An Empirical Analysis of the Influence of RMB Exchange Rate on SSE Real Estate Index

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Abstract
In this paper, the SSE Real Estate Index and RMB exchange rate are taken as the research objects, and the approaches and effects of the RMB exchange rate on the SSE Real Estate Index are further explored by means of literature and empirical research. The results show that the RMB exchange rate can boost SSE Real Estate Index in the short term, while this influence may be less prominent in the long term. In the end, based on the analysis and summary of the text, some specific suggestions are made to exert the influence of the RMB exchange rate, aiming to provide a reference for the further development of real estate in China.

Keywords-*RMB exchange rate; SSE Real Estate Index; Financial market*

1. Introduction

1.1. Research background

In the context of economic and financial globalization, financial and real estate markets are increasingly influenced by external markets, which in turn affects the real estate index of domestic financial markets through investors. In this process, the activities that foreign investors move in and out of the domestic financial markets will cause changes in the supply and demand of currency, which further results in the movements of the domestic exchange rate. Therefore, the exchange rate movements can reflect the changes in the real estate index in the financial markets. Moreover, under the influence of factors such as economic and investment globalization, the RMB exchange rate can help to affect the real estate sector index by taking advantage of the information and capital flows in the financial market.

The world's economies have a stronger interaction in economic globalization. As an important financial concept, the real effective exchange rate (REER) is the weighted average of a country's currency in relation to an index or basket of other major currencies. The weights are determined by comparing the relative trade balance of a country's currency against that of each country in the index. On July 21st, 2005, China carried out an exchange rate reform, and began to enter the era when the exchange rate was dominated by "a basket of currencies". However, the subprime mortgage crisis in 2008 damaged the effectiveness of the exchange rate system reform. During the crisis, China's exchange rate regime remained largely pegged to the dollar. The value of the RMB has been on a growth trend since that reform in 2005. It was not until the exchange reform on 11 August 2015 that China's exchange rate regime was adjusted steadily with reference to a basket of currencies, and the RMB had the devaluation followed by the revaluation. By December 2021, the RMB generally tended to depreciation. Additionally, according to the trends of exchange rate and real estate index, it can be roughly inferred that there is a connection between them, and the fluctuation of the exchange rate can also affect that of the SSE Real Estate Index by the intermediate transmission.

1.2. Review of literature

This paper focuses on whether the exchange rate has an impact on stock price, explaining how it works. The topic of this research, the correlation between exchange rate and house price, is expounded to the existing research results from three aspects.

The first aspect is about the theories related to the impact of the exchange rate on the stock price. Mansor (2000) concluded from an empirical study of Malaysia that short-term exchange rate fluctuations had a significant impact on the stability of stock prices.[1] Koutmos (2000) demonstrated the relationship between stock price fluctuation and currency appreciation and

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depreciation in history. The results showed that there was a strong correlation between stock price and exchange rate[2]. Kim (2003) selected the S&P 500 share prices and the real exchange rates from 1974 to 1998 and found a negative correlation between them.[3] Arora (2018) started with the Indian Rupee (INR) to US Dollar (USD) exchange rate and found that the exchange rates and the stock prices could not satisfy the cointegration test after the data validation from 2007 to 2017, which indicated that the cointegration relationship between them was zero. Yet, for all that, the exchange rate had an impact on the portfolio of the stock market, mainly because the exchange rate mechanism (ERM) affected the inflow and outflow of foreign investment funds, which in turn influenced the domestic stock prices.[4]

The second is about how the exchange rate affects stock price. Wei (2019)[5] used a TVP-VAR model to study the RMB exchange rate and stock prices from 2005 to 2017 with the policy after the RMB exchange rate reform in 2005, and concluded that there was a complex time-varying relationship between them. Also, Dai (2019)[6] explored the relationship between exchange rate and stock price by establishing a SAVR model in the context of the new exchange rate reform policy in 2015, and found that the long-term cointegration relationship between them was advanced after the reform, but due to the complexity of market transactions, the correlation couldn't correspond to the expected theoretical results. Using the DCC-GARCH model, Wang (2020)[7] investigated the RMB exchange rate and stock prices after the 2008 financial crisis. The results demonstrated that the inverse relationship between the two still existed in special economic periods, and the impact of the RMB exchange rate on stock prices gradually increased with the changes in the current account.

The third aspect is about how the exchange rate affects the real estate industry and housing price. Through the comparative analysis of the capital stock of international real estate portfolios with or without the exchange rate effect, she discovered that there was a significant difference between them. In other words, the exchange rate had a strong effect on the capital stock of the real estate portfolio (in non-single monetary conditions)[8]. Furthermore, Diala (2017) investigated whether exchange rate fluctuations had an impact on the returns to low-income residential real estate investments in Nigeria and the results showed that smaller exchange rate fluctuations yielded higher returns to investment for low-income residential real estate investments, which further explored the impact of exchange rate fluctuations on the real estate industry.[9] Among the various measure indexes of the real estate sector, house price is the most intuitive one. In this regard, Ohno (2015) screened eight countries in Asia with relatively high inflows of foreign capital, focusing on the impact of international capital fluctuations to house prices in the country, while observing whether the degree of national monitoring of foreign capital caused fluctuations in house prices. The results showed that the implementation of strict exchange rate control, as well as the control of international capital, would increase house prices.[10] While Ding et al. (2020) conducted a study combining the impact of RMB exchange rate reform on the correlation of house price increase, and the results showed that there is a correlation between the exchange rate and house price. Accordingly, the real estate market should be regulated from the perspective of currency stability [11].

The paper mainly chooses the real effective exchange rate, and the foreign research achievements are of great significance. Those studies mainly involve the specific derivation, i.e., the real effective exchange rate, as the explained variable, are studied through some relevant variables, or to explore its impact on other economic phenomena. While there are fewer studies about the real effective exchange rate's impact on real estate price. Baghestani (2019)[12] developed A-MA model to predict the real effective exchange rate of the UAE using monthly data of oil prices from 1994-2009, while the changes in the real effective exchange rate of the UAE were derived by a non-parametric approach based on the data from 2009-2019. Alleyne (2020) developed a disaggregated data demand model, focusing on the impact of the real effective exchange rate on tourism demand. The real effective exchange rate fluctuations had different effects on tourism demand for different income groups.

2. Model Design and Data

2.1. Data source and variable selection

1)Data source

The data selected for this paper are derived from China's State Administration of Foreign Exchange (SAFE) and China Stock Market & Accounting Research (CSMAR) Database, mainly including the monthly data of RMB exchange rate and Shanghai Real Estate Index from January 2000 to December 2021, with a total sample size of 264. The tool used for processing and analyzing the data in this paper is Stata 15.0.

2)variable selection and processing

In this paper, the SSE Real Estate Index is taken as the explained variable, denoted by DC. As the explanatory variable, the RMB real effective exchange rate index is denoted by REER. Besides, the control variables include loan interest rate and real estate price, denoted as INT and EP, respectively.

In order to eliminate heteroscedasticity, the SSE Real Estate Index, RMB real effective exchange rate and total investment in real estate development should be logarithmic processed to obtain LNDC, LNREER and LNEP, while the one-year loan interest rate can use the

original data INT.

2.2. Model Design

In order to avoid "spurious regressions" resulting from the long research period, the stability test of the required variables is carried out first, and the main method is the ADF unit root test. If the test results show stationarity, the data can be directly regressed, but if not, they should be stabilized by difference method. The stationary data after processing ought to be judged whether there is a linear relationship among the variables by the co-integration test, and if the test result is valid, it indicates that there is a co-integration relationship between these variables. The following steps of testing and modeling are performed on the basis of the Engle-Granger co-integration test method.

1) Build a long-term equilibrium equation model to obtain its residual series. The SSE Real Estate index is affected by complex and diverse factors, the influence of which varies in intensity and direction, i.e., there is a nonlinear relationship between the evolutionary characteristics and these factors, thus the relationship of nonlinear functions is adopted to establish the model as follows.

$$InDC_t = \alpha_0 + \alpha_1 INREER_t + \alpha_2 INT_t + \alpha_3 InEP_t + \varepsilon_t \quad (1)$$

2) Determine the stationarity of residual sequence/series. The equation is regressed to obtain the estimating equation, which in turn leads to the residual series of the following form:

$$\varepsilon_t = InDC_t - \alpha_1 INREER_t - \alpha_2 InINT_t - \alpha_3 InEP_t \quad (2)$$

3. Empirical analysis

3.1. Descriptive analysis

As shown in this table, we know that the maximum value of LNDC is 9. 0497, the minimum is 6.6521, and the mean is 8.1283, which indicates the large variation of this index. The maximum value of the LNREER variable is 4.8823, the minimum is 4.4048, and the mean is 4.6536, which indicates that LNREER is less volatile. The maximum value of the INT is 7.5600 and the mean is 5.6564, which indicates that INT changes slightly. The maximum value of LNEP is 9. 3083, the minimum is 7.6260, and the mean is 8.4895, indicating that the LNEP witnesses a big variation.

Table 1 Descriptive analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
LNDC	264	8.1283	0.6137	6.6521	9.0497
LNREER	264	4.6536	0.1475	4.4048	4.8823
INT	264	5.6564	0.7305	4.7500	7.5600
LNEP	264	8.4895	0.5077	7.6260	9.3083

3.2. ADF test result

In this paper, ADF method is used to test the stationarity of variables, and the results are as follows:

Table 2 Stationarity test for variables

Variable	ADF value	1% critical value	5% critical value	10% critical value	P-value	Stationarity
LNDC	-1.250	-3.459	-2.879	-2.570	0.6516	No
DLNDC	-14.843	-3.459	-2.880	-2.570	0.0000	Yes
LNREER	-0.170	-3.459	-2.879	-2.570	0.9420	No
DLNREER	-11.990	-3.459	-2.880	-2.570	0.0000	Yes
INT	-1.016	-3.459	-2.879	-2.570	0.7473	No
DINT	-10.581	-3.459	-2.880	-2.57	0.0000	Yes
LNEP	-0.920	-3.459	-2.879	-2.570	0.7814	No
DLNEP	-18.030	-3.459	-2.880	-2.570	0.0000	Yes

According to the above results, the ADF test values of the original sequence were all greater than the critical value at the significance level of 0.05, and the null hypothesis of the existence of unit root was accepted. Therefore, the original sequence was unstable. The ADF test value of the sequence after the first-order difference shows that it rejects the null hypothesis, so the sequences after the first-order difference are all stationary sequences.

3.3. Co-integration Test

Since LNDC, LNREER, INT and LNEP all show first-order integration, their long-term co-integration relationship can be further tested. Since the co-integration test is sensitive to lag order, the optimal lag test of VAR model is required before the test, and the results are shown in the following table (Table 3).

1) Information Criterion

Table 3 Information Criterion

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-209.764				.000061	1.64434	1.66636	1.69912
1	1760.600	3940.700	16	0.000	1.8e-11	-13.3892	-13.2791	-13.1153*
2	1796.450	71.695	16	0.000	1.5e-11	-13.5419	-13.3437	-13.0489
3	1824.410	55.925*	16	0.000	1.4e-11*	-13.6339*	-13.3476*	-12.9218
4	1833.170	17.528	16	0.352	1.5e-11	-13.5783	-13.2039	-12.6470

After comprehensively considering LR, FPE, AIC, SC, HQ statistics and system recommended options shown in the above table, it can be determined that the lag order to be selected in co-integration test is 2. After the lag order is defined, Johansen co-integration test can be carried out to obtain the following results.

2) Co-integration test results

Table 4 Co-integration test results

maximum				trace	5% critical
k	parms	LL	eigenvalue	statistic	value
0	20	1790.6662	.	40.1435*	47.21
1	27	1800.2613	0.0706	20.9532	29.68
2	32	1807.7042	0.0552	6.0675	15.41

As can be seen from Table 4, when the null hypothesis is that there is no co-integration relationship, Trace Statistic=40.1435>28.5881. Therefore, the null hypothesis is rejected, that is, the co-integration relationship exists. When the null hypothesis for at most one, two or even three collaborators are the relations, the Trace Statistic statistics were greater than 0.05 significant level, the critical value, and P values were bigger, therefore accept the null hypothesis, indicates that SSE Real Estate Index, the RMB real effective exchange rate, loan interest rates and there are multiple long-term co-integration relationship between real estate prices.

Table 5 Co-integration equation

Variable	Coef.	Std. Err.	t	P>|t|
LNREER	2.2924	0.3146	7.29	0.0000
INT	0.1229	0.0346	3.56	0.0000
LNEP	0.4482	0.0863	5.19	0.0000
C	-7.0397	1.0458	-6.73	0.0000

The co-integration equation is as follows:

LNDC=-7.0397+2.2924*
LNREER+0.1229*INT+0.4482*LNEP

It can be seen that RMB real effective exchange rate index has a positive effect on SSE Real Estate Index in the long run, and when RMB real effective exchange rate index increases by 1%, SSE Real Estate Index will increase by 2.92%. In addition, it can be seen from the co-integration equation that the interest rate is positively correlated with the SSE Real Estate Index, and the total investment in real estate development is positively correlated with the SSE Real Estate Index.

3) Granger causality test

Through the above analysis, it can be clear that there is a long-term co-integration relationship between RMB real effective exchange rate and SSE Real Estate Index. Granger causality test can be used to further analyze the causal relationship. Since the optimal lag order between variables is 3, the result of causality test for each variable is as follows.

Table 6 Granger causality test results

Null Hypothesis:	Obs	F-Statistic	Prob.
LNREER does not Granger-cause LNDC	261	2.63	0.0742
LNDC does not Granger-cause LNREER	261	2.19	0.1136
INT does not Granger-cause LNDC	261	0.44	0.6466
LNDC does not Granger-cause INT	261	5.55	0.0044

LNEP does not Granger-cause LNDC	261	2.42	0.0913
LNDC does not Granger-cause LNEP	261	0.01	0.9896

According to the above statistical results, at the significance level of 10%, the original hypothesis "LNREER does not Granger-cause LNDC" is rejected, while " LNDC does not Granger-cause LNREER " is not rejected. Therefore, it can be judged that RMB real effective exchange rate index is the Granger cause of SSE Real Estate Index, and only this one-way causal relationship exists. When the RMB real effective exchange rate index rose that a stronger currency, currency assets value rise, and in many renminbi assets, stocks and real estate as the main international capital investment objectives, but combined with the development of China's stock market is not mature but unusually hot real estate market present situation, has the stable high yield of the real estate market has become a major investment. Therefore, short-term international capital will enter the real estate market through a variety of channels, and the increase in demand will increase the profits of real estate developers, thus leading to the rise in stock prices.

At the significance level of 1%, the null hypothesis "INT does not Granger-cause LNDC" is not rejected, but the null hypothesis "LNDC does not Granger-cause INT" is rejected. Therefore, it can be judged that interest rate is not the Granger cause of SEE Real estate index fluctuation. And there is only this one-way causal relationship. At the significance level of 10%, the null hypothesis "LNEP does not Granger-cause LNDC" is rejected, while the null hypothesis "LNDC does not Granger-cause LNEP" is accepted. Therefore, at this significance level, the total investment in real estate development can be regarded as the Granger cause of SSE Real Estate Index, and only this one-way causal relationship exists.

3.4. Vector autoregressive (VAR) model

3.4.1. VAR model

VAR model is based on the statistical characteristics of data. Before modeling, co-integration test is needed to determine whether the relationship between variables is stable. The optimal lag order K is determined by Akchi Information criterion (AIC) and Schwartz criterion (SC), which enables the VAR model to reflect most of the interactive variables. The optimal lag order of VAR model in this paper has been determined by the multi-criteria method above, and since it has been concluded that all variables have first-order stability above, the VAR model with two-period lag is established by using the stationary data (ln all represents the logarithmic value, D represents the value after difference), and the model results are as follows:

Table 7 The VAR model of RMB exchange rate on SSE Real Estate Index

	DLNDC	DLNREER	DINT	DLNEP
L.DLNDC	0.0765	-0.0072	0.1944***	-0.00227
	(1.24)	(-0.93)	(3.16)	(-0.11)
L2.DLNDC	0.1049*	0.0114	0.0360	0.0578***
	(1.68)	(1.44)	(0.58)	(2.72)
L.DLNREER	0.3821	0.3604***	-1.2137**	-0.0928
	(0.75)	(5.58)	(-2.39)	(-0.53)
L2.DLNREER	0.6907	-0.00942	-0.265	0.3713**
	(1.34)	(-0.14)	(-0.52)	(2.11)
L.DINT	0.0202	0.00312	0.2802***	0.00820
	(0.33)	(0.40)	(4.60)	(0.39)
L2.DINT	-0.0365	0.000177	0.1911***	-0.0240
	(-0.62)	(0.02)	(3.23)	(-1.18)
L.DLNEP	0.1226	-0.0583**	0.0699	-0.0940
	(0.69)	(-2.58)	(0.39)	(-1.54)
L2.DLNEP	-0.1150	-0.0585***	0.2539	-0.321***
	(-0.65)	(-2.60)	(1.43)	(-5.28)
C	0.00201	0.00161**	-0.00306	0.00784***
	(0.33)	(2.09)	(-0.51)	(3.78)

R^2	0.0359	0.1514	0.2521	0.1288
Chi2	9.7224	46.5552	87.9654	38.5796

State: t statistics in parentheses * p<0.1, ** p<0.05, *** p<0.01

The results showed that the coefficient of delayed single-period LNREER was 0.3821, indicating that delayed single-period LNREER had a promoting effect on variable LNDC. In other words, LNREER changes by 0.3821 units for every change in the lag period. Similarly, the coefficient of LNREER (-2) is 0.6907, indicating that LNREER (-2) can improve variable LNDC, which changes one unit causes LNDC variable changes 0.6907 units.

As shown in the Table 7, the goodness of fit R^2 is small, mainly due to the fact that logarithmic difference series is used as the explained variable here, and variables in the VAR model are caused by stationary series. In order to be able to conduct impulse response analysis, the model should be tested for stationarity. Only on the basis of the stability of VAR model can impulse response and variance decomposition be carried out. In summary, the RMB exchange rate has a positive effect on the SSE Real Estate Index. While compared to the short term, the boosting effect is more obvious in the long term.

3.4.2. Unit circle test

In order to further verify the robustness of VAR model, unit circle test is carried out in this paper. When the reciprocal of all roots of the equation is in the unit circle, the model is stable. If it is not in the circle, that is, greater than 1, the model is unstable. The test results are shown in the Table 8 and Figure1.

Table 8 The unit root of AR

Eigenvalue	Modulus
0.5649829	0.5650
-.09458233+0.5091937i	0.5179
-.09458233-0.5091937i	0.5179
0.3003044+0.1795303i	0.3499
0.3003044-0.1795303i	0.3499
-0.2935299+0.0315844i	0.2952
-0.2935299-0.0315844i	0.2952
0.2336855	0.2337

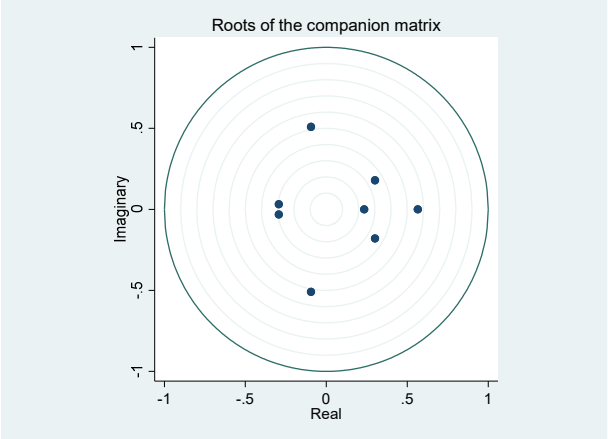

Figure1. The unit circle test

The test results of AR roots of the model show (Table 8 and Figure1) that AR roots are all within the unit circle, so it can be judged that the established VAR model is stable and capable of impulse response and variance decomposition analysis.

3.4.3. Pulse response analysis

Impulse response can reflect the fluctuation amplitude and duration of the dependent variable affected by a standard deviation shock in a short term. Its essence is the influence distribution of one variable on another variable, reflecting the dynamic influence between variables. Figure2 below shows the impulse response results of SSE Real Estate Index to RMB real effective exchange rate, interest rate and real estate development investment respectively, in which the vertical axis represents the response degree and the horizontal axis represents the lag period.

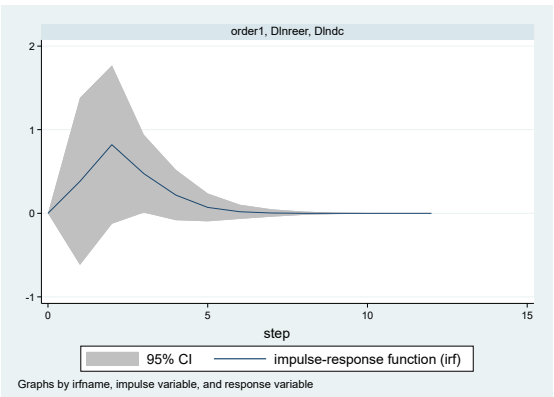

Figure2. Response of DLNDC to DLNREER

As can be seen from the Figure2, SSE Real Estate Index responds quickly to the impact of one standard deviation given by RMB real effective exchange rate index. The positive impact response reaches the

maximum value in the second phase, and then decreases gradually and tends to 0 after the seventh phase. On the whole, there is a positive correlation between the two, that is, RMB appreciation will help the SSE Real Estate Index rise. The RMB exchange rate has a great influence on the SSE Real Estate Index.

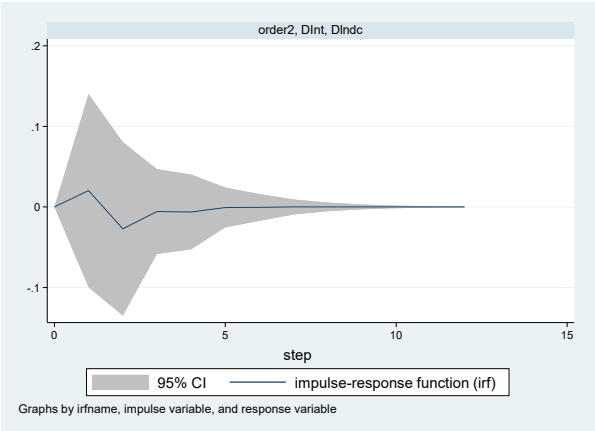

Figure3 Response of DLNDC to DINT

As can be seen from the figure above, the SSE Real Estate Index responds positively to the impact of one standard deviation on the one-year lending rate in the first phase, and then shows a negative growth, that is, the interest rate has a negative impact on the SSE Real Estate Index. Generally speaking, the shock reaction fluctuates slightly around 0 and gradually approaches 0, so the SSE Real Estate Index is less sensitive to the change of one-year lending rate.

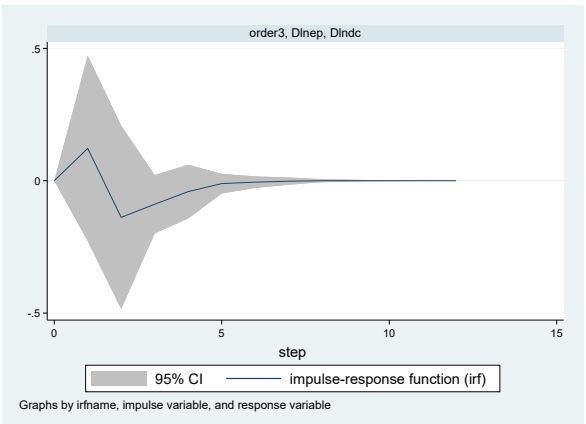

Figure4 Response of DLNDC to DLNEP

(X-axis represents time;Y-axis represents the impacted level of impact)

Can be seen from the Figure4, the SSE Real Estate Index of real estate development investment to give a reaction in the first phase of the impact of the standard deviation of positive impact response peak, then positive impact response decreases, until the third phase of the maximum of the negative impact of subsequent reaction and tend to be more positive, fluctuates up and down around zero. Therefore, the total investment in real estate development will have a positive effect on the SSE Real Estate Index in the early stage, but with the change of market supply and demand, its influence on the SSE Real Estate Index will change accordingly. When the supply exceeds the demand, the investment in real estate development will have a reverse effect on the SSE Real Estate Index.

3.4.4. Variance decomposition analysis

Table 9 Results of variance analysis（%）

step	S.E.	DLNDC	DLNREER	DINT	DLNEP
1	0	1	0	0	0
2	0.8612	99.4549	0.3268	0.0598	0.1585
3	1.4845	98.3245	1.1662	0.1575	0.3518
4	1.7747	97.9809	1.4232	0.1647	0.4313
5	1.8432	97.9026	1.4789	0.1703	0.4482
6	1.8497	97.8954	1.4848	0.1704	0.4494
7	1.8502	97.8947	1.4851	0.1705	0.4497
8	1.8502	97.8947	1.4851	0.1705	0.4497
9	1.8502	97.8947	1.4851	0.1705	0.4497
10	1.8502	97.8947	1.4851	0.1705	0.4497
11	1.8502	97.8947	1.4851	0.1705	0.4497
12	1.8502	97.8947	1.4851	0.1705	0.4497

As can be seen from the table, with the extension of time, the impact of RMB real effective exchange rate, real estate price and loan interest rate on the SSE real estate will increase and eventually become stable. After stabilizing, RMB real effective exchange rate, loan interest rate and real estate price contributed 1.4851%, 0.1705% and 0.4497% to the fluctuation of SSE Real Estate Index respectively. In general, the real effective exchange rate of RMB has the greatest influence on it, followed by real estate price and loan interest rate.

4. Conclusion

On the basis of literature review, this paper takes the

RMB exchange rate and the Shanghai Stock Exchange (SSE) real estate index as the research objects to analyze the impact of the RMB exchange rate on the SSE real estate index in terms of theories. Next, the empirical analysis is used to explore the influence path of RMB exchange rate and the SSE real estate index. In this stage, the data of the monthly exchange rate and housing price from January 2000 to December 2021 are used to establish variable indexes such as exchange rate, loan interest rate, and real estate price, and the relationships among them are analyzed by forming the VAR empirical model. The details are as follows.

First, based on the empirical analyses, it can be concluded that the RMB exchange rate can promote the SSE real estate index in medium-short terms. The change of RMB exchange rate affects the commodity price, with a rise in its cost. These changes affect the SSE Real Estate Index by influencing supply and demand and house prices in the market. Finally, the change of the RMB exchange rate results in the change of the SSE real estate index in the same direction. Under the floating exchange rate regime, international capital can directly affect the investment and production of China 's real estate industry through mechanisms, thus affecting the SSE real estate index.

Second, the RMB exchange rate does not significantly impact the SSE real estate index in a long-term period. The empirical analyses show that the RMB exchange rate has little effect on the SSE real estate index in a long-term period. The change of SSE real estate index in financial market is based on the development of China’s real estate industry. Because of the limited influence of the change of the RMB exchange rate on the development of real estate industry. It is difficult to affect the SSE real estate index in the long period. In addition, the change of the RMB exchange rate tends to affect the SSE real estate index through investment. In summary, the RMB exchange rate has little effect on the SSE real estate index.

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