

The Relationship between RMB's Real Exchange Rate and China's Import and Export to BRICS: An Empirical Study based on VAR Model

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ABSTRACT

With the acceleration of economic globalization and the rise of emerging market economies in the world, China's import and export trade with the BRICS is becoming more and more frequent. As a bridge and bond between China and other BRICS countries, exchange rate fluctuation will have a significant impact on import and export trade. In this paper, we studied the import and export trade between China and BRICS and measured the RMB's real exchange rate level in other BRICS countries by compiling the "BRICS" RMB's real exchange rate index. The monthly data of China's total import and export value with other BRICS countries from January 2017 to December 2021 in thousands of US dollars were used to express the level of China's import and export with other BRICS countries. This paper used the VAR time series model to empirically analyze the relationship between RMB's real exchange rate and import and export. It is found that the "BRICS" RMB's real exchange rate index harms import and export value. The negative impact on import value becomes positive after two periods and tends to be stable, while the negative impact on export value increases first and then decreases, and then tends to be stable after two periods. The impact of the RMB's real exchange rate index mainly comes from itself.

KEYWORDS

Exchange rate; VAR, Marshall-Lerner; Price elasticity

1 Introduction

As an important lever for a country to adjust its trade balance, the exchange rate plays a role in price conversion in international economic activities. A country's foreign trade balance is closely related to the change in the exchange rate. Generally speaking, countries rely on three types of macroeconomic policies to manage their internal and external problems[3]. Fiscal and monetary policies are often used to deal with internal problems (fighting recession or reducing inflation). Devaluation is used to manage external problems: reducing the current account or trade deficit.

In the globalized foreign trade, China, Russia, India, Brazil, and South Africa, five countries in a new "BRICS" face that appeared in the global political and economic stage, accounting for twenty-five percent of the world's economy, has contributed nearly half of the global economic growth, the BRICS has gradually become a model of mutual benefit and win-win cooperation among emerging economies. Due to the strong complementarity of resource endowment and industrial structure

between other BRICS countries and China, their status and role in China's import and export trade are also rising[1]. On September 3rd to 5th, 2017, the ninth BRICS Summit was held in Xiamen, Fujian Province, where the "BRICS Plus" cooperation model was proposed for the first time to enhance practical economic cooperation, ushering in the second "Golden Decade" of BRICS cooperation.

Few papers have studied foreign trade and exchange rates from the perspective of BRICS. Therefore, this paper studied the import and export trade between China and other BRICS countries and empirically analyzed the relationship between RMB's real exchange rate and import and export by constructing a VAR time series model.

2 Literature review

Yang Cao and Jianwu Li (2006) measured the volatility of RMB's real exchange rate with the AR-CARCH model and then studied the influence of its volatility on China's import and export trade with the Engle-Granger two-step method. Conclusion: With the increase in exchange rate volatility, China's export quantity will decrease, while the import quantity will increase. The price elasticity of export commodities is relatively high, while the price rigidity of import commodities exists. Wei Cao and Fangrong Yan et al. (2016) took "Belt and Road Initiative" countries as the research objects and used OLS, dependent regression, panel data two-stage instrumental variable method, and other estimation methods as well as a sensitivity analysis to study the impact of exchange rate fluctuations and neighboring effects on foreign trade between China and countries along "The Belt and Road Initiative". It is concluded that, on the whole, the current appreciation of RMB reduces China's import from countries along "The Belt and Road Initiative", but the lagged appreciation in the first period leads to the increase of imports, and the depreciation of RMB in the current period and lagged in the first period is advantageous to China's export. Mohsen Bahmani-Oskooee and Kaveepot Satawatananon (2010) classified the trade flows between Thailand and the United States, by commodity, and investigated the impact of currency depreciation on the export earnings of 118 export industries and export expenditure of 42 import industries of the United States.

To sum up, exchange rate fluctuation has a significant effect on a country's foreign trade. Different countries have different import and export structures, and exchange rate fluctuation will have different impacts. China is an important trading partner of more than 120 countries in the world. There are great differences in trade between different countries and China.

3 The analysis of RMB's exchange rate against other BRICS countries and foreign trade status

To measure the RMB's real exchange rate level in other BRICS countries, the Russian ruble, South African rand, Indian rupee, and Brazilian real were selected as the basket currencies of the "BRICS" RMB's real exchange rate index. The sample currency was priced at the average monthly exchange rate of RMB against the four national currencies from January 2017 to December 2021 (data source: China Foreign Exchange Trade System). By referring to the weights of the currencies of these four countries in the currency basket of the BIS RMB exchange rate Index, the weights of sample currencies were obtained as shown in Table 1.

The CPI of these four countries from January 2017 to December 2021 (data source: IMF database) was used to deflate the average monthly exchange rate of RMB against the four currencies to eliminate inflation. The base period of the index was selected in January 2017, and the base period value was 100. Finally, the weighted arithmetic average was carried out to obtain the "BRICS" RMB's

Table 1. Basket of currencies weights

Currency	Weight
RUB	0.0142
ZAR	0.0054
INR	0.0252
BRL	0.0121

real exchange rate index. The specific formula is as follows:

$$RATE_t = \frac{100 \sum_{i=1}^4 e_{it} \frac{CPI_{0t}}{CPI_{it}} \omega_i}{RATE_t} \quad (1)$$

$$RATE_1 = \sum_{i=1}^4 e_{i1} \frac{CPI_{01}}{CPI_{i1}} \omega_i \quad (2)$$

Where $RATE_t$ is the "BRICS" RMB's real exchange rate index in month t , e_{it} is the average monthly exchange rate of RMB against the i th currency, CPI_{0t} is the CPI value of China in month t , CPI_{it} is the CPI value of the i th country in month t , and ω_i is the BIS RMB exchange rate index currency basket weight of the i th country.

As can be seen from Figure 1, although the "BRICS" RMB's real exchange rate index fluctuated from January 2017 to December 2021, it showed an obvious upward trend on the whole. The exchange rate index declined significantly in the first half of 2017 but began to show an obvious upward trend in the second half of 2017. In 2018, the exchange rate index showed great fluctuation, but since 2019, its upward trend has become more obvious and stable, indicating that since 2019, the status and recognition of RMB among the BRICS have been steadily rising, and the internationalization process of RMB has been steadily advancing.

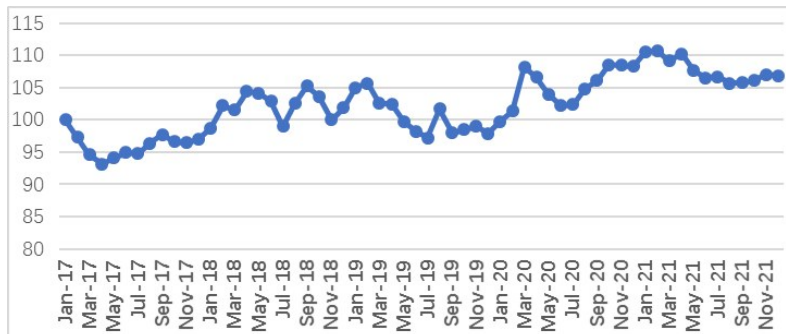


Figure 1. The "BRICS" RMB's real exchange rate index

The monthly total amount of China's imports and exports to other BRICS countries in thousands of US dollars from January 2017 to December 2021 was selected to represent the level of China's import and export to other BRICS countries (data source: CSMAR database). As can be seen from Figure 2, between 2017 and 2021, there was little difference in import and export between China and other BRICS countries, with balanced development of import and export. The slump in China's exports to other BRICS countries in early 2020 was mainly due to the pandemic, and then the total exports returned to normal levels; On the whole, China's total imports and exports to other BRICS countries show a large upward trend, which indicates that with the rise of emerging markets, trade between China and other BRICS countries is getting closer and closer, and trade cooperation has made positive progress.



Figure 2. China's total imports and exports to other BRICS countries

4 An empirical study on the impact of RMB's real exchange rate on foreign trade between China and other BRICS countries

4.1 Variable processing and stationarity test

The variables $\ln rate$, $\ln im$ and $\ln ex$ were obtained by taking the logarithms of the "BRICS" RMB's real exchange rate index rate, the total import value of China to other BRICS countries im and the total export value of China to other BRICS countries ex respectively. Unit root test was conducted on these three variables to test the serial stationarity by using ADF test. The test results are displayed in Table 2, the sequences $\ln rate$ and $\ln im$ are non-stationary, and all the sequences after the first difference are stationary.

Table 2. ADF test results

Variable	ADF statistic	1% critical value	5% critical value	10% critical value	Result
$\ln im$	-2.574	-3.567	-2.923	-2.596	Non-stationary
$\ln ex$	-3.607	-3.567	-2.923	-2.596	Stationary
$\ln rate$	-1.681	-3.567	-2.923	-2.596	Non-stationary
$d\ln im$	-9.000	-3.569	-2.924	-2.597	Stationary
$d\ln ex$	-12.244	-3.569	-2.924	-2.597	Stationary
$d\ln rate$	-7.319	-3.569	-2.924	-2.597	stationary

4.2 Determination of the optimal lag order of VAR model

In this paper, LR, FPE, AIC, SC, HQ and other criteria are used to determine the lag order of VAR model, and the test results are shown in Table 3. According to the majority principle, the optimal lag period is 2 periods.

Table 3. Maximum lag order test statistics

Lag	LogL	LR	FPE	AIC	SC	HQ
0	186.056	NA	2.6E-07	-6.65658	-6.54709*	-6.61424
1	198.266	24.42	2.3E-07	-6.7733	-6.33534	-6.60394
2	212.199	27.867*	1.9E-07*	-6.95271*	-6.18627	-6.65632*
3	217.011	9.6223	2.3E-07	-6.80039	-5.70548	-6.37698
4	220.388	6.7551	2.8E-07	-6.59593	-5.17255	-6.0455

4.3 Parameter estimation of VAR model

After ADF test and determining the optimal lag order, VAR model can be established. It is necessary to carry out unit root test on VAR model, as shown in Figure 3.

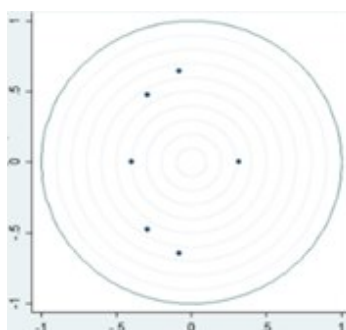


Figure 3. Unit root test

According to Figure 3, the modulus of the reciprocal of all roots of the VAR model is less than 1, that is, the reciprocal of all roots falls within the unit circle, indicating that the model with two lags has a high degree of fit and is relatively stable.

Table 4. Parameter estimation results

variable	dlnim	dlnex
dlnrate lag(1)	-1.467474**	-2.338152**
dlnrate lag(2)	-1.165247*	-0.2728251
dlnim lag(1)	-0.2882556**	0.3955808*
dlnim lag(2)	-0.032027	0.3194536
dlnex lag(1)	-0.0518697	-0.6306032***
dlnex lag(2)	-0.101043	-0.3962227***

Note: *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively.

According to Table 4, the parameter estimation results of the dependent variable $D(\ln im)$ are obtained as follows:

$$D(\ln im)_t = -1.4675D(\ln rate)_{t-1} - 0.2883D(\ln im)_{t-1} \quad (3)$$

The parameter estimation results indicate the growth of the "BRICS" RMB's real exchange rate index lagging one period will negatively affect the growth of import value in the current period, and the effect coefficient is -1.4675, which reveals that the rise of RMB's real exchange rate index, that is, the strengthening of RMB, will cause a decline in import value.

The parameter estimation results of the dependent variable $D(\ln ex)$ are obtained as follows:

$$D(\ln ex)_t = -2.3382D(\ln rate)_{t-1} - 0.6306D(\ln ex)_{t-1} - 0.3962D(\ln ex)_{t-2} \quad (4)$$

The results show that the growth of the BRICS RMB's real exchange rate index lagging one period will negatively affect the growth of export value in the current period, and the effect coefficient is -2.3382. This suggests that a stronger RMB would reduce export value.

4.4 Impulse response diagram

When analyzing VAR model, impulse response function can be used to reveal the dynamic impact between model variables. Impulse response function has more practical significance than parameter estimation. In order to see the dynamic relationship among $D(\ln im)$, $D(\ln ex)$ and $D(\ln rate)$, the impulse response functions as shown in figure 5~8 were drawn.

As can be seen from Figure 5, when the RMB's real exchange rate index is given a positive impact, it will have a negative impact on the import value with little fluctuation. Then it will decline steadily, and then rise steadily when it becomes positive. Finally, it will decline slowly and then approach 0. According to Figure 6, a positive impact on the RMB's real exchange rate index will have a negative impact on the export value, which gradually intensifies at the beginning, then rises

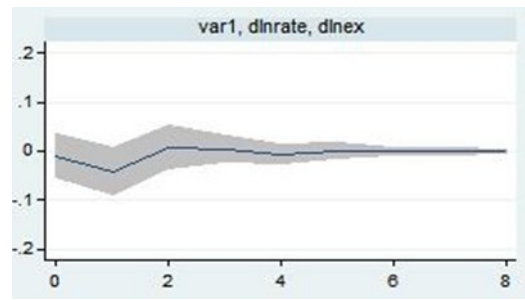


Figure 4. The response of D(lnim) to D(lnrate)

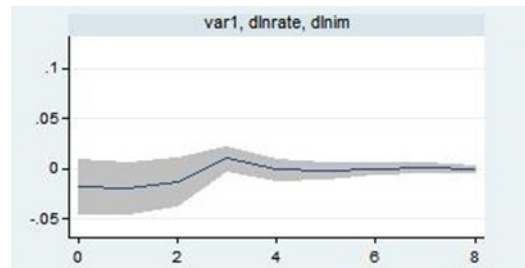


Figure 5. The response of D(lnex) to D(lnrate)

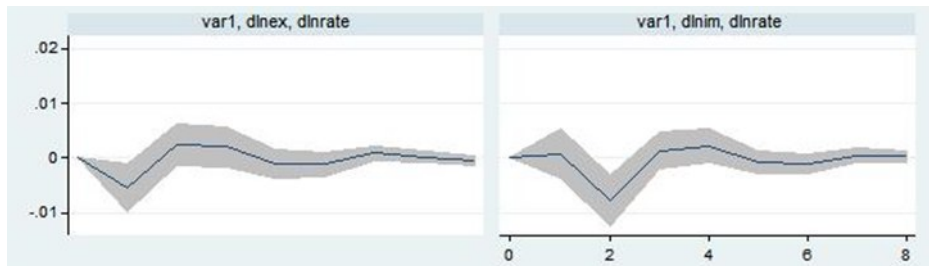


Figure 6. The response of D(lnrate) to D(lnex) and D(lnim)

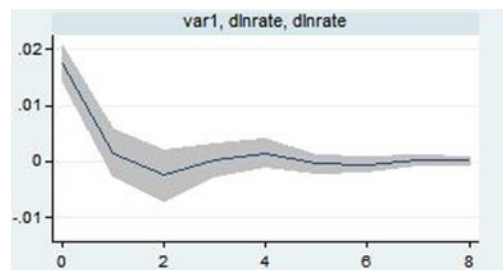


Figure 7. Response of D(lnrate) to itself

after reaching the low point, and finally tends to zero. As can be seen from Figure 7, a positive impact on the export value will have a negative impact on RMB's real exchange rate index, which gradually intensifies at the beginning, begins to rise when it reaches the low point, and continues to rise when it becomes positive. Then, after a period of no fluctuation, it slowly declines and finally approaches 0. When there is a positive impact on the import value, the RMB's real exchange rate index does not fluctuate for a period of time, and then has a negative impact on it, which gradually intensifies at the beginning, starts to rise after reaching the low point, and finally tends to zero. As can be seen from Figure 8, the impact of RMB's real exchange rate index on itself is positive at the beginning and decreases rapidly, reaches a low point in two periods, then rises steadily and finally

approaches 0. Compared with the impact of import and export value on the RMB's real exchange rate index, the index suffers more from its own impact.

4.5 The explanation of the negative impact of RMB's real exchange rate index on import and export value

4.5.1 The Analysis of China's Import Structure to other BRICS Countries

China's monthly imports from other BRICS countries in thousands of US dollars from January 2017 to December 2021 (data source: CSMAR database) were divided into seven industrial products by commodity type: agricultural food products, mechanical and electrical instruments and vehicles, minerals and metals, textile shoes and hats, rubber leather, toy clocks and watches, wood and paper and metalloid. And draw China's imports from Brazil, Russia, South Africa and India respectively.

As can be seen from Figure 8, China's imports from Brazil are mainly agricultural food products and minerals and metals. Imports of other products are small by comparison.

As can be seen from Figure 9, most of China's imports from Russia are minerals and metals, and the imports of other products is negligible compared with that of mineral and metal products.

As can be seen from Figure 10, China's imports from South Africa are mainly agricultural food products and minerals and metals, followed by toy clocks and watches.

As can be seen from Figure 11, the imports of minerals and metals accounted for the main part of China's imports from India, while the imports of other products was relatively small.

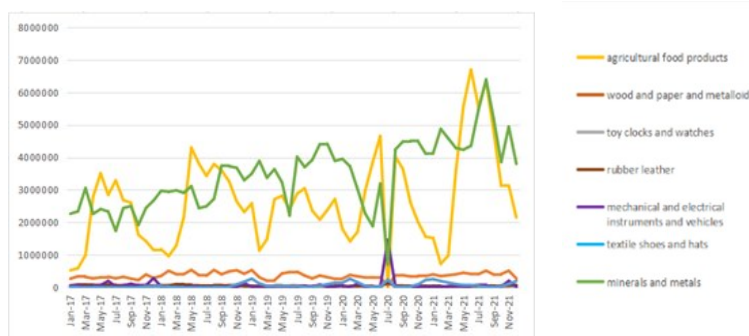


Figure 8. Imports from Brazil

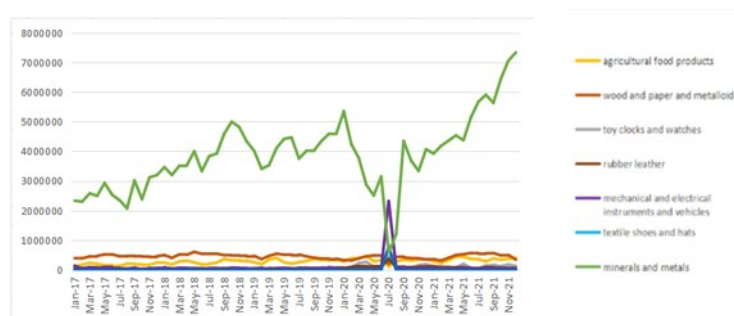


Figure 9. Imports from Russia

The analysis shows that China's imports of commodities from other BRICS countries are dominated by bulk commodities, which account for the vast majority of the total import value. And bulk commodities are inelastic commodities.

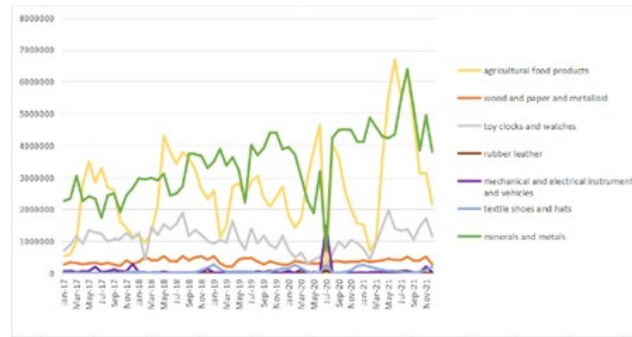


Figure 10. Imports from South Africa

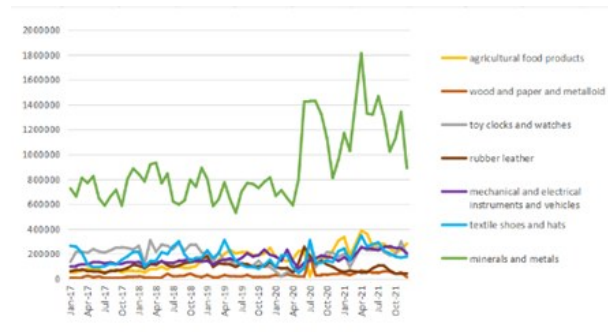


Figure 11. Imports from India

4.5.2 Mathematical deduction of elastic influence on the change of import and export value and Marshall-Lerner condition

Let the demand of import goods be Q , as a function of price P , expressed as

$$Q = f(P) \quad (5)$$

Let the import value be R ,

$$R = Q \cdot P = f(P) \cdot P \quad (6)$$

The definition of price elasticity of demand:

$$e = \frac{\frac{\Delta Q}{Q}}{\frac{\Delta P}{P}} = \frac{P}{Q} \cdot \frac{dQ}{dP} = \frac{P}{Q} \cdot f'(P) \quad (7)$$

$$R' = \frac{dR}{dP} = f'(P) \cdot P + f(P) \quad (8)$$

$$\frac{R'}{f'(P) \cdot P} = 1 + \frac{f(P)}{f'(P) \cdot P} = 1 + \frac{Q}{P} \cdot \frac{1}{f'(P)} = 1 + \frac{1}{e} \quad (9)$$

According to the microeconomic definition, the rate of change in demand for an inelastic good is less than the rate of change in the price. Thus, $|e| < 1$, that is $-1 < e < 0$;

The rate of change in demand for an elastic good is greater than the rate of change in price. Thus, $|e| > 1$, that is $e < -1$.

So if the import goods are inelastic, then $\frac{R'}{f'(P) \cdot P} = 1 + \frac{1}{e} < 0$, that is $R' < 0$. That is, when the price P decreases, the import value R decreases. If the import goods are elastic, then $1 + \frac{1}{e} > 0$, that

is $R' < 0$. That is, when the price P decreases, the import value R increases. The same is true for export goods.

The traditional Marshall - Lerner condition is expressed as follows: although the real depreciation of a country's currency will initially cause a reduction in net exports. In the short term, the change of demand of the import goods is likely to be slow, especially inelastic goods. However, the change of the price of import goods caused by the exchange rate fluctuation is rapid, that is, the change of the demand of import goods is much smaller than the change of its price, in the short run. This explains why the rise of the RMB's real exchange rate index in the first two periods had a negative impact on the import value. In the long run, the impact of changes in the relative prices of import goods becomes stronger over time. The low price of BRICS commodities will cause Chinese enterprises to reduce their demand for similar commodities in China and other countries, and this part of the demand will gradually shift to the commodities in BRICS countries. On the basis of the Marshall-Lerner condition, the increase in the amount of import will eventually be stronger than the negative effect of price, so that China's import value from other BRICS countries will increase.

In the short term, changes in the demand for Chinese exports are likely to be sensitive, which is closely related to the fact that most of China's exports to other BRICS countries are elastic. Therefore, when the RMB's real exchange rate index rises, it has a negative effect on export value, which gradually intensifies at first and reaches a low point. As time goes by, the response of the amount of export to price will gradually weaken, so the negative impact of RMB's real exchange rate index on export value will start to rise after reaching the low point, and tend to be stable in the long run.

Overall, when RMB's real exchange rate index rises, the price of China's imports from other BRICS countries falls relatively. And most of the imports are inelastic bulk commodities. In the short term, the change range of its demand is less than the change range of its price, so the import value will decline. Whereas, in the long term, the reaction of the amount of import will be stronger than the negative effect of price, eventually. Therefore, China's import value from other BRICS countries will rise, and eventually the RMB's real exchange rate index will have a positive impact on the import value and become stable.

When the RMB's real exchange rate index rises, the price of China's exports to other BRICS countries rises relatively. And most of the exports are elastic, so the export value will decline fast. Whereas, in the long run, the response of the amount of export to price will gradually weaken, so the negative impact of the RMB's real exchange rate index on export value starts to rise after reaching the low point. In the long run, RMB's real exchange rate index will have a negative impact on export value and become stable.

5 Conclusions

In this paper, by compiling the "BRICS" RMB's real exchange rate index and using the data of China's monthly import and export value from 2017 to 2021 to other BRICS countries, the VAR model was constructed to analyze the impact of RMB's real exchange rate index on import and export value, as well as the equilibrium relationship between the three. The results showed that:

Firstly, the "BRICS" RMB's real exchange rate index harms the import value in the short run, with little fluctuation and a steady decline after two periods. After that, the RMB's real exchange rate index contributes to the import value. The RMB's real exchange rate index is helpful to import value and tends to be stable in the long term.

Secondly, the "BRICS" RMB's real exchange rate index will have a persistent negative impact on export value. The negative impact gradually intensifies at the beginning and starts to rise after reaching the low point. In the long term, the negative impact of RMB's real exchange rate index on

export value tends to be stable.

Thirdly, the impact of the "BRICS" RMB's real exchange rate index mainly comes from itself. Compared with export value, the impact of import value on the RMB's real exchange rate index has an obvious lag.

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