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Empirical Analysis of Factors Influencing RMB Exchange Rate Volatility in the Context of RMB Internationalization

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Abstract: This paper selects and collates data on exchange rate volatility and its related influencing factors in China from 2002 to 2022 as a research sample, explores the causes of RMB exchange rate volatility in the context of RMB internationalisation, and proposes policy recommendations on how to maintain exchange rate stability in the process of RMB internationalisation. Using RMB exchange rate volatility as the explanatory variable, the following results were obtained by building a multiple linear regression model and introducing conditional variables to indicate the degree of RMB internationalisation: the amount of foreign exchange reserves, the Sino-US interest rate differential and the balance of payments differential have significant effects on RMB exchange rate volatility, while foreign direct investment, the relative inflation rate between China and the US and the GDP growth rate have insignificant effects on exchange rate volatility.

Keywords: RMB exchange rate volatility, Influencing factors, Multiple linear regression, RMB internationalization, Conditional variables.

1. Introduction

At present, against the backdrop of globalisation trends and economic integration, win-win cooperation is gradually becoming the new normal in international relations. And under the trend of reforming the current international monetary system, an important direction of world development is to achieve international monetary diversification. Therefore, in order to maintain stable global economic and financial development in the future, the current international monetary system must be fundamentally reformed, so as to diversify the systemic risks arising from the international monetary system's over-reliance on the US dollar [1]. Therefore, along with the continued growth of the Chinese economy and the liberalisation of external financial controls, the motivation and demand for the internationalisation of the RMB has emerged.

Since the reform and opening up of China in 1978, China's capital market has gradually opened up and international capital flows have been frequent, and a large number of foreign companies have started to invest and set up factories in China, boosting domestic economic development. For China's foreign trade transactions, balance of payments of the country has been in a double surplus for a long time, while facing the risk of exchange rate volatility [2]. After the "811" exchange reform in 2015, the central bank allowed the exchange rate to float wider and gradually let the market play a decisive role in exchange rate formation, which exacerbated the instability of the RMB exchange rate, resulting in the RMB exchange rate being more vulnerable to external economic influences [3]. 2022 In May, the IMF maintained the RMB as the third largest currency in the SDR basket. SDR basket as the third most weighted currency, while adjusting its weight upwards by 1.36 percentage points. The upward adjustment of the RMB's currency weighting in the SDR basket is a recognition by the international community of the results of China's continued financial liberalisation and an important development in the internationalisation of the RMB [4]. However, meanwhile, with the continuous opening of China's capital account, the continuous development of RMB internationalisation has amplified the uncertainty of various influencing factors in the global economic environment, thus putting higher demands on exchange rate stability, and coupled with the continued volatility of the international situation and the influence of international lobbyists waiting for an opportunity to arbitrage, the RMB exchange rate has experienced frequent fluctuations. In the long term, the two-way normalized volatility of the RMB is the main tone of the exchange rate trend. As an important embodiment of China's external value, the stability of the RMB exchange rate is crucial to the lifeblood of the national economy. Therefore, in the current context of RMB internationalisation, maintain the stability of China international exchange rate is not only important to stabilize the domestic economy, but also to the security and stability of the world economy plays an important role [5].

Based on the above reality and background, this paper will take the US dollar to RMB exchange rate from 2002 to 2022 as the base point, select six quantifiable economic variables, establish a multiple linear regression model, and according to previous studies, the key influencing factors of RMB exchange rate fluctuations under the background of RMB internationalization are further investigated, and policy suggestions for maintaining RMB exchange rate stability are put forward.

2. Empirical Analysis of Factors Influencing RMB Exchange Rate Volatility

2.1. Sample selection and data sources

This paper selects quarterly data of the US dollar to RMB exchange rate from 2002 to 2022, calculates the standard deviation of the exchange rate to represent the fluctuation of

RMB exchange rate, and it is used for the empirical analysis of explanatory variables. Secondly, according to China's current economic situation, the US-China spread (UCS), US-China relative inflation rate (UCCPI), GDP growth rate (GDPR), foreign direct investment (FDI), foreign exchange reserves (FER) and balance of payments (BOP) are selected as explanatory variables, where the US-China spread is the difference between China's 10-year treasury yield and the US 10-year treasury yield. Meanwhile, this paper introduces a conditional variable (RMBI) in the model to represent the degree of RMB internationalisation before Q4 2016 (RMBI=0) and Q4 2016 and beyond (RMBI=1), based on the RMB internationalisation index and the development history of RMB internationalisation. The main sources of data in this paper are as follows: National Bureau of Statistics, Wind database, WIEGO database, China Foreign Economic and Trade Yearbook, and Institute of International Monetary Studies, Renmin University of China. The following Table 1 shows the descriptive statistics of each variable.

Table 1. Descriptive statistics for each variable

Variable	Obs	Mean	Std. Dev.	Min	Max
UCER	84	7.023	0.744	6.12	8.28
UCS	84	0.475	1.143	-2.54	2.37
UCCPI	84	-0.115	2.267	-7	4.3
GDPR	84	8.619	2.956	0.4	18.7
FDI	84	1852.422	588.478	826.06	3752.72
FER	84	159662.14	72110.257	18838.4	245907.3
BOP	84	4938.719	2765.972	1037.5	14552.09
RMBI	84	0.31	0.465	0	1

2.2. Model setting and empirical analysis

2.2.1. Basic model

To synthesize the above analysis, the study uses the US dollar to RMB exchange rate as the explanatory variable, the US-China interest rate differential (UCS), the US-China relative inflation rate (UCCPI), the GDP growth rate (GDPR), foreign direct investment (FDI), foreign exchange reserves (FER) and balance of payments (BOP) as the main explanatory variables, and introduces the conditional variable (RMBI) to represent RMBI is introduced to represent the degree of RMB internationalization, and the random error term u is introduced as a random disturbance term to represent other random factors that are not included in the explanatory variables, and the following multiple linear regression model is constructed:

UCER=a+b1UCS+b2UCCPI+b3GDPR+b4lnFDI+b5lnFER+b6lnBOP+u

In order to eliminate bias in the data, weaken the multicollinearity and eliminate heteroskedasticity in the data, the sample data of foreign direct investment (FDI), foreign exchange reserves (FER) and balance of payments (BOP) variables were logarithmised to make the selected sample data smoother and more consistent with the assumption of normal distribution.

2.2.2. Model estimation

Using OLS estimation methods and regression analysis of the variable data with the help of the econometric software StataSE 17, Tables 2 and 3 were obtained respectively.

Table 2. Stata output from preliminary model estimates (RMBI=0)

ucer	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
ucs	0.03	0.045	0.67	0.505	-0.061	0.122	
uccpi	-0.02	0.02	-1.00	0.32	-0.061	0.02	
gdpr	0.099	0.018	5.48	0	0.063	0.135	***
lnfdi	-0.177	0.185	-0.96	0.343	-0.549	0.194	
lnfer	-0.902	0.066	-13.71	0	-1.034	-0.77	***
lnbop	0.084	0.046	1.82	0.074	-0.009	0.177	*
Constant	17.256	1.174	14.70	0	14.9	19.613	***

Mean dependent var	7.157	SD dependent var	0.851
R-squared	0.955	Number of obs	58
F-test	182.305	Prob > F	0.000
Akaike crit. (AIC)	-21.630	Bayesian crit. (BIC)	-7.207

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

According to Table 2, when the conditional variable RMBI = 0, i.e. the pre-internationalisation period of the RMB (2002 to Q3 2016), the multiple linear regression function of China's RMB exchange rate initially estimated by the model is

UCER=17.256+0.03UCS-0.02UCCPI+0.099GDPR-0.177lnFDI-0.902lnFER+0.084lnBOP+u

Table 3. Stata output from preliminary model estimates (RMBI=1)

ucer	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
ucs	-0.093	0.041	-2.26	0.036	-0.179	-0.007	**
uccpi	0.035	0.013	2.70	0.014	0.008	0.061	**
gdpr	-0.008	0.009	-0.91	0.376	-.026	0.01	
lnfdi	0.042	0.165	0.25	0.804	-.305	0.388	
lnfer	5.664	0.868	6.53	0	3.848	7.481	***
lnbop	-0.077	0.072	-1.07	0.297	-.228	0.074	
Constant	-62.171	10.525	-5.91	0	-84.201	-40.142	***

Mean dependent var	6.725	SD dependent var	0.236
R-squared	0.861	Number of obs	26
F-test	19.563	Prob > F	0.000
Akaike crit. (AIC)	-39.613	Bayesian crit. (BIC)	-30.806

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

According to Table 3, when the conditional variable RMBI = 1, i.e. the period of RMB internationalisation development (Q4 2016 to 2022), the preliminary multivariate linear regression function of China's RMB exchange rate estimated by the model is

UCER=62.171-0.093UCS+0.035UCCPI-0.008GDPR+0.042lnFDI+5.664lnFER-0.077lnBOP+u

2.2.3. Testing and correction of the model

(1) Testing and correction of multicollinearity

To further optimize the econometric model, the study calculated the correlation coefficients between the individual variables in Stata software, as shown in Table 4:

Table 4. Correlation coefficient matrix for each variable in the regression equation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ucer	1.000						
ucs	-0.768	1.000					
uccpi	-0.133	0.260	1.000				
gdpr	0.465	-0.445	0.269	1.000			
lnfdi	-0.694	0.628	-0.173	-0.580	1.000		
lnfer	-0.917	0.741	0.165	-0.441	0.757	1.000	
lnbop	-0.105	0.028	0.208	0.199	0.051	0.243	1.000

In this paper, each explanatory variable is introduced into the regression equation in the order of its absolute value of correlation coefficient with the explanatory variable, from the largest to the smallest, and the model is revised by eliminating multiple cointegration through stepwise regression method. The t-test and F-test were used to determine whether each explanatory variable could be introduced into the equation, and if the new explanatory variable could not pass the significance test after being introduced into the regression equation, the variable was removed. Based on the data in Table 4, lnFER, which has the highest absolute value of correlation coefficient with UCER, was first introduced into the regression equation, and the other explanatory variables were introduced according to the idea of stepwise regression method.

From the final stepwise regression results showed in Table 5, it is clear that the effects of foreign exchange reserves, the US-China interest rate differential and the balance of payments differential on RMB exchange rate fluctuations are significant. The three variables of foreign direct investment, GDP growth rate and relative inflation rate between the US and China will be removed from the model, and the final expression of the regression function will be

UCER = 16.049 - 0.845lnFER - 0.106UCS + 0.119lnBOP

Table 5. Regression results for each step of the stepwise regression method

	lnFER UCS lnFDI GDPR UCCPI lnBOP	R^2
UCER=f(lnFER)	-0.945 (-20.87)	0.842
UCER=f(lnFER,UCS)	-0.795 -0.128 (-12.43) (-3.16)	0.859
UCER=f(lnFER,UCS,lnFDI)	-0.816 -0.131 0.075 (-10.54) (-3.18) (0.49)	0.859
UCER=f(lnFER,UCS,GDPR	-0.783 -0.119 0.012 (-12.03) (-2.89) (1.02)	0.861
UCER=f(lnFER,UCS,UCCPI)	-0.792 -0.137 0.016 (-12.39) (-3.33) (1.12)	0.861
UCER=f(lnFER,UCS,lnBOP)	-0.845 -0.106 0.119 (-12.79) (-2.62) (2.29)	0.868

Note: Values in parentheses are t-statistics for each explanatory variable

The study compared and analysed the regression results of the modified ternary regression model in the pre-internationalisation and development periods of the RMB through further benchmark regressions to test the statistical model derived from the stepwise regression analysis, with the following results in Table 6 and 7:

Table 6. Stata output of the modified model (RMBI=0)

ucer	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
lnfer	-0.94	0.072	-13.10	0	-1.084	-.796	***
ucs	-0.109	0.046	-2.39	0.021	-0.2	-.017	**
lnbop	0.181	0.053	3.43	0.001	0.075	0.287	***
Constant	16.564	0.715	23.18	0	15.131	17.997	***
Mean dependent var		7.157		SD dependent var		0.851	
R-squared		0.925		Number of obs		58	
F-test		221.425		Prob > F		0.000	
Akaike crit. (AIC)		2.722		Bayesian crit. (BIC)		10.964	

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 7. Stata output of the modified model (RMBI=1)

ucer	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
lnfer	7.191	0.88	8.18	0	5.367	9.015	***
ucs	-0.056	0.035	-1.61	0.122	-0.129	0.016	
lnbop	-0.107	0.071	-1.51	0.145	-0.253	0.04	
Constant	-80.443	10.772	-7.47	0	-102.783	-58.103	***
Mean dependent var		6.725		SD dependent var		0.236	
R-squared		0.763		Number of obs		26	
F-test		23.559		Prob > F		0.000	
Akaike crit. (AIC)		-31.757		Bayesian crit. (BIC)		-26.725	

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Comparing the regression results for the pre-internationalisation period and the development period of RMB internationalisation, we can conclude that when RMB internationalisation enters the development period, only foreign exchange reserves have a significant effect on the RMB exchange rate, and the effect is greater compared to the pre-internationalisation period, but there is no significant evidence that the US-China interest rate differential or balance of payments differential has an equally significant effect on the RMB exchange rate.

(2) Autocorrelation tests and corrections

In this paper, the BG test was used to test the autocorrelation of the model and the following results were obtained:

Table 8. BG test results

Number of gaps in sample = 25 Breusch-Godfrey LM test for autocorrelation	df	Prob>Chi2
chi2		
0.000	1	1.000

H0: no serial correlation

According to the results in Table 8, the LM corresponds to a concomitant probability P=1>0.05 and therefore the original hypothesis is rejected and the model is not autocorrelated.

(3) Heteroskedasticity test and correction

In this paper, the White test was used to test the heteroskedasticity of the model and the following results were obtained:

Table 9. White test results

White's test H0: Homoskedasticity Ha: Unrestricted heteroskedasticity chi2(9) = 11.96 Prob > chi2 = 0.2155 Cameron & Trivedi's decomposition of IM-test	df	p
chi2		
11.960	9	0.215
2.260	3	0.520
0.290	1	0.592
14.510	13	0.339

Table 9 shows that the White test corresponds to a concomitant probability of P=0.215>0.05, therefore the

original hypothesis is rejected and there is no heteroscedasticity in the model.

3. Conclusions and Policy Recommendations

3.1. Empirical findings and analysis of results

Based on the data of exchange rate and its related influencing factors in China for two decades, including 2002 to 2022, as a sample, by establishing a multivariate

It is found that in the early stage of RMB internationalisation, an increase in the amount of foreign exchange reserves and an increase in the Sino-US interest rate differential will significantly reduce the RMB exchange rate, i.e. causing the RMB to appreciate, while the RMB exchange rate will be significantly improved by an increase in China's balance of payments surplus, i.e. causing the RMB to depreciate.

Unlike the significant effects on the RMB exchange rate of each explanatory variable in the pre-internationalization modified model of the RMB

The impact that when the RMB internationalisation process enters a developmental phase, only an increase in foreign exchange reserves will significantly increase the RMB exchange rate and lead to a depreciation of the RMB, which is clearly this is clearly inconsistent with the actual situation. The reason for this may be that as the RMB internationalisation process develops, the disturbances in the external economic environment increase, the uncontrollable factors of exchange rate fluctuations become more and more frequent.

3.2. Policy Recommendations

3.2.1. Combining exchange rate policy measures to enhance optimal management of foreign exchange reserves

Adequate foreign exchange reserves can maintain the stability of currency exchange rates, promote international trade and investment, and when the financial market has a serious impact, it has the function of maintaining market stability, while the size, composition and use of foreign exchange reserves also affect the exchange rate movement of the RMB. Therefore, in order to maintain the trade balance and exchange rate stability, foreign exchange reserves should be stabilised, optimised and structurally sound, more stable value foreign exchange reserve assets should be held, and the investment income from foreign exchange reserves should be fully utilised[6]. At the same time, certain mechanisms to control exchange rate fluctuations can be adopted in conjunction with exchange rate policy measures when appropriate.

3.2.2. Reasonable use of monetary policy to regulate interest rates and promote interest rate marketization

In recent years, under the pressure of sustained high inflation, the Federal Reserve has accelerated its tightening policy and the uncertain future direction of the Fed's interest rate policy has made the future direction of the US-China interest rate differential difficult to predict. Therefore, China should first set out to prevent the impact of changes in US interest rates on the RMB exchange rate domestically and accelerate the pace of interest rate marketisation to avoid abnormal volatility. Monetary policy can adjust interest rates by changing the discount rate to change the direction of capital flows internationally, indirectly causing changes in foreign exchange supply and demand conditions and keeping exchange rate fluctuations within a reasonable range[7].

3.2.3. Improving the efficiency of foreign investment utilization and maintaining balance of payments

A long-term surplus or deficit is a sign of a balance of payments imbalance and exacerbates exchange rate fluctuations. Therefore, China should gradually open up its capital account, improve the efficiency of foreign investment, and encourage enterprises to invest abroad to promote China's industrial structure upgrade[8]. Meanwhile, an expansionary fiscal policy can be adopted to stimulate domestic consumption demand and regulate the degree of foreign trade dependence to an appropriate level, so as to maintain a stable relationship between domestic economic development and the balance of payments.

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