Granger Causality between the Export Policy Intervention and Comparative Advantage in the China's Vaccine Product Trade

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Abstract: Vaccines play a vital role in the protection of human health. In the field of high-end vaccines, China still relies on imports, and exports are small, resulting in China has been in a trade deficit 21 years ago. And few experts and scholars have conducted in-depth research in this field. This article is aimed at the export of vaccine, using the vaccine data of the United Nations Statistics Office from 1987 to 2021, to calculate its export revealed symmetric comparative advantage (RX_{ck}) and export policy intervention index (HX_{ck}), and analyse the long-run and short-run Granger relationship between them. After experiments, it is found that under the optimal linear model, HX_{ck} is the short-run Granger cause of RX_{ck}, and HX_{ck} has a negative effect on RX_{ck} in the short term. At the same time, HX_{ck} is also a long-run Granger cause of RX_{ck}, and HX_{ck} has a positive effect on RX_{ck} in the long term.

1. Introduction

In today's world, various diseases and viruses have a great negative impact on human health, with the advancement of science and technology, for some diseases and viruses, human beings have developed targeted vaccines to enhance the body's resistance to the pathogenic virus. It can be said that vaccines play an important role in preventing diseases in human beings today. For example, COVID-19 vaccine to prevent the new coronavirus, HPV vaccine to prevent human papillomavirus, rabies vaccine to prevent rabies virus, hepatitis B vaccine to prevent hepatitis B virus, etc. In the current economic globalization environment, China's vaccine imports and exports are also developing, and China has also relied on the import of high-end foreign vaccines. However, at present, less experts and scholars have conducted large-scale in-depth research in this field, and this paper mainly starts from the impact of China's export policy on the export comparative advantage of vaccine, so as to promote the export of China's vaccine and better help the development of China's vaccine industry.

2. Indices used in the study

2.1. Net export ratio

The net export ratio (NX) represents the proportion of a country's net exports of k products to the country's total imports and exports of k products [1].

$$NX_{ck} = (X_{ck} - M_{ck}) / (X_{ck} + M_{ck}) \quad (1)$$

Among them, X represents export, M represents import, subscript c represents China, and subscript k represents vaccine products. The value range of NX_{ck} is [-1,1], the mean is 0, and NX_{ck} is symmetrically distributed around it. When NX>0, it means that China's vaccine trade is in a favorable position; When NX<0, China was in deficit in vaccine trade; When NX equals 0, the import and export are balanced.

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2.2. Revealed comparative advantage

Balassa (1965) proposed to use RCA_{ck} to measure the revealed comparative advantage of product k in a country's trade [2]. A country's revealed comparative advantage in exports of a product, the equation is:

$$RCAX_{ck} = (X_{ck}/X_k)/(X_{wk}/X_w) \quad (2)$$

Among them, the x means export, the subscript c represents China, the k represents k products, and the w represents the world. The X_{ck} means China's k product exports, the X_{wk} means the world's k product exports, when $RCAX_{ck} > 1$, it means that the export proportion of product k in country c is greater than the proportion of product k in the total export of the world, which shows that country c has obviously comparative advantages in the production of product k, higher than the world average. When $RCAX_{ck} < 1$, it means that the export ratio of country c in product k is less important than the proportion of product k in the total world export, that is, country c has no comparative advantage in product k.

Similarly, the equation for the revealed comparative advantage of imports equals:

$$RCAM_{ck} = (M_{ck}/M_k)/(M_{wk}/M_w) \quad (3)$$

where M stands for import, and its subscript has the same meaning as Equation (2). When $RCAM_{ck} > 1$, it means that country c has a comparative advantage in importing product k, so country c has no comparative advantage in producing product k. When $RCAM_{ck} < 1$, it means that country c has no comparative advantage in importing product k, that is, country c has a comparative advantage in the production of product k.

2.3. Revealed Symmetric Comparative Advantage

Dalum, Laursen and Villumsen (1998) noticed that the value range of RCA_{ck} is 0 to infinity, and the mean cannot be determined, so they proposed "revealed symmetric comparative advantage" (RSCA) to solve the problem that RCA cannot determine the range and mean [3]. The equation for "revealed symmetric comparative advantage" for exports is:

$$RX_{ck} = RSCAX_{ck} = (RCAX_{ck} - 1)/(RCAX_{ck} + 1) \quad (4)$$

Among them, X represents the export, its value range is -1 to 1, and the mean value is 0. When RX_{ck} is between 0 and 1, it means that country c has a comparative advantage in the export of k products; Conversely, when RX_{ck} is between -1 and 0, it means that country c has a comparative disadvantage in the export of k products. When RX_{ck} is 0, it means that country c has neither a comparative advantage nor a comparative disadvantage in the export of k products [4].

Correspondingly, the formula for the "revealed symmetric comparative advantage" of imports is as follows:

$$RM_{ck} = RSCAM_{ck} = -(RCAM_{ck} - 1)/(RCAM_{ck} + 1) \quad (5)$$

Among them, M means the import, and the meaning of the subscript is the same as that in equation (4). It should be noted that the minus sign in RM_{ck} is to ensure that RM_{ck} has the same meaning as RX_{ck} [5].

According to the theory of comparative advantage, all else being equal, the more products a country exports, the greater the comparative advantage. This study mainly studies the analysis of the export of vaccine products in China, so the index used is RX_{ck} [6].

2.4. The degree of import policy intervention

According to Ricardo's theory of comparative advantage, a country should specialize in producing and exporting products for which it has a comparative advantage, and importing products for which it does not have a comparative advantage. Under perfect free trade conditions without any policy intervention, RSCA and NX should be in equilibrium, that is:

$$NX_{ck} = RSCA_{ck} \quad (6)$$

The difference between the two is that:

$$HX_{ck} = NX_{ck} - RSCAX_{ck} \quad (7)$$

$$HM_{ck} = NX_{ck} - RSCAM_{ck} \quad (8)$$

That is to say, the difference between NX_{ck} and $RSCA_{ck}$ is the "policy intervention index" of country c in the import and export trade of product k. Since this study mainly studies the import of vaccines in China, HM_{ck} is used as an example. When $HM_{ck} = 0$, it means that the trade pattern is in equilibrium. When $HM_{ck} > 0$, it means that the net export ratio is greater than the comparative advantage of imports, indicating that country c has adopted a trade policy that restricts imports; and when $HM_{ck}<0$, it means that the net export ratio is less than the comparative advantage of imports, indicating that country c has adopted a trade policy of Trade policies to encourage imports.

3. Results and Discussion

3.1. Export mode of vaccine products

Figure 1 depicts the China's sample data indicators for RX_{ck} and HX_{ck} from 1987 to 2021.

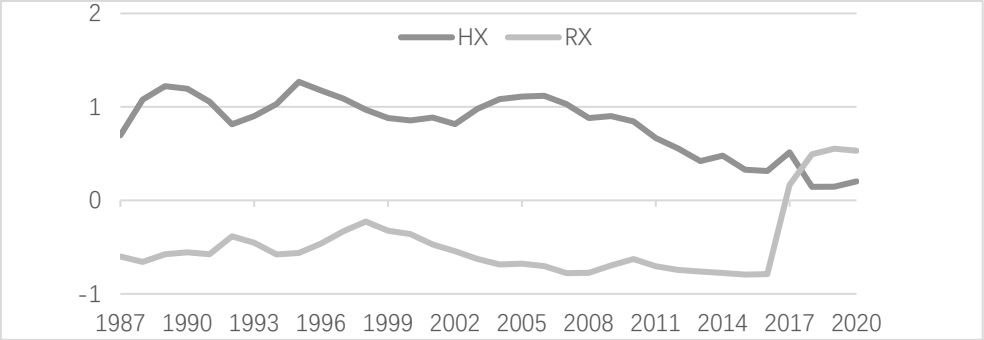

Figure 1 RX_{ck} and HX_{ck} of vaccine (1987-2021).

As can be seen from Figure 1, HX_{ck} has been positive, but the overall trend is declining, and its average value is 0.813, indicating that China's export policy of vaccine has always adopted policies to encourage exports. There were two small peaks around 1989 and 1995, which showed that China encouraged exports of vaccine in the export policy around 1989 and 1995. After 2011, it was below 0.5, indicating that China's export policy incentives for trade in vaccine declined after 2011.

RX_{ck}'s development trend was relatively stable before 2017, and its value was less than zero, but after 2017, it showed a clear upward trend, and in 2017, its value began to be greater than zero, indicating that 2017 was a turning point in China's comparative advantage in the export of vaccine. Before 2017, China's vaccine exports have been in a relatively disadvantaged state, and after 2017, China's vaccine exports began to show a comparative advantage. The reason may be that after the Shandong vaccine incident in 2016, the adjustment of the state's vaccine policy and the reform of vaccine production by manufacturers have greatly improved the overall quality of China's vaccines, and also promoted the export comparative advantage of China's vaccines.

3.2. ADF unit root test results

Table 1 shows the results of the enhanced Dicky-Fuller (ADF) unit root test for HX_{ck} and RX_{ck}.

Table 1 ADF unit test results.

Variable	Test type	ADF	Prob.	Variable	Test type	ADF	Prob.
HX_{ck}	(c, t, 0)	-3.233	0.095	ΔHX_{ck}	(n, n, 0)	-5.452	0.000
RX_{ck}	(n, n, 1)	-1.377	0.153	ΔRX_{ck}	(n, n, 0)	-4.102	0.000
ln (HX_{ck})	(n, n, 0)	-0.388	0.537	Δln (HX_{ck})	(n, n, 0)	-6.604	0.000
ln (RX_{ck})	(n, n, 0)	-1.170	0.216	Δln (RX_{ck})	(n, n, 0)	-4.765	0.000

Note: 1. "c,t,p" stands for "constant, trend and lag length";2. "n" is used when there is not a constant or a time trend.

From Table 1, it can be concluded that under the assumptions of linear and nonlinear model, only the horizontal time series of HX_{ck} is between 0.1-0.05, which belongs to marginal stationary, and its first-order differential series is less than 0.05, which is a stationary sequence. The remaining horizontal time series of ln (RX_{ck}), HX_{ck}, and RX_{ck} are all greater than 0.1, which belongs to non-stationary time series, but their first-order differential sequences are all less than 0.05, which indicates that their first-order differential sequences are stationary sequences. Therefore, all sequences are stationary sequences, which means we can make VEC models for further econometric analysis.

3.3. Determine linear or nonlinear model assumptions

Table 2 presents the results for VAR lag intervals satisfying the linear or nonlinear model assumptions.

Table 2 Linear/non-linear model selection results.

Lag	FPF	AIC	SC	HQ
Linear Model Assumption				
0	4.61E-03	0.295	0.485	0.353
1	6.69E-04	-1.638	-1.257	-1.522
2	3.82E-04	-2.207*	-1.636*	-2.033*
Non-linear Model Assumption				
0	4.14E-02	2.491	2.682	2.549
1	9.35E-03	0.999	1.380	1.116
2	2.96E-03*	-0.162*	0.409*	-0.013*

Note: 1. The maximum VAR lag period is 7, which is about one-fifth of the sample period (34 years); 2. "*" refers to the lag length selected by the minimum information criteria.

As can be seen from the table, for linear and nonlinear model assumptions, all the information criteria for FPE, AIC, SC, and HQ have chosen hysteresis order 2 as the optimal value. In addition, the information criterion statistic assumed by linear models is smaller than the assumptions for nonlinear models. Therefore, a linear VAR model with a hysteresis interval of 1-2 is selected, which means that the optimal VEC model is also linear with a hysteresis interval of 1-1.

3.4. Determine the VEC optimal model results

After obtaining the optimal lag period, the models of the VEC are compared, and the optimal model of the VEC is determined by the minimum information criterion. Table 3 shows the statistics of the information criteria for all five possible linear VEC models.

In the table, model 1 assumes no intercept or deterministic trend in both CE; model 2 assumes an intercept but no deterministic trend in CE; model 3 assumes an intercept-only but no deterministic trend in both CE; model 4 assumes both intercept and deterministic trend in CE; and model 5 assumes a quadratic deterministic trend.

Table 3 VEC model specification results.

Information Criteria	Model 1	Model 2	Model 3	Model 4	Model 5
Determinant resid covariance (dof adj.)	3.57E-04	3.57E-04	3.81E-04	3.36E-04*	3.48E-04
Determinant resid covariance	2.95E-04	2.95E-04	2.94E-04	2.59E-04	2.50E-04*
Log likelihood	40.484*	40.486	40.529	42.590	43.182
Akaike information criterion	-1.969*	-1.908	-1.850	-1.915	-1.890
Schwarz criterion	-1.606*	-1.500	-1.397	-1.416	-1.346

It can be seen from the table that "Model 1" is selected for both AIC and SC standards, so this study determines "Model 1" as the optimal VEC model.

3.5. Johansen co-integration test results

The Johansen cointegration test is mainly to test whether there is a cointegration relationship

between multiple variables, and its purpose is to prevent spurious regression. Table 4 shows the results of the Johansen cointegration test.

Table 4 Summary of the Johansen cointegration test results.

Data Trend	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	1	2	2	1	2
Max-Eig	1	0	0	0	2

Note: Critical values based on MacKinnon-Haug-Michelis (1999).

The results of the Johansen cointegration relationship test showed that there was a cointegration relationship at the 5% significance level.

3.6. Short-run Granger causality test

A short-run Granger causality test or block exogenous Wald test was performed on the basis of the optimal VEC model. Table 5 shows the short-run Granger causality. Table 5 shows the short-run Granger causality.

Table 5 Short-run Granger causality test results.

Variable	HX_{ck}			RX_{ck}		
	Prob.	Chi-sq	SE	Prob.	Chi-sq	SE
HX_{ck}	——	——	——	0.530	0.395	——
RX_{ck}	0.000	12.464	-0.384	——	——	——

As can be seen from the data in the table, RX_{ck} has a short-run negative effect on HX_{ck}, and its short-run effect is -0.384.

3.7. Long-run Granger causality test results

Tables 6 is the Long-run Granger causality test results for the two equations.

Table 6 Long-run Granger causality test results.

Variable	HX_{ck}				RX_{ck}			
	F-stat	F-Df	Prob.	LE	F-stat	F-Df	Prob.	LE
ECT	1.091	(1,30)	0.305	——	4.372	(1, 30)	0.045	——
ECT, d (HX (-1))	1.136	(2,30)	0.335	——	2.301	(2, 30)	0.118	——
ECT, d (RX (-1))	6.246	(2,30)	0.005	0.149	4.078	(2, 30)	0.027	-0.062

Note: LE denotes the long-run effect which are the convergence values of the impulse-response functions, at the 100-th period after the impulse.

From the data in the table, it can be seen that the lag period of d(RX(-1)) and ECT have a long-run positive effect on HX, with a long-run effect of 0.149 (50th), and a long-run negative effect on RX, with a long-run effect of -0.062 (50th). This shows that the comparative advantage of vaccine products in exports has a positive impact on their export policies.

3.8. Discussion

China still has a certain gap compared with foreign countries in some advanced vaccine fields, which makes China in a perennial trade deficit in vaccine trade, but with the outbreak of the new crown epidemic, China responded quickly and developed a new crown vaccine, and the large export of new crown vaccines has gradually reversed China's deficit in vaccine product trade, gradually turning from deficit to surplus. Moreover, China has always adopted a policy of encouraging exports in vaccine exports, and according to the empirical results, China's comparative advantage in the export of vaccine has a negative effect on its export policy in the short term, but it has a positive effect in the long run, which shows that the greater the export comparative advantage, although it has a negative impact on the export policy in the short run, but in the long run, it is conducive to the implementation of the export policy.

4. Conclusion

By using the annual data of China's vaccine products from the United Nations Statistics Office from 1987 to 2021, this paper calculates the "revealed export symmetric comparative advantage" (RX_{ck}) and "export policy intervention index" (HX_{ck}) of vaccine. And carried out time series analysis, including short-run and long-run Granger causality test, and reached the following conclusions:

1) Since 1987, China has adopted a policy of encouraging exports of vaccine products. Before 2017, China was at a comparative disadvantage in the export of vaccine products, and after 2017, China's exporters of vaccine products began to have a comparative advantage.

2) In the short run, there is a Granger relationship between export policy intervention and export comparative advantage of vaccine, and the improvement of export comparative advantage has a short-run negative impact on the implementation of export policy.

3) In the long run, the export comparative advantage of vaccine products has a positive impact on export policy intervention, while HX_{ck}'s lag has a negative impact on itself, which means that China's trade incentive policy intervention is not inertia.

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