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Dynamic Correlation between the RMB Exchange Rate and China's Import and Export Trade before and after the COVID-19 Pandemic

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ABSTRACT

This research employs data on the real effective exchange rate of the Renminbi, alongside aggregate import and export statistics, to construct a vector autoregression model. The objective of this investigation is to look into the dynamic interplay between the CNY currency rate and trade flows amidst the COVID-19 pandemic. The research reveals a persistent equilibrium connection between the REER, import volumes, and export volumes. Moreover, import trade is subject to Granger causality influence from changes in the real exchange rate of the RMB, suggesting that this exchange rate significantly affects fluctuations in total imports. Further analysis reveals that the impact of imports and exports on fluctuations in the RMB exchange rate is relatively minor. However, the impact of the Renminbi exchange rate on trade flows is increasingly considerable and becomes more clearly observable over an extended period.

KEYWORDS

The COVID-19 pandemic; The real effective exchange rate; Import and export trade; VAR model

1. INTRODUCTION

The COVID-19 pandemic spread globally in 2020, posing unprecedented challenges to Chinese economy system and the exchange rate of the RMB. Since late January 2020, affected by the COVID-19 outbreak in Wuhan, the Renminbi versus USD exchange rate began to decline rapidly, which also brought significant impacts on foreign commerce of China. At the initial stage of the pandemic, domestic production and operations were forced to cease, resulting in China being unable to fulfill its international commerce orders as usual. With the further outbreak of the pandemic globally, the need for international trade products from various countries also decreased accordingly, which further deteriorated China's foreign trade environment. As a leading global exporter, modifications in the volume and composition of China's trade in goods can profoundly influence the CNY conversion rate. Conversely, variations in the CNY conversion rate can directly impact the competitive edge of foreign commerce of China. Consequently, amidst the COVID-19 pandemic, the interaction between the Renminbi currency exchange rate and China's trade sector dynamics has garnered significant attention. While extensive research has been accomplished on the interaction between exchange rates and international commerce, investigations into the nuanced interplay between the Renminbi (RMB) exchange rate and China's import and export dynamics within the context of the COVID-19 pandemic are notably deficient. To address this gap, this study collects data on China's real effective exchange rate (REER), total exports (EX) and total imports (IM) from January 2017 to December 2023. By establishing a vector autoregressive model (VAR), this study aims to explore: (1) The reciprocal

influence between the exchange rate of the RMB and import and export; (2) The causal connection between the Renminbi (RMB) exchange rate and international trade.

2. LITERATURE REVIEW

In the academic field of investigating the impact of currency conversion rates on global trade, numerous scholars from both domestic and international circles have conducted in-depth research. Guneren and Artar (2014) focused on emerging countries and revealed through panel cointegration analysis the long-term integration between currency values and commerce of these countries. Domestic researchers Cao Yang and Li Jianwu (2006) also explored the integrated connection between currency values and commerce, drawing different conclusions from the perspectives of long and short term impacts: as the volatility of exchange rates increases, China's export volume is likely to reduce while import volume increases, although the short term impact of rising exchange rate volatility on trade is not significant. Moreover, Chaudhry and Yuce (2019) examined the short and long term impacts of currency fluctuations on Canada's trade. They found that in the long term, changes in the foreign exchange value are inversely correlated with total export volume, export volume to the US, total import volume, and import volume from the US; whereas in the short term, such fluctuations exhibit a bidirectional interaction. Li Lan (2022) filled the research void regarding the effects of RMB currency conversion rate variations on China's global trade and its causal relationships, finding that exchange rate movements lead to a unidirectional causal relationship with import trade volume.

The Vector Autoregression (VAR) model, as an important analytical tool, has also been extensively applied in previous studies. Studies conducted by researchers such as Duasa (2009), Azu and Nasiri (2015), Qi Yasha (2011), and Guo Huanhuan (2017) have employed the VAR model to analyze the correlation between exchange rates, import/export price levels, economic growth, and China's international trade under diverse circumstances. Among them, Duasa (2009) analyzed the dynamic association among nominal exchange rates, money supply, and import and export prices in the context of exchange rate shocks in Malaysia using VECM, variance decomposition, and impulse response functions; Azu and Nasiri (2015) assessed the connection between actual exchange rate volatility, economic expansion, and trade flows in Nigeria using the VAR model.

In summary, this study purposes to build upon the foundation of previous research achievements to further investigate the changing correlation between the RMB's exchange ratio and China's trading interactions before and after COVID-19. This study aims to offer an in-depth view of understanding complex macroeconomic phenomena by drawing on and applying the VAR model, offering scientific support for the formulation of monetary and trade policies in the post-pandemic era. Additionally, it aids import and export firms in comprehending the dynamic interplay between the Renminbi (RMB) exchange rate and global trade, consequently allowing them to fine-tune their strategic approaches.

3. DATA COLLECTION AND METHODOLOGY

3.1. Data Collection and Transformation

When examining the nexus between currency values and trade dynamics, the REER emerges as the most apt metric, offering a superior comparison to both nominal and actual currency conversion rates. The REER incorporates the impact of inflation and accurately mirrors a nation's currency value relative to its principal trading partners, employing a weighted average methodology. Therefore, this paper selects the REER, total domestic exports (EX), and total domestic imports (IM) as endogenous variables. The sample data includes monthly observations from January 2018 to December 2023. The information concerning the REER is sourced from the International Financial Statistics, as issued by

the International Monetary Fund. Meanwhile, the figures for aggregate exports (EX) and imports (IM) are sourced from the National Bureau of Statistics.

Affected by the COVID-19 pandemic, data for imports and exports in January and February 2020 are missing. This study obtains complete data through linear interpolation. Furthermore, the EX and IM data exhibit pronounced seasonal trends, hence the X-12 method is employed to adjust for these seasonal patterns. Additionally, to eliminate the impact of inflation, it is necessary to deflate the data using the Consumer Price Index (CPI) to obtain real values. In order to minimize the heteroscedasticity of the variables as much as possible, this study applies logarithmic transformation to all variables.

3.2. Methodology

The Vector Autoregression (VAR) model, pioneered in the early 1980s, is frequently employed for forecasting interconnected time series systems and assessing the temporal repercussions of random disturbances on variables. This enables the examination of diverse shocks' impacts on economic variables. Its operating principle involves using the previous values of all internal variables within the model to elucidate the present value of each internal variable. Its mathematical expression is

$$y_t = \varphi_1 y_{t-1} + \ldots + \varphi_p y_{t-p} + Hx_t + \varepsilon_t,\ t=1,\ 2,\ 3,\ ...,\ T.$$

In this model, Matrix y_t comprises an endogenous variable column vector with k elements, while Matrix x_t contains an exogenous variable column vector also comprising k elements. The notation p signifies the lag order, and T denotes the total number of observations. $\varepsilon_t$is a disturbance column vector containing k variables.

The equation above can be expanded and expressed as:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ M \\ y_{kt} \end{bmatrix} = \varphi_1 \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ M \\ y_{kt-1} \end{bmatrix} + \ldots + \varphi_p \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \\ M \\ y_{kt-p} \end{bmatrix} + H \begin{bmatrix} x_{1t} \\ x_{2t} \\ M \\ x_{kt} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ M \\ \varepsilon_{kt} \end{bmatrix},\ t=1,\ 2,\ ...,\ T.$$

The VAR model requires the time series to be stationary, so we need to first test the series for stationarity. For non-stationary variables, it is required to transform them into stationary time series through differencing. If the variables are single-integrated, this paper will use the cointegration method for analysis. Subsequently, the Granger causality test will be applied to explore the causative connection between the Renminbi exchange rate and import-export dynamics. Finally, this paper will further analyze using impulse response analysis and variance decomposition.

4. RESULTS AND DISCUSSION

4.1. Stationarity Test

Table 1. ADF Test Results

Variable	t-Statistic	Prob.*
LNREER	-2.406801	0.1430
LNEX	-1.941818	0.3119
LNIM	-1.843656	0.3572
D(LNREER)	-5.379656	0.0000
D(LNEX)	-16.83592	0.0001
D(LNIM)	-14.48802	0.0001

Prior to executing regression analyses on time series data, it's crucial to test the data for stationarity to avert pseudo-regression. This necessitates that the applied time series be stationary, devoid of any random or deterministic trends. Stationarity is assessed through graphical representations and unit root tests, encompassing ADF, DF, and PP tests. The tests for the smoothness of the data are graphical and unit root tests, of which the unit root tests include ADF, DF and PP tests. For this study, the ADF test is used, and the results (Table 1) indicate that LNREER, LNEX, and LNIM are non-stationary at the 5% significance level. However, their first-order differenced series are stationary at the same level. This suggests that these variables are all part of a first-order single-integrated series. Consequently, there may be a long-run co-integration among the REER, overall export quantities, and overall import quantities. Thus suggesting that the REER, total exports and total imports may have long-term co-integration.

4.2. Cointegration Test

In the realm of macroeconometric analysis, the cointegration technique introduced by Granger (1987) has emerged as a pivotal tool for exploring quantitative relationships among non-stationary economic variables. The importance of cointegration analysis resides in its ability to ascertain whether the causal linkages depicted by a regression equation are genuine or merely the result of a spurious regression. In essence, it evaluates the presence of consistent and stable associations among variables over time. Consequently, the process of examining causality within non-stationary series is synonymous with conducting a cointegration test. The principal cointegration tests include the Engle-Granger two-step approach and the Johansen test. In this study, the Johansen test is utilized to ascertain whether there exists a long-term stable cointegrating relationship among the REER, total exports, and total imports. The Johansen test, which is grounded on regression coefficients, necessitates the formulation of a VAR model. In accordance with this prerequisite, this study employs the LR, AIC, SC, and HQ to ascertain the appropriate lag order for the VAR model, resulting in an optimal lag selection of 2. The Johansen test primarily employs two methods: the trace test and the maximum eigenvalue test.

The data (Table 2) reveals that at the 5% significance level, A single co-integrating relationship exists among these three variables, demonstrating that there is a co-integrating connection between the endogenous variables within the model. Furthermore, a standardized long-run equilibrium relationship is obtained:

$$\begin{gathered} LNEX=-1.277594*LNIM-0.689926*LNREER. \\ (0.06814) \qquad (0.25451) \end{gathered}$$

From the equation above, a negative relationship exists between total exports and the REER, as well as total imports. Both an uplift in the REER and a rise in total imports will lead to a decrease in total exports.

Table 2. Cointegration Test Results

Hypothesized No. of CE (s)	Eigenvalue	Trace			Max-eigenvalue		
		Trace Statistic	5% Critical Value	Prob.** Critical Value	Max-Eigen Statistic	5% Critical Value	Prob.** Critical Value
None*	0.260216	35.15208	29.79707	0.0110	24.71460	21.13162	0.0150
At most 1	0.081829	10.43748	15.49471	0.2486	7.00050	14.26460	0.4891
At most 2	0.041048	3.43699	3.84147	0.0637	3.43699	3.84147	0.0637

4.3. Granger Causality Test

When variables exhibit co-integration, this implies that there is a minimum of one-way Granger causality between them. Therefore, after establishing the cointegration relationship between the variables, this paper further tests whether there is a important Granger causality between the variables.

The empirical findings presented in Table 3 indicate that, at a 10% significance level, there is no indication to suggest that either total imports or total exports Granger-cause the REER. Similarly, the data does not support the notion that the REER Granger-causes total exports. Similarly, total exports do not Granger-cause changes in total imports. In other words, fluctuations in total imports and exports are not significant factors causing variations in the REER; volatility in the REER is not a significantly factor causing fluctuations in total exports; and changes in total exports are not a significant factor leading to variations in total imports. However, at a 5% significance level, total imports do Granger-cause total exports, and the REER does Granger-cause total imports. This implies that total imports are a significant factor influencing changes in total exports, and the REER is a significant factor causing fluctuations in total imports.

Table 3. Findings From The Granger Causality Test

Dependent variable	Excluded	Chi-sq	df	Prob.
LNEX	LNIM	10.73761	2	0.0047
	LNREER	2.098755	2	0.3502
	ALL	12.28449	4	0.0154
LNIM	LNEX	1.934679	2	0.3801
	LNREER	6.075507	2	0.0479
	ALL	8.528352	4	0.074
LNREER	LNEX	1.810462	2	0.4044
	LNIM	0.122575	2	0.9406
	ALL	7.806302	4	0.0989

4.4. Establishment of VAR Model

Determining the lag order is an important issue in establishing a VAR model. Too few lags may fail to fully reflect the dynamic relationships between variables, while too many lags can lead to a reduction in degrees of freedom, this impairs the efficiency of model parameter estimation. In the cointegration testing section, the ideal lag for the VAR model was ascertained to be 2 using the LR, AIC, SC, and HQ information criteria. Therefore, the model adopts a lag order of 2. The model expression is as follow:

$$\begin{pmatrix} \mathrm{LNEX} \\ \mathrm{LNIM} \\ \mathrm{LNREER} \end{pmatrix} = \begin{pmatrix} 0.256026 & 0.324308 & -0.776190 \\ 0.090747 & 0.528400 & -1.421202 \\ -0.016176 & 0.004701 & 1.424164 \end{pmatrix} \begin{pmatrix} \mathrm{LNEX}(-1) \\ \mathrm{LNIM}(-1) \\ \mathrm{LNREER}(-1) \end{pmatrix} + \begin{pmatrix} 0.460583 & -0.033611 & 0.741991 \\ 0.082435 & 0.304850 & 1.339938 \\ 0.025018 & -0.006598 & -0.494371 \end{pmatrix} \begin{pmatrix} \mathrm{LNEX}(-2) \\ \mathrm{LNIM}(-2) \\ \mathrm{LNREER}(-2) \end{pmatrix}$$

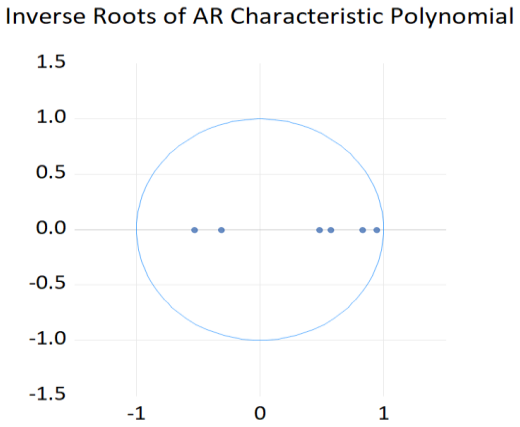

Figure 1. Figure for Discriminating the Stability of VAR Mode

To test whether the model is stable, this paper employs the AR root test method. If all eigenvalues are positioned inside the unit circle, it signifies that the model is stable. The test results are shown in Fig.1. According to Fig.1, all eigenvalues of the companion matrix are located inside the unit circle. Therefore, the constructed model is stable.

4.5. Impulse Response Analysis and Variance Decomposition

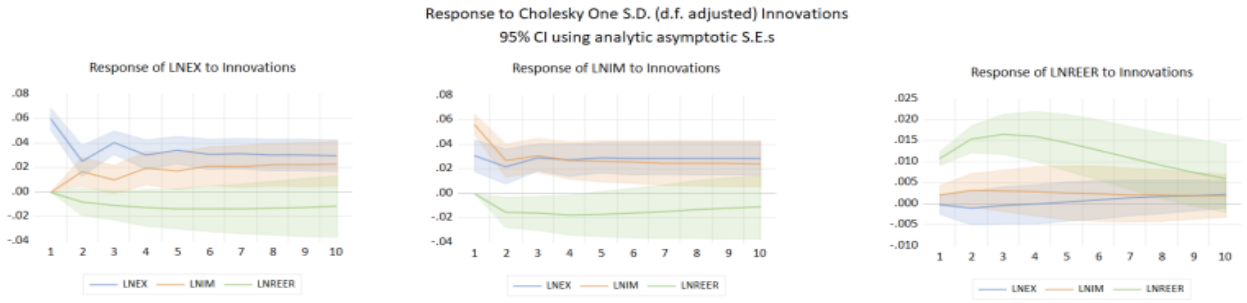

Figure 2. Response Function

Impulse response analysis examines how the variation in the disturbance term of a variable influences itself and other variables within the system. Fig.2 represents the impulse response functions over time, with the dotted lines indicating the positive and negative two standard deviation bands of the forecast effects. The impulse response curves show that imports and exports exert a specific level of impact on the RMB exchange rate, with both having a negative influence on the shock to the exchange rate. The shock effect of imports on the REER starts to strengthen from the first period, reaches its peak in the second period, and then gradually declines, converging to an equilibrium level. This indicates that an increase in imports can appreciate the REER in the short term, after which the shock effect diminishes; at the same time, after the REER is subjected to a one standard deviation information shock from total exports, the negative effect of the shock becomes prominent from the first period, begins to slowly decrease after the second period, and turns positive by the fourth period, continuing to increase thereafter; when the export amount is impacted by a one standard deviation information shock from the REER, it generates a negative influence that gradually increases, with a slow reduction trend in the negative impact by the sixth period; similarly, the REER's shock on imports also produces a negative impact, with the negative shock effect rapidly increasing from the first period, slowing down by the second period, and gradually weakening by the fourth period.

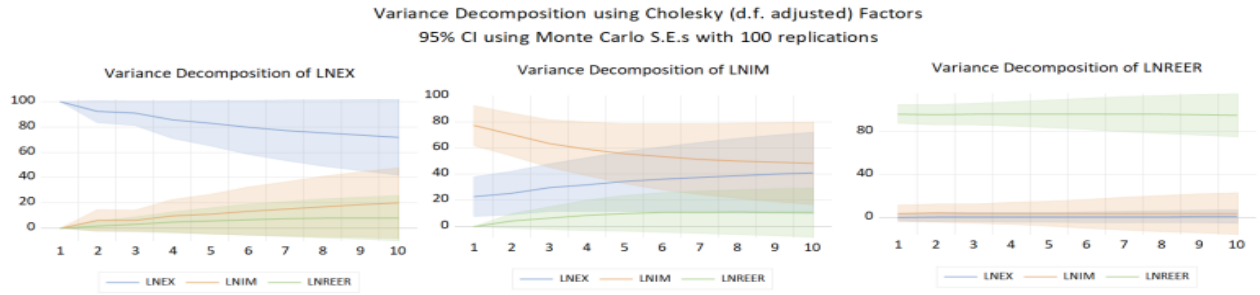

Figure 3. Variance Decomposition

Variance decomposition is utilized to assess the effects of fluctuations in the disturbance term of a variable on the overall forecast error variance for each variable, allowing for the assessment of the importance of various structural disturbances. From the variance decomposition values of REER shown in Table 4, the fluctuations in REER are mainly attributed to its own inertial shock, which explains around 96% of the variation, both in the short and long term, with the remainder explained by waves in imports and exports. The contribution of exports to REER remains consistently within 1%, while imports' contribution to REER is generally maintained at around 3.6%, indicating that the impact of imports and exports on REER is not very significant. The contribution rate of the REER to exports shows an increasing trend, stabilizing after the seventh period, with the equation's contribution to the forecast error remaining at a level of approximately 7.8%. This suggests that the consequence of REER on exports is relatively pronounced in the short term but gradually diminishes over time. The contribution degree of REER to imports (IM) initially shows a rapid increase, reaching a stable level of around 10.5% by the seventh period, indicating that the consequences of REER on IM is noticeable in the short term. The findings align with the outcomes of the impulse response function analysis.

5. CONCLUSIONS

The empirical examination of the correlation between the real effective exchange rate of the RMB, total imports, and total exports yields the following conclusions:

Cointegration analyses reveal a persistent, long-term association among the real effective exchange rate, aggregate imports, and aggregate exports. Notably, total exports exhibit an inverse correlation with both the real effective exchange rate of the Renminbi and aggregate imports.

Analysis of the Granger causality test results shows that neither aggregate imports nor exports Granger-cause the Renminbi's real effective exchange rate, and conversely, the Renminbi's real effective exchange rate does not Granger-cause total exports, while the real effective exchange rate of the RMB is a Granger cause for imports, meaning that the real effective exchange rate is a significant factor causing fluctuations in total imports.

The findings from impulse response analysis and variance decomposition indicate that the influence of imports and exports on the fluctuations of the RMB exchange rate is relatively small, whereas the impact of the RMB exchange rate on imports and exports is larger. The real effective exchange rate of the RMB is greatly influenced by itself, with about 96% stemming from its own effects, 0.1%~1% coming from changes in exports, and compared to exports, the impact of imports on the fluctuations of the RMB exchange rate is larger, accounting for 3.5%~4%. The influence of the RMB on imports and exports gradually becomes evident in the long term, reaching over 10% for imports. This phenomenon can be attributed to the lagged effect of exchange rate adjustments, which become evident only in the long-term perspective.

Table 4. Variance Decomposition Findings

	Variance Decomposition of LNEX				Variance Decomposition of LNIM				Variance Decomposition of LNREER			
Period	S.E.	LNEX	LNIM	LNREER	S.E.	LNEX	LNIM	LNREER	S.E.	LNEX	LNIM	LNREER
1	0.059	100.000	0.000	0.000	0.064	22.823	77.177	0.000	0.011	0.023	3.616	96.361
2	0.067	92.352	6.105	1.544	0.074	25.535	70.225	4.240	0.019	0.310	4.036	95.653
3	0.080	91.105	5.906	2.989	0.087	29.843	63.623	6.534	0.025	0.205	3.713	96.082
4	0.089	85.855	9.596	4.549	0.097	32.034	59.239	8.726	0.030	0.147	3.608	96.245
5	0.097	83.190	11.051	5.759	0.106	34.355	55.730	9.915	0.034	0.139	3.503	96.358
6	0.105	79.847	13.490	6.663	0.113	36.027	53.372	10.601	0.036	0.186	3.478	96.335
7	0.113	77.530	15.187	7.283	0.120	37.595	51.527	10.879	0.038	0.301	3.492	96.207
8	0.119	75.326	17.001	7.673	0.127	38.897	50.186	10.917	0.039	0.474	3.549	95.977
9	0.126	73.603	18.503	7.894	0.133	40.080	49.118	10.803	0.040	0.705	3.636	95.658
10	0.132	72.089	19.922	7.989	0.138	41.116	48.282	10.602	0.040	0.985	3.751	95.264

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