*** (6.857)	168.941*** (-27.386)
Explained variable		price1	price2	price3	price1	price2	price3	price1
Explanatory variables	sc/scr/scln	-1.880*** (0.616)	-2.016*** (0.937)	-	-2.158** (0.933)	-3.837** (1.707)	-3.585** (1.552)	-
	csc/cscln/cscr	-	0.005* (0.003)	0.012** (0.005)	-	0.694 (0.407)	0.859** (0.370)	-
	imc/imcln/imcr	-	-	-0.192* (0.106)	-	-	-	-
	fc/fcln/fcr	-	-	-0.018 (0.010)	-0.278 (-0.178)	-0.921** (-0.421)	-0.912** (0.383)	-
	nc/ncln/ncr	-	-	-	1.978* (1.107)	4.033** (1.923)	3.621** (1.749)	2.775** (1.099)
	nv/nvln/nvr	0.940*** (0.308)	1.587** (0.607)	-	-	-	-	1.261* (0.703)
	ns/nsln/nsr	0.004 (0.003)	-	0.014** (0.005)	-	-	-	-
	oap/oapln/oapr	-	-	-	0.935** (0.347)	1.148* (0.580)	1.211** (0.527)	15.848*** (4.256)
	pap/papln/papr	0.006* (0.004)	-	-	-	-	-	-7.130*** (1.650)
	ul/ulr	-11.727*** (4.401)	-	-	-	-	-	-94.032*** (-28.631)
	pcdi/pcdiln/pcdir	-	-1.849** (0.667)	-	-	-	-	-
	pm/pmr	0.063 (0.050)	-	0.119 (0.074)	-	-	-	10.140*** (2.889)
	wco	2.869** (1.069)	5.074*** (1.716)	-	-	-	-	-
P-value (BP test)		0.494	0.705	0.607	0.990	0.517	0.692	0.321
GlobalStat		0.656	8.800	3.556	7.108	3.554	6.075	1.224

Note: a) t value in parentheses. * * *, * *, * and · represent significant aboriginality in 99.9 %, 99 %, 95% and 90% confidence intervals, respectively; b) Using gvlma () function to calculate GlobalStat value to test whether the OLS assumption is satisfied; c) Using the vif () function to calculate the variance expansion factor to test whether there is multicollinearity; d)Using BP test () function for heteroscedasticity test; 6)Shanxi Province, Gansu Province and Qinghai Province not included in M7 due to the lack of data.

4.3Analysis of model results

Overall, the quality of model M1, M3, M4, M6 and M7 is better, which can more accurately reflect and analyze the influence mechanism of various factors on aquatic price.

First, all indicators for cold chain infrastructure construction correlate with aquatic price.

Cold storage capacity shows a negative correlation with aquatic price. In Model M1, the price index decreases by 1.88 for every 1 million ton increase in cold storage capacity. Aquatic products have the characteristics of seasonality and regionality. The increase of cold storage capacity can prolong the sales cycle and realize cross-season sales, so as to ensure the supply and demand balance of products in the off-peak season and meet the market demand. [8]

Aquatic price increases with the improvement of refrigeration capacity of aquatic cold storage. It is a key indicator to measure the technical level of cold storage. When the technical level is higher, the construction cost of the cold storage is higher, and finally increase aquatic price.

Ice-making capacity and freezing capacity of aquatic cold storage shows a negative correlation with price. The higher the ice-making capacity and freezing capacity are, the stronger the storage and preservation ability of cold storage is. Cold storage can not only ensure the quality of products, but also put products into the market, according to the supply and demand situation, meet the strong consumer demand of products and reduce price.

The more cold chain vehicles, the higher aquatic price. Due to the high circulation loss rate of aquatic products, it's vital to ensure that they are always in an ultra-low temperature environment during transportation. However, the high operating costs of cold chain vehicles determine that the cost of using them is higher than other modes of transport, and ultimately increase aquatic price. In addition, the use of cold chain vehicle transport could reduce the transit time to ensure that products have better sales conditions and easier to sell high prices in the terminal market.

The more cold chain logistics enterprises, the higher aquatic price. They will affect price from the following aspects. First, act as the intermediary of product value realization. The enterprises could realize the time-space migration of products and promote the realization of value. Secondly, promote aquatic products to achieve maximum value. The enterprises promote the transfer of products from low value areas to high value areas, which is conducive to maximizing the value of products. Finally, help aquatic products to achieve value added. The enterprises help products to achieve secondary circulation and processing to improve the added value, and ultimately raise prices.

Second, the more aquatic seedlings, the higher aquatic price. In the model M3, price index will increase by 0.014 for every 100 billion increases in the number of aquatic seedlings. Theoretically, the increase of aquatic seedlings will directly raise the yield of aquaculture, thereby increasing the market supply and ultimately reducing price. The main reason for the deviation theory and reality may be that the scale efficiency of aquaculture in China has not reached effectively (scale efficiency < 1) the proportion of provinces is 70.97%. Most provinces have not achieved optimal scale production. [9]

There is no significant correlation between aquaculture area and aquatic price. Theoretically, the expansion of aquaculture area will directly increase the yield of products, thus indirectly

affecting price. However, the reason for theory does not match reality may be: the China Fishery Statistical Yearbook statistical indicators don't include the "seawater factory farming area", "freshwater factory farming area", "seawater deep-water cage culture area" into the total area of aquaculture. Therefore, using the data of aquaculture areas in China Fishery Statistics Yearbook as the input index of production factors may lead to the application of multiple linear regression analysis to calculate the correlation between aquaculture area and aquatic price.

Third, both aquatic production and aquatic processing volume showed a significant correlation with price. In the model M4, M6 and M7, it can conclude that the higher the yield of aquatic products, the higher price. The main reasons for the correlation between the two are as follows. First, changes in factors such as input by means of production will indirectly affect price. Second, the circulation cost will affect price. Third, the sales costs will greatly affect aquatic price.

In model M1, there's a positive correlation between price and product processing, but in model M7, there's a negative correlation between them. Theoretically, aquatic products through deep processing improve the added value and improve the price. However, the reason for the inconsistency between model M1 and M7 may be that different sample data cause inconsistent regression results. The empirical analysis of product processing volume on aquatic price remains to be further studied.

Fourthly, social environmental factors correlate with price.

The urbanization level will affect aquatic product consumption from three aspects. First, the urban residents have more demand for aquatic products than rural residents. Second, the improvement of the urbanization level directly promotes the convenient development of sales market, and the acquisition of products in the urban area is greatly enhanced. Finally, the demand for high quality products will be greatly improved due to the increasing income level of the urban residents. [10] When the traditional aquatic products could not meet people's demand, the aquatic price will decline.

There is no significant correlation between aging level and aquatic price. Although the elderly population is a vital consumer group of high-quality products, the current contribution rate of the elderly population to the consumption of aquatic products in China is still at a low level, which has little impact on aquatic price.

The high per capita disposable income, the higher price. As of 2015, Chinese per capita consumption of aquatic products is 11.41 kg, three times the level of 20 years ago. The rise in per capita disposable income promotes residents' consumption demand for high-grade aquatic products. Therefore, the increase of per capita disposable income will drive the aquatic price through the demand side.

In model M7, there's a significant positive correlation between aquatic price and livestock meat price. Livestock, meat and aquatic products are substitutes for each other. When the price of livestock, meat rises, the demand for products is stimulated, and aquatic price will also rise.

There is a significant positive correlation between coastal and aquatic price. The main reasons are as follows. First, the construction level of cold chain infrastructure in coastal areas is higher than that in inland areas. Second, the huge consumption demand in coastal areas will raise aquatic price. Third, the coastal areas have geographical advantages, which will directly promote the quality of aquatic products. Thus, the price is much higher than in the inland areas.

Fourthly, according to Analysis on influencing mechanism of China's seafood consumption, regional differences in demand price elasticity of aquatic products will affect the demand of aquatic products and ultimately affect the price. [11]

5 CONCLUSION

According to the above analysis results, the following conclusions can be drawn: the main factors that have a positive correlation with aquatic price are: the refrigeration capacity of aquatic cold storage, the number of cold chain logistics enterprises and vehicles, the number of aquatic seedlings, the output of aquatic products, the processing capacity of aquatic products, the price of substitutes and coastal factors; the factors that have negative correlation with price are: cold storage capacity, ice-making capacity, freezing capacity, urbanization level and residents' income level. Based on the above analysis, the paper will put forward the following policy recommendations:

First, further promote the lean development of cold chain infrastructure. The cold chain infrastructure indirectly affects the price by improving the freshness of products, prolonging the sales cycle of products, and increasing the added value of products. However, the Chinese cold chain started late and the foundation is weak. There are still some problems, such as imperfect cold chain logistics system, etc., and there's a big gap with developed countries. [12] So based on the current situation of cold chain infrastructure construction, it's pivotal to improve the cold chain infrastructure. In terms of storage, by improving the cold storage capacity to meet the storage demand of products, by enhancing the cold storage capacity, ice making capacity and freezing capacity to provide a better storage environment so as to ensure the product quality. In terms of transportation, improve the technical level of vehicles and ensure that aquatic products are always in an ultra-low temperature environment during distribution to reduce product depreciation or impairment. In terms of distribution, cold chain logistics enterprises should formulate scientific supply plans to meet the demand for products in a different time and space.

Second, improve the scale efficiency of aquaculture and optimize the aquatic environment. The Fourteenth Five-Year Plan recommends that the Yangtze River fully launch the Ten-Year Fishing Ban Policy on 1 January 2021. The comprehensive ban on fishing shows that aquaculture will become the main source of aquatic products in China. China is a large population country, and the residents have huge demand for aquatic products. Under the condition of huge supply and demand, it's vital to realize the sustainable development of aquaculture. Therefore, the government should establish a more perfect governance system, regulate ecological problems and introduce foreign advanced aquaculture technology to promote the sustainable development of aquaculture. Aquaculture enterprises should innovate methods and technologies. Under the concept of green environmental protection, they should improve the scale efficiency of aquaculture and promote the improvement of aquaculture benefits. [13]

Third, strengthen the processing capacity to enhance the added value of aquatic products. In recent years, with the rapid development of China's fresh e-commerce and the expansion of the international market, the aquatic industry is ushering in a golden period of development, so it's crucial to strengthen the processing capacity of aquatic products. The enterprises should accelerate the deep processing and provide higher value-added aquatic products to meet demand.

Government should accelerate the application of high-tech to improve the overall production efficiency of aquatic products processing industry.

Fourth, plan the production and sales of aquatic products in different areas to promote a balance between supply and demand. Government should innovative sales channels and formulate reasonable pricing strategies for different consumer groups. [14] They should adjust the supply structure of aquatic products at different consumption terminals to further promote the balance between supply and demand.

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