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Empirical Analysis on Transmission Efficiency of New LPR Interest Rate

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Abstract

Currently, the domestic economy of China is in a state of relative sluggishness. The Loan Prime Rate which represents a crucial milestone in the journey towards interest rate liberalization, has been instituted with the overarching objective of clearing the bottlenecks in the interest rate transmission pathway within the loan market and promoting a more efficient allocation of resources. It gradually plays an important role in the interest rate transmission mechanism. This research constructs a Vector Autoregression model, by treating the reform of the LPR as a significant watershed moment, the study is designed to comprehensively explore and analyze the influence exerted by the LPR reform on the efficiency of interest rate transmission. The empirical results obtained from the model reveal that the implementation of the LPR mechanism has led to a more pronounced and direct linkage between the market interest rate and the lending rate. The interest rate transmission mechanism, as a result, has become more overtly characterized by market-driven forces, thereby providing substantial evidence in support of the effectiveness of the LPR reform initiative. Consequently, it is imperative to further deepen the reform of interest rate liberalization and elevate the level of marketization of the LPR mechanism.

Keywords: Loan prime rate, Interest rate marketization, Interest rate transmission mechanism, Vector autoregression model.

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1. Introduction

At present, the economy has not yet achieved a full and rapid recovery to the pre-pandemic level as anticipated. Instead, it confronts a series of challenges, including insufficient effective demand, weak social expectations, a protracted slump in the real estate market, and a complex and austere external environment. Interest rate, a crucial regulator of economic activities and a vital nexus between the macro-economy and micro-economy, serves as a barometer of economic operations. Its trend mirrors a wealth of essential information within the economic landscape. Given the current economic sluggishness, interest rates, which play a pivotal role, are at a low ebb. This situation is highly correlated with the loan market quoted rate, which currently functions as China's benchmark loan interest rate. Interest rate is a fundamental macro-economic variable, and interest rate liberalization constitutes one of the core reforms within the economic and financial domains. Since the initiation of reform and opening-up, China has been steadily advancing the marketization of interest rates. This involves establishing and enhancing an interest rate formation mechanism determined by market supply and demand, with the central bank guiding market interest rates through the utilization of monetary policy tools. The Loan Prime Rate (LPR) represents the quoted rate in the loan market. As a product of interest rate marketization reform, the objective of its mechanism formation is to unclog the interest rate transmission channel in the loan market, enhance the efficiency of the loan market, and enable loan interest rates to more accurately mirror the relationship between market funds' supply and demand. As the loan market's quotation rate, the LPR embodies the loan market interest rate quotation mechanism, and its formation is intricately linked to the historical evolution of China's loan interest rate pricing. During the initial stage of LPR reform from 2014 to 2019, the central bank introduced a centralized quotation mechanism associated with LPR. However, at that time, the quotation was still anchored to the benchmark interest rate. Since 2019, the central bank has continuously deepened this reform, making more far-reaching alterations to the LPR quotation method. The shift to the open-market interest rate as the basis for quotation has rendered the LPR mechanism more capable of reflecting the degree of change in market demand for funds. Consequently, to further propel the market-oriented reform of interest rates, optimize the efficiency of interest rate transmission, and effectively reduce the real economy's financing costs, this paper commences from the perspective of LPR reform. It analyzes the transformation of the monetary policy interest rate transmission mode before and after its implementation and empirically examines the changes in interest rate transmission efficiency.

2. Literature Review

This paper mainly analyzes the impact efficiency of interest rate liberalization on the interest rate transmission mechanism of monetary policy, the role of the new Loan Prime Rate (LPR) mechanism in interest rate liberalization, and the impact efficiency of the new LPR mechanism on the interest rate transmission efficiency of monetary policy.

2.1 The Impact of Interest Rate Liberalization on Interest Rate Transmission Efficiency

Existing literature generally holds that the reform of interest rate liberalization is conducive to improving the efficiency of monetary policy transmission, thereby enhancing the impact of monetary policy shocks on the real economy. With the continuous development and improvement of China's financial market, the transmission effect of China's interest rates from short-term to long-term has been gradually improving, which has increased the transmission efficiency of monetary policy (Shang et al., 2023). The advancement of interest rate liberalization can enhance the co-movement relationship between short-term and long-term interest rates, and thus play a certain role in weakening the Bernanke's puzzle of monetary policy transmission and improving the effectiveness of monetary policy (Zhan et al., 2023). Under the practical condition of the dual-track interest rate system, for the role of market interest rates, the impact effect of the deposit benchmark interest rate is the most obvious, and its effect is stronger than that of the reserve requirement ratio. Compared with the former two, the effect of open market operations is the least obvious, which reflects that market interest rate liberalization has improved the transmission efficiency (He et al., 2011). The segmentation of the market and the misalignment of capital prices have deteriorated the effect of the interest rate transmission channel, and the deepening of interest rate liberalization has enhanced the effect of interest rate transmission (Yang et al., 2018). Interest rate liberalization has made the output and inflation respond more strongly to interest rate shocks. Using the Dynamic Stochastic General Equilibrium (DSGE) model and the Time-Varying Parameter Vector Autoregression (TVP-VAR) model, it is empirically concluded that after the introduction of the LPR mechanism, interest rate liberalization has made the output and inflation respond more significantly to interest rate shocks, thus strengthening the transmission effect of the interest rate channel (Xu et al., 2020). By using a dynamic adjustment cost model of imperfect competition for testing, the determinants of the transmission of market interest rates to bank loan interest rates are examined, and it is pointed out that the degree of competition in the bank retail market is a favorable factor. The more intense the competition, the more it can weaken the hindrance of lagged and expected interest rates, and thus improve the transmission efficiency (Kopecky et al., 2012). A dynamic equilibrium model with price stickiness is constructed, and the effect of policies before and after interest rate liberalization is simulated. The research shows that with the advancement of the interest rate liberalization reform, China's capital

market is no longer in a segmented state, and the impact of monetary policy on economic variables is gradually increasing (Guo et al., 2015). Using the TVP-VAR model to test the transmission efficiency of monetary policy, it is found that the interest rate regulation in the planned track still occupies a dominant position, indicating that there is a blockage in the transmission of market track interest rates to the credit market. The advancement of interest rate liberalization can improve the regulatory effects of both market track and planned interest rates (Liu et al., 2017). The interest rate system in China under the condition of interest rate liberalization is sorted out, and it is explained that by adjusting the liquidity of the banking system through monetary policy tools, releasing the regulatory signals of policy interest rates, guiding the market benchmark interest rate to operate around the policy interest rate as the center, and transmitting it to the loan interest rate through the banking system, the allocation of resources is adjusted and optimized, and then the goals of monetary policy are achieved (Yi, 2021).

As the degree of interest rate liberalization deepens, interest rate shocks have a positive effect on economic growth (Wang et al., 2007). The LPR reform mechanism, as a part of interest rate liberalization, is conducive to the development of the real economy and is of great significance for reducing macroeconomic fluctuations (Sheng et al., 2023). The interest rate liberalization in some countries has been empirically proven to have a positive effect on the economy. By studying the impact of interest rate liberalization on the long-term development of China's macroeconomy in combination with the vector autoregressive model, it is shown that interest rate liberalization is conducive to the stable and sound development of the macroeconomy (Zhang et al., 2010). By selecting the quarterly economic data of Turkey, it is found that in the process of interest rate liberalization, monetary policy has a continuously increasing impact on the profits of the banking industry and the real economy by influencing the changes in interest rates and yield curves (Aydemir et al., 2016). The reform of interest rate liberalization can prompt enterprises to improve the efficiency of capital use and productivity, and promote the stable growth of the macroeconomy (Li, 2020). From the perspective of the money supply, a mediating effect model and a VAR model for the money supply, market interest rates and economic growth are constructed. It is concluded that the rise of China's market interest rates has a significant positive impact on economic growth, and it is believed that it is an inevitable choice to use market interest rates instead of the money supply as an intermediate target of monetary policy in the future (Yao, 2022).

2.2 The Impact of the New LPR Mechanism on Interest Rate Liberalization

The new LPR mechanism has deepened the role of interest rate liberalization. Based on macro time series data and provincial survey data, it is found that since the interest rate liberalization, with the inclusion of market interest rates in the cost accounting of funds of some commercial banks, the transmission efficiency of market interest rates has been enhanced, and it is also found that both the source of funds and the fluctuations of market interest rates are important factors affecting the pricing mechanism of loan interest rates (Guo et al., 2018). Through international experience and empirical testing research on China, it is pointed out that the degree of interest rate convergence in China can be further deepened, and some relevant policy interest rates, such as the rediscount rate, should continue to be incorporated into the central bank's seven-day reverse repurchase rate, etc. (Zhang et al., 2020). The reformed LPR has opened up the downward channel of loan interest rates, driving down the financing costs of the real economy's supply. Commercial banks are accelerating their adaptation to LPR pricing, and expanding derivative businesses helps to improve their asset quality (Tang et al., 2020). The new LPR formation mechanism affects the deposit and loan pricing capabilities of commercial banks by influencing different aspects of banks (Du et al., 2021). Using the TVP-VAR model to test the time-varying characteristics of LPR, M2, economic growth and price level respectively, it shows that the counter-cyclical regulatory effect of LPR on economic growth and price level is relatively obvious, and as the interest rate liberalization deepens, the effect is enhanced. Economic growth is also affected by the degree of interest rate liberalization and the external economic environment (Xu et al., 2024).

2.3 The Impact of the New LPR Mechanism on Interest Rate Transmission Efficiency

The reformed LPR mechanism further promotes the interest rate transmission efficiency. The LPR reform helps to improve the interest rate transmission efficiency (Liu et al., 2017). By re-analyzing the current interest rate convergence effect, the change of the LPR formation mechanism can more effectively unblock the credit transmission channel of monetary policy (Li et al., 2020). The LPR is a part of the "integration of the two tracks into one track" and is the last step of the interest rate liberalization reform. The new LPR plays an important role in promoting the transformation of price-based monetary policy, reducing the actual loan interest rate, and dealing with the severe external environment (Zhang et al., 2019). As a market-oriented benchmark interest rate, the promotion and application of LPR are conducive to decoupling bank loan interest rates from the official interest rate, thereby improving the marketization of loan pricing, enhancing the bank's ability to set prices, making the credit interest rate better reflect the bank's marginal capital cost, and thus improving the transmission efficiency (Sun et al., 2019). By studying the interest rate transmission in combination with the expansion of the collateral for Medium-term Lending Facility (MLF) and the policy of the new

regulations on asset management, it is proved that the proposed LPR reform mechanism is conducive to interest rate transmission (Liu et al., 2022). The process of the LPR quotation mechanism is theoretically modeled, taking into account the two-stage point-adding characteristics of commercial banks and the global game characteristics of the quotation process, and it is expanded into an equilibrium model. Then, through numerical simulation, the interest rate reduction effectiveness and financial stability effect of the LPR quotation mechanism are explored, which proves that the new LPR mechanism has broken the implicit lower limit of loan interest rates and improved the transmission efficiency of the central bank to loan interest rates (Yin et al., 2024). A research framework for interest rate transmission efficiency with the coexistence of short-term and medium-term paths is constructed, indicating that the transmission effect of medium-term policy interest rates is significant after the LPR reform (Jiang et al., 2020). By constructing a vector autoregressive model with policy interest rates, market benchmark interest rates and loan interest rates as representative variables for research, it is shown that the LPR reform can effectively improve the interest rate transmission efficiency (Zhao et al., 2022). Considering the regime switching characteristics among different stages of interest rate liberalization, using a research method combining theoretical model construction and empirical analysis, based on the Markov-Switching Dynamic Stochastic General Equilibrium (MS-DSGE) model and the TVP-VAR model, it is proved that the LPR mechanism has a significant strengthening effect on the transmission efficiency of monetary policy (Wang et al., 2024). Therefore, these literatures fully illustrate that the LPR has a positive effect on the transmission of monetary policy, and this paper further demonstrates its role in the interest rate transmission efficiency based on the mechanism after the LPR reform.

3. LPR interest rate transmission path

After the operation of LPR mechanism, the interest rate transmission of monetary policy has added a new channel for policy interest rate to transmit credit interest rate. In this channel, the bank loan interest rate is directly anchored with LPR instead of the official benchmark interest rate, and LPR is directly related to the policy interest rate MLF, so that the policy-related signals can be fully reflected in the LPR quotation, and the overall quotation form also reflects the characteristics of marketization.

The operation of LPR mechanism not only changes the transmission path of policy interest rate, but also changes the way of releasing price signals to market entities as a quotation system with market characteristics, thus causing the behavior of real economic entities to change accordingly. Through the continuous improvement of the quotation system, market participants will be more sensitive to the policy, and the transmission of policy intentions will have a clearer transmission channel, which will affect the transmission efficiency of monetary policy to the real economy.

Interest rate transmission takes the policy interest rate determined by the central bank as the starting point and the market interest rate as the intermediate goal, and

finally achieves macroeconomic regulation and control goals such as inflation and economic growth. This paper can divide the interest rate transmission mechanism in China into three stages. The first stage is the guiding effect of policy interest rate on market interest rate system, the second stage is the transmission effect of market interest rate on other financial market interest rates, and the third stage is the influence of other financial market interest rates on real economic variables.

LPR reform has actually created a new monetary policy transmission mechanism, which makes the policy interest rate affect the loan interest rate of commercial banks more effectively through the medium-term lending convenience interest rate. That is, "monetary policy interest rate $\rightarrow$ medium-term lending convenience interest rate $\rightarrow$ LPR $\rightarrow$ bank loan interest rate $\rightarrow$ real economy", which is more concise, direct, clear and regular than the existing transmission channels. This paper focuses on the path of "LPR $\rightarrow$ bank loan interest rate $\rightarrow$ real economy", from the perspective of loan interest rate. The empirical test of this paper is mainly to test the influence efficiency of monetary policy on loan market interest rate.

4. Model Design

4.1 Data Sources and Processing

The time interval of the variable was set from December 2014 to June 2024, covering the time when all data since the establishment of LPR were available and the important time node of LPR reform, so as to better test the changes in the transmission efficiency of monetary policy interest rates before and after the reform since the operation of LPR mechanism. The Weighted average interest rate for loans from financial institutions was chosen. Under normal circumstances, the benchmark loan interest rate is the representative interest rate of the loan interest rate, but the benchmark loan interest rate has hardly changed from July 2012 to October 2014, and after October 2015, and China continues to carry out interest rate liberalization reform, so the loan interest rate needs to be replaced by other interest rates. The public website of the People's Bank of China publishes Weighted average interest rate for loans from financial institutions on a quarterly basis, but there are a lot of missing values in the data. In order to avoid the information loss caused by the quarterly interest rate published by the People's Bank of China, This paper will refer to the practice of Guo Yumei (2018) and estimate the weighted average interest rate of financial institutions with monthly frequency by using information such as benchmark loan interest rate and the proportion of floating range of loan interest rate. The calculation method is as follows:

$$RD_t = RM_t * \sum_k (0.5 * (a_k + b_k) s_t^k) \tag{1}$$

Where, t represents the month, LR_t is the monthly frequency loan interest rate to be estimated, and RMt is the benchmark loan interest rate of 6 months to 1 year (inclusive). $K = 1, 2, ..., 6$ is the ordinal number of the interest rate range. $K = 1$

means that the interest rate is less than 10% lower than the base rate, $K = 2$ means that the interest rate is not floating, $K = 3$ means that the interest rate is less than 30%, $K = 4$ means that the interest rate is 30% to 50%, $K = 5$ means that the interest rate is 50% to 100%, $K = 6$ means that the interest rate is more than 100%. a_k represents the upper limit of the floating proportion of the K floating range, and b_k is the lower limit. For $K = 6$, the average loan interest rate can be regarded as 2.1 times of the benchmark interest rate. st_k is the proportion of loans in the KTH floating range in the total loan, and finally, the average loan interest rate of each floating range is added up using it as the weight. You get the Weighted average interest rate for loans from financial institutions. The micro representative of loan interest rate is the loan interest rate of 18 commercial banks.

This paper chooses Shanghai Interbank Offered Rate (Shibor) and Depository-Institutions Repo Rate (DR) as the research objects of market interest rate. Shibor is the Shanghai Interbank Offered Rate, which has been in operation since January 4, 2007. It reflects the interest rate at which banks borrow funds from each other. It is reported by 18 commercial banks that are active in renminbi trading, and the remaining interest rate is calculated by averaging each trading day after removing the highest and lowest four offers. Shibor has strong volatility and is widely used in market interest rate. Firstly, this paper selects it as the representative of market interest rate, selects Shibor01 interest rate as the interest rate variable, and adjusts the data frequency to monthly. DR is a depository-institutions repo rate, and its participants are mainly commercial banks, including other deposit-taking financial institutions with bond trading qualifications. Unlike Shibor, which only takes the quoted interest rate as the pricing benchmark of financial products, DR stands for real transactions and mainly takes interest rate bonds as the target, so the scope is relatively narrow. DR001 interest rate is selected as the representative, and the data frequency is adjusted to monthly.

The explained variable in this paper is weighted average interest rate for loans from financial institutions, which is divided into macro data and micro data of loan interest rates of 18 commercial banks selected from the national level. The explanatory variables in this paper are Loan Prime Rate (LPR), Shanghai interbank offered rate (Shibor) and depository-institutions repo rate (DR). This paper selects the monthly data of interest rate and real economy-related variables. The data come from Wande database and The People's Bank of China website. Variable names and abbreviations are shown in Table 1.

Table 1: Variable Summary

Variable name	Variable Symbol
Weighted average interest rate for loans from financial institutions	RD
Loan Prime Rate	LPR
Shanghai Interbank Offered Rate	SHIBOR01
Depository-Institutions Repo Rate	DR001

4.2 Data Sources and Processing

The vector autoregressive (VAR) model is generally used to analyze or predict the dynamic relationship between variables and the response of system variables after being disturbed. By observing the impact of random disturbance on endogenous variables at present and in the future, the impact of the impact on system variables can be explained. Based on this, this paper mainly uses VAR model to investigate the dynamic interaction characteristics between interest rates and economic growth indicators. The mathematical expression of VAR model is:

$$Y_t = A_0 + A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + B_1 X_t + \ldots + B_q X_{t-q} + U_t (t = 1,2,3,\ldots, T) \quad (2)$$

Among them, Y_t is the k-dimensional endogenous variable vector, X_t is the r-dimensional exogenous variable vector, p is the lag order, t is the number of samples, $A_1,...,A_p$ and $B_1,...,B_p$ is the parameter matrix to be estimated, and U_t is the random disturbance term.

4.3 Data Sources and Processing

The descriptive statistics of the variables included in the model are shown in Table 2. The thesis first makes descriptive statistics of the variables to be used in this chapter. Interest rate variables are LPR, RD, SHIBOR01, DR001. Before model estimation, in order to have a preliminary understanding of the research objects and data. Descriptive statistics can preliminarily see that the average value of the Weighted average interest rate for loans from financial institutions (RD) is 5.1586, the maximum and minimum values are 6.7700 and 3.6800, respectively, and the standard deviation is 0.6940, indicating differences between different years; the average value of the Loan Prime Rate (LPR) is 4.0958, the maximum and minimum values are 5.5100 and 3.4500, respectively, and the standard deviation is 0.4556, indicating that the fluctuation trend of Loan Prime Rate is small; the average value of Loan Prime Rate (SHIBOR01) is 1.9965, the maximum and minimum values are 3.34 and 1.01 respectively, and the standard deviation is 0.4848, indicating that the fluctuation trend of Shanghai Interbank Offered Rate is small; the average value of the Depository-Institutions Repo (DR001) is 1.989, the maximum and minimum values are In addition, the standard deviation of each variable in the descriptive statistics of each variable is less than the average, indicating that the data tends to be stable, there is no extreme outlier, and the data does not need to be further processed.

Table 2: Descriptive Statistics

Statistics	Observed value	Mean	Standard deviation	Maximum	Minimum
RD	115	5.1586	0.6940	6.7700	3.6800
LPR	115	4.0958	0.4556	5.5100	3.4500
SHIBOR01	115	1.9965	0.4848	3.3400	1.0100
DR001	115	1.9890	0.4936	3.3900	0.9900

5. Empirical analysis of LPR mechanism to loan interest rate transmission

According to the interest rate transmission mechanism, The Weighted average interest rate for loans from financial institutions, the Shanghai interbank offered rate and Depository-Institutions Repo should be adopted Rate Two paths.

5.1 Granger Causality Test

Granger causality test is a statistical hypothesis test, which is used to test whether one time series (X) contains information that is helpful to predict another time series (Y). Specifically, if the past value of (X) can significantly improve the prediction ability of (Y), it is considered that (X) Granger leads to (Y). Granger causality indicates the predictive power between time series. Granger causality is defined as that if the y_{t+s} mean square error predicted based on ($y_t, y_{t-1,\ldots}$) is the same as that predicted based on ($y_t, y_{t-1},\ldots$) and ($x_t, x_{t-1},\ldots$) for all s>0, then Y is not caused by X Granger. For linear functions, if any

$$MSE\left[\tilde{E}\left(y_{t+s}\middle|y_t, y_{t-1},\ldots\right)\right] = MSE\left[\tilde{E}\left(y_{t+s}\middle|y_t, y_{t-1},\ldots, x_t, x_{t-1},\ldots\right)\right] \tag{3}$$

It can be concluded that X can't cause Y by Granger, or X is exogenous to Y, that is, X has information about the future Y wireless influence.

5.1.1 Stationarity Test

In the process of analyzing the data of the time series, it is first necessary to ensure that the data itself is stable. In order to avoid the "pseudo-regression" phenomenon of regression results caused by the unstable time series, it is necessary to test the stability of the data first to determine whether the prerequisites for establishing a VAR model can be met. The ADF unit root test method is used for stability test. The P value of the significance level is greater than 0.1, indicating that the original hypothesis is not rejected. There is a unit root in the sequence, that is, the trend is not stable, otherwise the trend is stable. The root test results of each variable unit are shown in Table 3. it can be seen that the values of the ADF test statistics of each variable of the unit root in the case of intercept items are: -2.7230, -4.1479, -3.7030, -4.0114 respectively. Obviously, the ADF test statistics of RD are greater than its critical value, thus accepting the original hypothesis, indicating that the existence of unit root in the original sequence of RD is a stable sequence. After the first-order differential processing of all variables, they become a stationary sequence, that is, these four sequences are all a single integer sequence of the same order through the first-order difference. From the test results, it can be seen that each variable meets the conditions for the establishment of the VAR model, so it can be further modeled and analyzed.

Table 3: Augmented Dickey-Fuller Test

Variable	Formal testing (C,T,K)	ADF value	1% Critical value	5% Critical value	10% Critical value	P-value	Stability
RD	(C,T,4)	-2.7230	-4.0436	-3.4512	-3.1510	0.2296	Unstable
dRD	(C,0,3)	-2.7600	-3.4908	-2.8879	-2.5809	-0.0675	stable
LPR	(C,T,0)	-4.1479	-4.0405	-3.4497	-3.1501	0.0072	stable
dLPR	(C,T,1)	-3.6589	-4.0420	-3.4504	-3.1505	0.0294	stable
SHIBOR01	(C,T,0)	-3.7030	-4.0405	-3.4497	-3.1501	0.0261	stable
dSHIBOR01	(C,T,1)	-9.3761	-4.0420	-3.4504	-3.1505	0.0000	stable
DR001	(C,T,0)	-4.0114	-4.0405	-3.4497	-3.1501	0.0109	stable
dDR001	(C,T,0)	-4.0114	-4.0405	-3.4497	-3.1501	0.0109	stable

Note：*, ** and*** indicate rejection of the null hypothesis at levels of 10%, 5% and 1% respectively.

5.1.2 Determination of the optimal lag order for VAR model

Before establishing the VAR model, it is necessary to estimate and determine the hysteresis order in the VAR model. There are certain contradictions in the selection of the model lag order. On the one hand, it is necessary to extend the lag as much as possible to reflect the dynamic characteristics of the model. On the other hand, because the lag order and the degree of freedom of the model are negatively correlated, too much lag is easy to make freedom too small. Therefore, in the actual measurement analysis and testing process, it is necessary to balance the two. Through the minimum estimation
multivariate linear regression test, the optimal hysteresis order of the model is determined according to the AIC and SC test criteria. The specific method is:

$$\begin{aligned} AIC &= -2l/T + 2n/T \\ SC &= -2l/T + n\ln T/T \end{aligned} \tag{4}$$

Where l represents the natural logarithm of the data, T is the sample length and n is the sum of model parameters. In the specific operation of the following VAR model, this method will be strictly followed to ensure the stability of the model and the accuracy of data analysis.

Generally speaking, the greater the lag order of VAR model, the smaller the degree of freedom, and at the same time, it can better express the dynamic characteristics of the model. In this paper, LR, FPE, AIC, SC, HQ and other criteria are used to determine the lag order of VAR model, and the test results are shown in Table 4. It can be seen that the optimal lag order displayed by LR, FPE, AIC, SC and HQ is all lag order 2, so it can be determined that the optimal lag order is lag order 4. Therefore, this paper chooses to establish VAR model for the 4 variables studied.

Table 4: Maximum lag order test statistic

Lag	LogL	LR	FPE	AIC	SC	HQ
0	207.5313	NA	3.20e-07	-3.602325	-3.505780	-3.563148
1	716.6399	973.1632	5.19e-11	-12.32991	-11.84719	-12.13403
2	777.9519	112.8576*	2.33e-11*	-13.13189*	-12.26299*	-12.77930*

5.1.3 Johansen cointegration test

After determining the optimal lag order, this article uses Johansen cointegration test for analysis, and the test results are shown in Tables 5 and 6. Co-integration test results show that there are at least three co-integration relationships among variables, that is, RD, LPR, SHIBOR01 and DR001 have a long-term equilibrium relationship, and the construction of VAR model can be continued.

Table 5: Johansen cointegration test results (trace test)

Number of cointegration equations	Characteristic value	Maximum eigenvalue statistic	5% Critical value	P-value
None *	0.450973	138.4956	47.85613	0.0000
At most 1 *	0.318753	70.73999	29.79707	0.0000
At most 2 *	0.214681	27.36711	15.49471	0.0005
At most 3	0.000522	0.058950	3.841466	0.8081

Table 6: Johansen cointegration test results (Maximum eigenvalue test)

Number of cointegration equations	Characteristic value	Maximum eigenvalue statistic	5% Critical value	P-value
None *	0.450973	67.75558	27.58434	0.0000
At most 1 *	0.318753	43.37288	21.13162	0.0000
At most 2 *	0.214681	27.30816	14.26460	0.0003
At most 3	0.000522	0.058950	3.841466	0.8081

5.1.4 VAR model stability test

The VAR model is further tested for the stability of AR characteristic polynomial roots, and the stability of the VAR model is judged by observing the characteristic values of the VAR model. The eigenvalues are generally in the form of complex numbers. In the coordinate plane, the real part a is the horizontal axis and the imaginary part b is the vertical axis. The AR characteristic polynomial root of this VAR model is obtained, as shown in Figure 1. The results show that the reciprocal of all the root modes in the model falls within the unit circle, and the values are less than 1. Therefore, this VAR model can be considered to be stable and the results obtained are effective, and the impulse response research and variance decomposition analysis can be carried out in the future.

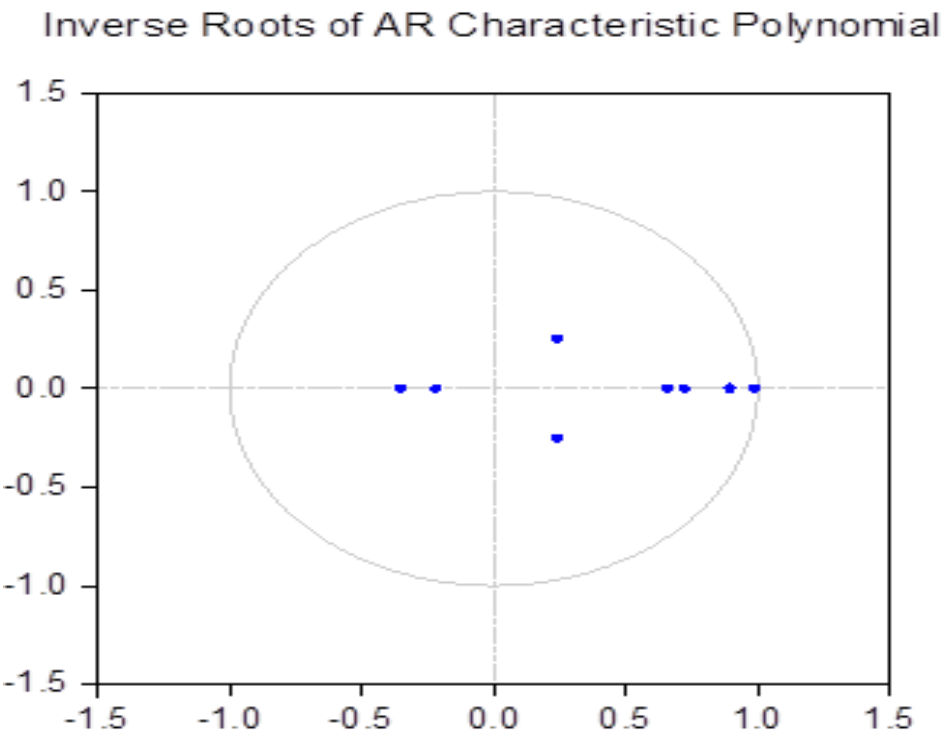

Figure 1: Inverse roots of AR characteristic polynomial

5.1.5 Analysis of impulse response results

When analyzing the VAR model, the impulse response function method is often used to analyze the dynamic influence on the current and future situation of the coefficient when an error term changes, that is, the model is impacted. The impulse response function describes the impact of the impact of one endogenous variable on other endogenous variables in the VAR model.

Combined with the above analysis, the optimal lag order of the VAR model in this paper is 1 order, and Table 7 shows the estimation results of the VAR model. It can be seen that in the Influencing factors of Weighted average interest rate for loans from financial institutions, the lagred average interest rate for loans from financial institutions is highly positively correlated with the current Weighted average interest rate for loans from financial institutions, followed by the lagred Loan Prime Rate is highly positively correlated with the current Weighted average interest rate for loans from financial institutions. It shows that in the test results of the VAR model, Weighted average interest rate for loans from financial institutions will be highly affected by their previous prices on the one hand, and the high impact of Loan Prime Rate on the other. When the Loan Prime Rate is high, the Weighted average interest rate for loans from financial institutions will also increase accordingly. That is, there is a positive relationship between Loan Prime Rate and Weighted average interest rate for loans from financial institutions.

Table 7: Estimation result of VAR model

	RD	LPR	SHIBOR01	DR001
RD(-1)	1.7135	0.3279	1.9124	1.9536
	[22.2555]	[4.63045]	[4.50680]	[4.52133]
RD(-2)	-0.7165	-0.2996	-1.7080	-1.7515
	[-9.15437]	[-4.16253]	[-3.95966]	[-3.98777]
LPR(-1)	0.2914	0.6974	0.3075	0.3133
	[3.02666]	[7.87671]	[0.57954]	[0.57990]
LPR(-2)	-0.2770	0.1926	-0.3288	-0.3365
	[-3.08382]	[2.33177]	[-0.66410]	[-0.66754]
SHIBOR01(-1)	0.2235	0.1274	-4.1287	-4.2990
	[0.74311]	[0.46047]	[-2.49053]	[-2.54674]
SHIBOR01(-2)	0.0569	-0.3037	-1.2993	-1.4122
	[0.53000]	[-3.07568]	[-2.19597]	[-2.34399]
DR001(-1)	-0.2313	-0.1197	4.7540	4.9121
	[-0.78464]	[-0.44164]	[2.92620]	[2.96932]
DR001(-2)	-0.0653	0.3258	1.2211	1.3423
	[-0.61356]	[3.32933]	[2.08210]	[2.24772]
C	-0.0171	0.2319	0.0389	0.0598
	[-0.41716]	[6.15420]	[0.17244]	[0.26011]
R-squared	0.9966	0.9927	0.7944	0.7877
Adj. R-squared	0.9963	0.9921	0.7785	0.7714
Sum sq. resids	0.1695	0.1434	5.1476	5.3372
S.E. equation	0.0404	0.0371	0.2225	0.2265
F-statistic	3810.5130	1764.0750	50.2184	48.2459
Log likelihood	207.0491	216.5062	14.1802	12.1369
Akaike AIC	-3.5053	-3.6727	-0.0917	-0.0555
Schwarz SC	-3.2881	-3.4555	0.1255	0.1617
Mean dependent	5.1307	4.0708	1.9802	1.9696
S.D. dependent	0.6671	0.4183	0.4728	0.4738

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

5.2 Analysis of VAR model partition system

5.2.1 Analysis of the specific characteristics of the district system

The above is the basic estimation using the benchmark VAR model, and what impact it will have on the weighted average interest rate for loans from financial institutions under different monetary policies, and further zoning analysis using the VAR model is needed below. Taking the LPR reform in August 2019 as the dividing line, this paper divides the sample into two parts: "before the LPR reform" (December 2014-July 2019) and "after the LPR reform" (August 2019-June 2024), and analyzes the sample data in different time periods.

5.2.2 Analysis of estimated results before LPR reform

From the return results of Table 8, it can be seen that before the LPR reform, there was still a positive correlation between Weighted average interest rate for loans from financial institutions and its previous Weighted average interest rate for loans from financial institutions, and the relationship between the lag behind Loan Prime Rate and Weighted average interest rate for loans from financial institutions was significantly positive. From the results of Granger's causality test, LPR is the Granger reason for the loan interest rate and the main reason for determining the bank's loan interest rate.

Table 8: Estimation results before LPR reform

	RD	**LPR**	**SHIBOR01**	**DR001**
RD(-1)	1.6431	0.2090	2.0103	2.0773
	[15.8280]	[1.88976]	[2.80205]	[2.84702]
RD(-2)	-0.6755	-0.2253	-1.6832	-1.7532
	[-6.78683]	[-2.12481]	[-2.44700]	[-2.50621]
LPR(-1)	0.2985	0.4551	0.4773	0.5033
	[2.97391]	[4.25686]	[0.68815]	[0.71355]
LPR(-2)	-0.3009	0.3921	-0.6772	-0.7058
	[-3.24475]	[3.96921]	[-1.05674]	[-1.08305]
SHIBOR01(-1)	0.1862	-0.0630	-3.7193	-3.8738
	[0.71848]	[-0.22829]	[-2.07693]	[-2.12704]
SHIBOR01(-2)	-0.0081	-0.4180	-1.8462	-1.9776
	[-0.09205]	[-4.45001]	[-3.03009]	[-3.19142]
DR001(-1)	-0.1898	0.0456	4.4234	4.5596
	[-0.74964]	[0.16898]	[2.52831]	[2.56260]
DR001(-2)	0.0071	0.4795	1.5514	1.6884
	[0.08010]	[5.09978]	[2.54312]	[2.72152]
C	0.2035	0.6456	0.4911	0.5409
	[2.35051]	[6.99931]	[0.82071]	[0.88874]
R-squared	0.9936	0.9897	0.8077	0.8042
Adj. R-squared	0.9925	0.9878	0.7735	0.7694
Sum sq. resids	0.0407	0.0462	1.9448	2.0115
S.E. equation	0.0301	0.0320	0.2079	0.2114
F-statistic	879.3407	538.4274	23.6257	23.1027
Log likelihood	117.5105	114.0931	13.1209	12.2107
Akaike AIC	-4.0189	-3.8923	-0.1526	-0.1189
Schwarz SC	-3.6874	-3.5608	0.1789	0.2126
Mean dependent	5.6460	4.4165	2.2628	2.2504
S.D. dependent	0.3477	0.2904	0.4368	0.4403

5.2.3 Analysis of estimated results after LPR reform

Table 9 presents the results which there is still a positive correlation between the weighted average interest rate for loans from financial institutions and its previous weighted average interest rate for loans from financial institutions after the LPR reform. However, the influence of Loan Prime Rate, which is one period behind, on the weighted average interest rate for loans from financial institutions has declined. And from the Granger causality test results, SHIBOR and DR001 are Granger reasons for the loan interest rate, while the weighted average interest rate for loans from financial institutions has a decline in the impact on the benchmark loan interest rate after the loan interest rate control is "liberalized". After the reform, the influence of Shanghai Interbank Offered Rate and Depository-Institutions Repo Rate on bank loan interest rate is greater than that before the reform.

As can be seen from Table 10, after the reform of LPR mechanism, Shanghai Interbank offered rate and the repo rate pledged by interbank deposit financial institutions with interest rate bonds have become significant factors affecting the weighted average loan interest rate. However, the direct impact of LPR on loan interest rate has decreased significantly, indicating that the direct transmission efficiency of LPR has declined. To sum up, before the LPR reform, the impact of LPR on the weighted average loan interest rate was achieved through direct transmission, while the transmission of Shanghai Interbank offered rate and the repo rate pledged by interbank deposit financial institutions with interest rate bonds had no significant effect on the loan interest rate. After the LPR reform, the reform improves the transmission efficiency of Shanghai Interbank Offered Rate and the repo rate pledged by interbank deposit financial institutions with interest rate bonds, and the empirical results also show that the LPR reform also enhances the impact of Shanghai interbank offered rate and the repo rate pledged by interbank deposit financial institutions with interest rate bonds on the loan interest rate. This indicates that the monetary policy interest rate is transmitted through the channels of Shanghai Interbank Offered Rate and the repo rate pledged by the interest rate bonds of the interbank deposit financial institutions after the reform. Although the direct efficiency of the transmission through the LPR is somewhat reduced after the LPR reform, it also reflects that the LPR reform makes the market interest rate more closely related to the loan interest rate. It shows that the transmission efficiency of market interest rate to loan interest rate is more significant after the reform, proves that in the process of interest rate liberalization, the interest rate transmission mechanism has more prominent market-oriented characteristics, and proves that the reform of LPR is effective.

Table 9: Estimation results after LPR reform

	RD	**LPR**	**SHIBOR01**	**DR001**
RD(-1)	1.5076	0.2027	1.6431	1.6566
	[11.9915]	[2.26838]	[2.68758]	[2.66996]
RD(-2)	-0.5241	-0.1336	-1.2733	-1.2766
	[-3.91337]	[-1.40285]	[-1.95498]	[-1.93141]
LPR(-1)	0.1115	0.7462	-0.8202	-0.8986
	[0.59817]	[5.63077]	[-0.90466]	[-0.97662]
LPR(-2)	-0.0526	0.0578	0.0358	0.0695
	[-0.31882]	[0.49264]	[0.04459]	[0.08535]
SHIBOR01(-1)	0.4330	0.5044	-3.8614	-4.0372
	[0.57346]	[0.93977]	[-1.05171]	[-1.08349]
SHIBOR01(-2)	0.0627	-1.2521	1.0424	1.0042
	[0.08644]	[-2.42977]	[0.29569]	[0.28070]
DR001(-1)	-0.4480	-0.4872	4.3109	4.4743
	[-0.60353]	[-0.92326]	[1.19421]	[1.22134]
DR001(-2)	-0.0966	1.2435	-0.8777	-0.8258
	[-0.13415]	[2.42823]	[-0.25053]	[-0.23226]
C	-0.0810	0.3956	1.9367	2.0468
	[-0.36509]	[2.50901]	[1.79530]	[1.86960]
R-squared	0.9929	0.9775	0.5694	0.5602
Adj. R-squared	0.9917	0.9738	0.4976	0.4870
Sum sq. resids	0.0997	0.0504	2.3578	2.4284
S.E. equation	0.0456	0.0324	0.2216	0.2249
F-statistic	838.5198	261.0964	7.9344	7.6441
Log likelihood	100.0569	119.5112	9.9019	9.0616
Akaike AIC	-3.1950	-3.8776	-0.0316	-0.0022
Schwarz SC	-2.8724	-3.5550	0.2909	0.3204
Mean dependent	4.6251	3.7368	1.6953	1.6861
S.D. dependent	0.5006	0.2001	0.3127	0.3140

Table 10: Granger causality test results

Before the LPR reform			
Null hypothesis	**F-statistic**	**P-value**	**Conclusion**
LPR does not Granger Cause RD	6.48213	0.0032	Reject
RD does not Granger Cause LPR	6.75188	0.0026	Reject
SHIBOR01 does not Granger Cause RD	0.62367	0.5402	Accept
RD does not Granger Cause SHIBOR01	6.25917	0.0038	Reject
DR001 does not Granger Cause RD	0.73604	0.4842	Accept
RD does not Granger Cause DR001	5.65887	0.0062	Reject
After the LPR reform			
Null hypothesis	**F-statistic**	**P-value**	**Conclusion**
LPR does not Granger Cause RD	0.28858	0.7505	Accept
RD does not Granger Cause LPR	5.85641	0.0051	Reject
SHIBOR01 does not Granger Cause RD	2.80214	0.0699	Reject
RD does not Granger Cause SHIBOR01	3.51341	0.0371	Reject
DR001 does not Granger Cause RD	2.83292	0.0680	Reject
RD does not Granger Cause DR001	3.46876	0.0385	Reject

6. Conclusion and Recommendations

This article establishes a VAR econometric model using monthly data on interest rates and variables related to the real economy from December 2014 to June 2024. The model is comprehensively analyzed through a series of advanced techniques, including stationarity tests, cointegration tests, model estimation, and impulse response analysis. Specifically, a VAR model is crafted to dissect the transmission mechanism of interest rates within the Loan Prime Rate (LPR) framework, assess the efficiency of interest rate transmission, and evaluate the impact of interest rates on the real economy.

The empirical results reveal that prior to the LPR reform, the influence of LPR on the weighted average loan interest rate was realized via direct transmission. Subsequent to the LPR reform, the reform has significantly enhanced the transmission efficiency of the Shanghai Interbank Offered Rate (SHIBOR) and the repo rate of interbank deposit financial institutions pledged with interest rate bonds. This clearly indicates that the monetary policy interest rate is transmitted through the channels of SHIBOR and the aforesaid repo rate subsequent to the reform. Although the transmission efficiency through LPR has witnessed a decline, it concurrently demonstrates that the LPR reform has forged a closer connection between market interest rates and loan interest rates. Post-reform, the transmission efficiency of market interest rates to loan interest rates has become more pronounced, corroborating that during the process of interest rate marketization, the

interest rate transmission mechanism exhibits more prominent market-oriented characteristics, thereby validating the effectiveness of the LPR reform.

Notwithstanding the fact that the current reform has seemingly achieved certain accomplishments, there still remains a considerable gap to reach the ultimate goal of interest rate marketization. Evidently, the present reform merely represents a modest stride within the broader process of interest rate marketization.

In light of the above-mentioned research findings, this paper puts forward the following incisive insights and well-considered policy recommendations:

Firstly, it is imperative to persistently deepen the interest rate marketization reform and further augment the market-orientation of the LPR formation mechanism. Strengthen the supervision and guidance over quotation banks, conduct regular fitness-based elimination of quotation banks, and underscore that quotations should be grounded in the actual loan interest rates for the most credit-worthy customers. By continuously enhancing the quality of LPR quotations, the efficiency of the LPR interest rate transmission mechanism can be improved, thereby attaining the objectives of interest rate marketization.

Secondly, it is essential to enhance the referential value of LPR quotations. As per the foregoing analysis, all new loans are benchmarked against LPR. This implies that LPR pricing necessitates a more robust reference to effectively fulfill its role in propelling the interest rate marketization process.

Thirdly, it is crucial to optimize the pricing mechanism of commercial banks. Facilitate the establishment of a more robust Funds Transfer Pricing (FTP) mechanism at all levels of banks and guide banks to incorporate LPR interest rates into their internal pricing systems. The construction of the FTP mechanism in commercial banks should integrate deposit and loan operations and, simultaneously, be extended to small and medium-sized banks.

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