The Determinants of Chile's Aquatic Products Export: A Gravity Approach

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Abstract—Chile is a major exporter of aquatic products. Chile's exports of aquatic products continue to rise. In order to study the main influencing factors of its export growth, we used the trade gravity model and introduced importing country's APEC membership and colony relations as two dummy variables. Chile's aquatic products exports to the top 25 markets between 2001 and 2018 were examined. The export data of aquatic products come from the trade map website, the GDP and GDP per capita data of each country come from the World Development Index database of the World Bank, and the distance data between the two countries come from the CEPII database. Chile's economic size and per capita income have no effect on its exports of aquatic products; the economic size of importing countries, APEC membership, and colonial relations have a positive impact on Chile's aquatic product exports; the economic distance between the two countries and the income level of importing countries have a negative impact on Chile's aquatic products exports.

Keywords— Chile, aquatic products export, trade gravity model

1 INTRODUCTION

Chile is the longest and narrowest coastal country in the world, with more than 4,300 kilometers from north to south, but an average east-west width of only 180 kilometers, with a coastline of about 10,000 kilometers. Chile has abundant marine fishery resources and relatively developed marine fisheries. At the same time, the domestic aquaculture industry is quite large and has the comparative advantage of exporting a large number of aquatic products. Aquatic products are Chile's fourth-largest category of export products and occupy an influential position in the international market. As shown in Table 1, in 2018, Chile was the world's fifth-largest exporter of aquatic products after China, Norway, Vietnam and India.

Table 1. The export value of aquatic products in the top ten countries in 2018

country	2001		2018	
	exported value billion USD	market share %	exported value billion USD	market share %
China	2.6	6.20%	13.3	10.6%
Norway	3.1	7.40%	11.7	9.4%
India	1.2	2.90%	6.4	5.1%
Viet Nam	1.7	4.10%	6.4	5.1%
Chile	1.4	3.30%	5.9	4.7%

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Canada	2.4	5.70%	4.9	3.9%
United States of America	2.8	6.80%	5.3	4.2%
Russian Federation	0.4	0.90%	4.3	3.4%
Sweden	0.4	0.90%	4.7	3.7%
Ecuador	0.4	0.90%	3.6	2.9%

Source: Authors' calculation according to the data from www.trademap.org

Export volume of Chilean aquatic products has experienced a wave-like growth in this century. As shown in Figure 1, it has increased from US$1.41 billion in 2001 to US$5.91 billion in 2018, and its international market share has also increased from 3.3% in 2001 to 4.7% in 2018. During this period, Chilean aquatic product exports increased by 320%, while its international market share only increased by 42%. Obviously, the growth rate of exports exceeds the growth rate of international market share, indicating that the world market for aquatic products has expanded faster. In contrast, Chile's imports of aquatic products are very small. What are the factors leading to the growth of Chilean aquatic product exports and international market share? Some literature uses the gravity model of trade to conduct empirical tests on aquatic product trade and find that a country's seafood exports are positively correlated with the income level and output of the exporting country, the GDP of the importing country, and the scale of seafood consumption; negatively correlated with the distance. The export of some products is negatively related to the per capita income of the importing country. Regional trade agreements are conducive to promoting seafood exports [12]. Research on this issue will help to clarify the determinants of Chilean aquatic product exports and provide a basis for the formulation of Chilean aquatic product export policies. Chile's aquatic product exports are mainly primary products, so this article only takes Chile's HS03 aquatic product exports as the research object.

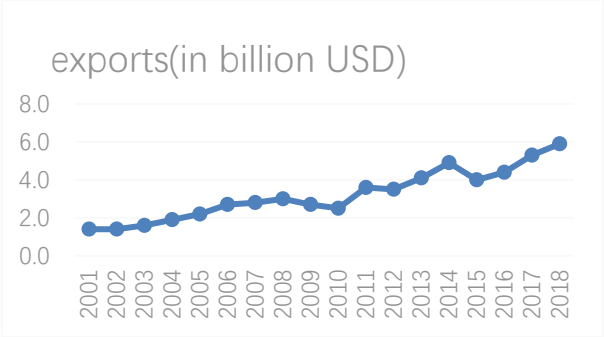

Figure 1 Chilean aquatic product export value from 2001 to 2018

Source: Authors' calculation according to the data from www.trademap.org

In customs statistics, aquatic products mainly include HS03 products, which are divided into 8 sub-categories. As shown in Table 2, Chilean aquatic products exports are mainly concentrated in three types of products, of which HS0304 accounts for 47.6%, followed by HS0303 which accounts for 32.2%, and HS0302 which accounts for 15.5%.

Table 2. The structure of Chilean aquatic product exports in 2018 (in million $)

Code	Product label	exported value	percentage
HS 0304	Fish fillets and other fish meat, whether or not minced, fresh, chilled or frozen	2740.9	46.6%
HS 0303	Frozen fish (excluding fish fillets and other fish meat of heading 0304)	1820.2	30.9%
HS 0302	Fish, fresh or chilled (excluding fish fillets and other fish meat of heading 0304)	864.4	14.7%
HS 0307	Molluscs, fit for human consumption, even smoked, whether in shell or not, live, fresh, chilled, ...	240.0	4.1%
HS 0308	Aquatic invertebrates other than crustaceans and molluscs, live, fresh, chilled, frozen, dried, ...	61.5	1.0%
HS 0306	Crustaceans, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine, ...	94.6	1.6%
HS 0305	Fish, fit for human consumption, dried, salted or in brine; smoked fish, fit for human consumption, ...	64.4	1.1%
HS 0301	Live fish	0.60	0.0%

Source: Authors' calculation according to the data from www.trademap.org

2 MODEL CONSTRUCTION

2.1Gravity model construction

The gravity model of trade is derived from the law of gravitation in physics. It is believed that the bilateral trade flow of two countries (regions) depends to a large extent on the economic scale of the two countries (regions) and the distance between the two countries (regions). Its basic form is as shown in formula (1). This model was first applied to empirical research on international trade by Tinbergen [14], and has since been continuously developed and improved, with a solid economic theoretical foundation [1] [4] [15]. It has been widely used in the study of trade flow and has become an important research tool in the empirical study of international trade [6] [8]. The trade gravity model was first used to study the flow of total trade, and then gradually expanded to study the trade flow of a single product. Especially with the free access of various online databases of international organizations such as the United Nations and the World Bank, data acquisition has become increasingly simple. As a result, there have been a large number of documents using the gravity model to study single product trade, such as the gravity model is used to study wheat trade [9], meat trade [10], agricultural products and food trade [5] [13], and wine trade [11].

$$T_{ij} = A(\mathrm{GDP}_i \bullet GDP_j) / Dis_{ij} \tag{1}$$

i and j denote exporting country and importing countries (regions) respectively; T represents the bilateral trade volume between the two countries; A is a constant term; GDP represents the economic scale of a country (region), measured by GDP; Dis represents the distance between the two countries. To facilitate the estimation, the logarithmic form is generally used. Many papers use the panel data model [7]. In order to build a panel data model, it is necessary to use data from different years. Therefore, taking the natural logarithm form on both sides of equation (1) at the

same time, the basic model shown in equation (2) can be obtained, where C is a constant term, t is a year, and u is an error term.

$$LnT_{ijt} = \beta_0 + \beta_1 LnGDP_{it} + \beta_2 LnGDP_{jt} + \beta_3 Dis_{ijt} + u_{ijt} \quad (2)$$

In some empirical studies that use the single-country gravity model to examine a country's exports, it is sometimes found that the GDP coefficient of the exporting country is not statistically significant [2]. It's needed to make some adjustments to formula (2) for establishing the model used in this article. First of all, a country's economic development level, measured by GDP per capita, has a direct impact on imports and exports, and is usually included in the model, or used the difference or ratio of the per capita GDP of the two countries as an indicator [3]. This article takes into account the economic development level of importing and exporting countries and directly uses the GDP per capita of the two countries. Secondly, considering that international economic integration will promote trade among member nations and colonial relations are beneficial to trade relations between the suzerain country and colonial countries, APEC and colony relations are introduced into the model as dummy variables.

After introducing the three indicators of per capita GDP of the two countries, APEC and Colony to expand the basic model, the model used in this article can be rewritten into the form of (3), where GDP_{it} and GDP_{jt} represent the per capita GDP of the exporting country and the importing country respectively. X is the export value; APEC and colony respectively denote APEC membership and colonial relations.

$$\begin{aligned} LnX_{ijt} &= \beta_0 + \beta_1 LnGDP_{it} + \beta_2 LnGDP_{jt} + \beta_3 Lnincome_{it} + \beta_4 Lnincome_{jt} \\ &+ \beta_5 LnDis_{ijt} + \beta_6 APEC_j + \beta_7 colony_j + u_{ijt} \end{aligned} \quad (3)$$

The meanings and expected sign of each variable are shown in Table 3.

Table 3. Description of each variable

Variable	Variable description	Expected sign
X_{ijt}	export value of aquatic products from country i to country (region) j in year t	
GDP_{it}	GDP of Chile in yeat t	+
GDP_{jt}	GDP of importer j in yeat t	+
$income_{it}$	Per capita GDP of Chile in yeat t	+
$income_{jt}$	Per capita GDP of importer j in yeat t	+
Dis_{ijt}	The distance between the two countries (regions)	-
$APEC_j$	Dummy, take value 1 if the importer is an APEC member; take value 0 otherwise	+
$Colony_j$	Dummy variables, take value 1 if the importer is Spain that has colonial relation with Chile, take value 0 otherwise	+

2.2 Data description and sources

The explained variable in this article is the export value of aquatic products, and its data is taken from the United Nations International Trade Center website, and the time span is 2001-2018.

Because the Chilean aquatic product export market is highly concentrated, the export of aquatic products to the top 25 markets accounted for 97% of the total Chilean aquatic product export in 2018, which can well represent Chile's aquatic product export trade. The selected 25 major exports markets are shown in Table 4. Among them, the United States, Japan, Brazil, Russia and China are Chile's top five export markets.

Table 4. the top 25 export markets in 2018

Country/region	*Percentage*	*Country/region*	*Percentage*	*Country/region*	*Percentage*
USA	31.5%	Israel	1.6%	Peru	0.6%
Japan	20.2%	Nigeria	1.1%	Poland	0.5%
Brazil	9.9%	Taipei, Chinese	1.1%	Belgium	0.4%
Russian	7.6%	Germany	1.1%	Singapore	0.3%
China	6.7%	Canada	1.1%	Portugal	0.3%
Spain	2.7%	Viet Nam	1.0%	Philippine	0.3%
Korea, Republic of	2.4%	France	1.0%	Italy	0.3%
Mexico	2.0%	Argentina	1.0%		
Thailand	1.9%	Colombia	0.8%		

Source: Authors' calculation according to the data from www.trademap.org

The GDP and per capita GDP data of each country comes from two places. The data for 2001-2017 mainly comes from the United Nations Statistics Office, and the data for 2018 comes from the World Development Index (WDI) database of the World Bank. The units are all US dollars.

Distance is an important resistance factor in the gravity model, but it does not change with time, so it's unable to estimate fixed effects in Eviews software. Therefore, this article uses economic distance expressed as the product of spatial distance and international crude oil prices. Among them, the spatial distance data comes from the CEPII database, and the spatial distance between the capitals of the two countries (regions) is used, and the unit is kilometers. The annual average international crude oil price is based on the U.S. domestic crude oil price excluding inflation. The data comes from the InflationData.com website.

Two dummy variables are assigned using the following method. Chile is a member of APEC. If the importer is also a member of APEC, this variable assigns a value of 1, otherwise, it is 0; among the 25 major export markets for Chilean aquatic products selected in this article, there are 13 APEC members countries (regions), including Canada, China, Japan, South Korea, Russia, Mexico, Peru, the Philippines, Singapore, Thailand, Taiwan, the United States and Vietnam. Chile used to be a colony of Spain, so Spain's colony variable takes the value 1, and other countries (regions) are 0.

2.3 Descriptive statistics of data

This article selects Chile's exports of aquatic products to the most important 25 countries as the research object. The time span is from 2001 to 2018, so there are 450 observations (N=25, and T=18). Enter the data into the software Eviews7.1 to obtain the descriptive statistical results of the sample data, as shown in Table 5.

Table 5. Descriptive statistics of sample data

	Mean	*Maximum*	*Minimum*	*Std. Dev.*
LnX_{ijt}	10.4141	13.81486	7.828148	1.33466
$LnGDP_{it}$	25.88093	26.42113	24.97316	0.487219
$LnGDP_{jt}$	27.27765	30.65361	24.21019	1.35795
$Lnincome_{it}$	9.239242	9.676675	8.408865	0.438334
$Lnincome_{jt}$	9.416733	11.07569	5.998503	1.183458
$LnDis_{ijt}$	13.33201	14.51939	10.52002	0.792908
$APEC_j$	0.52	1	0	0.500156
$Colony_i$	0.04	1	0	0.196177

3 RESULT ANALYSIS AND TRADE POTENTIAL

3.1 Result analysis

Mixed regression, fixed effect, and random effect estimation were performed respectively. The Eviews software cannot estimate fixed effects for models with dummy variables that do not change over time, so the fixed effects model does not include dummy variables. Eviews7.1 is used to process the data, and the results are shown in Table 6.

Table 6. Model estimation results

variable	*Pool (OLS)*	*Fixed Effect*	*Random Effect*
$LnGDP_{it}$	2.304123***	0.181573	0.36259
	(3.115704)	(0.421427)	(0.864937)
$LnGDP_{jt}$	0.994031***	1.017613***	1.006896***
	(73.03373)	(29.25824)	(34.03814)
$Lnincome_{it}$	-2.400304***	0.062400	-0.149563***
	(-2.907514)	(0.127507)	(-0.314382)
$Lnincome_{jt}$	-0.179376***	-0.21951***	-0.202707***
	(-11.1819)	(-4.763341)	(-5.263780)
$LnDis_{ijt}$	-0.20116***	-0.378707***	-0.364547***
	(-8.890181)	(-13.03324)	(-13.01975)
$APEC_j$	0.381388***	/	0.451191***
	(11.30882)		(3.257222)
$Colony_i$	1.003725***	/	1.064545***
	(12.79971)		(3.057935)
C	-7.580533***	-12.15911***	-11.88311***
	(-3.680062)	(-9.519601)	(-9.883492)
Adjusted R^2	0.94	0.99	0.94
F	1086.080***	2095.617***	974.8269***

* Means significant at the 10% level, ** means significant at the 5% level, and *** means significant at the 1% level.

In order to determine whether to use a fixed-effects model or a mixed regression model, an F test was performed on the fixed-effects model. The result was 198.9689, and the concomitant probability was 0.0000. So the null hypothesis can be rejected, and the fixed effects model should be adopted. Then, performing the Hausman test on random-effects model results, the result is

3.4066, and the concomitant probability is 0.6376. So the null hypothesis can be accepted, the random-effects model should be adopted. Therefore, a random-effects model should be used for comprehensive consideration.

The results of random effect estimation show that, except for the coefficients of $LnGDP_{it}$ and $Lnincome_{it}$ that cannot pass the significance test, the estimated values of the coefficients of other variables are statistically significant. The F value is 974.8269, which is also very significant. The corrected R^2 is 0.9382, which is very ideal. In addition, except that the coefficients of $LnGDP_{jt}$ and $Lnincome_{jt}$ are negative and do not match expectations, the sign of coefficients of other variables compound economic expectations.

The economic scale of the importer and exporter has different impacts on Chilean aquatic product exports. Chile's GDP is not statistically significant, which means that as an exporting country, Chile's economic scale has no effect on its exports of aquatic products. The importer's GDP represents the size of the import market, which is a stimulus factor for Chilean aquatic product exports. Because of the logarithmic form, the coefficient represents elasticity, that is, when other conditions remain unchanged, the importer's GDP increases or decreases by 1%, Exports increase or decrease by 1.0069 percentage points accordingly.

The income levels of importers and exporters have different effects on Chilean aquatic product exports too. Chile's per capita GDP is not statistically significant, and it can be considered that it has no impact on aquatic product exports. Although the importer's per capita GDP coefficient is statistically significant, it is negative, indicating that the increase in income of importers will not increase the demand for Chilean aquatic products The existing aquatic product trade research literature has also confirmed this point. It is found that the per capita income of importing countries is negatively correlated with some aquatic product trade [5]. The estimated coefficient is -0.2027, which means that the per capita GDP of the importer increases by 1%, and its imports of aquatic products from Chile will decrease by 0.2027 percentage points.

Bilateral distance is a negative factor for Chilean aquatic products exports. Distance is one of the main resistance factors of international trade. It is generally believed that distance is directly proportional to the cost of international trade. The longer the distance, the higher the cost of trade. This paper considers the economic distance with changes in oil prices. If the distance between two countries increases by 1%, Chile's aquatic product exports will decrease by 0.3645 percentage points.

Joining the APEC has promoted Chile's aquatic products exports to its members. Although APEC, including important countries such as the United States, China, Japan, and Canada, is only a forum-type organization, the annual summit meeting provides an opportunity for official exchanges among members. APEC has had a positive effect on promoting trade among its members, and Chile's aquatic product exports have also benefited a lot from it.

Finally, the colonial relationship with Spain is also conducive to promoting Chile's aquatic product exports to Spain. Chile has a deep historical relationship with Spain. Chile was a colony of Spain (1540-1818) and its official language was Spanish. Hundreds of years of colonial history enabled Chile to maintain close economic ties with Spain after its political independence. Chile's exports of aquatic products to Spain are much higher than its exports to other countries with the same conditions.

3.2 Trade potential

The trade potential of each market can be estimated by calculating the ratio of the actual value of exports to the predicted value of the model. Only 2018 is taken as an example to estimate the trade potential, and the results are shown in Figure 2. The ratios of 10 countries including South Korea, Israel, Nigeria, Thailand, Brazil, Singapore, Mexico, Japan, and Italy are higher than 1.2, meaning that these markets are well developed; 5 countries including China, Poland, Russia, Canada and Argentina are lower than 0.8, so there is still huge potential in these markets. The ratios of the other 10 countries (regions) including Portugal, Peru, France, Spain, Belgium, the United States, the Philippines, Vietnam, Colombia, Germany and Taiwan, are between 0.8 and 1.2, so there is still some market space.

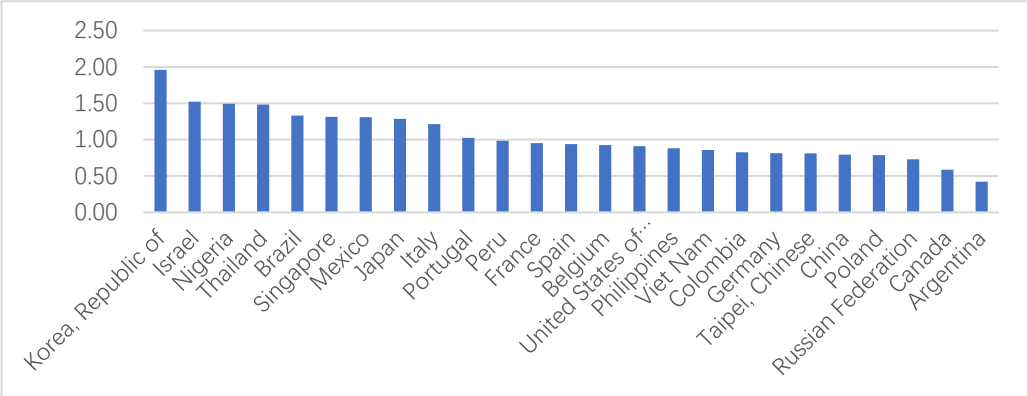

Figure 2 Calculation of trade potential in 2018

4 CONCLUSIONS AND POLICY RECOMMENDATIONS

4.1 Conclusion

By using the trade gravity model, the following conclusions can be drawn: Chile tends to export more aquatic products to importers with larger economies, and the market size of these countries is relatively large. The income level of the importer has a negative impact on its import of aquatic products from Chile, and the increase in its income level will reduce its import demand for Chilean aquatic products This is probably because the preferences of consumers in these countries (regions) change with the increase in income level. The distance which means the cost of trade is an important factor hindering the export of Chilean aquatic products. Joining APEC has greatly promoted Chile's export of aquatic products to APEC members. Chile was once a colony of Spain, and Chile and Spain still maintain Close trade relations.

4.2 Policy recommendations

In 2018, more than 50% of Chilean aquatic products were exported to the United States and Japan. The market is too concentrated, and it is urgent to develop emerging markets to diversify risks. Efforts for market development in countries (regions) with smaller economies should be increased. The results of the gravity model reflect that Chile is more inclined to export aquatic

products to partners with larger economies, while not paying enough attention to markets with smaller economies. However, there are a large number of countries (regions) with small economies. If exports to these small markets are increased, it is bound to expand the international market share to a certain extent. Therefore, the government should also guide enterprises to pay attention to these small markets and provide policy support for them.

Chile's aquatic product exports are mainly concentrated in three types of products: HS0304, HS0303, HS0302, and the other five types of products account for a very low proportion. From a global perspective, the export growth rate of 0304 and 0303 products is significantly lower than the average growth rate of aquatic product exports. Therefore, it is necessary to appropriately adjust the production structure and increase the export of high-growth products to optimize the structure of export commodities. Chile's exports of deep-processed aquatic products are relatively small, so it's needed to consider extending the value chain of aquatic products and developing deep-processing of aquatic products, especially for high-income countries (regions).

Chile's regional economic cooperation has been fruitful. Measures such as joining APEC and signing bilateral free trade agreements with many countries and regional economic organizations have played a decisive role in the optimization of the aquatic product export market. As a forum organization, APEC played a huge role in promoting Chile's exports. Other free trade zones that completely abolish internal tariffs will inevitably produce better results. Therefore, on the one hand, the government needs to continue to strengthen cooperation with APEC partner countries. On the other hand, it is also necessary for the government to sign free trade agreements with more countries, expand the scope and intensity of cooperation, and even form some higher-level integrated organizations.

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