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Article

Study on the factors influencing the RMB internationalization—from the perspective of international monetary functions

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Abstract: Since 2022, global geopolitical conflicts have intensified, and there has been a notable increase in the international community's demand for currency diversification. This has created a new opportunity for the internationalization of the Renminbi (RMB). This paper examines the factors influencing the internationalization of the RMB, with a particular focus on its role as a unit of account, medium of exchange and store of value. These functions are considered in conjunction with the digital technological innovation represented by e-CNY. The methodology employed is based on the vector autoregression (VAR) model, Granger causality test and variance decomposition analysis. The Granger causality test indicates that digital technology innovation is not the primary driver of RMB internationalization at this juncture. The impulse response analysis and variance decomposition analysis revealed that the impact and direction of influence exerted by the various factors on RMB internationalization exhibit considerable discrepancies.

Keywords: currency internationalization; international monetary functions; digital technology innovations; VARs

1. Introduction

Since 2022, global geopolitical conflicts have intensified, which has increased the friction cost of financial institutions in various countries and led to a significant rise in the international community's demand for currency diversification. This has created a new opportunity for the internationalization of the RMB. In March 2023, the Brazilian government announced its intention to settle trade with China directly in its own currency, thereby eliminating the use of the US dollar as an intermediate currency. In February 2023, the Central Bank of Iraq announced its intention to permit the use of the RMB for trade settlement with China. During the same period, Association of Southeast Asian Nations (ASEAN) finance ministers and central bankers convened in Indonesia to deliberate on strategies for a gradual transition towards local currency settlements and a reduction in reliance on the United States (US) dollar, the euro, and the Japanese yen in financial transactions. In light of the aforementioned considerations, we put forth the following three questions for discussion:

- What are the factors that influence the internationalization of the RMB?
- To what extent do the various factors exert influence on the internationalization of the RMB?
- What are the long-term consequences of the various factors on the internationalization of the RMB?

2. Theory, concept and literature review

2.1. Currency internationalization

The concept of currency Internationalization has been defined from a variety of perspectives by numerous scholars. For example, Cohen (1971) and Lai et al. (2015) defined currency Internationalization from the perspective of currency function. Among these definitions, the one based on the currency function perspective provides a more comprehensive framework for studying the issue of currency Internationalization. This is because it encompasses a more extensive range of factors that contribute to the Internationalization of a currency. Accordingly, this paper employs the currency function perspective to define the connotation of currency internationalization, utilising it as the foundation for an investigation into the influencing factors of RMB Internationalization. In consideration of the roles that money plays, scholars such as Lai et al. (2015) have built upon Cohen's (1971) work to assert that a currency on the international stage typically fulfils three functions: unit of account, medium of exchange and store of value.

An international currency is defined as a currency that operates beyond the boundaries of a single nation-state, serving a global role. It is not merely a medium for domestic transactions within the issuing nation; it also plays a pivotal role in transactions between entities in disparate countries. In essence, an international currency serves as a substitute for the local currencies of the parties engaged in cross-border transactions, which may encompass the acquisition of merchandise, services, or financial instruments (Lai et al., 2015).

Table 1 shows the three roles played by international currencies. Cohen's (1971) study suggests that a currency can be considered fully internationalised when it fulfils all three monetary roles beyond its home economy (Bianca Orsi et al., 2023).

Table 1. Three functions of international money.

functions of money	Private	official
Medium of exchange	Vehicle currency,trade settlement	Inervention currency
Unit of account	Trade invoicing currecny	Exchange rate anchor
Store of value	Investment currency	Reserve currency

Source: Cohen and Benney (2013).

The function of money as a medium of exchange in the global economy is of paramount importance for the facilitation of trade. It serves as a universal payment mechanism in international markets. In the context of private transactions, a currency may be considered an international medium when it is employed for foreign exchange transactions or to settle trade. Although these functions are interrelated, they are not identical. As elucidated by Goldberg and Tille (2008), a currency serves as a "vehicle" for facilitating trades between non-directly tradable currency pairs. Moreover, it functions as the actual medium for the exchange of goods and services. For central banks, the capacity to employ an international medium of exchange is of paramount importance for the implementation of effective foreign exchange market interventions.

The function of money as a unit of account is to enable the assessment of the value of assets, goods, and services across borders. The Internationalization of a currency as a unit of account is indicated when foreign entities utilise that currency for the purpose of trade invoicing. Notwithstanding the potential for discrepancies between the invoicing and settlement currencies, studies by Friberg and Wilander (2008) and Ito and Chinn (2014) indicate a tendency for these to align. In the context of international transactions, irrespective of the settlement currency, a single currency must be employed for the denomination of contracts. Moreover, a currency may be regarded as an international unit of account when it is employed by the monetary authorities of other nations as a benchmark for their exchange rate policies. This is illustrated by instances where a central bank establishes a link between the value of its currency and that of an international unit of account.

The function of money as a store of value, which refers to the capacity of a currency to maintain its purchasing power over time. Investors seek to preserve their wealth by investing in assets that are denominated in currencies that are perceived to be stable in terms of both exchange rates and inflation rates. This aspect of international finance is frequently designated an "investment currency," as observed by Cohen and Benney (2014). In the official sector, central banks also maintain reserves in stable international currencies with the objective of ensuring the preservation of their value.

2.2. Factors influencing the development of media of exchange

The international currency as a medium of exchange is influenced by a number of interrelated factors, including cross-border trade settlements, imports and exports, foreign exchange and interest rate futures and options.

To illustrate, the RMB settlement volume has a considerable impact on its adoption, with economic scale being the most influential factor. However, this effect may diminish over time (Wei and Pak, 2023). Empirical analyses demonstrate that the RMB has exerted a significant influence on cross-border trade settlements from 2009 to 2014 (Huo et al., 2018).

The function of international currencies as a medium of exchange is of great consequence in facilitating global trade, particularly in the context of exports and imports. Currencies such as the U.S. dollar and the pound sterling have become known as vehicle currencies due to their extensive acceptance and the reduction of transaction costs in international trade. Krugman's model demonstrates how transaction costs impact the selection of a vehicle currency, underscoring the pivotal role of geographical factors and trade agreements in determining currency denomination in trade (Krugman, 1980; Witte and Ventura, 2016). Moreover, the preponderance of a currency can bestow an 'exorbitant privilege' upon the issuing country, thereby enhancing its economic welfare during trade interactions (Chahrour and Valchev, 2019). This interplay between currency choice and trade dynamics underscores the necessity of comprehending the structural factors that regulate international exchange.

Despite the RMB's advancement towards Internationalization, its impact remains constrained in comparison to established currencies such as the US dollar. Empirical simulations indicate that if the RMB were fully convertible, its share in global reserves

could be considerable. Projections indicate that with the implementation of a more liberalised policy, the RMB could become a global currency within a decade (Qiu et al., 2013).

Furthermore, the development of offshore RMB markets and the normalisation of RMB swaps are also of critical importance in enhancing the global standing of the currency (Wang, 2022).

In conclusion, these findings highlight the intricate interrelationship between economic and policy variables in the RMB's process of Internationalization (Wang, 2022). In light of the aforementioned evidence, we put forth the following 4 hypotheses:

Hypothesis 1: Cross-border trade settlements in RMB is the cause of internationalization of RMB.

Hypothesis 2: Total volume of imports and exports of China i is the cause of RMB internationalization.

Hypothesis 3: Global foreign exchange in RMB is the cause of RMB internationalization.

Hypothesis 4: Global interest rate futures and options in RMB is the cause of RMB internationalization.

2.3. Factors influencing the development of unit of account

The international currency as a unit of account is influenced by a number of interrelated factors. In the context of the offshore RMB-denominated bond market, in particular the dim sum bonds in Hong Kong, there has been a rapid expansion, with the market reaching a value of over RMB 186.8 billion and comprising 329 issues in less than five years (Fung et al., 2012). Furthermore, the total volume of China's bond market surpassed RMB 70.4 trillion, thereby becoming the third largest globally (Fareniuk, 2019). The Internationalization of the RMB is supported by a number of factors, including comprehensive strength, currency yield and network externality, which are crucial for enhancing its competitiveness in the international debt securities market (Papadamou et al. 2019; Song, 2017). Moreover, the opening of bond markets is crucial for facilitating currency flowback and attracting foreign investment, thereby promoting RMB Internationalization (Guo et al., 2021).

This study analyses the factors influencing the Internationalization of the RMB from the perspective of its function as a unit of account. Furthermore, the vector autoregression (VAR) estimation method is employed to test the factors influencing a currency to become a bond currency. The results demonstrate that an increase in the degree of RMB appreciation is associated with a more stable RMB exchange rate, a more developed Chinese bond market, a larger economy, and a higher share of global trade, which in turn is linked to a larger scale of RMB-denominated international bond issuance (Bin Ma, 2015).

Notwithstanding these advancements, challenges persist, including the necessity for enhanced openness in the domestic debt securities market to fully actualise the potential of the RMB in global finance. Although the RMB displays considerable promise, its current status as a unit of account is constrained by structural challenges and competition from established currencies. This necessitates the implementation of

substantial reforms to facilitate broader acceptance in international markets. In light of the aforementioned considerations, we put forth the following hypothesis:

Hypothesis 5: The issuance of RMB-denominated international securities is the cause of RMB internationalization.

2.4. Factors influencing the development of store of value

The international currency as a store of value is influenced by a number of interrelated factors. As China's economy continues to expand and its financial markets become increasingly accessible, the potential of the RMB as a store of value is becoming increasingly apparent. The degree of Internationalization of the RMB is reflected in the holdings of domestic RMB financial assets by overseas entities, which encompass stocks, bonds, loans and deposits. An increase in the holdings of these assets is indicative of a greater acceptance and utilisation of the RMB on a global scale.

Some studies have indicated that an increase in the level of RMB Internationalization can positively affect its credibility in international economic activities, as well as expand the effective demand for financial services trade and optimise the supply structure. Empirical analyses have demonstrated that the development of overseas RMB securities is a crucial factor in enhancing the level of RMB Internationalization, thereby reducing the US-China financial services trade deficit (Lei, 2024).

Empirical evidence indicates an increase in demand for RMB-denominated assets, which suggests a shift in global financial dynamics. Furthermore, the opening of bond markets attracts foreign investors (Guo et al., 2021). Based on this evidence, we propose the following hypothesis:

Hypothesis 6: Domestic RMB Financial Assets Held by Overseas Entities are the cause of RMB internationalization.

2.5. Technology innovation

The Internationalization of the RMB may be driven by a number of digital developments, including the cross-border use of the e-CNY, the digitisation and expansion of China's clearing system (CIPS). It is possible that these developments may result in the RMB becoming a widely used, liquid and stable store of value.

The e-CNY, a Central Bank Digital Currency (CBDC) project, has been in development since 2014. The e-CNY, with its technical features, adopts the framework of "one coin, two repositories, and three centers" (**Figure 1**). The primary objective of the digital yuan is to enhance the convenience and efficiency of the retail payment system. This approach differs from the wholesale-focused CBDC strategies of some other countries. The development of multi-CBDCs, which join up CBDCs across borders and feature a jointly operated payment system hosting multiple CBDCs, could spur RMB internationalization (BIS 2021). The multi-CBDC bridge project, in which the People's Bank of China (PBOC) is a participant, is an experimental arrangement that utilises distributed ledger technology (DLT) to facilitate cross-border payments. The project advocates for interoperability between domestic CBDCs or between domestic CBDCs and existing payment systems, rather than relying on a single CBDC for transactions across borders. Consequently, the PBOC favours a

system in which domestic CBDCs are converted to other currencies during cross-border transactions.

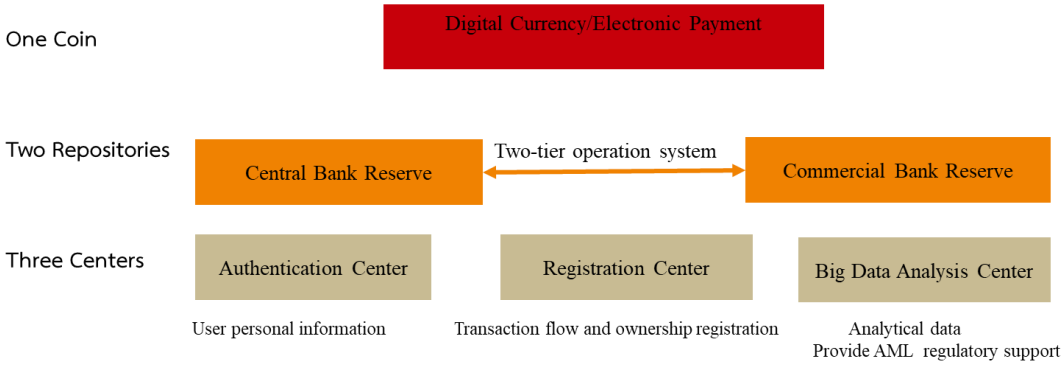

Figure 1. e-CNY "One Currency, Two Repositories, Three Centers" Structure.

e-CNY "One Currency, Two Repositories, Three Centers" Structure China's e-CNY initiative, which aims to partially replace cash in circulation, and the prospective utilisation of the e-CNY in international transactions will exert a considerable influence on the Internationalization process of the RMB (van der Linden et al., 2023). Consequently, we propose the following hypothesis:

Hypothesis 7: CIPS II system is the cause of RMB internationalization.

The research conceptual framework for this paper is shown in **Figure 2**:

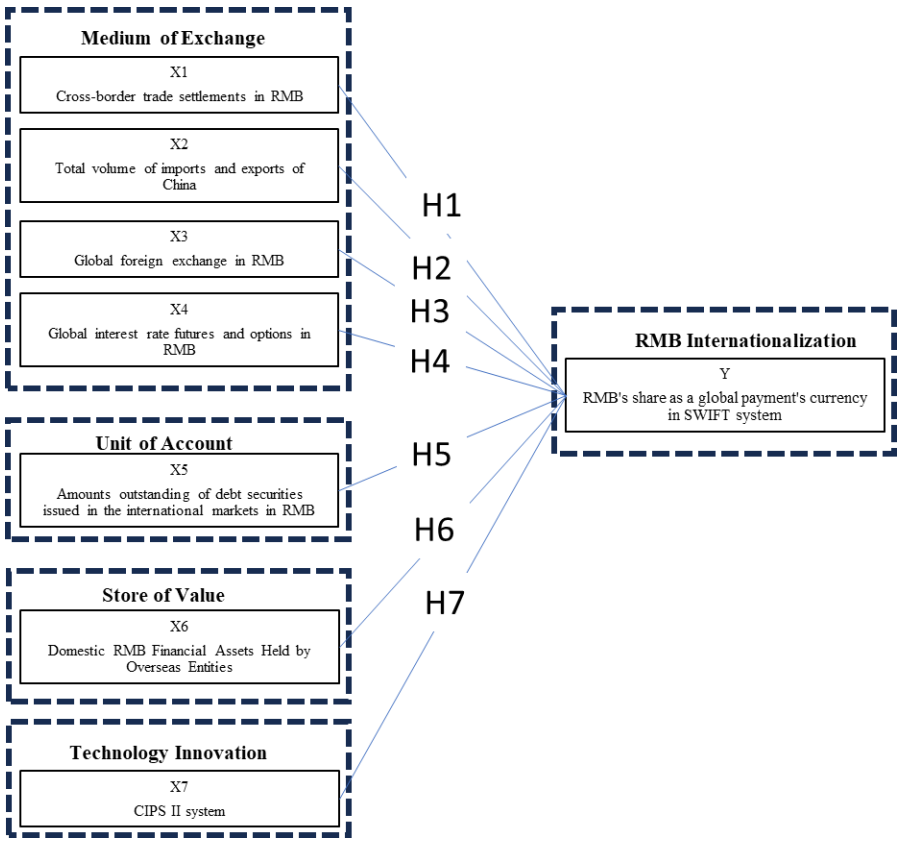

Figure 2. Research conceptual framework.

2.6. Research overview

The existing research on the influencing factors of currency internationalization from the perspective of international monetary function commenced at an earlier point in time and has reached a more advanced stage of development. However, the extant research on the factors influencing the Internationalization of the RMB is still deficient in the following respects. Firstly, the majority of research in this field is conducted from the perspective of a specific function of the international currency. Secondly, the current corpus of quantitative research is insufficient. Thirdly, previous studies have not accounted for the complex global political and economic context in which China currently operates, nor have they considered the potential impact of emerging technologies, such as the central bank's digital currency.

In light of the aforementioned considerations, this paper seeks to integrate the theoretical framework of currency Internationalization with the reality of China's economic development. This is achieved by examining the three functions of international currencies and the impact of emerging technologies, such as central bank digital currencies. Moreover, it employs a comprehensive approach that integrates both qualitative and quantitative analysis in order to identify the factors influencing the Internationalization of the RMB in a systematic manner.

This paper employs a three-function framework for international currency to analyse the factors that influence the Internationalization of the RMB. The contribution degree of each influencing factor is calculated, and the long-term trend and strength of each influencing factor are predicted. The objective is to provide a comprehensive integration of the rapid enhancement of China's economic strength with the digital technological innovation exemplified by the e-CNY.

3. Research methods

3.1. Data collection

In consideration of the accessibility and completeness of the data, this paper selects the period from November 2014 to December 2023, encompassing a total of 110 monthly data for analysis.

The eight research variables are presented in **Table 2**:

Table 2. Data collection and measurement.

Variables		Symbol	Description	Source	References
RMB internationalization		Y	RMB's share as a global payment's currency in SWIFT system	SWIFT tracker	Wang et al., 2024; Zhang and Perez-Saiz, 2023.
International currency's three functions	Medium of exchange	x_1	Cross-border trade settlements in RMB	PBoC	Huo et al., 2018; Wei and Pak, 2023.
		x_2	Total volume of imports and exports of China	Wind	Krugman, 1980; Witte and Ventura, 2016.
		x_3	Global foreign exchange in RMB	BIS Wind	Wang, 2022.
		x_4	Global interest rate futures and options in RMB	BIS Wind	Qiu et al., 2013; Wang, 2022.

	Unit of account	x_5	Amounts outstanding of debt securities issued in the international markets in RMB	BIS Wind	Guo et al., 2021; Song, 2017.
	Store of value	x_6	Domestic RMB Financial Assets Held by Overseas Entities	PBoC	Lei, 2024.
Other	Technology innovation	x_7	CIPS II system launch time	CIPS	Bin Ma, 2015; Deng, 2024

Y: RMB's share as a global payment's currency in Society for Worldwide Interbank Financial Telecommunications (SWIFT) system, data source is SWIFT tracker;

x_1: Cross-border trade settlements in RMB, data source is PBoC;

x_2: Total volume of imports and exports of China, data source is Wind.

x_3: Global foreign exchange in RMB, data source is Bank for International Settlements (BIS) and Wind;

x_4: Global interest rate futures and options in RMB, data source is BIS and Wind;

x_5: Amounts outstanding of debt securities issued in the international markets in RMB, data source is BIS and Wind;

x_6: Domestic RMB Financial Assets Held by Overseas Entities, data source is PBoC;

x_7: CIPS II system launch time, data source is Cross-border Interbank Payment System (CIPS). CIPS Phase II online time was chosen as a dummy variable (Sun, 2021; Wu, 2021). The CIPS Phase I system was completed and launched by China in October 2015. The CIPS Phase II system was launched in March 2018, Accordingly, the value of the dummy variable for March 2018 and subsequent periods has been set at 1, with the value of not online set at 0.

Given the availability and completeness of the data set, the analysis was conducted on a subset of 110 periods, spanning from November 2014 to December 2023. The data was processed using SPSSRO, which included:

- Missing value processing: linear interpolation was done onx_1, x_3, x_4, x_5.
- Data standardisation: Z-SCORE was applied to the data except x_7.

3.2. Research method

The conventional empirical techniques employed to examine the determinants of economic phenomena typically utilise Ordinary Least Squares (OLS) to estimate the parameters. However, this necessitates the fulfilment of several stringent assumptions, including strict exogeneity, spherical perturbation term, and the absence of multiple covariance, among others. However, in the case of time series, due to the fact that economic activities usually have durability and continuity, the serial autocorrelation will violate the assumption of the spherical perturbation term. This makes the *t*-test and *F*-test invalid, despite the fact that the goodness-of-fit and significance level indicators are satisfactory.

A vector autoregression (VAR) model is a multiple equation model that allows for the simultaneous consideration of the dynamic relationship between multiple time series (Dimitriadis et al, 2024). In a VAR model, each time series is considered to depend on its own past values as well as the past values of all other time series. This

model structure makes VAR particularly suitable for analyzing economic variables that are complexly linked to each other.

Vector autoregression model:

$$y_t = A_0 + A_1\, y_{t-1} + \cdots + A_p y_{t-p} + Bx_t + \varepsilon_t \quad (1)$$

In this equation, y_t represents a vector of endogenous variables of order k, $x_t$denotes a vector of exogenous variables of order d, and B and Ap are coefficient matrices to be estimated. The error vector, ε_t is uncorrelated with its own lagged values and with all variables on the right-hand side. However, it may be contemporaneously correlated. Nevertheless, the issue of contemporaneous correlation can be effectively addressed by ensuring that the right-hand side of the equation incorporates only the lagged values of the endogenous variables.

In light of the preceding analysis of the factors influencing the internationalization of the RMB, this paper presents the following empirical equation:

$$y_t = \varphi_0 + \varphi_1\, x_{1t} + \varphi_2\, x_{2t} + \varphi_3\, x_{3t} + \varphi_4\, x_{4t} + \varphi_5\, x_{5t} + \varphi_6\, x_{6t} + \varphi_7\, x_{7t} + \varepsilon_t \quad (2)$$

3.3. Descriptive statistical analysis

The descriptive statistical analysis of the variables is presented in the **Table 3**, which shows the sample size, minimum, maximum, mean, standard deviation and Coefficient of each variable:

Table 3. Descriptive statistics of variables.

Variable	*N*	Max	Min	Mean	Sd.
Y	110	4.945	−1.296	0	1
*X*1	110	2.907	−1.298	0	1
*X*2	110	2.189	−1.927	0	1
*X*3	110	2.359	−1.769	0	1
*X*4	110	2.113	−1.224	0	1
*X*5	110	2.509	−1.915	0	1
*X*6	110	1.656	−1.302	0	1

As x_{7t} is an virtual variable devoid of any numerical significance, it was not subjected to descriptive statistical analysis.

4. Results of data analysis

4.1. ADF test

Prior to the construction of a vector autoregression (VAR) model for empirical analysis of the variables, it is essential to assess the stationarity of the variables, given that the majority of economic and financial time series are non-stationary. In this paper, the Augmented Dickey-Fuller (ADF) test is employed to ascertain the presence of a unit root in the all variables.

Table 4. ADF test.

Variable	*t*	*P*	Critical Confidence Level		
			0.01	0.05	0.1
Y	−0.059	0.953	−3.492	−2.889	−2.581
*X*1	1.623	0.998	−3.5	−2.892	−2.583
*X*2	−1.849	0.357	−3.5	−2.892	−2.583
*X*3	−0.003	0.958	−3.5	−2.892	−2.583
*X*4	0.032	0.961	−3.5	−2.892	−2.583
*X*5	−0.897	0.789	−3.498	−2.891	−2.583
*X*6	−0.966	0.765	−3.495	−2.89	−2.582
*X*7	−1.318	0.621	−3.492	−2.888	−2.581

Note: ***, **, * represent 0.01, 0.05, and 0.1 significance levels respectively.

As illustrated in **Table 4**, the outcomes of the ADF test, given that all $P > 0.1$, it can be concluded that the original series is non-stationary.

4.2. Lag period

Given that the original time series is non-stationary, it is first necessary to determine the lag period of the VAR model p. In most cases, the selection of the lag period is based on an information criterion, such as the Akaike Information Criterion (AIC) or the Bayesian Information Criterion (BIC).

Table 5 presents the results of the optimal lag test of the vector autoregression (VAR) model, including the logLikelihood (logL), the Final Prediction Error (FPE), the Akaike Information Criterion (AIC), the Sample Criteria (SC), and the Hannan-Quinn Information Criterion (HQ). The logL is involved in the calculation of the FPE, AIC, SC, and HQ, and is ultimately evaluated by the aforementioned indicators.

Table 5. Comparison of different lag period.

Period	logL	AIC	SC	HQ	FPE
0	−596.945	−11.704	−11.508	−11.624	0
1	410.522	−28.914	−27.137	−28.193	0
2	554.955	−30.461	−27.084	−29.092	0
3	629.374	−30.729	−25.733	−28.703	0
4	706.141	−31.045	−24.412	−28.357	0
5	759.489	−30.922	−22.631	−27.562	0
6	807.035	−30.684	−20.717	−26.646	0
7	919.171	−31.697	−20.032	−26.972	0
8	1023.94	−32.584	−19.202	−27.165	0
9	1143.439	−33.781	−18.66	−27.66	0
10	1372.345	−37.19	−20.308	−30.358	0
11	1941.166	−47.535*	−28.871*	−39.983*	0.0*

The results of the four evaluation indexes (FPE, AIC, SC, and HQ) indicate that the final lag period should be selected as the 11 period, which will be used to construct the VAR (11) model in this paper.

4.3. Robustness tests

Robustness testing is a part of method validation. A robust VAR model is one in which the model shocks decay over time, rather than persisting indefinitely. The robustness of a model is typically evaluated through the calculation of the inverse of the mode of the unit roots. If the modes of all the unit roots are less than one, the model is deemed to be robust.

The robustness of the VAR (11) model was tested, and the inverse values of all the unit roots were found to lie within the unit circle (see **Figure 3**). This proves the stability and reliability of the model. Accordingly, the model is now suitable for further Granger causality tests, impulse response analysis and variance decomposition.

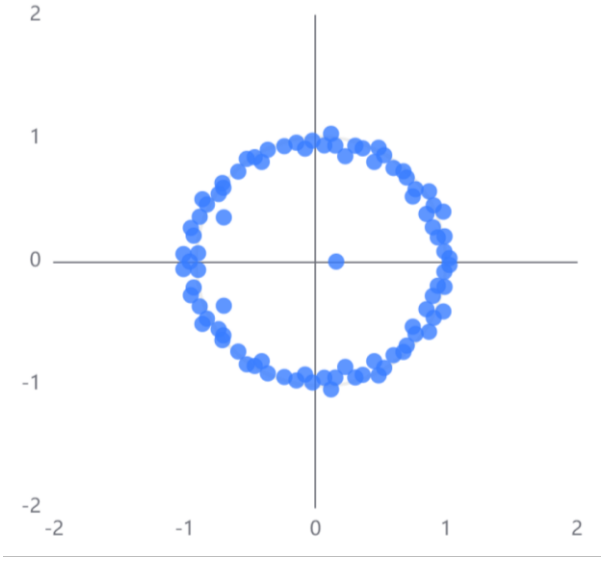

Figure 3. Inverse roots of AR characteristic polynomial.

4.4. Granger causality test

A further test can be conducted based on the VAR model analysis to ascertain whether the relevant variables have a statistically significant causal relationship. The F-statistic is then subjected to further analysis to ascertain its significance. Should the F-statistic be deemed significant ($P < 0.1$), it signifies the rejection of the original hypothesis. This implies that the variables situated on the left side are capable of instigating alterations in the variables located on the right side. Consequently, there exists Granger causality. Conversely, in the absence of a significant *F*-statistic ($P > 0.1$), Granger causality is absent. The following table presents the results of the Granger causality test, including paired samples, sample size, *F*-statistic, and *p*-value.

Table 6. Granger causality test.

Sample Pairings		***F***	***P***
x_1	*Y*	3.068	0.002***
x_2	*Y*	2.44	0.012**
x_3	*Y*	1.955	0.045**
x_4	*Y*	1.218	0.005***
x_5	*Y*	2.064	0.033**

x_6	Y	1.224	0.031**
x_7	Y	0.506	0.893

Note: ***, **represent 0.01 and 0.05 significance levels respectively.

As can be seen from **Table 6**, the *P*-value is 0.002 when the variables.

x_1 and Y are taken into account, indicates a statistically significant result, thereby accept the hypothesis 1. Similarly, it can be concluded that the variables x_2 ,x_3, x_4, x_5 and x_6 are all significant, it can be posited that x_2 ,x_3, x_4 , x_5 and x_6 can cause changes in Y, thereby accepting hypotheses 2, hypotheses 3, hypotheses 4, hypotheses 5 and hypotheses 6. Based on the variable x_7 and Y, the *P*-value of 0.893 does not allow us to reject the original hypothesis, and therefore we cannot conclude that x_7 causes changes in Y, so we reject the Hypothesis 7.

4.5. Impulse response analysis

The impulse response function (IRF) is a vital tool for analyzing vector autoregressive (VAR) models. It illustrates how a specific variable reacts to a sudden change in another variable. The IRF enables the comprehension of the influence exerted by a change in one variable on other variables, as well as the evolution of this impact over time.

This paper employs the use of orthogonalized impulse responses, which are subsequently analyzed as follows:

First, orthogonalized impulse response graphs illustrate the dynamic impact of a shock to a variable on the variable itself or on other variables.

Second, if the value is greater than zero, it indicates a positive shock. Conversely, if the value is less than zero, it represents a negative shock. The magnitude of the shock is proportional to the absolute value of the impulse response, with larger values implying a more significant shock.

In this section, the results obtained from the VAR (11) model are employed to investigate the dynamic effects of a one-standard-deviation shock applied to all variables over a 10-period horizon, with Y serving as the response variable.

4.5.1. Response of Y to Y

Figure 4 illustrates the impact of a positive shock applied to Y (RMB's share as a global payment's currency in SWIFT system) with a 10-period lag. The overall effect of the impact of Y on itself is characterised by a high degree of volatility, with positive and negative effects occurring in alternation. The positive effect is the most influential in period 1, while the negative effect is the largest in period 5. This result indicates that the historical performance of RMB internationalization exerts both promoting and hindering effects on future RMB internationalization.

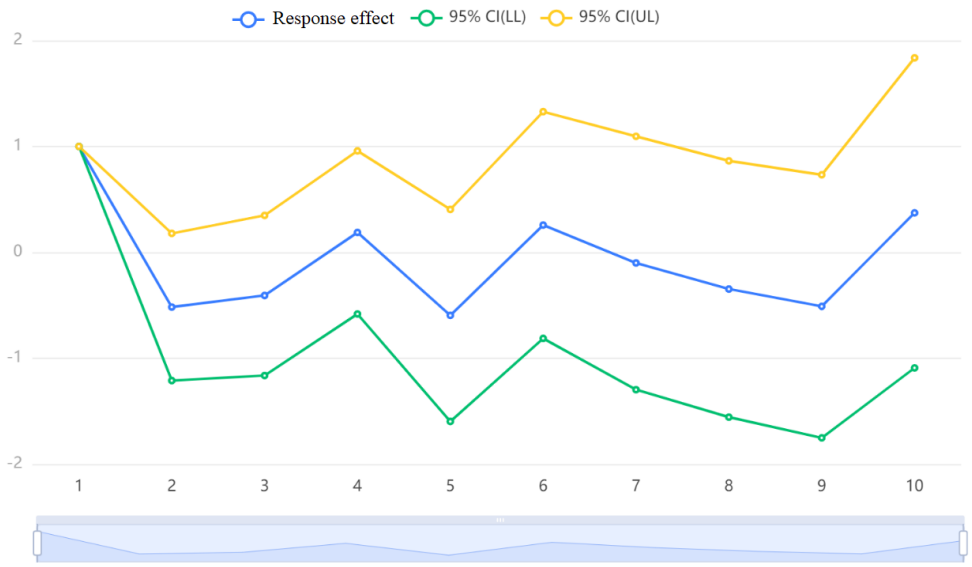

Figure 4. Response of Y to Y.

4.5.2. Response of Y to x_1

Figure 5 illustrates the response of a positive shock to x_1 (cross-border trade settlements in RMB) with a 10-period lag on Y. The impact of x_1 on RMB internationalization is characterised by volatility, with positive and negative effects occurring alternately. The positive effect is most influential in period 5, while the negative effect is the largest in period 6. The results demonstrate that cross-border trade settlements in RMB exerts both promoting and hindering effects on RMB internationalization.

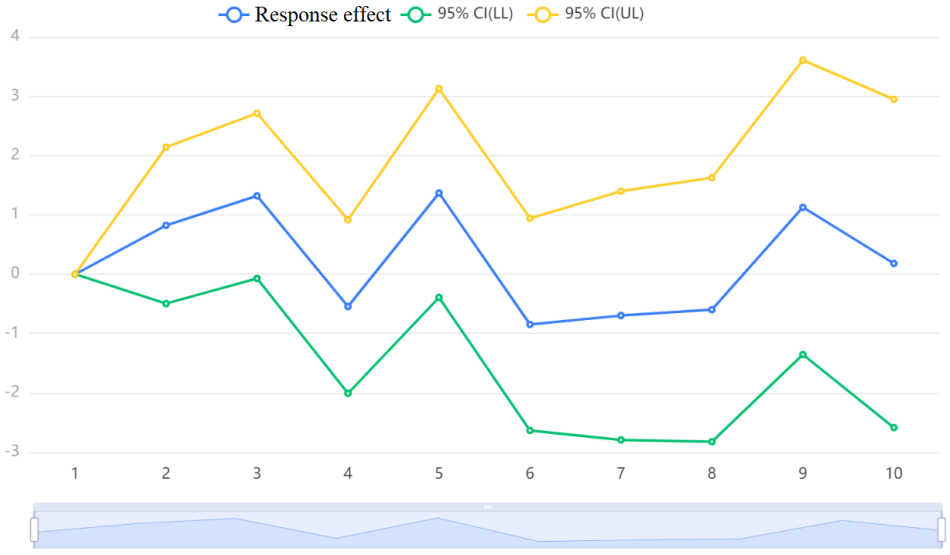

Figure 5. Response of Y to x_1.

4.5.3. Response of Y to x_2

Figure 6 illustrates the response of a positive shock to x_2 (total volume of imports and exports of China) with a 10-period lag to Y. The impact of x_2 on RMB internationalization is characterised by volatility, with positive and negative effects occurring in alternation. However, this volatility tends to stabilise over time. The

positive effect is most pronounced in period four, while the negative effect is most significant in period six. This result indicates that total volume of imports and exports of China exerts a certain degree of promotion or hindrance on RMB internationalization, although this effect is likely to diminish over time.

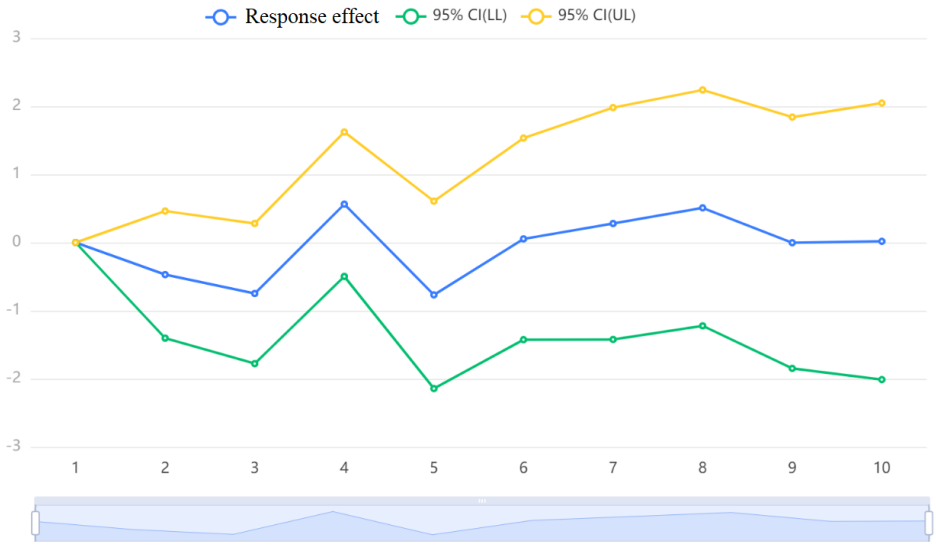

Figure 6. Response of Y to x_2.

4.5.4. Response of Y to x_3

Figure 7 illustrates the response of a positive shock to x_3 (global foreign exchange in RMB) with a 10-period lag to Y. The impact of x_3 on RMB internationalization is characterised by a volatile pattern, exhibiting alternating positive and negative effects, with the volatility reaching a plateau over time. The positive effect is most influential in the fourth period, while the negative effect is the largest in the seventh period. These findings indicate that global foreign exchange in RMB exerts a certain degree of promotion or hindrance on RMB internationalization, although this effect is likely to diminish over time.

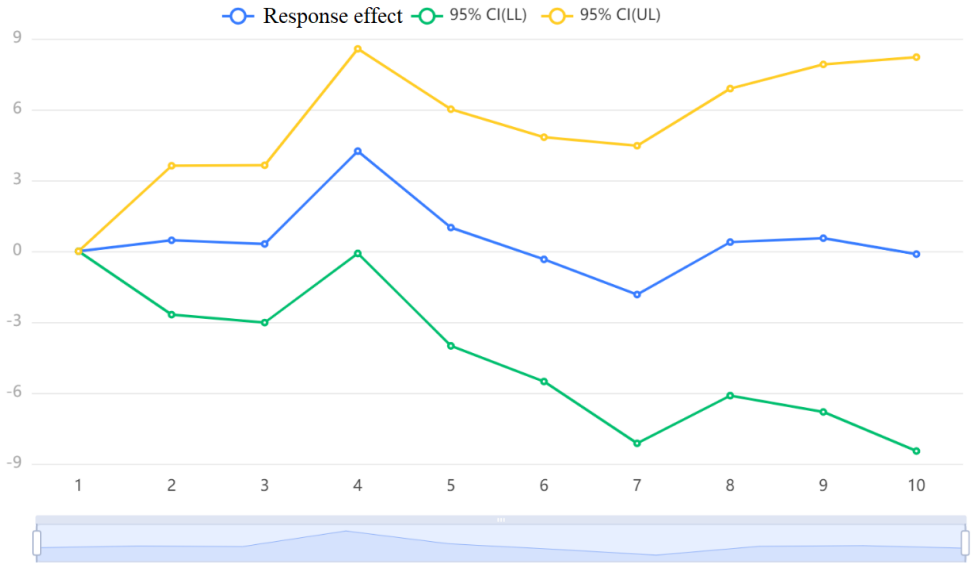

Figure 7. Response of Y to x_3.

4.5.5. Response of Y to x_4

Figure 8 illustrates the response of a positive shock to x_4 (global interest rate futures and options in RMB) with a 10-period lag to Y. The impact of x_4 on RMB internationalization is characterised by volatility, with positive and negative effects occurring alternately. The positive effect is most influential in period 2, while the negative effect is largest in period 8. The results demonstrate that global interest rate futures and options in RMB exerts both facilitating and hindering effects on RMB internationalization.

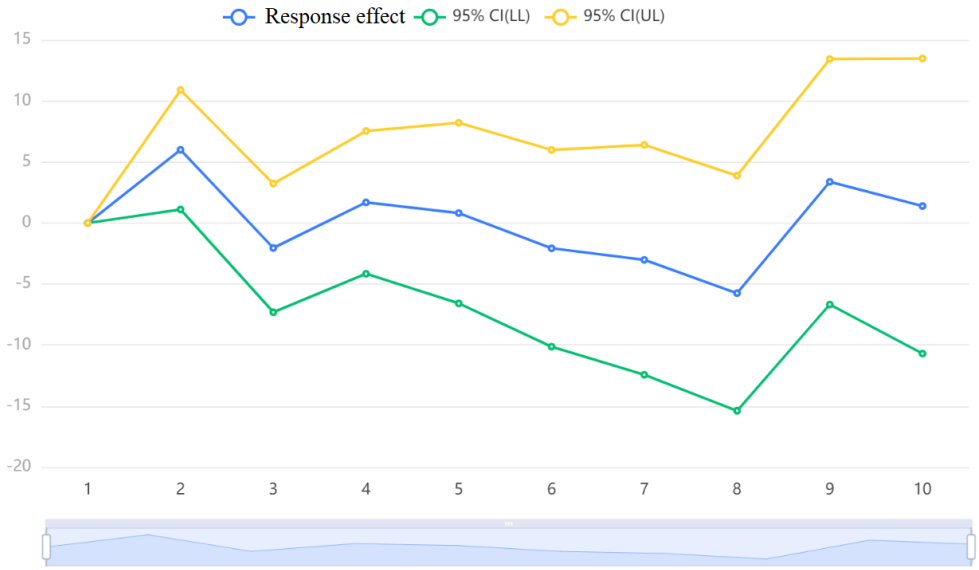

Figure 8. Response of Y to x_4.

4.5.6. Response of Y to x_5

Figure 9 illustrates the response of a positive shock to x_5 (amounts outstanding of debt securities issued in the international markets in RMB) with a 10-period lag to Y. The impact of x_5 on RMB internationalization is characterised by a volatile pattern, exhibiting a positive effect followed by a negative one. Its positive effect is the most pronounced in period 4, and then gradually diminishes towards zero. This result demonstrates that amounts outstanding of debt securities issued in the international markets in RMB exerts a predominantly driving effect on RMB internationalization, although this effect attenuates over time.

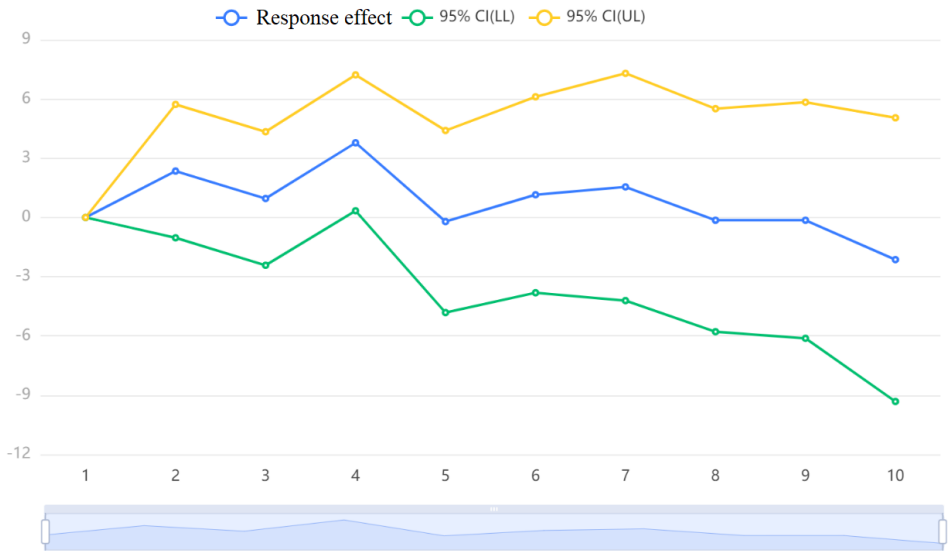

Figure 9. Response of Y to x_5.

4.5.7. Response of Y to x_6

Figure10 illustrates the response of a positive shock to x_6 (domestic RMB financial assets held by overseas entities) with a 10-period lag to Y. The data indicate that x_6 has a negative effect on RMB internationalization, which gradually shifts to a positive effect. The negative effect is most pronounced in period five, while the positive effect is most significant in period eight. This result demonstrates that domestic RMB financial assets held by overseas entities initially exerts a hindering influence on RMB internationalization, before transitioning into a driving effect.

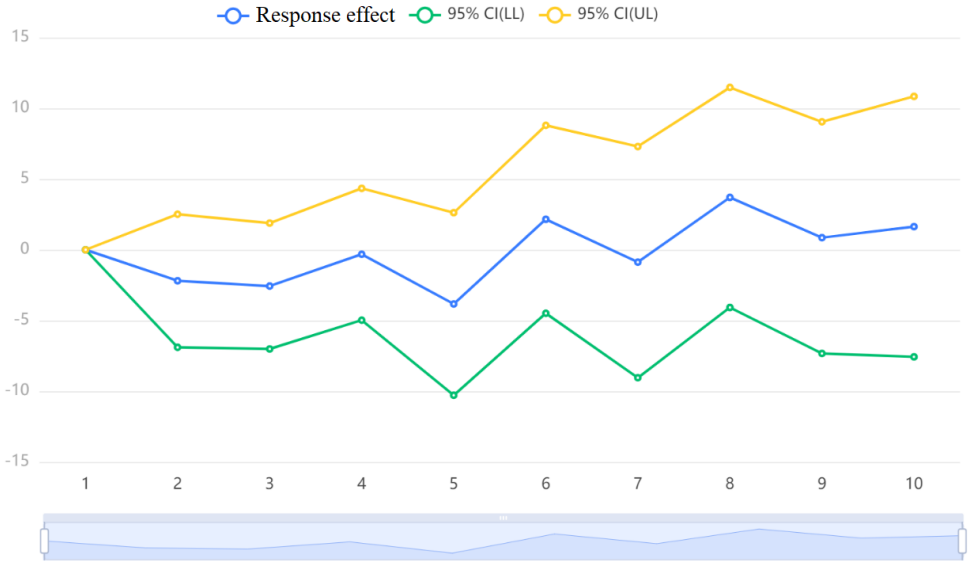

Figure 10. Response of Y to x_6.

4.5.8. Response of Y to x_7

Figure 11 illustrates the response of a positive shock to x_7 (CIPS II system launch time) with a 10-period lag to Y. The impact of x_7 on RMB internationalization is characterised by a high degree of volatility, with positive and negative effects

occurring in alternation, and a tendency for this volatility to dissipate over time. The positive effect is most pronounced in period 2, while the negative effect is most significant in period 4. The results demonstrate that the introduction of the CIPS II system initially facilitates and subsequently impedes the internationalization of the RMB. Ultimately, this effect attenuates over time.

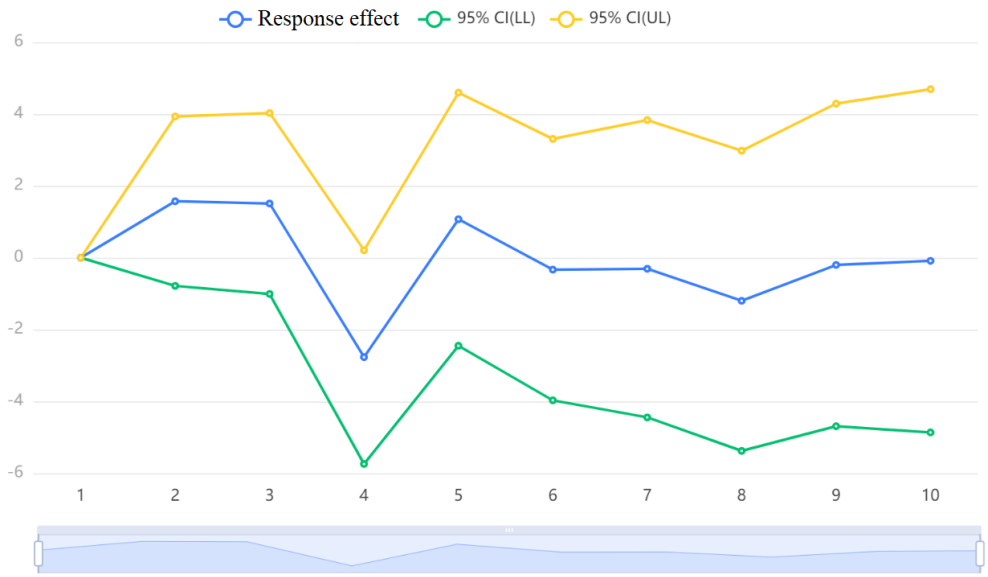

Figure 11. Response of Y to x_7.

4.6. Variance decomposition

Table 7 and **Figure 12** present the variance decomposition of the prediction error.

Table 7. Variance decomposition of Y.

Period	S.E.	Y(%)	x_1(%)	x_2(%)	x_3(%)	x_4(%)	x_5(%)	x_6(%)	x_7(%)
1	0.374	100	0	0	0	0	0	0	0
2	0.449	74.743	9.28	3.187	1.61	2.136	5.451	0.531	3.061
3	0.506	59.228	10.562	5.389	1.463	12.595	5.441	0.688	4.634
4	0.614	47.716	7.991	4.803	15.357	8.925	3.705	3.303	8.201
5	0.658	44.234	12.095	4.862	16.377	8.408	3.321	2.885	7.819
6	0.716	38.87	21.138	4.72	14.95	7.844	3.369	2.461	6.649
7	0.753	36.958	21.189	4.325	14.174	11.881	3.12	2.3	6.053
8	0.832	43.135	19.493	3.577	12.575	11.307	2.555	1.884	5.474
9	0.908	37.543	28.685	3.032	10.625	11.78	2.145	1.582	4.607
10	0.93	36.627	28.144	3.024	10.223	13.784	2.266	1.535	4.397

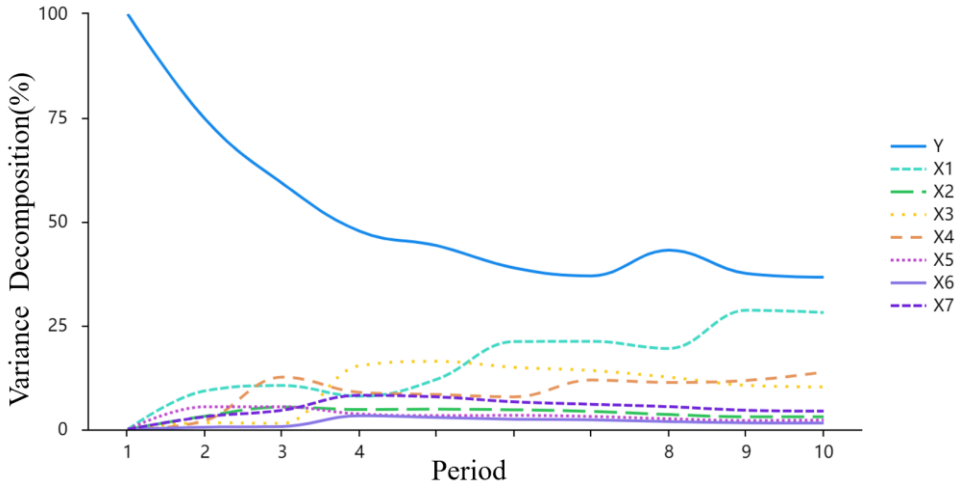

Figure 12. Variance decomposition.

The variance decomposition demonstrates that among the various influencing factors of RMB internationalization, Y (RMB's share as a global payment currency in the SWIFT system) exerts the most significant influence on itself, although this influence gradually diminishes over time. Nevertheless, it still accounts for 36.627%. x_1 (cross-border trade settlements in RMB) contributes the second-most significant influence, and its influence increases nearly to 28.685% over time. Furthermore, the contribution of x_3 (global RMB foreign exchange turnover) and x_4 (global interest rate futures and options in RMB) is also considerable, with effects of 16.377% and 13.784% respectively. The remaining variables x_2, x_5, x_6 and x_7, collectively account for less than 10%.

5. Discussion and conclusion

5.1. Discussion

5.1.1. Limitations of the study

5.1.1.1. VAR model

A criticism that VARs face is that they are atheoretical; that is, they are not built on some economic theory that imposes a theoretical structure on the equations. Besides, the more coefficients that need to be estimated, the larger the estimation error entering the forecast (Rob J Hyndman and George Athanasopoulos, 2018). This, in turn, affects the effectiveness of the prediction.

The first issue is addressed by leveraging Granger causality tests to enhance the VAR model's limitations, while the second issue is addressed by expanding the sample size and employing impulse response analysis and variance decomposition analysis for trend forecasting.

5.1.1.2. Secondary data

Due to the availability of data, we primarily use secondary data for the its analyses. While we do refer to relevant authoritative literature (see **Table 2** for details), it is possible that secondary data may make decision-makers be more likely to focus

on the data that supports their existing beliefs and overlook contradictory evidence (Alphanome, 2023).

In response to the possible bias potential biases in using secondary data mentioned above, this paper adopts a qualitative analysis to reassess the hypotheses presented in order to keep an open mind to such conflicting results.

5.1.1.3. Future directions for research

Despite the inclusion of proxy variables reflecting technological innovation (x_7) in the analysis, the causal relationship is not significant. There are two reasons for this. Firstly, although the application of central bank digital currencies, exemplified by the e-CNY has become more mature, the primary use case remains the domestic market, the cross-country application of e-CNY is still in the experimental phase. Secondly, due to the unavailability of data, the proxy variables selected in this study may not directly reflect the utilisation and advancement of the e-CNY. This perspective aligns with the view that single CBDC is unlikely to qualitatively change the economic forces that lead to the international use of currencies, it could quantitatively reinforce the incentives behind currency substitution and currency internationalization (IMF, 2020).

In light of the previous study, further research on the RMB's future Internationalization is warranted. China can take advantage of the phenomenon of reverse globalisation and the intensification of regional cooperation to accelerate the development of financial infrastructure, with a particular focus on the Regional Comprehensive Economic Partnership (RCEP) region and countries participating in the Belt and Road Initiative. In the short term, the potential path of RMB internationalisation could involve leveraging the Belt and Road strategy, expanding the scale of bilateral local currency swaps, and utilising RMB to pay for imports to China, with the aim of becoming a denominated currency. In the long run, there is a possibility that the RMB could be exported from commodity imports, and foreign investment in RMB assets could return RMB internally to establish a closed loop of RMB flow, and ultimately realise its potential in the fields of Cross-border loans, international debt securities, Forex (FX) transaction volume and official FX reserves to enhance the international payment share of the RMB.

5.2. Conclusion

This paper incorporates the impact of technology innovation into the traditional analytical framework of the three functions of international currencies. It empirically verifies conflicting views on the impact of digital currencies on currency internationalisation using the VAR model and Granger causality test. The results confirm that, in the Chinese scenario, the e-CNY does not influence factors of RMB internationalisation. The discussion concludes that RMB internationalisation should proceed in regional economic cooperation.

The conclusions of this paper are as follows: First, the results of the Granger causality test analysis indicate that the medium of exchange, unit of account and store of value functions are all statistically significant. However, the innovation of digitalisation technology is not statistically significant, suggesting that it is not a factor affecting the Internationalization of the RMB. Second, the results of the impulse response analysis indicate that the factors have different effects on the future

Internationalization of the RMB. Third, the results of variance decomposition indicate that the effects of the different influencing factors are quite different. The main findings of the paper are shown in **Table 8**.

Table 8. Research findings.

Variables	RMB Internationalization	Medium of Exchange				Unit of Account	Store of Value	Other Technology Innovation
		Trade Dimension		Financial Dimension				
Symbol	Y	X1	X2	X3	X4	X5	X6	X7
Description	RMB's share as a global payment's currency in swift system	Cross-border trade settlements in RMB	Total volume of imports and exports in China	Global foreign exchange in RMB	Global interest rate futures and options in RMB	Amounts outstanding of debt securities issued in the international markets in RMB	Domestic RMB financial assets held by overseas entities	CIPS II system launch time
Significance Levels of Granger Causality Test	N/A	***	**	**	***	**	**	
Impulse Response Analysis	+ ~ -	+ ~ -	- → + ↓	+ ~ -	+ ~ -	+ → -	- → +	+ → - ↓
Variance Decomposition	100%	28.685%	5.389%	16.377%	13.784%	5.451%	3.303%	8.201%

Note: ***, **represent 0.01 and 0.05 significance levels respectively; + indicates a positive shock, - indicates a negative shock, indicates alternating positive and negative shocks, denotes a change in direction of positive and negative shocks, indicates convergence of shock fluctuations; the data indicate the maximum variance contribution of the variable.

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References

Bank for International Settlements Innovation Hub Hong Kong Centre, Hong Kong Monetary Authority, Bank of Thailand, Digital Currency Institute of People's Bank of China & Central Bank of the United Arab Emirates. (2021a). Inthanon-LionRock to mBridge: building a multi CBDC platform for international payments.

Chinn, M. D., Eichengreen, B., & Ito, H. (2014). A forensic analysis of global imbalances. Oxford Economic Papers, 66(2), 465-490.

Cohen, B. J., & Benney, T. M. (2014). What does the international currency system really look like?. Review of International Political Economy, 21(5), 1017-1041.

Cohen, B., 1971, The Future of Sterling as an International Currency, London:

Deng, H. (2024). Negotiating currency internationalization: An infrastructural analysis of the digital RMB. Finance and Society, 10(1), 1–17. doi:10.2218/fas.2023.2

Dimitriadis, K. A., Koursaros, D., & Savva, C. S. (2024). The influential impacts of international dynamic spillovers in forming investor preferences: a quantile-VAR and GDCC-GARCH perspective. Applied Economics, 1-21.

Eichengreen, B., Macaire, C., Mehl, A., Monnet, E., & Naef, A. (2024). Currency internationalization with Chinese characteristics: Is capital-account convertibility required for the RMB to acquire reserve-currency status? International Finance, 27, 102–128. https://doi.org/10.1111/infi.12447

Factors influencing the choice of the invoicing currency in international trade: Panel data analysis for 55 countries. Equilibrium. Quarterly Journal of Economics and Economic Policy, doi: 10.24136/eq.2023.005

Fareniuk, N. (2019). The specifics of yuan's internationalization in the debt financial istruments markets. Actual Problems of International Relations, (139), 107-114.

Friberg, R., & Wilander, F. (2008). The currency denomination of exports—a questionnaire study. Journal of international economics, 75(1), 54-69.

Fung, Hung-Gay and Tzau, Derrick and Yau, Jot, The Chinese Offshore Renminbi-Denominated Bonds: Dim Sum Bonds (February 1, 2012). Available at SSRN: https://ssrn.com/abstract=2080636 or http://dx.doi.org/10.2139/ssrn.2080636

Goldberg, L. S., & Tille, C. (2008). Vehicle currency use in international trade. Journal of international Economics, 76(2), 177-192.

Guo, D., & Zhou, P. (2021). Green bonds as hedging assets before and after COVID: A comparative study between the US and China. Energy Economics, 104, 105696.

Hann-Pyng, Wang. (2022). 2. Current Status of RMB Cross-border Trade Settlement and an Empirical Analysis of the Influencing Factors of Its Scale. doi: 10.2991/aebmr.k.220307.383

Ilias, Filippou., Mark, P., Taylor. (2021). 2. Pricing ethics in the foreign exchange market: Environmental, Social and Governance ratings and currency premia. Journal of Economic Behavior and Organization, doi: 10.1016/J.JEBO.2021.08.037

Isabelle, Mejean., Victor, Lyonnet., Mustafa, Noman. (2022). 4. Invoicing Currency and Financial Hedging. Journal of Money, Credit and Banking, doi: 10.1111/jmcb.12966

Krugman, Paul R. 1984. "The International Role of the Dollar: Theory and Prospect." In Exchange Rate Theory and Practice, edited by John F.O. Bilson and Richard C. Marston, 261—278. Chicago, IL: University of Chicago Press.

Lai, E. L.-C. (2021). One Currency, Two Markets: China's Attempt to Internationalize the Renminbi. Cambridge University Press.

Lai, Edwin L.-C. and Xiangrong Yu. 2015. "Invoicing Currency in International Trade: An Empirical Investigation and Some Implications for the RMB." The Wold Economy, 38(1), 193-229. 5

Lei, Y. (2024). Impact of RMB internationalization on China's competitiveness in financial services trade based on the VAR model: Evidence from China-US. Plos one, 19(6), e0302845.

Longmei, Zhang., Hector, Perez-Saiz. (2023). Renminbi Usage in Cross-Border Payments: Regional Patterns and the Role of Swaps Lines and Offshore Clearing Banks. IMF Working Papers, doi: 10.5089/9798400235559.001

Ma, Bin. (2015). A Study on the Influencing Factors of the Internationalization of the Renminbi [D], Dongbei University of Finance and Economics.

Mark, David, Witte., Luigi, Ventura. (2016). 4. An Empirical Examination of the Currency Denomination of Trade. International Economic Journal, doi: 10.1080/10168737.2015.1103771

Oliver, Xie. (2024). 1. Financial Hedging and Optimal Currency of Invoicing. doi: 10.31235/osf.io/v8zdk

Orsi, B., Junior, A. J. A., & de Melo Modenesi, A. (2023). Costs and benefits of currency internationalization: theory and the experience of emerging countries. In Central Banks and Monetary Regimes in Emerging Countries (pp. 1-18). Edward Elgar Publishing.

Panpan, Wang., Xiaoxing, Liu., Sixu, Wu., Tsungwu, Ho., Changqian, Xie. (2024). Measuring the International Influence of the RMB and its Regional Heterogeneity: Theory and Evidence from the Global FX Market Network. Emerging Markets Finance and Trade, doi: 10.1080/1540496x.2024.2318313

Papadamou, S., Kyriazis, N. A., & Tzeremes, P. G. (2019). Unconventional monetary policy effects on output and inflation: A meta-analysis. International Review of Financial Analysis, 61, 295-305.

Paúl, Krugman. (1980). 1. Vehicle Currencies and the Structure of International Exchange. Journal of Money, Credit and Banking, doi: 10.2307/1991725

Qi Jialin. A study of the development and influencing factors of sovereign digital currency[D]. Tianjin University of Commerce, 2022. Available at: https://doi.org/10.27362/d.cnki.gtsxy.2022.000416.

Rob J Hyndman, George Athanasopoulos. (2018). Forecasting: Principles and Practice (2nd). otexts.com

Ryan, Chahrour., Rosen, Valchev. (2017). 2. International Medium of Exchange: Privilege and Duty. Research Papers in Economics,

Song, D. (2017). Bond market exposures to macroeconomic and monetary policy risks. The Review of Financial Studies, 30(8), 2761-2817.

Sun Jixuan. A study of the impact of China's central bank digital currency on RMB cross-border payments[D]. Southwest University of Finance and Economics, 2021.

The Overconfidence Bias in Finance: How Excessive Data Can Lead to Misguided Decisions. (2023).Alphanome.AI

van der Linden, R.W., Łasak, P. (2023). The Digitalization of Cross-Border Payment Systems and the Introduction of the CBDC. In: Financial Interdependence, Digitalization and Technological Rivalries. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-27845-7_7

Wang Panpan, Wu Sixu and Shi Jianxun. An assessment of the global influence on the process of RMB internationalization and a consideration of future prospects[J]. Financial Research, 2023, 49(2).

Wang Xiaofang, Lu Keji. The reform of the international monetary system and the internationalization of the RMB[J]. The Economist, 1(2), 2023. 45–55.

Wei J, Pak Y. (2023). 1. Enhancing Trade Settlement: A Meta- Analysis and VAR Model Approach to RMB Activation in International Transactions. Journal of Korea Trade, doi: 10.35611/jkt.2023.27.6.81

Weidong, Huo., Fuhua, Deng., Jiandong, Chen. (2018). 3. An empirical analysis of the Renminbi: Exchange rates and cross-border trade settlement. The World Economy, doi: 10.1111/TWEC.12548

Wenzhuo, Jiang., Yun, Fan., Yajie, Wang. (2024). 3. Comparison of Factors Affecting the Internationalization Level of SDR Basket Currencies. doi: 10.62517/jel.202414216

World Bank (2021). "Implementation considerations for fast payment systems." June.

Wu, Yun-Eun. (2021). Central bank legal tender and RMB internationalization. Modern Business (03), 121-123. doi:10.14097/j.cnki.5392/2021.03.037.

Xiaocun, Qiu., Tianjie, He., Dow, Jones. (2013). 4. Quantifying the prospects and impacts of rmb internationalization.

Xie, Duanchun & Miao, Qihu. (2021). Impact of digital currency on cross-border capital flow management and countermeasures. Hainan Finance (02), 54-60+74.

Yushi, Yoshida., Junko, Shimizu., Takatoshi, Ito., Kiyotaka, Sato., Taiyo, Yoshimi., Uraku, Yoshimoto. (2024). Invoicing Currency Choice: Strategic Complementarities and Currency Matching. doi: 10.2139/ssrn.4852464