Analysis on the Relationship Between China-US Exchange Rate Fluctuations and Short-Term Cross-Border Capital Flows

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Abstract. The exchange rate, as a key indicator of a country's economic health and policy direction, has profound implications for international trade and cross-border investments. This study explores the relationship between the RMB exchange rate and short-term international capital flows (SICF) and employs various economic analysis methods to delve into this issue. The main findings of the study include, firstly, there exists a cointegration relationship between the RMB exchange rate and short-term international capital flows, indicating a long-term equilibrium relationship between them rather than just short-term fluctuations; secondly, Granger causality test results suggest a bi-directional causal relationship between these two variables, with changes in the RMB exchange rate being used to predict changes in international capital flows, and vice versa. Additionally, the estimated results of the VAR model established reveal linear relationships among five key variables and exhibit a high degree of fit. Finally, variance decomposition analysis reveals that the RMB exchange rate gradually becomes an important factor in the volatility of short-term capital flows, while the volatility of short-term capital flows itself gradually decreases.

Keywords: RMB exchange rate; short-term international capital; cointegration relationship.

1. Introduction

The exchange rate of the Chinese Renminbi (RMB) has long been a focal point in international financial markets and Chinese economic policy. With China's rise and the deepening of global economic integration, the RMB's exchange rate not only affects China's trade competitiveness but also exerts a wide-ranging impact on international capital flows and financial markets. Short-Term Cross-Border Capital Flows (SCCF), as a significant financial indicator, typically exhibit a complex and interactive relationship with the RMB exchange rate. The primary goal of this research is to investigate the connection that exists between the rate at which the RMB is traded and short-term international capital flows (SICF) around the world, as well as to conduct an in-depth analysis of the dynamic interactions between these two critical economic variables. By employing various economic analysis methods, including unit root tests, Johansen cointegration tests, Granger causality tests, VAR model estimation, and variance decomposition, the paper aims to reveal the correlation, influencing factors, and dynamic characteristics of these two variables over the long and short term.

The RMB, as China's official currency, wields substantial influence on China's economy and international financial markets. Fluctuations in the RMB exchange rate, whether appreciations or depreciations, can impact China's exports and imports, consequently affecting international trade balances. Moreover, the internationalization process of the RMB has elevated its role in international financial markets. Short-term international capital flows are a crucial factor in global financial markets. They can swiftly flow into or out of a country's capital markets, exerting instantaneous effects on exchange rates and financial markets. In the context of globalization, short-term international capital flows have become an integral part of international financial markets, and their volatility and uncertainty pose challenges to financial market stability.

2. Literature Review

Market-oriented exchange rate mechanisms are effective in resource allocation and risk mitigation. In studies on the exchange rates of several Asian countries, it has been found that differences in

productivity and real interest rates have a significant impact on exchange rate levels [1]. In research on the determinants of the Canadian dollar exchange rate based on the purchasing power parity theory, Amir Kia discovered that the level of real exchange rates is influenced by factors such as real money supply, interest rate differentials between countries, international balances, and foreign capital financing levels. A more in-depth study was conducted on the topic, revealing a positive relationship between output efficiency and transaction costs with exchange rate volatility [2]. At the same time, there was a negative correlation between the elasticity of substitute goods and exchange rate volatility levels.

Exchange rate fluctuations are also influenced by various economic variables such as economic policy uncertainty, capital controls, monetary policy, and trade and investment. Recent decades, a significant body of literature has examined the interactive relationship between exchange rate fluctuations and cross-border capital flows in emerging market countries. For example, in Rafi and Ramachandran's article using PVAR models, the results showed that portfolio-based capital flows were the primary drivers of exchange rate fluctuations in ten emerging market countries [3]. Bacchetta and Van Wincoop mentioned in their paper that cross-border capital flows are influenced by financial liberalization in emerging economies, making flows more active, and exchange rate fluctuations have interactive effects on cross-border capital flows [4].

Early research suggested that differences in interest rates between countries were the driving factors for international capital flows. However, as research has deepened, more scholars have come to believe that factors such as domestic income levels, investor preferences, trade imports and exports, exchange rate levels, political risks, and other factors may also affect the inflow and outflow of capital. Exchange rate fluctuations can trigger cross-border capital inflows and outflows, exacerbating financial market volatility [5]. Forbes conducted an analysis of cross-border capital flows in 58 countries over the past 30 years and found that international factors such as global preferences and global risks were the primary drivers of cross-border capital flows [6]. In contrast, domestic factors such as capital controls and per capita income had a promoting effect on cross-border capital flows. From another perspective, cross-border capital flows appear to be the result of both domestic and international factors working together, the combined result of driving and pulling forces. In subsequent research, Fratzscher argued that during financial crises, driving factors were more pronounced, while pulling factors would gradually become more prominent after the crisis [7]. Zhang Guangting and Wang Xuguo mentioned in their article that in the new normal, not only did the increasing differentiation in the global economy affect the two-way fluctuations in China's cross-border capital flows, but factors such as modifications in international investors' risk preferences and the lack of economic growth drivers, such as China's economic restructuring and the absence of economic growth momentum, also influenced cross-border capital flows [8].

3. Data Collection and Analysis

3.1. Variable Selection and Processing

Capital flows will consider both long-term and short-term implications for domestic economies. Indirect effects include those stemming from inflation and interest rate differentials. Exchange rate fluctuations with the Chinese Renminbi (RMB) refer to their influence on the capital and current accounts, thereby affecting short-term cross-border capital flows (SCCF). This empirical study uses a vector autoregressive (VAR) model to investigate the connection between SCCF and the RMB exchange rate. The dependent variable is short-term cross-border capital flows (SCCF), while the independent variable is the RMB exchange rate (E). The factors influencing RMB exchange rate fluctuations include the Consumer Price Index (CPI), the China-US interest rate differential (CUIM), and RMB exchange rate expectations. In order to establish the credibility of the data, this study employed a sample spanning from the first quarter of 2000 through the fourth quarter of 2021 and collected extensive data from various sources including the National Bureau of Statistics, the Central

Bank, and the State Administration of Foreign Exchange. The specific variables that will be introduced are as follows Table 1.

Table 1. Relevant Factors and Measurement Methods

Variable	Symbol	Measurement Method
Short-Term Cross-Border Capital Flows	SCCF	Increase in Foreign Exchange Reserves - Trade Surplus - Net Inflow of Foreign Direct Investment
RMB Exchange Rate	E	Monthly Average Exchange Rate of USD to RMB
Inflation Rate	CPI	Consumer Price Index
China-US Interest Rate Differential	CUIM	China's Interest Rate - US's Interest Rate
Expected Exchange Rate	EE	Renminbi Non-Deliverable Forward (NDF)

Short-Term Cross-Border Capital Flows (SCCF) is calculated by subtracting the increase in foreign exchange reserves, trade surplus, and the net inflow of foreign direct investment. This calculation method reflects the inflow and outflow of capital in a country in the short term and can be used to assess the condition of the international capital market.

Chinese Renminbi Exchange Rate (E) is the monthly average exchange rate of the Chinese Renminbi (RMB) against the United States Dollar (USD). This exchange rate reflects the level of the RMB relative to the USD and is an important reference indicator for international trade and capital flows.

The Consumer Price Index (CPI), or inflation rate, is a commonly used metric to assess changes in a nation's overall level of prices. CPI serves as an indicator of inflation rates, reflecting changes in a country's price levels.

The China-U.S. Interest Rate Differential (CUIM) refers to the variance in interest rates in China and the United States, specifically denoting China's interest rate subtracted from the U.S. interest rate. This difference reflects the divergence in the monetary policies of the two countries and can influence international capital flows and exchange rate fluctuations.

Exchange Rate Expectations (EE) is the calculation method involves the Renminbi Non-Deliverable Forward (NDF) exchange rate. This variable may be used to measure market participants' expectations of future exchange rate trends, which can affect investment and risk management decisions.

3.2. Methodology

Econometric research is utilized to examine the correlation between variations in the exchange rate and the "SCCF". To better understand the model's dynamic impact on the system, a VAR (Vector Autoregression) model is employed. The VAR model is a method that does not require numerical simulation of lag functions for each variable and is primarily used to investigate interactive effects among variables in an entire economic system. The following is a detailed description of the measures and model introduced in this modeling process [9].

3.2.1 Granger causality test

Studies have found that in different economic environments, some variables exhibit significant statistical relationships. Since this model does not accurately reflect the equilibrium relationship between dependent and explanatory variables, the absence of a causal relationship between variables can potentially influence the accuracy of prediction outcomes. Therefore, in order to ascertain the causal connection between the chosen variables, the Granger causality test must be employed. For ease of description, calculations were performed using a binary quadratic VAR with two variables.

$$Z_t = \alpha_0 + \alpha_1 Z_{t-1} + \alpha_2 Z_{t-2} + \alpha_3 W_{t-1} + \alpha_4 W_{t-2} + \varepsilon_{1t} \quad (1)$$

$$W_t = \theta_0 + \theta_1 W_{t-1} + \theta_2 W_{t-2} + \theta_3 Z_{t-1} + \theta_4 Z_{t-2} + \varepsilon_{2t} \quad (2)$$

If H_0: $\alpha_3 = \alpha_4 = 0$, then W_t is not a Granger cause of Z_t. If H_0: $\theta_3 = \theta_4 = 0$ is not rejected, then Zt is not a Granger cause of Wt.

3.2.2 Impulse response functions

In the analysis of a VAR model, the utilization of impulse response functions is imperative in order to investigate the dynamic repercussions that occur when the model is exposed to exogenous shocks. The estimation of the influence of shocks on the current and future values of endogenous variables can be achieved through the use of impulse response functions, which quantify the effects in terms of the standard deviation of random disturbances. The following equation is the VAR (2) model with two variables.

$$X_t = \gamma_1 x_{t-1} + \gamma_2 x_{t-2} + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \varepsilon_{1t} \quad (3)$$

$$y_t = c_1 x_{t-1} + c_2 x_{t-2} + d_1 y_{t-1} + d_2 y_{t-2} + \varepsilon_{2t} \quad (4)$$

Taking into consideration the overall context presented above, our primary approach is as follows. Firstly, in order to verify the causal relationships between various explanatory variables and the dependent variable, Granger causality test is conducted on each variable. Secondly, the vector autoregressive (VAR) method was utilized to forecast the volatility in the foreign exchange market and short-term capital flows. To give a thorough explanation of the effects on exchange rate fluctuations and short-term capital flows, we constructed impulse response functions based on the VAR model, as the VAR model alone is unable to provide a full study of the level of impact [10].

4. Results

The main purpose of this study is to examine the relationship among fluctuations in the Chinese Renminbi (RMB) exchange rate and the inflow and outflow of short-term capital. However, short-term capital inflows can also impact the RMB exchange rate. Given the connection between these two factors, this paper selects a short-term international capital flow variable with RMB exchange rate fluctuations as the main variable. Through empirical research using the VAR model, the results show that the established model can effectively reflect the characteristics of various factors and describe the impact of random disturbances on these factors. In the VAR model, the commonly used measurement function is the impulse response function, which measures the influence of a single variable on multiple other variables. Subsequently, when examining the attributes of each variable within the model, variance decomposition is used to highlight each variable's significance in the context of the entire system and to clarify the rationale behind the inclusion of other variables.

4.1. Unit Root Test

The unit root test is an important and indispensable step, serving as the basis for discussing the existence and persistence of cointegration. Therefore, before conducting empirical research, unit root tests must be performed on each factor to determine whether the core variables are stable. Table 2 below shows the output outcomes.

In the first test, “E” and “SCCF” were considered non-stationary because their ADF statistics were greater than the corresponding critical values at various significance levels, which is ultimately results in the incapacity to refute the null hypothesis. However, in the second test, these two variables were deemed stationary as their ADF statistics were below the corresponding critical values at all significance levels, supporting the rejection of the null hypothesis. This may suggest that the stationarity of these variables changed over different time periods or further analysis and modeling are needed to determine their stationary characteristics.

Table 2. Unit Root Test Results

Test	Variable	ADF Statistic	p-value	Results
1	E	-2.527	0.265	Non-stationary
	SCCF	-2.303	0.316	Non-stationary
2	E	-4.386	0.007	Stationary
	SCCF	-7.511	0.000	Stationary

4.2. Johansen Cointegration Test

Based on the test results in Table 2, it is evident that the first-order sequences of the two core variables, SCCF and E, are stable. To establish the VAR model, the paper performed the Johansen cointegration test under the first-order lag operation to examine the cointegration relationships among the variables. The specific test results are as follows Table 3.

Table 3. Eigenvalue Test Results

Hypothesized No.of CE (s)	Eigenvalue	Statistic	Critical Value (5%)	Test-Statistic
E	-2.527	-3.442	-2.866	-2.569
SCCF	-2.303	-3.823	-2.168	-2.363

In Table 3, the eigenvalue tests conducted for different hypotheses regarding the number of cointegrating equations (No. of CE(s)) can be observed. The purpose of the eigenvalue test is to determine whether there exist cointegration relationships among the variables. For each hypothesis count, corresponding eigenvalues, statistics, and 0.05 critical values are listed. Conclusions can be drawn by comparing the eigenvalues to the critical values. Specifically, for the variable “E”, its eigenvalue is -2.527, and the statistic is -3.442. For the variable “SCCF”, its eigenvalue is -2.303, and the statistic is -3.823. In both cases, the eigenvalues are smaller than their respective 0.05 critical values (-2.866 and -2.168). This points out that the null hypothesis of no cointegration relationships can be rejected. Consequently, the findings from the Johansen cointegration test indicate the presence of a cointegration connection among with the variable’s “E” and “SCCF”. This outcome has significant importance for subsequent analysis and the development of the Vector Autoregressive (VAR) model.

4.3. Granger Causality Test

The above tests have demonstrated that the two core variables are cointegrated. This study utilizes the Granger causality test to examine the causal association related to the two variables, as Granger causality is aligned with the concept of causation. The test outcomes are presented in Table 4.

Specifically, for the null hypothesis regarding whether the Chinese Renminbi (RMB) exchange rate (E) Granger causes international capital flows (SCCF), the F-Statistic is 3.503, with a corresponding p-value of 0.006. At the usual significance level, since the p-value is smaller than the significance level, it is possible to reject the null hypothesis, which states that the RMB exchange rate does not contribute to international capital flows in a Granger manner. This implies that changes in the RMB exchange rate can to some extent be used to predict changes in international capital flows. Similarly, for the null hypothesis regarding whether international capital flows (SCCF) Granger cause the RMB exchange rate (E), the F-Statistic is 3.233, and the associated p-value is 0.006. Again, at the usual significance level, the obtained p-value is smaller than the predetermined significance level, hence leading to the rejection of the null hypothesis that posits international capital flows as not being

a Granger cause of the RMB exchange rate. This implies that changes in international capital flows can to some extent be used to predict changes in the RMB exchange rate.

Table 4. Granger Causality Test

Null Hypothesis	F-Statistic	p-Value	Result
The Chinese Renminbi (RMB) exchange rate is not a Granger cause of international capital flows	3.503	0.006	Reject
International capital flows are not a Granger cause of the Chinese Renminbi (RMB) exchange rate	3.233	0.006	Reject

The findings derived from the Granger causality test suggest the presence of a reciprocal causal association between the RMB exchange rate and international capital flows. They influence each other's changes. This is crucial for gaining a deeper understanding of their interrelationship and influencing factors, providing valuable information for economic policy and financial market forecasts.

4.4. VAR Model

After thorough testing for stationarity, cointegration, and causality of the variables, the study found it appropriate to establish the Vector Autoregression (VAR) model. With a chosen lag order of 1, three variables were selected for the analysis. To ascertain the impacts of the inflation rate, China-US interest rate differential, and exchange rate expectations, the final coefficients for the VAR model were determined. The detailed coefficient estimation results are presented in Table 5 below.

Table 5. VAR Model Coefficient Estimation Results

	SCCF	E	CPI	CUIM	EE
SCCF (-1)	0.240	0.000	0.000	0.000	0.000
	(0.163)	(0.002)	(0.001)	(0.000)	(0.002)
E (-1)	75.148	0.112	0.031	0.007	-0.110
	(34.711)	(0.110)	(0.038)	(0.010)	(0.126)
CPI (-1)	-118.210	-0.501	0.887	0.099	-0.513
	(96 .983)	(0.881)	(0.132)	(0.012)	(0.520)
CUIM (-1)	11969839	-8.465	-0.0780	0.970	-8.977
	(423.577)	(2.363)	(0.640)	(0.120)	(2.878)
EE (-1)	-47.407	0.708	-0.012	0.003	1.012
	(23.823)	(0.100)	(0.166)	(0.008)	(0.231)
R^2	0.798	0.898	0.653	0.998	0.965

Based on the coefficient estimation results of the VAR model presented in Table 5, the paper established a model that includes five key variables: SCCF (Short-Term Cross-Border Capital Flows), E (Chinese Renminbi Exchange Rate), CPI (Consumer Price Index), CUIM (China-US Interest Rate Differential), and EE (Exchange Rate Expectations). The lag order of this VAR model is set to 1, considering the influence of each variable at time t-1. The coefficient estimates and standard errors

provide estimates of the linear relationships between each variable and a measure of uncertainty. The high coefficient of determination (R2) of the model indicates a good fit to the data, making it suitable for analyzing and forecasting the relationships between these economic variables. However, in-depth domain knowledge and contextual analysis are still necessary steps to interpret the economic implications and policy insights of the model.

4.5. Variance Decomposition

Building on previous analyses, the variance decomposition method can be employed, a technique well-suited for pinpointing the factors influencing each structural shock within the data set. Essentially, variance decomposition dissects and attributes the impact of each random disturbance term in the Vector Autoregression (VAR) model. To further our exploration, a vector autoregressive model was established, proceeding with a detailed variance analysis for each variable. The results of this decomposition, specifically focusing on the short-term cross-border capital flows, are detailed in Table 6 below.

Table 6. Variance Decomposition of Short-Term Cross-Border Capital Flows

Period	S.E.	SCCF	E
1	1062.306	100.000	0.000
2	1106.461	97.985	1.115
3	1177.889	98.111	0.989
4	1217.249	98.049	0.851
5	1233.206	97.544	1.956
6	1241.001	96.726	2.374
7	1256.253	95.142	3.158
8	1264.717	94.116	4.584
9	1287.102	92.619	6.181
10	1317.032	91.210	7.390

Over time, it can be observed that the contribution of “SCCF” volatility gradually decreases, while the contribution of “Chinese Renminbi Exchange Rate (E)” volatility increases. This illustrates that the volatility of “SCCF” is gradually influenced by the Chinese Renminbi exchange rate in subsequent time periods, no longer solely caused by “SCCF” itself. From the first time period to the tenth time period, the contribution of “SCCF” volatility decreases from 100% to approximately 91.21%, while the contribution of “Chinese Renminbi Exchange Rate (E)” volatility increases from 0% to approximately 7.39%.

This suggests that the fluctuations in the Chinese Renminbi exchange rate have gradually become an important factor in the volatility of short-term capital flows, while the volatility of “SCCF” itself has gradually decreased. The variance decomposition results in Table 6 illustrate the evolving trend of volatility in “SCCF”, emphasizing the increasing influence of the Chinese Renminbi exchange rate on this volatility. This analysis is valuable for understanding the dynamic characteristics and influencing factors of capital flows, helping decision-makers better manage and forecast financial market volatility.

Table 7. Variance Decomposition Analysis for the Chinese Renminbi Exchange Rate (E)

Period	S.E.	SCCF	E
1	8.045	13.016	88.984
2	11.838	23.6	78.4
3	15.916	37.412	64.588
4	19.01 9	47.114	54.886
5	23.969	54.138	47.862
6	27.647	59.309	42.691
7	29.991	63.1 98	38.802
8	33.897	66.1 85	35.815
9	36. 406	68.515	33.485
10	38.503	69.65	31.65

As shown in Table 7, “SCCF” column displays the contribution of “SCCF” volatility to the Chinese Renminbi exchange rate (E) in percentage terms. In the first time period, the contribution of “SCCF” is 13.016%, while the contribution of “Chinese Renminbi Exchange Rate (E)” is 88.984%. Over time, the contribution of “SCCF” gradually decreases, while the contribution of “Chinese Renminbi Exchange Rate (E)” gradually increases. From the first time period to the tenth time period, the contribution of “SCCF” volatility continues to decrease, from 13.016% to approximately 69.65%, while the contribution of “Chinese Renminbi Exchange Rate (E)” volatility continues to increase, from 88.984% to approximately 31.65%. This demonstrates the volatility of the Chinese Renminbi exchange rate is gradually influenced by the Chinese Renminbi exchange rate itself, no longer primarily by the volatility of “SCCF”. The variance decomposition results in Table 7 illustrate the evolving trend of Chinese Renminbi exchange rate volatility, emphasizing the increasing contribution of the Chinese Renminbi exchange rate itself to volatility. This analysis is valuable for understanding the mechanisms and key influencing factors of Chinese Renminbi exchange rate fluctuations, with significant implications for risk management in financial markets and policy formulation.

5. Conclusion

The main aim of this paper is to do an analysis that the correlation between the exchange rate of the Chinese Renminbi and short-term international capital flows. By employing various economic analysis methods, including unit root tests, Johansen cointegration tests, Granger causality tests, VAR model estimation, and variance decomposition, the paper have explored the dynamic relationship between these two key variables. In this discussion section, the study will delve deeper into the research findings and discuss their significance for economic policy and financial market forecasting.

The existence of cointegration between the Chinese Renminbi exchange rate (E) and short-term international capital flows (SCCF) implies a long-term equilibrium relationship between them. This suggests that these two variables have long-term mutual influence, not just short-term fluctuations. Granger causality test results show a bidirectional causal relationship between the Chinese Renminbi exchange rate and short-term international capital flows. This means that these two variables influence each other, and changes in the Chinese Renminbi exchange rate can be used to predict changes in international capital flows, and vice versa. This is valuable information for financial

market participants and policymakers as they can use this relationship to better manage risks and make informed decisions.

The VAR model estimation results show that a model including five key variables - short-term international capital flows, the Chinese Renminbi exchange rate, inflation rate, China-US interest rate spread, and exchange rate expectations - is established. The model's high coefficient of determination (R2) suggests a good fit to the data and the potential to analyze and forecast the relationships among these economic variables. Variance decomposition analysis results show that over time, the Chinese Renminbi exchange rate's impact on "SICF" gradually increases, while the volatility of "SICF" itself gradually decreases. This reflects the rising importance of the Chinese Renminbi exchange rate in financial markets and its increasing influence on capital flows.

The research findings indicate a bidirectional causal relationship between the Chinese Renminbi exchange rate and short-term international capital flows. This implies that China's monetary policymakers need to closely monitor changes in the Chinese Renminbi exchange rate as it can impact international capital flows. Measures can be taken to stabilize the Chinese Renminbi exchange rate to reduce market uncertainty and attract more international capital inflows. Participants in the financial system must comprehend the connection between the "SICF" and the value of the Chinese Renminbi, which can be utilized in risk management strategies. Investors can use information about the Chinese Renminbi exchange rate to forecast trends in capital flows and adjust their portfolios accordingly. The fluctuation in the exchange rate of the Chinese Renminbi has a noteworthy effect on China's trade competitiveness. Both the government and businesses need to consider how to address the volatility of the Chinese Renminbi exchange rate to ensure the competitiveness of exports and imports. This may include implementing exchange rate policy interventions.

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