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Time-varying influence of interest rates on stock returns: evidence from China

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ABSTRACT

Whether a stock market should matter or not when monetary policy is concerned seems to be a controversial issue. The purpose of this study is to indicate whether the central bank should use monetary policy to help the stock market or not. Based on macroeconomic data such as interest rate and the stock market, we adopt a novel Bayesian time-varying regression model and determine that the impact of interest rate changes on stock returns varies over time in China, after controlling various macroeconomic factors. Although on average interest rates negatively impact stock price returns, they tend to have an abnormal positive effect at market high points, following a time-varying dynamic pattern. Surprisingly, during periods of overheated economic development, an increase in interest rates cannot suppress the rise in stock prices. Therefore, policymakers need to pay attention when accelerating the marketisation of interest rates and initiating the preventive role of timely and strategic adjustment of interest rates.

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1. Introduction

Monetary policymakers may promulgate policies and measures that are subject to specific macroeconomic characteristics and social backgrounds worldwide, by controlling and regulating money supply or credit quantity to achieve specific economic goals (Wade, 2004). For example, the Federal Open Market Committee (FOMC) in the United States (U.S.) adjusts interest rates mainly through open market operations, discount windows, and other means (inflation, unemployment rate, GDP growth etc.), while the U.S. Federal Reserve seldom considers any means to stabilise the stock market; perhaps only during harsh times, when the economy is under great financial pressure or the economic barometers go off-track, would the U.S. Fed make any move to adjust the interest rates (Shiller, 2015). For the European Union, as long as

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the stock market conflict does not affect the financial fundamentals of the Eurozone, the central bank will not take action (Obstfeld, 1998). However, a few other central banks do seem to consider the stock market conditions as they develop monetary policies, such as Switzerland and China (Bohl et al., 2007).

Mr Xiaochuan Zhou had been in charge of the People's Bank of China for over 10 years, during which time he facilitated the reform of the shareholding system of the state-owned commercial banks and promoted the implementation of financial reform measures, such as interest rate marketisation and the development of the Renminbi exchange rate formation mechanism (Ma et al., 2013). Mr Gang Yi, the current successor of Mr. Zhou, propels the reform of the financial market and suggests that a prudent monetary policy is formulated to maintain the stability of the financial industry, strengthen the transmission of interest rate effects to the real economy and financial markets, loosen the control of deposit and lending rates, and enable market supply, and demand to play a major role in determining interest rates (Yi, 2019).

Overall, in countries such as China, stable and optimal operation of the financial market helps guarantee the sustainable development of the whole national economy (Kyereboah-Coleman & Agyire-Tettey, 2008; Naughton, 2006). The stock market, as the core and most active part of the financial market, is the 'barometer' of the real economy (Krippner, 2005). It is an important place for firms to raise capital and for ordinary people to manage their savings (Kim & Mauborgne, 1999). Although China's financial market remains dominated by state-owned banks while its stock market emerged relatively late, and various mechanisms have not been perfect, it is a dynamic correlation (Wang & Li, 2020), and there is no synchronicity in stock price (Long et al., 2020). There is serious information asymmetry between investing and financing market players, considering one example (Carpenter & Petersen, 2002). When a market fails, a government's 'visible hand' has to adjust and control, and interest rate regulation is one of the most frequently deployed means through which it does this in China – the central bank mainly influences the money supply and interest rate through deposit reserve, rediscount rate, and open market business (Lin & Ho, 2019; Thornton, 1986). Given the background of interest rate marketisation, the application of monetary policy can theoretically improve the efficiency of the stock market and compensate for potential market failure to some extent (Kontonikas & Kostakis, 2013).

However, in execution, there is often a serious time lag in the procession formulation, transmission, and actual functioning of interest rate policies, while the existence of the stock market enriches the transmission channels and improves the timeliness (Marcucci & Quagliariello, 2008). The study on the effect of China's interest rate adjustment and stock price fluctuation has appeared in recent years, with debating results though – some researchers determine that interest rate is inversely related with stock returns, while others land on a positive relation (Gay, 2016).

Motivated by the aforementioned questions and some research findings, the following are the research questions: Does China's monetary policy help stabilise the stock market? What is the empirical evidence of the dynamic time-varying relationship between interest rate adjustment and stock returns? Is it necessary to implement

interest rate marketisation reform? The purpose of this study is to answer the above questions so that policymakers can understand their role in the capital market before taking any further measures.

The rest of this paper proceeds in the following structure. Part 2 reviews the literature that explores the mechanism of interest rate on the stock price. Part 3 proceeds to offer a theoretical analysis and further elaborates the relationship among interest rate, stock price, and the macroeconomy. Part 4 provides the data, variable definitions, and model specifications. Part 5 provides an empirical test and corresponding analysis, using a Bayesian time-varying model. Part 6 discusses endogeneity. Part 7 summarises major results, outlines several conclusions, and offers some implications.

2. Literature review

Interest rate and stock market affect economic development, and the study of the relationship between interest rate and stock price is of great significance (Levine & Zervos, 1999). Numerous studies have examined this relationship; however, different results are produced given the heterogeneity in model specifications and sample choice.

Scholars have different opinions on whether the interest rate significantly affects the stock price or not. Chatziantoniou et al. (2013) adopt the VAR model to study the impact of the monetary and fiscal policy shocks on stock market performance in Germany, the U.K., and the U.S. They determine that the German fiscal policy has no direct effect on stock market performance, and observe that the money supply has a positive effect on the German stock index. However, they observe that the interest rate channel in Germany has no significant effect, while the U.S. money supply affects interest rates; this negatively affects stock markets. Musawa and Mwaanga (2017) use empirical methods such as the autoregressive distributed lag (ARDL) model, co-integration test, and vector error correction. Their results indicate that the stock price index has a long-term (co-integrated) and short-term relationship with the interest rate, exchange rate, copper, and oil prices. They emphasise the fact that only interest rates and copper prices have a long-term impact on stocks. However, if there were a sharp cut in interest rates, it would be positive for Zambia's stock market, since it would provide a demand-pull for more investors to move from bonds to equities. Sim and Wright (2017) employ the dividend-pricing model to construct the intrinsic value of the stock, which is equal to the sum of the present value of the cash flow in the future. Liow and Huang (2006) determine that real estate stocks are usually sensitive to changes in long-term and short-term interest rates. In different market conditions, the sensitivity and volatility of interest rates vary often, i.e. sensitivity to the size and direction of interest rate levels and volatility across regional real estate markets and different market conditions should also be considered during the construction and management of the stock portfolio, as this will help reduce interest rate risk or hedge interest rate risk. Özer et al. (2020) use a frequency domain causality approach; the evidence of significant spillover effects between South-East European stock markets is identified.

Regarding the monetary policy and stock price in China, a few studies are examining this topic. Research conducted by Sun and Wang (2018) uses the nonlinear VAR models to conduct impulse analysis and variance decomposition; this enables them to identify the correlation between the monetary policy and the stock market. The research indicates that money supply has a certain influence on stock price: M1 has no significant impact on stock prices; M2 has a significant impact on stock prices. The bank deposit and loan interest rate indirectly influence the stock price, and the interbank offered rate has a significant direct influence on the stock price. Interest rates move in the opposite direction from share prices, and money supply is aligned with share prices. However, this effect is statistically asymmetrical, and the influence of monetary policy on the stock market exceeds that of the reverse.

There are different views on the long-term and short-term effects of interest rates on stock prices. Many scholars determine that the effect of interest rate adjustment on stock price is only produced with difficulty during the short term (Dabbous & Tarhini, 2021; Holston et al., 2017; Rafay & Farid, 2019). Rabushka and Kress (2019) offer a comparative analysis of stock prices in the U.K., the U.S., Japan, Hong Kong, and mainland China. They determine that when compared with mature stock markets, China's monetary policies affect the stock market index only within relatively short periods. As evidenced in hysteresis and persistence, interest rate negatively affects the stock price index; however, the effects can be fully comprehended in the long term. However, Papadamou et al. (2017) determine that over a longer period the interest rate adjustment will have a long-term stable impact on stock yield. The short-term impact on stock price is not obvious when the interest rate and deposit reserve ratio are adjusted; only the rate cut has a significant short-term effect on the stock market. This is because lowering interest rates implies an economic downturn; this will spark investor concern and send the stock market into a tailspin.

Nevertheless, some researches indicate that monetary policy affects the stock market diversely at different times (Acharya et al., 2020; Yang et al., 2017). While the basic assumption is that the model parameters remain unchanged, some researchers determine early evidence regarding the parameter variations. During the second half of 2014, the central bank sought to respond to China's economic depression by adopting interest rate reduction measures. Cross and Nguyen (2017) adopt a time-varying parameter autoregressive model and identify the parameter revises given China's economic slowdown.

In sum, although there have been some research results on the transmission relationship between interest rate and stock price, there are few studies on the quantitative and in-depth description of the time-varying transmission relationship between interest rate and stock price in China, especially from the perspective of different quantiles. This study focuses on the time-varying relationship between interest rate and stock price and may further explore the relationship between the stock market and its major monetary policy in China, especially from the perspective of different quantiles, using monthly data obtained from China's stock market between January 2005 and February 2018 as a sample. A Bayesian time-varying regression model is adopted to study the effect that interest rate adjustment has on stock returns, and

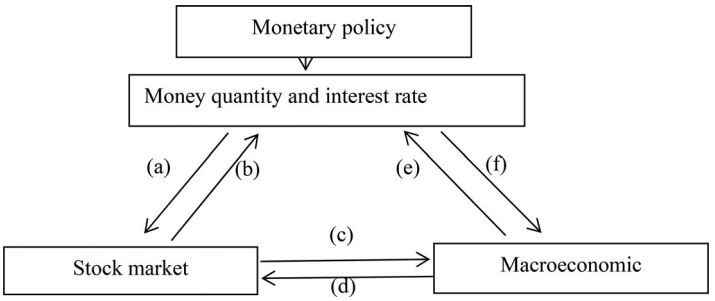

Figure 1. Relationship between monetary policy, stock market, and macroeconomy. Source: Prepared by the authors.

focus on documentary evidence that gives a more rigorous and clearer picture of the relation of China's interest rate policy and stock returns.

The innovation and contribution of this study are in three aspects: firstly, this study documents evidence regarding the relationship between interest rate adjustment and stock returns from a major country with a rapidly changing economic environment and strong government control – China maintained double-digit growth for over a decade, and its monetary policies often serve to stabilise the stock market. This particular setting can hardly be identified in other countries, where the central banks' monetary policies are mostly not affected by their stock markets. Secondly, this study proposes a novel Bayesian time-varying model, which captures a dynamic component regarding all of its regression parameters. This fits better with China's macroeconomic conditions and reconciles with previous conflicting research results. Lastly, this study advises on China's monetary policymakers regarding their choice of interest rate policy, given that the interest rate effect may reverse at market highs. Therefore, Chinese policymakers need to pay special attention when accelerating the marketisation of interest rates and initiating the preventive role of timely and strategic adjustment of interest rates.

3. Theoretical analysis

According to the theory of the relationship between money supply and stock price (Sahu et al., 2011) and the transmission relationship with the economy (Ugurlu et al., 2021), Figure 1 presents the dynamic interactions between monetary policy, stock market, and the macroeconomy. Firstly, when the central bank tightens monetary policy, there will be a decline in the money supply. When interest rates and firms' financing costs rise, investors will reduce their stock and choose other values of financial assets – this will result in a fall in share prices. Secondly, the reaction of the stock market to the formulation of monetary policies takes the following form: as stock price rises, the investors' expectations of stock returns also rise. In cases where risk preference is unchanged, investors will seek to hedge risks by increasing their demand for safe assets; this will lead to an increase in money demand. Thirdly, the existence of the stock market enables idle funds in the society to gather; this is conducive to the financing of small and medium-sized firms, which enables them to expand the scale of production. When the stock market booms, the macroeconomy,

under the influence of income and investment effect, grows accordingly. Fourthly, when aggregate demand exceeds aggregate supply, firms accelerate production; this results in rapid economic growth that takes the form of a rise in the gross domestic product, accompanied by slight inflation. The development of the macroeconomy will affect investors' expectations of the stock market; this will affect the stock price. Finally, the formulation of monetary policy is often based on changes in the macroeconomic environment and is applied with aim of ensuring the stable development of the macroeconomy.

In general, the monetary policy shall be prudent. It should moderately stimulate aggregate demand, and prevent excessive leverage and asset bubble risk that have been caused by excessive money supply. Therefore, it is necessary to correlate the relationship between several objectives, which include stable growth, structural adjustment, bubble suppression, and risk prevention. During an economic downturn, the central bank may adopt an expansionary (loose) monetary policy to stimulate the consumption and investment demand of residents by increasing the money supply and lowering interest rates. In an overheating economy, the central bank may adopt a contractionary (tightening) monetary policy to restrain the demand for investment and financing – this will be achieved by reducing the money supply and raising interest rates.

However, in reality, interest rates and stock returns in some cases indicate an abnormal 'positive' relationship; this is mainly because of the low degree of marketisation of interest rates in China and the serious hysteretic nature of interest rate policies, which extends from interest rate policy formulation to transmission and onto the ultimate adjustment. Furthermore, state-owned enterprises still account for a large proportion of the listed companies in China's stock market, some of which can request the state to guarantee their sources of funds. Rising capital costs that occur because of interest rate increases; hence, it will have little impact on them. In these exceptions, stock returns are not sensitive to the interest rate adjustment.

4. Data, variable definitions, and model specifications

4.1. Data

This study selects a sample of 158 monthly stock return data sets from January 2005 to February 2018. The CSI 300 index that is used to calculate stock returns (logarithms) is from the Shanghai Stock Exchange. The 7-day weighted average interbank lending rate, M2 annually, and the US dollar to RMB exchange rates are all extracted from the People's Bank of China. All other data are obtained from China's National Bureau of Statistics, which are also yearly.

4.2. Variable definitions

Table 1 presents variable descriptions for the empirical test. This study selects the weighted average interest rate (r) of the national interbank offered rate as the independent variable, which includes all the quotations in the interbank offered market. Baglioni and Monticini (2008) suggest that the interbank lending market is the most

Table 1. Variable descriptions.

Variable	Symbol	Type	Data Source
Stock returns (logarithms, %)	*stock*	Dependent variable	Shanghai Stock Exchange
National interbank rate (weighted, %)	*r*	Independent variable	China's National Bureau of Statistics
Broad money M2 (%)	*m2*	Control variable	People's Bank of China
Producer price index (PPI, %)	*ppi*	Control variable	China's National Bureau of Statistics
Consumer price indices (CPI, %)	*cpi*	Control variable	China's National Bureau of Statistics
Industrial production (%)	*indz*	Control variable	China's National Bureau of Statistics
Total retail sales of social consumer goods (%)	*shls*	Control variable	China's National Bureau of Statistics
Exchange rate (Exchange dollars into Renminbi)	*exc*	Control variable	People's Bank of China

Source: Shanghai Stock Exchange, China's National Bureau of Statistics, and People's Bank of China.

active part of the currency market, and observe that this is attested to by a large trading volume, a high trading frequency, and a high degree of marketisation. This measurement is better and more inclusive than Shanghai interbank offered rate (Shibor), which is also widely used for empirical tests.

Concerning the selection of the stock index as the dependent variable, some scholars separately engage with the Shanghai and Shenzhen stock exchange markets. To undertake a comprehensive study of China's stock market, the logarithmic yield of the CSI 300 index (stock) is selected (Hou & Li, 2014; Suo et al., 2015; Yang et al., 2012).

According to previous studies and previous theoretical analysis, the relationship between interest rates and stock returns is bound to involve the influence of macroeconomic, monetary policy, exchange rate, inflation, and other price factors. Therefore, this study selects the broad money (*m2*), consumer price indices (*cpi*), producer price index (*ppi*), the exchange rate (*exc*), total retail sales of social consumer goods (*shls*), and industrial production (*indz*) as the control variables, to capture the influence of the macroeconomy conditions. Slight inflation captured by *cpi* can stimulate economic growth while excessive inflation can result in sustained price increases and social unrest; *ppi* is a measure of the cost of goods and services purchased by firms; when the central bank increases the money supply *m2*, investors can optimise the allocation of assets and promote the development of the stock market; *indz* is closely related to GDP and can effectively reflect economic performance; as the exchange rate *exc* rises, the volume of domestic trade increases and the stock market liquidity increases; *shls* can reflect people's material living standard and real purchasing power during a certain period.

4.3. Model specifications

From the above theoretical analysis, there is a certain transmission mechanism between the interest rate and the stock market, and whether it is long-term or short-term, the relationship between the two should be time-varying. This transient feature is not only evident in developing countries' capital markets such as India (Kumari & Mahakud, 2015) and Brazil (Hillier & Loncan, 2019), but also in developing countries' capital markets such as Europe (Ferrer et al., 2016). Whether it is the time-varying relationship between interest rate and the stock market, or the time-varying impact

path of interest rate on stock returns, the Bayesian regression method is more suitable than the regression method in the sense of frequency. The reason is that the Bayesian regression method not only assumes that the response variables are generated from the probability distribution but also assumes that the model parameters are derived from the probability distribution. This ensures the convergence and stability of the estimation parameters at the time point, and more efficiently captures the time-varying relationship between the interest rate and the stock market in line with the actual situation of China.

Therefore, this study adopts a time-varying regression model drawn from the Bayes method, which is more consistent with actual economic conditions in China. This model is an extension of the basic linear regression; in its simplest form, it can be regressive with additional time series and allows for the use of a special modelling method, which predicts that the impact of variables changes across different times. To eliminate potential endogeneity problems, the Bayesian inference model and Markov chain Monte Carlo (MCMC) algorithm are introduced. More specifically, the dynamic linear regression model is defined as follows:

$$\begin{aligned} y_t &= \beta_t x_t + \gamma_{t-1} x_{t-1} + e_t, t = 1, 2, \ldots, n \\ \beta_{t+1} &= \beta_t + \eta_t \\ \gamma_{t+1} &= \gamma_t + \nu_t \end{aligned} \tag{1}$$

where $\boldsymbol{y_t}$ is the observed value at time t, containing the corresponding predictive variable, $\boldsymbol{\beta_t}$ is a k-dimensional vector of regression coefficient at time $\boldsymbol{t}$, $e_t \sim N(0, \sigma^2_{e_t})$, $\eta_t \sim N(0, D)$, $\nu_t \sim N(0, H)$, $\boldsymbol{D}$ and $\boldsymbol{H}$ are a diagonal matrix whose diagonal elements are $\boldsymbol{K \times K}$ dimensions, $\boldsymbol{i = 1,2, \ldots \ldots, k}$. Define unknown parameters of the model $\beta_t = (\beta_{t1}', \ldots, \beta_{tn}'), \gamma_{t-1} = (\gamma'_{t-1,1}, \ldots, \gamma'_{t-1,n})$, $\sigma = (\sigma_e, \sigma_{1,\eta}, \ldots, \sigma_{k,\eta})$. Definition $\beta_i \sim N(\mu_{\beta_i}, \sigma_{\beta_i}), \gamma_i \sim N(\mu_{\gamma_i}, \sigma_{\gamma_i}),$, $\sigma_i \sim N(\mu_{\sigma i}, \sigma_{\sigma i})$, $i = 1, 2, \ldots, k$.

In Model (1), the parameters to be estimated are time-varying and the first-order delay of the explanatory variable is used to overcome the endogeneity problem, and the time-varying regression parameters follow the random walk process. Moreover, the model adapts to a non-stationary time series. For MCMC sampling, this study follows the practices of Vihola et al. (2020) and Chan and Eisenstat (2017), which can quickly and accurately obtain the edge tail $\rho(\sigma|y)$. The regression coefficient is subsequently simulated with the given standard deviation of edge posterior, and the corresponding joint posterior relationship is obtained: $\rho(\sigma, (\beta, \gamma)|y) = \rho((\beta, \gamma)|\sigma, y)\rho(\sigma|y)$. The mean and variance of$E((\beta, \gamma)|\sigma, y)$ parameters can also be obtained by calculating $Var((\beta, \gamma)|\sigma, y)$ and (β, γ) with the standard Kalman smoothing.

5. Empirical analysis

5.1. Descriptive statistics

Table 2 demonstrates that the numerical distribution of stock is concentrated at 0.0081. The variance and standard deviation suggest that the dispersion degree of stock is small. When compared with the standard normal distribution, the stock is relatively gentle and has a left-skewed feature. The value of r is concentrated at 2.9151. Following the variance and standard deviation, it will be observed that the

Table 2. Descriptive statistics.

Statistics	*stock*	*r*	*m2*	*ppi*
Mean	0.0081	2.9151	15.7070	1.4486
Standard error	0.0071	0.0829	0.3618	0.3673
Median	0.0130	3.0300	14.7500	2.6000
Standard deviation	0.0892	1.0422	4.5484	4.6165
Variance	0.0080	1.0861	20.6877	21.3118
Kurtosis	1.4254	0.8070	1.5818	−1.1143
Skewness	−0.5160	0.5231	1.1307	−0.2189
Minimum value	−0.2825	0.9900	8.1000	−8.2000
Maximum value	0.2419	6.9819	29.7400	10.0600
	cpi	*Shls*	*exc*	*indz*
Mean	2.6302	12.2493	6.8446	11.5915
Standard error	0.1608	0.1955	0.0521	0.4001
Median	2.0731	11.8650	6.7108	10.7500
Standard deviation	2.0216	2.4579	0.6554	5.0298
Variance	4.0867	6.0415	0.4295	25.2989
Kurtosis	0.9306	0.0208	−0.3915	0.0125
Skewness	0.7671	0.6668	0.9039	0.2802
Minimum value	−1.8000	7.5500	6.1043	−2.9300
Maximum value	8.7000	19.1200	8.2765	29.2000

Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations.

dispersion degree is relatively large – when compared with the standard normal distribution; it evidences the feature of right deviation.

As can be seen from Figure 2, the chart of stock and *r* demonstrate that the stock yield and interbank interest rate peaks and troughs at key points, which include May 2007, July 2008–May 2009, May 2013, and January 2015. It will be observed that the interest rate has a significant impact on stock returns.

5.2. Bayesian time-varying regression models

5.2.1. Model 1

In Model (1), parameter estimation adopts MCMC weighted importance-sampling estimators, close proxies for the marginal distribution of each variable. Considering the stationarity of all variables, this model can directly utilise the distribution information of these variables even if there is a high degree of correlation among them. Considering the positive effect of money supply on stock price, along with inflation and the factory-gate price index, this model jointly tests the effect of interbank interest rate on stock yield. In other words, variables (***r, m2, ppi, cpi***) and their lagged variables (***r_1, m2_1, ppi_1, cpi_1***) are included in Model (1).This is the empirical analysis of Model 1 and the parameter estimation results are presented in Table 3.

Table 3 demonstrates that under the condition of 95% confidence level, the interest rate (***r***) sufficiently explains stock yield. For every 1% increase in the interest rate, stock returns drop by 0.004%, averagely. At quantiles of 2.5%, 25%, and 50%, the interest rate negatively impacts the stock price, fully reflecting the liquidity characteristics of China's stock market. This reveals that when the stock market volatility is relatively small, interest rate plays a policy-regulating role; at quantiles of 75% and 97.5%, interest rate positively impacts stock return; this establishes that when the stock market fluctuates relatively largely, China's monetary policy to raise interest

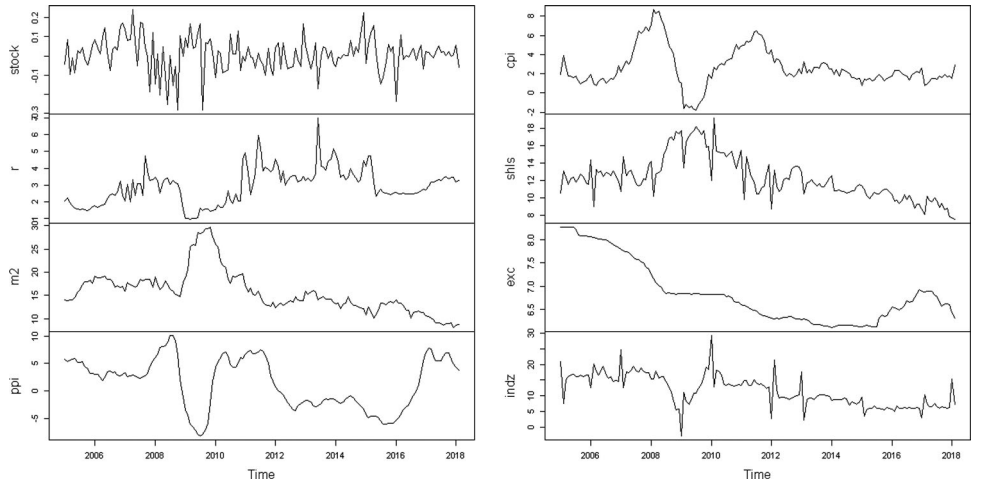

Figure 2. Tendency charts of all variables. Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations.

Table 3. Regression results of time-varying parameters (Model 1).

Statistics	Intercept	*r* *(r-1)*	*m2* *(m2_1)*	*ppi* *(ppi_1)*	*cpi* *(cpi_1)*
Mean	0.1106***	−0.0040***	−0.0040***	0.0101***	−0.0056***
		(0.0012***)	(-0.0009***)	(0.0009***)	(-0.0013***)
Se_mean	0.0033	0.0004	0.0002	0.0004	0.0003
SD	0.1375	0.0171	0.0093	0.0183	0.0134
		(0.0175)	(0.0085)	(0.0181)	(0.0133)
T-stat.	34.0326	−10.5535	−19.2940	23.3963	−17.9134
		(3.1016)	(-4.7882)	(23.7742)	(-4.0751)
2.50%	−0.1528***	−0.0378***	−0.0222***	−0.0265***	−0.0324***
		(-0.0343***)	(-0.0181***)	(-0.0447***)	(-0.0270***)
25%	0.0187***	−0.0148***	−0.0102***	−0.0018***	−0.0144***
		(-0.0098***)	(-0.0062***)	(-0.0214***)	(-0.0102***)
50%	0.1066***	−0.0040***	−0.0040***	0.0103***	−0.0055***
		(0.0014***)	(-0.0008***)	(0.0101***)	(-0.0012***)
75%	0.2024***	0.0068***	0.0021***	0.0222***	0.0030***
		(0.0124***)	(0.0049***)	(0.0016***)	(0.0075***)
97.50%	0.3941***	0.0301***	0.0143***	0.0458***	0.0207***
		(0.0359***)	(0.0156***)	(0.0272***)	(0.0249***)
n_eff	1791.6911	1989.9199	1987.5899	1804.7205	1826.7531
		(1942.4780)	(2000.0000)	(1968.8024)	(1824.5045)
Rhat	0.9999	1.0000	0.9994	1.0000	0.9994
		(0.9992)	(0.9992)	(0.9999)	(0.9994)

Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations. *** is significant at levels of 0.01.

rates worsens the case. This is further verified by the positive effect of the interest rate of the lag period on the overall stock yield. The money supply and consumer price index of the current period and the lag period indicate a consistent significantly negative impact on stock returns, while the producer price index (***ppi***) of the current period and the lag period has a significantly positive relation on stock returns. The distribution of each parameter is asymmetric, steep, and concentrated, with that of the interbank lending rate having the characteristic of being left-tailed; this implies that in some cases, it has a relatively great negative impact on the stock yield.

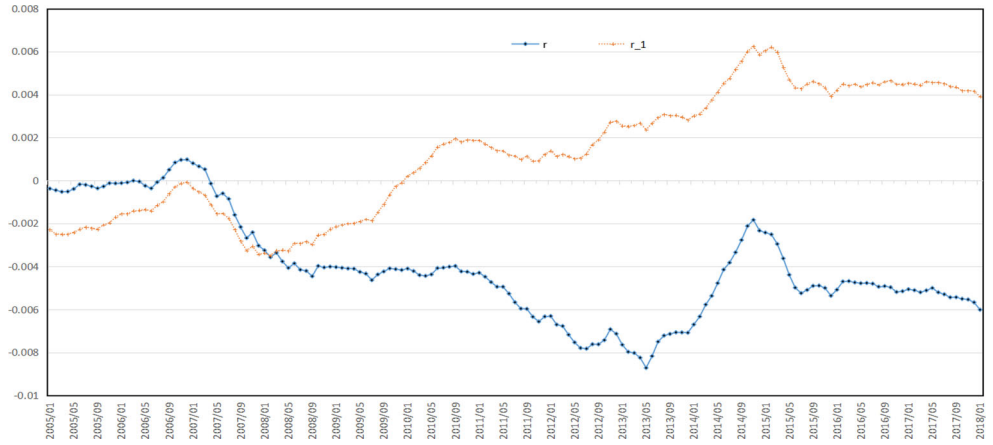

Figure 3. The influence path of interest rate r and its lag period r_1 (Model 1). Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations.

A close look at the peaks and troughs of Figure 3 indicates that the interest rate has a significantly positive impact on stock returns between September 2006 and May 2007, with the largest negative impact in May 2013. Especially after the financial crisis in 2008, the lagged path of interest rate impact continued to rise and gradually formed a long-term positive.

5.2.2. Model 2

This study further introduces macroeconomic factors, specifically industrial benefit and total retail sales of social consumer goods. Industrial benefit reflects the total output of industrial production in a certain period from the perspective of production, while the total retail sales of social consumer goods reflect the total consumption of residents in a certain period from the perspective of consumption – this largely reflects macroeconomic development. In other words, variables (***r, m2, ppi, cpi, indz, shls***) and their lagged items are included in Model (1). This is the empirical analysis for Model 2. Once the variables of industrial benefit and total retail sales of social consumer products are added, it shall be observed, regarding Table 4, that under the confidence level of 95%, the interest rate (***r***) can still explain stock yield well. At the 2.5%, 25%, and 50% quantiles, interest rates negatively impact stock prices; at 75% and 97.5% quantiles, interest rates have a positive effect on stock returns. On average, the current interest rate negatively affects stock returns – when other control variables are added, the same effect is evidenced – for every 1% rise in lending rates, the stock yields fall by 0.0047. However, the effect of interest rate lagging behind one period on stock returns is positive as a whole. The current money supply (***m2***), consumer price index (***cpi***), industrial benefit (***indz***), and total retail sales (***shls***) have significant negative effects on stock returns, while the current producer price index (***ppi***) has significant positive effects. It can be seen from the information of different quantiles estimated by parameters, which include interbank lending rate and money supply – this is asymmetrical and has a steeper shape; this indicates that time-varying parameters are more concentrated. The time-varying parameter distribution of the

Table 4. Regression results of time-varying parameters (Model 2).

Statistics	Intercept	*r* *(r-1)*	*m2* *(m2_1)*	*ppi* *(ppi_1)*	*cpi* *(cpi_1)*	*indz* *(indz_1)*	*shls* *(shls_1)*
Mean	0.1526	−0.0047***	−0.0045***	0.0147***	−0.0061***	−0.0003***	−0.0009***
		(0.0009***)	(0.0002)	(−0.0119***)	(−0.0011***)	(−0.0020***)	(−0.0019***)
Se_mean	0.0048	0.0004	0.0002	0.0005	0.0004	0.0001	0.0002
SD	0.2136	0.0184	0.0106	0.0228	0.0160	0.0043	0.0088
		(0.0186)	(0.0092)	(0.0226)	(0.0158)	(0.0048)	(0.0086)
T-stat.	31.7290	−11.1834	−18.7480	28.6487	−17.0084	−3.3413	−4.3311
		(2.2234)	(1.1875)	(-22.9568)	(-3.1613)	(-18.3641)	(-9.8332)
2.50%	−0.2707	−0.0403***	−0.0254***	−0.0308***	−0.0379***	−0.0087***	−0.0180***
		(0.0360***)	(−0.0177)	(−0.0551***)	(−0.0329***)	(−0.0116***)	(−0.0192***)
25%	0.0137	−0.0164***	−0.0116***	−0.0001***	−0.0166***	−0.0031***	−0.0068***
		(−0.0110***)	(−0.0059***)	(−0.0269***)	(−0.0102***)	(−0.0051***)	(−0.0074***)
50%	0.1512	−0.0050***	−0.0043***	0.0148***	−0.0060***	−0.0004***	−0.0009***
		(0.0010***)	(0.0002)	(−0.0122***)	(−0.0010***)	(−0.0020***)	(−0.0018***)
75%	0.2897	0.0066***	0.0027***	0.0296***	0.0044***	0.0024***	0.0052***
		(0.0130***)	(0.0064)	(0.0026***)	(0.0093***)	(0.0011***)	(0.0039***)
97.50%	0.5878	0.0335***	0.0158***	0.0599***	0.0255***	0.0084***	0.0163***
		(0.0371***)	(0.0184)	(0.0332***)	(0.0300***)	(0.0074***)	(0.0145***)
n_eff	1973.6581	1939.2387	1979.9360	1972.5232	1995.9870	1970.4265	1894.9649
		(1947.6114)	(2000.0000)	(1903.1026)	(1998.2125)	(1857.4346)	(1991.4222)
Rhat	1.0000	1.0000	1.0000	0.9996	0.9992	0.9998	0.9993
		(0.9996)	(0.9998)	(1.0000)	(0.9994)	(0.9999)	(0.9995)

Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations. *** is significant at levels of 0.01.

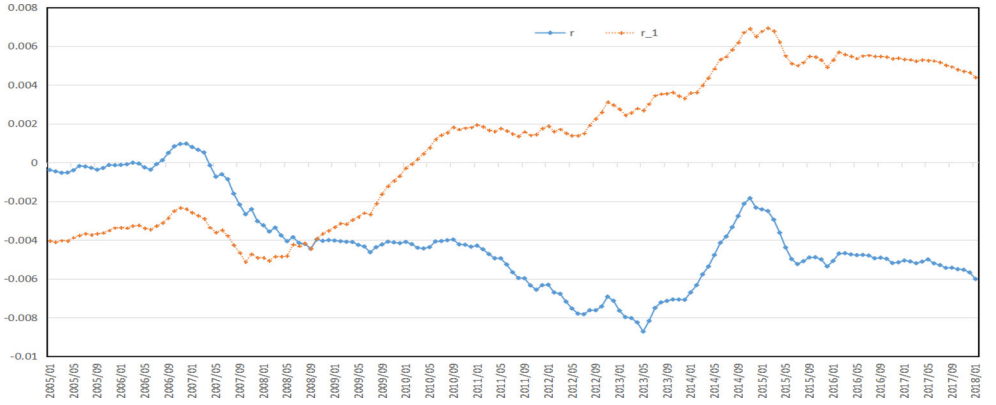

Figure 4. The influence path of interest rate r and its lag period r_1 (Model 2). Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations.

interbank lending rate has the characteristics of a left trailing tail; this indicates that in some cases, the interest rate (***r***) has a significant negative effect on the stock return rate.

It can be seen from Figure 4 that from September 2006 to May 2007, the lending interest rate had a significant positive influence on stock returns; thus, after this point, a significantly negative impact was evidenced, with the most significant negative impact being evidenced in May 2013 and May 2014. During this period, China's economic growth slowed down from the previous high-speed to a single-digit rate, reaching a new general equilibrium. Especially after the financial crisis in 2008, the

lagged path of interest rate impact continued to rise and gradually formed a long-term positive.

5.2.3. Model 3

The external factors of the financial system exchange rate are added to further study the impact of interbank lending rate on stock yield. Interest rate parity theory suggests that when there is an interest rate differential between the two countries, capital flows from countries with low-interest rates to countries with high-interest rates; additionally, investors will re-allocate capitals and adjust the optimal portfolio. Therefore, investment returns are affected by interest and exchange rates. In other words, variables (***r, m2, ppi, cpi, indz, shls, exc***) and their lagged items are included in Model (1). This is the empirical analysis for Model 3.

When the effect of the exchange rate is included, Table 5 indicated that at the confidence level of 95%, the interest rate (***r***) could still explain the stock return rate to a high degree; this influence is stable. Under the sub-points of 2.5%, 25%, and 50%, the interest rate negatively impacts stock price; under the sub-point of 75% and 97.5%, the interest rate positively impacts stock return. The interest rate negatively impacts stock return, averagely. For every 1% increase in the borrowing rate, stock returns drop by 0.0059. However, the effect of interest rate lagging behind one period (r-1) on stock returns is positive as a whole. The current money supply (***m2***), current consumer price index (***cpi***), industrial benefit (***indz***), total retail sales (***shls***), and current exchange rate change (***exc***), all have significant negative effects on stock returns, while the current producer price index (***ppi***) and exchange rate lagging one period (***exc_1***) have significantly positive effects on the same object. From the information of different quantiles estimated by parameters, the distribution of the standard deviation of time-varying parameters of control variables, such as interbank lending rate and money supply, is asymmetrical and steep, indicating that time-varying parameters are distributed more centrally and have a more stable effect. The time-varying parameter distribution of the interbank lending rate still has the characteristics of the left trailing tail, indicating that in some cases, the interbank lending rate has a significant negative effect on stock yield. Exchange rates have a significantly bigger impact on stock returns than other variables. The addition of exchange rate variables seems to alleviate the influence of other variables on stock returns; however, it is similar to the time-varying parameter chart of Models 1 and 2.

After the addition of the exchange rate presented in Figure 5, the effect of interest rate on stock price was slightly negative from September 2006 to May 2007; the interest rate still indicated a significant positive effect on the stock price. Meanwhile, in May 2013 and May 2014, the interest rate had a significant negative effect on stock returns. After the financial crisis in 2008, the lagged path of interest rate impact continued to rise and gradually formed a long-term positive.

5.3. Further elaborations on the timeline of structural shifts in China

The time-varying path and the 'positive' abnormal relationship seem to be largely correlated with the structural shifts of China's economy in the most recent decade.

Table 5. Regression results of time-varying parameters (Model 3).

Statistics	Intercept	*r* *(r-1)*	*m2* *(m2_1)*	*ppi* *(ppi_1)*	*cpi* *(cpi_1)*	*indz* *(indz_1)*	*Shls* *(shls_1)*	*exc* *(exc_1)*
Mean	−0.5575	−0.0059***	−0.0045***	0.0157***	−0.0120***	−0.0009***	−0.0007***	−0.3234***
		(0.002***)	(0.0012***)	(−0.0067***)	(0.0012***)	(−0.0020***)	(−0.0019***)	(0.4243***)
Se_mean	0.0182	0.0005	0.0003	0.0005	0.0004	0.0001	0.0002	0.0050
SD	0.8149	0.0198	0.0109	0.0232	0.0168	0.0045	0.0090	0.2172
		(0.0199)	(0.0097)	(0.0242)	(0.0162)	(0.0047)	(0.0088)	(0.2267)
T-stat.	−30.598	−13.1838	−18.0399	30.187	−31.9578	−9.1293	−3.6253	−64.6255
		(4.4107)	(4.4139)	(-11.5137)	(3.3395)	(-19.0907)	(-8.9698)	(80.0536)
2.50%	−2.1718	−0.0442***	−0.0266***	−0.0301***	−0.0457***	−0.0099***	−0.0184***	−0.7590***
		(−0.0384***)	(−0.0177***)	(−0.0528***)	(−0.0312***)	(−0.0116***)	(−0.0194***)	(−0.0442***)
25%	−1.0808	−0.0186***	−0.0116***	0.0009***	−0.0225***	−0.0038***	−0.0067***	−0.4705***
		(−0.0102***)	(−0.0053***)	(−0.0229***)	(−0.0093***)	(−0.0050***)	(−0.0076***)	(0.2676***)
50%	−0.5564	−0.0061***	−0.0045***	0.0156***	−0.0118***	−0.0009***	−0.0006***	−0.3244***
		(0.0023***)	(0.001***)	(−0.0072***)	(0.0014***)	(−0.0019***)	(−0.0019***)	(0.4217***)
75%	−0.0202	0.0061***	0.0029***	0.0305***	−0.0012***	0.0020***	0.0050***	−0.1722***
		(0.0146***)	(0.0076***)	(0.0089***)	(0.0118***)	(0.0010***)	(0.0040***)	(0.5807***)
97.50%	1.0356	0.0347***	0.0166***	0.0616***	0.0207***	0.0078***	0.0169***	0.1020***
		(0.0405***)	(0.0209***)	(0.0417***)	(0.0317***)	(0.0071***)	(0.0154***)	(0.8588***)
n_eff	2000.0000	1928.2735	1885.2731	1988.9834	1999.0042	1994.8864	1952.9381	1884.2053
		(1942.6639)	(1391.2573)	(1746.9595)	(1974.0386)	(1972.0076)	(1800.0546)	(1830.0937)
Rhat	1.0000	0.9998	0.9993	1.0000	0.9995	0.9997	1.0000	1.0000
		(0.9997)	(1.0000)	(1.0000)	(0.9995)	(1.0000)	(0.9992)	(1.0000)

Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations. *** is significant at levels of 0.01.

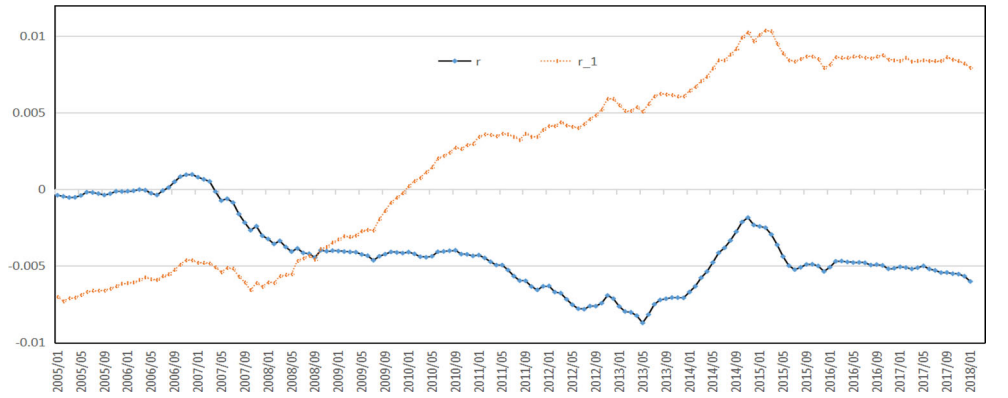

Figure 5. The influence path of interest rate r and its lag period r_1 (Model 3). Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations.

Since 2006, China's economy has been developing rapidly, and investors have a positive attitude towards the development of the stock market. A large amount of 'hot money' has poured into the stock market, and the blind 'chasing after the rise' behaviour has led to the emergence of a stock market bubble. In 2007, the central bank, seeking to prevent the overheating of the economy, tightened monetary policy and raised interest rates six times consecutively; however, minor rate increases could not prevent investors from investing in the stock market. Shares soared, and, the interest rate on stock prices acted against the norm to develop the positive effects, which are captured by Models 1, 2, and 3. In Model 3, after adding the influence of the exchange rate, the influence of the interest rate on stock price still indicates time-varying characteristics.

The 2008 financial crisis in the U.S. impacted the whole world, and China was no exception; many factories closed down, workers lost their jobs, and the economy slowed down. To stimulate the stumbling economy, the central bank alternated between a loose and tight monetary policy again. In 2012, China entered the so-called 'new normal stage' of economic development, which coincided with a shift from high-speed (GDP $>$ 8%) to a medium-high speed of growth (GDP 6%$\sim$7%). The central bank lowered the benchmark interest rate to stimulate the economy. At this time, the interest rate reduction had a significant negative impact on stock returns.

Since October 2014, the stock market has ushered in a new 'bull market', and the stock market bubble has constantly accumulated. The CSI 300 index broke the 5000 mark in May 2015, and the interest rate once again indicated an abnormal positive impact on stock returns.

6. Discussion on endogeneity

Based on the strong consistent empirical results and given that this study sheds light on models from previous empirical studies, the time-varying Bayesian model proposed in this study largely overcomes the missing variable issues and shows robustness regarding the statistical significance and test variable signs. Considering that an

Table 6. Relevance test between model fitting residuals and variables.

Variable	Variable type	Model 1			Model 2			Model 3		
		Cor	T-stat	P-value	Cor	T-stat	P-value	Cor	T-stat	P-value
R	Independent	0.0021	0.0271	0.9778	0.0001	0.0015	0.9989	0.0013	0.0382	0.9765
m2	Control	−0.0045	−0.0514	0.9645	0.0010	0.0121	0.9895	−0.0034	−0.0433	0.9641
ppi	Control	0.0013	0.0169	0.9865	0.0022	0.0322	0.9862	0.0045	0.0811	0.9656
cpi	Control	−0.0011	−0.0145	0.9882	0.0012	0.0032	0.9723	0.0012	0.0215	0.9805
indz	Control				0.0001	0.0010	0.9994	−0.0016	−0.0243	0.9792
shls	Control				0.0023	0.0056	0.9686	0.0003	0.0063	0.9954
exc	Control							0.0012	0.0216	0.9891

Source: Shanghai Stock Exchange, China's National Bureau of Statistics, People's Bank of China, and authors' calculations.

endogeneity issue is an inevitable problem in most econometric specifications, it is worthwhile to extend the discussion further.

To identify the potential endogeneity problem, this study adopts a Pearson's product-moment correlation t-test to construct the correlation coefficients between the fitting residuals given by the proposed Bayesian models, the independent variables, and the dependent variables. Based on Table 6, nearly all correlation coefficients are close to 0, with very small t-statistics. At a confidence level of 95%, the chance to accept the null hypothesis (H_0: uncorrelated) is above 96%. Therefore, it is safe to conclude that during the transmission process of interest rates policy effects to stock returns, endogeneity concern is of second order. The reason that it indicates little significance in this model is because the new models inherit a time-varying random-walking parameter structure, adopting the Bayesian MCMC algorithm.

7. Conclusions and implications

General economic theory suggests that the interest rate is the cost of capital use. When the central bank tightens monetary policy by adjusting interest rates, it raises the cost of firms and lowers the expectations that investors have regarding the prospects of the particular firms. This may cause share prices to drop consequently, though most central banks presently declare that they have no intention to influence the stock market.

In this study, a novel Bayesian time-varying model is proposed to study the interest rate effects on stock market returns in China, after controlling various macroeconomic factors. The reason to choose the China setting is that it offers a great opportunity to explore market reactions towards monetary policy, given a central bank that aims at correcting the alleged 'market failure'.

Empirical results indicate that on average, China stock market returns are significantly negatively correlated with interest rates, following a time-varying dynamic pattern. This implies that the central bank in China often plays a role in controlling the stock market through interest rate policies. However, statistics indicate that during economic overheating periods, i.e. at left tail conditions, the aforementioned relation reverses, accompanied by China's structural shifts in the macroeconomy. Especially after the financial crisis in 2008, the lagged path of interest rate impact continued to rise and gradually formed a long-term positive. This implies that the central bank still has *limits* regarding applying interest rate policies when the stock market goes far

beyond the border – that may give grounds to China's official statement of control 'within a reasonable range'. These results are consistent and robust given different model specifications and endogeneity checks.

The first implication of this study is to accelerate interest rate marketisation in China. Long-term interest rate control will result in negative real interest rates and the reduced reserve capacity of financial institutions. Due to the shortage of money supply, these institutions can only choose firms with less credit risk when extending loans; this will make it more difficult to finance small and medium-sized firms. Therefore, it is necessary to speed up the process of interest rate marketisation and gradually loosen controls on interest rates, so that the stock market may function by itself. Furthermore, it is important to allow financial institutions to independently determine interest rates following market trends and fund supply conditions – this will contribute to the formation of an interest rate system that is determined solely by market supply and demand.

The second implication is to strengthen the government's supervision role, rather than direct influence, through timely monetary policy announcements. The formulation and implementation of an interest rate policy often take long periods; there will inevitably be a certain time lag for the market to understand the information. To give full play to the preventive role of interest rate adjustment, i.e. to warn the market, it is necessary to simplify the procedure of interest rate setting and constantly improve the information transmission channels. Therefore, the central bank should issue timely guidance to send clear signals to the stock market.

In the future, we should cancel the benchmark interest rate of deposits and loans immediately, and under the new mechanism of interest rate marketisation, laws and regulations should guarantee the effective transmission of monetary policies such as interest rates to the stock market.

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