Simulation Study on the Development of Chinese Bank Industry Based on System Dynamics

Cheng Gang Li[1,2] and Xin Tong Zuo[2(✉)]

[1] Guizhou Key Laboratory of Big Data Statistical Analysis, Guizhou University of Finance and Economics, Guiyang 550025, Guizhou, China

[2] School of Big Data Application and Economics, Guizhou University of Finance and Economics, Guiyang 550025, Guizhou, China

Abstract. There are many factors influencing the development of the bank industry, and scholars have paid much attention to the influence of these factors on the development of the bank industry. In order to better promoting the healthy and steady development of China's bank industry, studying the influence of the factors on the development of the bank industry, this paper uses Vensim PLE software to build a simulation model for the development of the bank industry. This paper simulates and analyzes the impact of the changes in money supply and supervision level on the profit level of the bank industry. The simulation results show that the profit level of the bank industry will increase when the money supply is reduced. Higher levels of regulation make banks less profitable. The simulation results also show that the change of money supply has no obvious effect on the nonperforming loan balance.

Keywords: Bank industry · System dynamics · Simulation analysis

1 Introduction

The bank industry has always played an important role in China's development. Lu and Zhou (2019) [1] believed that the development of China's bank industry played an important role in the high-quality economic development. The China central economic conference proposed to increase the proportion of direct financing, so as to solve the problem of the financing difficulty and high cost of private enterprises. However, compared with developed countries, the proportion of direct financing in China has always been relatively low. In 2001, the outline of the tenth five-year plan for national economic and social development proposed to gradually increase the proportion of direct financing. Therefore, Shu and Cao (2018) [2] believed that the period from 2002 to 2012 was a period of vigorous development of financing reform in China. During this period of vigorous development, the scale of direct financing increased from 99.5 billion RMB in 2002 to 2.5006 trillion RMB in 2012, and the proportion of direct financing increased from 4.93% in 2002 to 21.52% in 2012. Meanwhile, the share of indirect financing decreased from 95.07% in 2002 to 78.48% in 2012. By 2019, the proportion of direct financing reached 14.71%, while indirect financing decreased to 85.29%.

H. Song and D. Jiang (Eds.): SIMUtools 2020, LNICST 369, pp. 427–441, 2021.
https://doi.org/10.1007/978-3-030-72792-5_35

With the continuous development of direct financing, the importance of indirect financing has decreased. However, it can be seen from data that the main financing channels in China are still indirect financing dominated by the bank industry. In the report on China's regional financial operation released by the People's Bank of China in 2016, it was pointed out that P2P online lending had had a positive impact in supporting financing of small and medium-sized enterprises. This report affirms the development of Internet finance from a policy perspective, stimulates the rapid development of Internet finance in China, and direct financing develops even more rapidly. However, in recent years, Internet financial "credit crisis" events keep happening, and financing platforms keep "running off the road". This is because the most essential difference between direct financing and indirect financing is that direct financing is subject to less supervision by financial regulators and is more prone to credit risk. Therefore, the bank industry has an indispensable position in the financing market.

However, banks have been fined and notified repeatedly. Due to the development of financial innovation, the deposit-taking capacity of the bank industry is limited, and the bank industry has been paying higher regulatory costs than other non-bank financial institutions. So the profit of the bank industry has been severely damaged. In view of the incompleteness of the current regulatory system, the scope of supervision often cannot cover all banking businesses. The bank industry will rely on regulatory loopholes to participate in high-risk investment projects and increase additional revenue through regulatory arbitrage. For example, under the policy environment of supporting the financing of "small and micro" and "agriculture, rural areas and farmers" enterprises, in order to stimulate the commercial banks to increase loans to these enterprises, the central bank will adopt monetary policy tools such as differential ratio, refinancing and rediscount monetary policy tools. While enjoying these preferential policies, commercial banks channel funds to high-risk projects to obtain high returns. Therefore, the central bank to strengthen the supervision of commercial banks.

Since there are many influencing factors for the development of China's bank industry, it is of great significance to systematically study the influencing factors of the development of the bank industry. Furthermore, we need to explore the influence of the changes of different factors on the profit of the bank industry. This will reduce the operational risk of the bank industry and promote the healthy and sustainable development of the bank industry.

The purpose of this paper is to explore the influence of changes in different factors on the profit of the bank industry. This paper simulates the real development environment of the bank industry by simulation analysis. Also, this paper simulates the influence of these factors on the profit of the bank industry in advance, so as to effectively maintain the stable development of the bank industry. The contribution of this paper lies in: starting from the realistic environment of the development of the banking industry, analyzing the subsystem of the development of the banking industry in China, constructing the system flow diagram of the development of the banking industry, and using the system dynamics model to carry out simulation analysis of the development of the banking industry in China.

The rest structure of this paper is organized as follows: the second part is the literature review. The third part is the construction of the system dynamics model, including the

theoretical basis of system dynamics, the system boundary and main variables set by the model, the drawing of causal loop diagram and system flow diagram, and variable assignment and function relation determination. The fourth part is the model test and simulation analysis, including the test of model effectiveness, and the scenario simulation results analysis when changing money supply and supervision level. The fifth part is the conclusion and policy recommendations.

2 Literature Review

The development of China's bank industry has been fully discussed in the existing literature. Based on the dynamic panel model, Li et al. (2014) [3] found that Chinese Banks could reduce the credit risk and bankruptcy risk by developing non-interest business. Qiu et al. (2015) [4] thought that the administrative monopoly had a negative impact on the market structure of China's bank industry. Peng et al. (2016) [5] found that the interest rate liberalization had a significant impact on the interest margin of China's banking sector through the research results of the H-S model. Gu and Yang (2017) [6] used the threshold panel model to find that monetary policy was an important factor influencing the credit scale difference of Chinese Banks. Dong et al. (2017) [7] found that the development of China's direct financing market had a positive impact on the profitability and robustness of the bank industry. Meng and Yang (2017) [8] pointed out that the profit level of China's bank industry changed in the same direction due to the changes in GDP and CPI. Wang and Shi (2017) [9] believed that the technology finance had a heterogeneous impact on total factor productivity of China's regional banks. Jiang and Huang (2017) [10] argued that the increase of bank liabilities significantly increased the risk level. Jiang and Fei (2017) [11] concluded that the asset-backed bond business could mitigate the impact on banks' lending capacity during the crisis. Guo and Zhao (2017) [12] believed that the development of shadow banking stimulated the deposit competition and increased the systemic risk of the bank industry. Wang and Li (2017) [13] found that the role of price-based monetary instrument was stronger than that of quantitative-based monetary instrument, which increased the risk taking of the bank industry.

In recent two years, many scholars researched the influencing factors of the development of banking industry. Based on the empirical results of the panel data, Yao (2018) [14] found that the development of human resources could promote the positive development of bank industry. Zhu et al. (2018) [15] used the multi-directional efficiency analysis method to research the efficiency of China's bank industry, and found that the main reasons for the low efficiency of China's bank industry were the low level of non interest income and the high level of non-performing loan balance. Fang et al. (2018) [16] found that the risks of China's banking sector increased due to the risk changes in the real estate market and the stock market.Yang et al. (2018) [17] pointed out that there was heterogeneity impact of the final Basel III on China's banking sector. Wang (2018) [18] found that the deleveraging decision-making operation could reduce the bankruptcy probability of China's bank industry. Shen and Zhao (2018) [19] argued that non-interest income business had a positive impact on the income level of the bank industry. Li (2019) [20] thought that the strengthening of official supervision promoted

the internal competition of bank industry. Gao et al. (2019) [21] believed that the scale of residential mortgage loans had a negative impact on the risk of China's bank industry. Based on the panel data of the bank industry from 2011 to 2017, Li (2019) [22] found that asset securitization had a positive effect on the credit risk of China's bank industry. Zhang and Zhang (2019) [23] pointed out that the excessive competition reduced the operating efficiency of regional commercial banks. Based on the inter-provincial panel data, Su and Meng (2019) [24] found that local government intervention could promote the competition of the bank industry. Wang et al. (2019) [25] showed that the deposit insurance system reduced the risk faced by the bank industry due to the change of net interest margin.

For the research of System Dynamics, since its birth in 1956, System Dynamics has been widely used. There are many studies on the application of system dynamics in supply chain in foreign literatures. Tian et al. (2014) [26] studied green supply chain management based on the system dynamics model. Sana et al. (2018) [27] used the system dynamics model to analyze the operational and financial relationships among channel members in the supply chain. Rebs et al. (2019) [28] analyzed the impact of stakeholders on sustainable supply chain management by establishing a system dynamics model. At present, there are many literature in China discussing economic correlation based on the system dynamics model. Liu et al. (2015) [29] studied the influence of the four operating tools of monetary policy on the broad money supply (M2) based on system dynamics model. Dong et al. (2016) [30] analyzed the development of China's financing structure by constructing the system dynamics model. Li et al. (2018) [31] studied the development of China's trust industry based on system dynamics model.

From the above literature, it can be seen that the existing studies focus on investigating the impact of one banking business on the development of the bank industry, but few literature systematically analyzes the development of the whole bank industry from the perspective of the multiple banking businesses. Moreover, there is a lack of literature on the development of China's bank industry based on system dynamics model. Based on system dynamics, this paper uses Vensim PLE software to build a simulation model for the development of China's bank industry, analyzes the impact of changes in different factors on the development of the bank industry by simulation analysis, and predicts the future development trend.

3 Model Construction

3.1 Theoretical Basis

System dynamics is an interdisciplinary subject that studies information feedback and system problems (Zhong, 2015) [32]. System dynamics is based on the close dependence between the system behavior and the internal mechanism, and is obtained through the establishment and manipulation of mathematical models, and gradually excavates the cause-effect relationship that produces the change form. The thought of using system dynamics method to analyze the research object is as follow: firstly, determine the boundaries of the research target. Secondly, according to the determined boundaries, divide the system hierarchy which lays the foundation for drawing causal loop diagram and system flow diagram owing to the relationship of variables. Thirdly, establish the

model for the simulation operation and compare with historical data to test the validity of the analysis model. Fourthly, carry out scenario analysis of the model and obtain the results of the simulation analysis.

3.2 Determination of System Boundaries and Subsystems

Considering the complexity of the whole banking environment, this paper divides the model of the bank industry thought into three subsystems, namely the economic environment subsystem, the banking industry subsystem and the policy environment subsystem.

For the economic environment subsystem, Tan (1999) [33] believed that the development of China's financial institutions would promote economic growth. Sun and He (2015) [34] mentioned that Internet finance was a kind of financial innovation and had a great impact on China's bank industry. Therefore, in the subsystem of economic environment, the main influencing variables are defined as GDP and financial innovation.

For the the banking industry subsystem, Ge (2005) [35] believed that bank scale expansion had a positive impact on the development of China's bank industry. Zheng and Niu (2007) [36] pointed out that non-interest income played an increasingly important role in the income structure of China's bank industry. Li and Suo (2009) [37] pointed out that non-performing loans had a great impact on the credit supply of China's bank industry. Therefore, in the bank industry subsystem, the main influencing variables are defined as loan income, deposit reserve ratio, non-interest income, scale, non-performing loan balance and profit. Bank industry subsystem here only considers the basic business and non-interest income of "taking deposits and making loans". This paper sets the absorbed deposits by all banks are used to make loans.

For the policy environment subsystem, Rose and Hudgins (2002) [38] once mentioned that banking is one of the most heavily regulated industries in the world. Jin et al. (2014) [39] believed that the monetary policy would influence the credit and investment decisions of China's bank industry. Therefore, the subsystem of policy environment mainly considers the two variables of supervision cost and money supply.

The main variables of the three subsystems are shown in Table 1.

Table 1. Main variables of the system

Economic environment subsystem	GDP, financial innovation
Bank industry subsystem	Loan income, deposit reserve ratio, non-interest income, scale, non-performing loan balance and profit
Policy environment subsystem	Regulatory costs, the money supply

3.3 Establishment of Causal Loop Diagram and System Flow Diagram

The causal loop diagram refers to the loop diagram drawn according to the causal relationship between the selected main variables to be studied. The variables are connected by

causal chains. The positive arrow represents positive feedback, indicating trend strengthening, while the negative arrow represents negative feedback, indicating trend weakening. The causal loop diagram of bank industry development is shown in Fig. 1. As can be seen from Fig. 1, non-interest income and loan income will have positive feedback to profits, regulatory costs and non-performing loan balance will have negative feedback to profits, while profits will eventually have positive feedback to GDP.

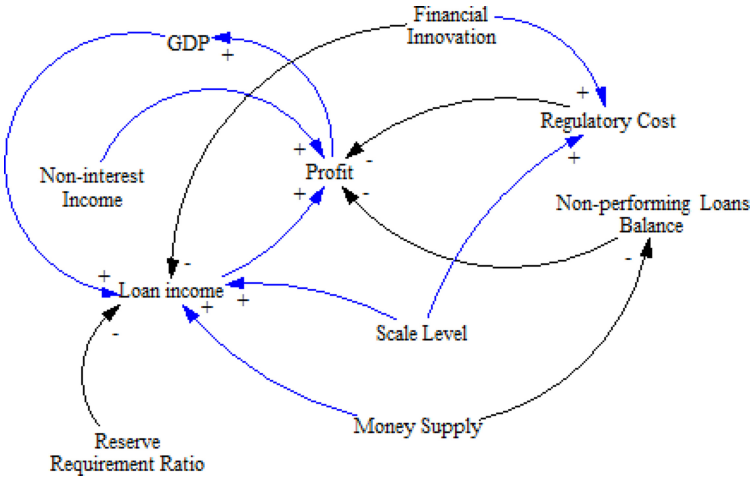

Fig. 1. Causal loop diagram of banking development

The system flow diagram is the stock flow diagram drawn on the basis of the causal loop diagram. By setting horizontal variables, rate variables and auxiliary variables, the structure of the flow diagram of the whole system is improved by adding functional relationships among the variables. In this paper, the development of the bank industry is mainly concerned with the changes in the profit variables. The changes in the income and expenditure are used to investigate the changes in the overall profit level, which will eventually have an impact on economic growth. The variables of banking income are considered as the impact of loan income, non-interest income and scale of banking business, while the variables of expenditure are considered as the impact of banking regulatory costs, deposit interest expense, loan loss provision and scale expansion. Therefore, referring to the system dynamics model for the development of China's trust industry designed by Li et al. (2018) [31], on the basis of the causal loop diagram, this paper constructs the system dynamics model for the development of the bank industry. The system flow diagram is shown in Fig. 2.

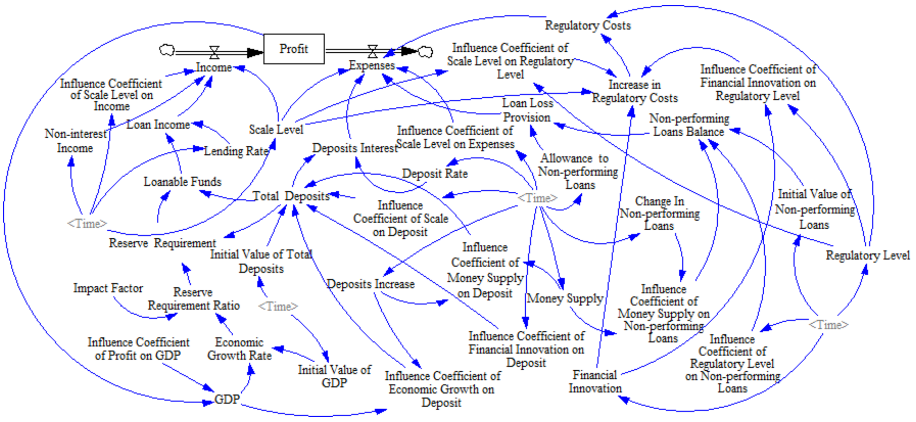

Fig. 2. System flow diagram of banking development

3.4 Variable Assignment and Function Relation Determination

The data in the whole model are selected from the annual data from 2011 to 2018, which are from the China Banking Regulatory Commission, the People's Bank of China, the National Bureau of Statistics and the World Bank. The functional relationship and assignment of some variables in the flow diagram are determined by setting up table functions and then determined by least square regression. Some variables are assigned by reference and historical data estimation results.

4 Test and Simulation

4.1 Model Test

The test methods of system dynamics are divided into intuitive test, operational test and historical test (Liu, 2011) [40]. Visual test means to check whether the bounds, main variables, causality and system equations of the model are appropriate. Running test refers to the test of units and equations in the system flow diagram by running Vensim PLE software. If the units of variables in the flow diagram or the functional relationship between variables are not suitable, the software will appear a warning interface, indicating that the units or equations need to be changed. During the operation test of this model, the unit setting was not appropriate, and all variables connected by causal chain were not included in the equation setting. After repeated modification and improvement, the final setting of the model was reasonable. Historical test means comparing the simulation results with the existing historical data to verify the validity of the model.

In this paper, the relative error test method is used for historical test. The test formula of relative error is shown in Formula (1).

$$e_i = (\hat{y}_i - y_i)/y_i \tag{1}$$

Where, $\hat{y}_i$ represents the simulation value of phase i, and y_i represents the actual value of phase i.

GDP and loan loss reserve are used to test the relative error. The test results are shown in Table 2. It can be found from Table 2 that there are some errors between the simulation values of the two indicators and the actual data. There are many factors influencing the development of the bank industry. Considering that the influencing factors set in this paper are the main variables in the selection of many factors, it is normal to have some errors in the results. In addition, the error between simulation value and actual data is small. Therefore, the simulation model of banking development set up in this paper is reasonable.

Table 2. Historical test results

Indicators	GDP (unit: 100 million Yuan)			Provision for loan losses (unit: RMB 100 million)		
Year	The actual value	The simulation value	The relative error	The actual value	The simulation value	The relative error
2011	487940.2	487932	−0.0017%	11898	11920.1	0.19%
2012	538580.0	538346	−0.0434%	14564	14717.5	1.05%
2013	592963.2	594425	0.2465%	16740	16850.6	0.66%
2014	641280.6	642107	0.1289%	19552	19487.2	−0.33%
2015	685992.9	686426	0.0631%	23089	23152.3	0.27%
2016	740060.8	741040	0.1323%	26676	26623.2	−0.20%
2017	820754.3	820533	−0.0270%	30944	31022.6	0.25%
2018	900309.5	900137	−0.0192%	37734	37711.9	−0.06%
The average error	0.08%			0.33%		

4.2 Scenario Simulation

(1) The Impact of Changes in Money Supply

The simulation result of the impact of a 5%, 10% and 15% reduction in the money supply on the non-performing loan balance is shown in Fig. 3. In Fig. 3, the solid line represents the non-performing loan balance at the current money supply level, the long dashed line represents the non-performing loan balance after reducing the money supply by 5%. The dotted line represents the non-performing loan balance after reducing the money supply by 10%. The short dashed line represents the non-performing loan balance after reducing the money supply by 15%. The Fig. 3 shows that the reduction in the money supply will increase the non-performing loans balance. However, as other conditions have not changed, the non-performing loan balance increases steadily after a period of time, so it is shown as a horizontal change in the Fig. 3. The increase of the non-performing loans balance is more obvious when reducing the money supply by 10% and 15% than that of educing the money supply by 5%.

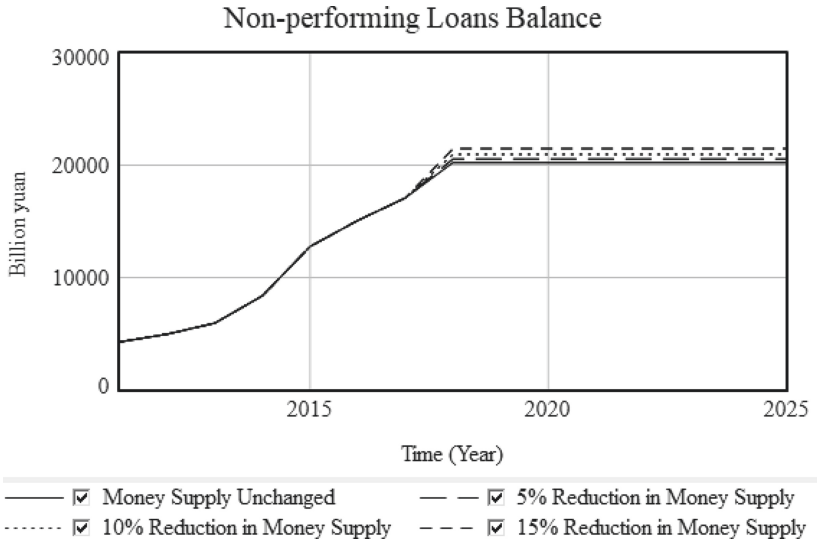

Fig. 3. The influence of money supply changes on non-performing loan balance

The simulation results of the impact of the reduction in money supply on the total deposits is shown in Fig. 4. In Fig. 4, the solid line represents the total deposits in the current money supply level. The long dashed line represents the total deposits after a 5% decrease in the money supply. The dotted line represents the total deposits after a 10% decrease in the money supply. The short dashed line represents the total deposits after a 15% decrease in the money supply. It can be seen from Fig. 4 that in the context of decreasing money supply, the total amount of deposits will continue to increase. The decrease of money supply will not only increase the non-performing loans balance, but also increase the total amount of deposits.

The impact of a 5%, 10% and 15% reduction in money supply on profit level is shown in Fig. 5. In Fig. 5, the solid line in the figure represents the profit level under the current money supply level. The long dashed line represents the profit level after the reduction of 5% money supply. The dotted line represents the profit level after the reduction of 10% money supply. The short dashed line represents the profit level after the reduction of 15% money supply. Figure 5 shows that with the decrease of money supply, the profit level of the bank industry will continue to rise. The larger the decrease of money supply, the higher the increase of profit level. As the increase of money supply leads to a large increase in the total amount of deposits and a small increase in the non-performing loans balance, the growth of the income side is higher than that of the expenditure side, so the profit level of the bank industry continues to increase.

(2) The Impact of the Changes in the Supervision Level

Because of its importance to the economy, the development of the bank industry has always been the focus of regulators. With the continuous development of financial innovation, the bank industry is faced with the business squeeze of internet finance. In

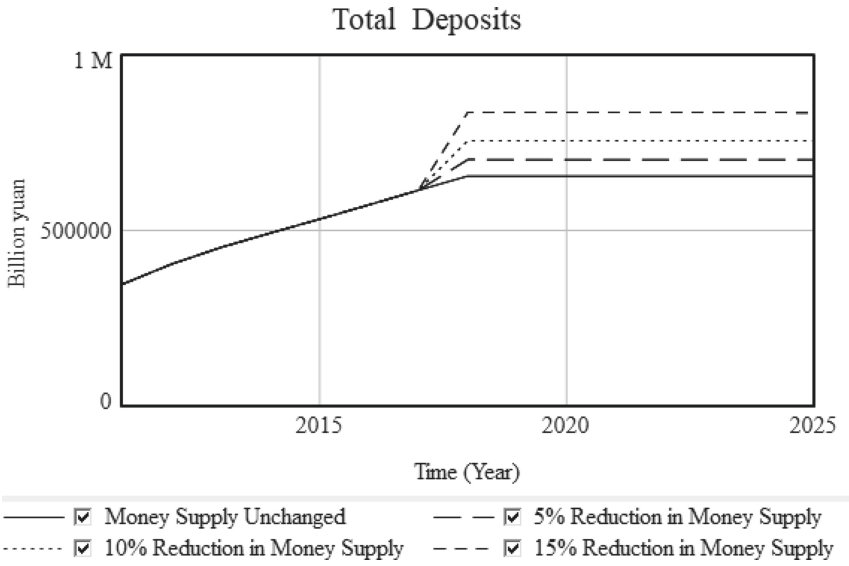

Fig. 4. The effect of changes in money supply on total deposits

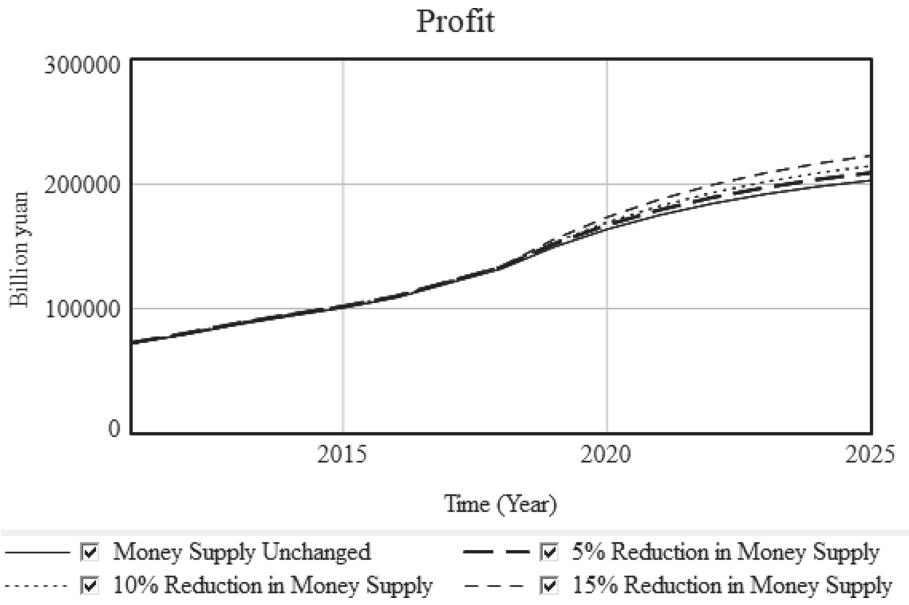

Fig. 5. The effect of changes in the money supply on the level of profits

order to seek more profits, the bank may pursue high-risk business, which forces the regulatory authorities to strengthen supervision. In 2016, the People's Bank of China

established the macro-prudential assessment system (MPA). In 2017, financial products were included in the MPA index, and in 2018, interbank certificates of deposit were included in the MPA index. Wang (2019) [41] believes that the bank industry has entered a period of strict regulation. This paper sets the supervision level referring to the development simulation model of P2P network lending platform designed by Zhao and Gou (2015) [42]. This paper sets a series of constant values for the supervision level in the simulation model. Under the supervision level set in this paper, the scenario simulation is carried out to increase the regulation level by 5%, 10% and 15%, respectively.

The impact of the supervision level on the regulation cost is shown in Fig. 6. In Fig. 6, the solid line indicates the supervision cost under the supervision level set in this paper. The long dashed lines represents the change of the regulatory costs under the supervision level increased by 5%. The dotted line represents the change of regulatory costs under the supervision level increased by 10%. The short dashed line represents the change of the regulatory costs under the supervision level increased by 15%. As can be seen from Fig. 6, the greater the supervision level, the greater the supervision costs. If the supervision level is increased, the regulation cost will increase significantly in a short period of time.

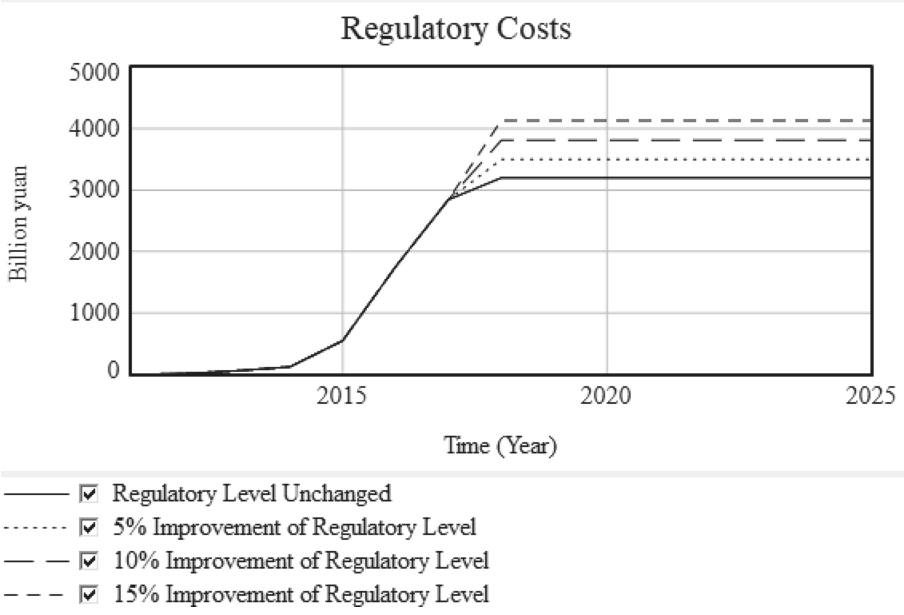

Fig. 6. The influence of regulatory level adjustment on regulatory cost

The impact of the supervision level on the profit level is shown in Fig. 7. According to the system flow diagram set up in this paper, it can be seen that higher regulatory costs and higher expenses will lead to lower profits. In Fig. 7, we can see that the profit level gradually decreases over time with the increase of supervision level, and the more the supervision level increases, the more the profit level decreases.

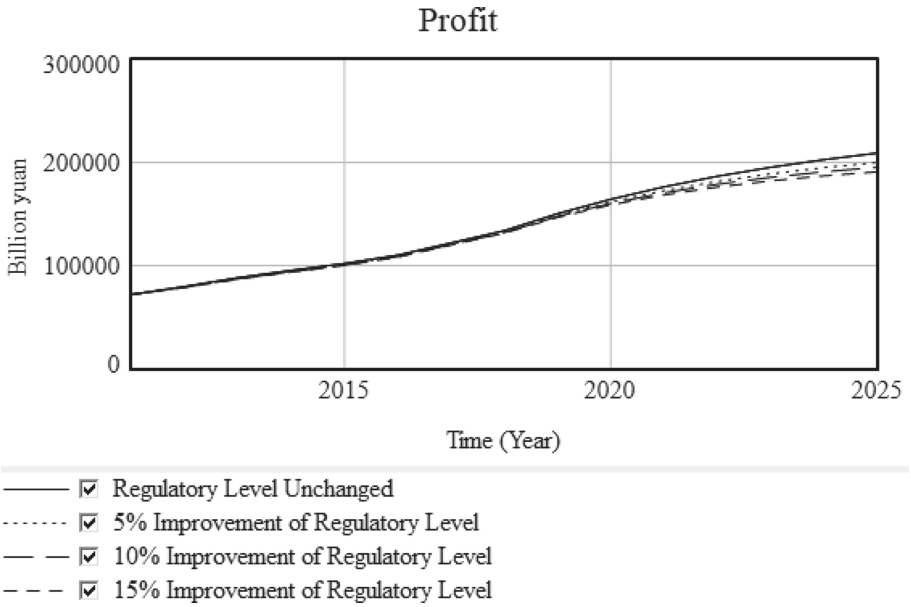

Fig. 7. The impact of regulatory level adjustment on profit level

4.3 Discussion

According to the results of the above scenario simulation, when the level of money supply is reduced, the increase of total deposits is greater than the increase of the non-performing loans balance, and the profit is greater than the loss, resulting in the increase of profit. It can also be seen from Fig. 3 that the changes in money supply do not have a significant impact on the non-performing loans balance. When adjusting money supply, policy makers should comprehensively consider its impact on the non-performing loans balance and total deposits. When strengthening the supervision level, the increase of supervision cost will lead to the decrease of the profit level of the bank industry. When the policy makers decide to strengthen supervision in order to rectify the current financial environment, they cannot ignore that the increase of supervision cost of the bank industry will have a negative impact on the profits. Considering that it will not affect the normal earnings of the bank industry, policy makers should set a reasonable supervision level.

5 Conclusion and Policy Recommendations

Based on the analysis of the main factors influencing the development of China's bank industry and the theory of system dynamics, this paper establishes a system dynamics simulation model for the development of China's bank industry. This paper analyzes the impact of the changes of money supply and supervision level on the bank industry. First, this paper simulates and analyzes the impact of the money supply changes on the non-performing loan balance, total deposits and profit level. Then, this paper simulates and analyzes the impact of regulatory level changes on banking regulatory costs and

profit level. The simulation results show that the profit level of the bank industry will increase when the money supply is reduced. Higher levels of regulation make banks less profitable. The simulation results also show that the change of money supply has no obvious effect on the nonperforming loan balance.

Based on the above research conclusions, this paper puts forward the following three policy recommendations:

First, stabilize the money supply. Since the increase or decrease of the money supply is inversely related to the profit level of the bank industry, when the policy makers expand the money supply in order to promote economic development, they cannot ignore that this policy will restrict the profit increase of the bank industry.

Second, promote the marketization of interest rate. Policymakers should continue to actively promote the liberalization of interest rate, accelerate the transition from quantitative intermediary indicators to price intermediary indicators, and increase the means of adjusting the economy through price indicators, so as to reduce the impact of quantitative indicators adjusting the economy on the profit level of the bank industry.

Finally, maintain reasonable supervision. Due to the reverse relationship between the regulatory level and the profit level of the bank industry, policy makers should not blindly pursue the strong supervision of the financial environment and ignore the vitality creation of the bank industry. They should consider multiple factors and set a reasonable regulatory strength, so that the bank industry can retain certain innovation vitality and develop actively.

Under the background that there is a lack of literature on the development of China's bank industry by using the method of system dynamics, this paper constructs a system dynamics model of the development of bank industry. This paper simulates and analyzes the impact of the changes of money supply and supervision level on the development of the bank industry. The scenario simulation analysis provides policy makers with decision reference. It has important practical significance. However, the actual environment faced by the bank industry is more complex. This paper fails to comprehensively analyze some more influencing factors of the development of the bank industry. The established model has some shortcomings. In the future, more influencing factors of bank industry development will be included. A better system dynamics model of bank industry development will be built to simulate and analyze the influence of these factors on the development of bank industry.

Acknowledgments. This paper was supported by Guizhou Key Laboratory of Big Data Statistics Analysis (No. Guizhou Science and Technology Cooperation Platform Talent [2019] 5103).

References

1. Lu, M.F., Zhou, J.Y.: A review of the development footprint of Chinese banking industry over the past 70 years and a study of future trends. J. Univ. Jinan (Soc. Sci. Edn.) **29**(4), 5–19+157 (2019)
2. Shu, H.T., Cao, L.K.: An overview of the development and evolution of China's corporate financing policy – from the perspective of 40 years of reform and opening up. Enterp. Econ. **12**, 41–47 (2018)

3. Li, M.H., Liu, L.Y., Sun, S.: Is it good for banks to develop non-interest businesses? – Based on the empirical analysis of china's banking industry. Stud. Int. Finan. **11**, 11–22 (2014)
4. Qiu, Z.X., Liu, H., An, S.Y.: On the impact of administrative monopoly on Chinese banking market structure. J. Finan. Res. **2**, 175–191 (2015)
5. Peng, J.G., Wang, S.J., Guan, T.Y.: Does interest rate liberalization narrow interest margins of commercial bank? Empirical evidence based on Chinese banking industry. J. Finan. Res. **7**, 48–63 (2016)
6. Gu, H.F., Yang, L.X.: Monetary policy, bank size differences and credit transmission characteristics: evidence from China's banking industry in 2006–2015. Stud. Int. Finan. **12**, 53–64 (2017)
7. Dong, N., Fu, L., Xu, S.: The impact of direct financing on the franchise value of China's banking industry: an empirical study based on Panzar-Rosse model. Stud. Int. Finan. **6**, 65–74 (2017)
8. Meng, C., Yang, X.C.: Market concentration changes and performances of China's banking industry. Rev. Ind. Econ. **1**, 87–100 (2017)
9. Wang, Y., Shi, Y.D.: Heterogeneity of technological finance nurturing banks—empirical evidence from China's regional banks. Stud. Sci. Sci. **35**(12), 1821–1831 (2017)
10. Jiang, H., Huang, M.: The impact of debt structure on bank risk-taking: an empirical study based on China's listed banks. Stud. Int. Finan. **7**, 54–65 (2017)
11. Jiang, H.S., Fei, X.: The impact of asset securitization on bank credit channels—based on the panel data of European banking industry. Finan. Econ. **9**, 12–26 (2017)
12. Guo, Y., Zhao, J.: Deposit competition, shadow banking and bank systemic risk: evidence from the listed banks in China. J. Finan. Res. **6**, 81–94 (2017)
13. Wang, J.B., Li, B.: Empirical study on the effects of China's monetary policy on risk taking behaviors of commercial banks. J. World Econ. **40**(1), 25–43 (2017)
14. Yao, S.Ã.: Bank development and human development in WAEMU countries: evidence from panel data estimation. Int. J. World Policy Dev. Stud. **4**(6), 50–59 (2018)
15. Zhu, N., Liang, L., Shen, Z.Y., et al.: Endogenous efficiency of Chinese commercial banks and its decomposition under the China's new normal economy. J. Finan. Res. **7**, 108–123 (2018)
16. Fang, Y., Chen, M., Yang, P.P.: The spillover effect and channel identification of financial market to banking systemic risk. Nankai Econ. Stud. **5**, 58–75 (2018)
17. Yang, K.S., Liu, R.X., Feng, Q.: The impact and countermeasures of the finalisation of Basel III. J. Finan. Res. **2**, 30–44 (2018)
18. Wang, L.J.: A study on deleveraging and the stability of banking system – based on the empirical evidence of China's banking industry. Stud. Int. Finan. **10**, 55–64 (2018)
19. Shen, C., Zhao, S.M.: The study on the impact of market competition degree and non-interest income on bank returns. Nankai Econ. Stud. **1**, 50–66 (2018)
20. Li, S.F.: The impact of bank regulation and supervision on competition: evidence from emerging economies. Emerg. Mark. Finan. Trade **55**(10), 2334–2364 (2019)
21. Gao, B., Li, Y., Li, M.: Analysis of residential mortgage loan and bank risk: empirical evidence from China's commercial banks. Ind. Econ. Res. **4**, 101–112 (2019)
22. Li, J.: Can asset securitization ease bank credit risk? – Empirical evidence from China's banking sector. Stud. Int. Finan. **6**, 57–66 (2019)
23. Zhang, D.Y., Zhang, Z.W.: An empirical study based on regional commercial banks in China. J. Finan. Res. **4**, 111–129 (2019)
24. Su, Q., Meng, N.N.: How does local government intervention affect regional financial inclusion? – Spatial econometric analysis based on provincial panel data. Stud. Int. Finan. **8**, 14–24 (2019)
25. Wang, X.B., Xu, Q.Y., Xin, F.F.: Empirical study on the impact of deposit insurance system on commercial banks' interest rate risk. J. Manage. Sci. China **22**(5), 110–126 (2019)

26. Tian, Y.H., Govindan, K., Zhu, Q.H.: A system dynamics model based on evolutionary game theory for Green supply chain management diffusion among Chinese manufacturers. J. Clean. Prod. **80**(1), 96–105 (2014)
27. Sana, S.S., Ferro-Correa, J., Quintero, A., et al.: A system dynamics model of financial flow in supply chains: a case study. RAIRO-Oper. Res. **52**(1), 187–204 (2018)
28. Rebs, T., Thiel, D., Brandenburg, M., et al.: Impacts of stakeholder influences and dynamic capabilities on the sustainability performance of supply chains: a system dynamics model. J. Bus. Econ. **89**(7), 893–926 (2019)
29. Liu, C., Xu, F.H., Lu, Y.: Multi-target interactions of monetary policy based on system dynamics. Syst. Eng. **33**(4), 82–91 (2015)
30. Dong, Z., Li, X.T., Dong, J.C.: Simulation of financing structure based on system dynamics. Syst. Eng. Theor. Pract. **36**(5), 1109–1117 (2016)
31. Li, Z.M., Zhong, C.L., Liu, J.J., et al.: A simulation study of the development of China's trust industry based on system dynamics. Manage. Rev. **30**(4), 3–11 (2018)
32. Zhong, Y.G., Xia, X.J., Qian, Y., et al.: System Dynamics. 2th Edition. Science Press, Beijing (2015)
33. Tan, R.Y.: An empirical study on the relationship between financial development and economic growth in China. Econ. Res. J. **10**, 53–61 (1999)
34. Sun, J., He, C.: Internet finance innovation and traditional bank transformation based on big data. Finan. Econ. **1**, 11–16 (2015)
35. Ge, Z.Q.: Bank mergers and acquisitions, the growth of commercial banks and the development of China's banking industry. Stud. Int. Finan. **2**, 30–36 (2005)
36. Zheng, R.N., Niu, M.H.: A study on the relationship between non-interest business and bank characteristics in China's banking industry. J. Finan. Res. **9**, 129–137 (2007)
37. Li, L., Suo, Y.F.: Economic volatility, non-performing loans and systemic risks in the banking sector. Stud. Int. Finan. **6**, 55–63 (2009)
38. Rose, P.S., Hudgins, S.C.: ANK Management and Financial Services, 8th edn. China Machine Press, Beijing (2013)
39. Jin, P.H., Zhang, X., Gao, F.: The effect of monetary policy on bank risk taking: from the banking industry perspective. J. Finan. Res. **2**, 16–29 (2014)
40. Liu, W.J.: The Construction of System Dynamics Model of Financial Efficiency from the Perspective of Capital Running. Ocean University of China, Qingdao (2011)
41. Wang, G.G.: 70 years of banking in China: brief history, main features and historical experience. Manage. World **35**(7), 15–25 (2019)
42. Zhao, B.G., Gou, J.K.: Network hatred: obstruction and decomposition of order construction in virtual public domain. J. Beijing Univ. Posts Telecommun. (Soc. Sci. Edn.) **17**(4), 41–49 (2015)