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Research on the Indirect Impact of Monetary Policy Uncertainty and Loan Default – Based on Two Channels of Banks and Enterprises

Yanni LIU* and Yaqing HU

School of Economics and Management, Northwest University, Xi'an, China; lyn@nwu.edu.cn; huyaqing@stumail.nwu.edu.cn

* Corresponding author: lyn@nwu.edu.cn

Abstract: Based on the financial data of 15 listed banks from 2011 to 2020, this paper makes an empirical analysis of the panel model, examines the indirect impact mechanism between the uncertainty index of monetary policy and the non-performing loan ratio of banks, and verifies the intermediary effect of bank risk-taking and enterprise loan cost between the uncertainty of monetary policy and the non-performing loan ratio of banks, In addition, it also tests the heterogeneity of the equity nature of listed banks in order to make a comprehensive analysis of the indirect impact channels of monetary policy uncertainty on loan default. The results show that: (1) there are some intermediary effects between loan cost and bank risk-taking on loan default when the uncertainty of monetary policy increases. (2) The impact of monetary policy uncertainty on the non-performing loan ratio of state-owned banks and joint-stock banks is significantly positive, and the impact coefficient on the non-performing loan ratio of state-owned banks is greater than that of joint-stock banks.

Keywords: monetary policy uncertainty; loan default; risk bearing of banks; non-performing loan ratio; loan cost

JEL Classification: E52

1. Introduction

Since 2016, China has steadily promoted the supply side structural reform. The central bank's active monetary policy innovation and expected fine-tuning will inevitably lead to an increase in policy uncertainty. The flexibility advantage of monetary policy is that it can deal with the contradictions of China's internal economic structure adjustment, but it also brings uncertainty. The government flexibly uses various monetary policies to adjust the macro-economy. However, the camera of monetary policy and the inconsistency between policies will bring uncertainty. The Sixth Plenary Session of the 19th CPC Central Committee pointed out: "in terms of economic construction, the balance, coordination and sustainability of China's economic development have been significantly enhanced, the country's economic strength, scientific and technological strength and comprehensive national strength have leapt to a new level, and China's economy has embarked on a higher quality, more efficient, more equitable, more sustainable and safer development path." Therefore, in order to stabilize monetary policy, ensure the stability, continuity and sustainability of monetary policy implementation, and reduce the uncertainty of monetary policy, we must pay attention to the impact of monetary

policy uncertainty. At the same time, the financial stability report of China's central bank in 2021 pointed out: "at present, the changes of the century and the epidemic situation of the century are intertwined and superimposed... The instability and uncertainty at home and abroad have increased significantly. Domestic financial risks are still many and wide, regional financial risks still exist, the breach risk of some enterprises has increased, and the risk of individual small and medium-sized banks is more prominent...". At present, under the normalization of the epidemic and the complex international environment, it is very important to continue to maintain financial stability, maintain the continuity and stability of financial policies, reduce the risk of bank loan default and promote the improvement of financial development level. Based on this background, an in-depth study of the impact of monetary policy uncertainty on bank loan default risk is not only conducive to the stability and sustainable development of the policy, but also effectively prevent and control financial risks. The two global financial crises in the 1920s and 1930s and the early 21st century have alerted all countries and governments to the impact of economic policy uncertainty on banking, finance and macro-economy. Both financial crises were the result of excessive monetary expansion. The direct cause of the great depression was insufficient investment, loan default and credit contraction. Therefore, we must pay attention to the relationship between monetary policy uncertainty and bank risk-taking, and it is necessary to consider the mechanism of government monetary policy uncertainty on loan default. As for the uncertainty of monetary policy, there is no unified conceptual expression at present. Due to the low degree of marketization of interest rate in China, the uncertainty of China's monetary policy mainly comes from the uncertainty generated in the operation of AD-AS model under the monetary model and Phillips curve model when the central bank realizes the goal of price stability. The uncertainty in the monetary model comes from the regulation of monetary policy objectives, money stock and money circulation speed. The uncertainty in the Phillips curve model comes from the relationship between the expected rate of change of price and actual output. Western economists examine uncertainty under the complete model of Phillips curve. At present, most scholars believe that the uncertainty of monetary policy is the uncertainty in the implementation and transmission of monetary policy caused by the variability of monetary policy tools and the uncertainty of macroeconomic situation (Wang & Wang, 2020; Li, 2016). Apergis and Miller (2007) distinguished the two concepts of the impact of monetary policy level and the impact of monetary policy uncertainty are easy to be confused. The difference between the two lies in the different transmission mechanism. The former is on the aggregate demand side and the latter is on the aggregate supply side. Cook and Corn (1991) as well as Kurov and Stan (2017) first put forward the "policy expectation hypothesis" about the uncertainty of monetary policy. They believe that the uncertainty of monetary policy mainly affects the asset price of the financial market through the guidance of the public's future policy expectation, which means that the increase of monetary policy uncertainty will lead to the deviation between the actual price and the expected price. Cogley et al. (2011) found that the uncertainty of monetary policy comes from the uncertainty of models and parameters, and Bayesian estimation should be used to evaluate the uncertainty. Other scholars have examined the relationship between monetary policy and uncertainty. Bekaert et al. (2013) believes that loose

monetary policy reduces risk aversion and uncertainty. Due to expansionary money, the central bank provides sufficient liquidity. The uncertainty of monetary policy has a tightening effect on the macro economy. The tightening effect can restrain consumption, investment and labor employment through the addition of Preventive Savings, sticky prices and endogenous marginal costs (Wu et al., 2021; Nam et al., 2021; Zhou et al., 2021). Husted et al. (2019) pointed out that the uncertainty of monetary policy will lead to the decline of enterprise investment through financial channels such as real option effect and financial friction effect.

As for the research on the impact of monetary policy uncertainty on loan default, the previous literature research has a variety of perspectives. Through extensive collection of literature, it focuses on the two factors of monetary policy uncertainty and loan default, and makes a literature review from the aspect of indirect impact. The indirect influence literature can be summarized into the following three perspectives. The first is to study the relationship between indicators that can reflect the fluctuation of monetary policy, such as loan interest rate, money supply and non-performing loan rate, but this study lacks the overall grasp of monetary policy. Christiano et al. (2016) constructed the default risk factor through BGG model and concluded that when the fluctuation of monetary policy intensifies, the default risk increases. The second is to study the relationship between economic policy uncertainty and enterprise loan cost, enterprise credit scale and enterprise investment from the enterprise level. The third is to study the relationship between economic policy uncertainty and bank risk-taking from the bank level.

From the perspective of indirect impact, for the specific indicators of monetary policy, some scholars have studied the impact of short-term loan interest rate and money supply on non-performing loans by building models (Xie, 2009; Lu, 2012; Fernández-Villaverde et al., 2015; Ma & Shen, 2017). Therefore, the research on non-performing loans from this perspective mainly focuses on the impact of a specific indicator in monetary policy, which is lack of comprehensiveness and analysis of indicators that can reflect the overall monetary policy. For the level of enterprise loan cost, the increase of monetary policy uncertainty will lead to the increase of enterprise loan cost (Song et al., 2019; Francis et al., 2014). It is generally believed that when the uncertainty of monetary policy increases, the loan cost of enterprises increases, and the profitability of enterprises decreases. Due to the failure to repay the principal and interest on time, the non-performing loan rate of banks increases. Tan and Zhang (2017) pointed out that when the economic uncertainty rises, the factor price and asset price of the enterprise will fluctuate, the profitability of the enterprise's investment projects will be affected, and the solvency cannot be judged. Therefore, the bank will strengthen the review of the enterprise's loan projects, increasing the loan cost of the enterprise. Bolton et al. (2019) found that the uncertainty risk leads to the increase of enterprise financing cost, and the financing decision of the enterprise depends on the profitability and liquidity of the enterprise. When the policy uncertainty increases, the risk borne by the enterprise increases, and the enterprise financing requires higher risk compensation, so the agency cost and financing cost will increase. For the level of bank risk-taking, there are few studies on the analysis of monetary policy uncertainty and bank risk-taking mechanism. Liu & Hou (2020) pointed out that monetary policy uncertainty will increase the bank's ex ante risk-taking level through loan scale and liquidity,

but will reduce the bank's ex ante risk-taking level through the change of asset return. Uncertainty is inversely proportional to the bank's subsequent risk-taking. Based on the DSGE model, Li and Huang (2021) concluded that the increase of monetary policy uncertainty will increase the bank's non-performing loan ratio and inhibit the bank's credit activities, so as to increase the bank's risk-taking level. In addition, other scholars study how economic policy uncertainty affects bank risk-taking from the perspective of monetary policy. Brana et al. (2019) as well as Matthys et al. (2020) analyzed that the loose monetary environment may stimulate banks to increase their risk appetite by issuing loans with lower spreads to higher risk companies. Most scholars have investigated the relationship between economic policy uncertainty and bank risk-taking. They believe that economic policy uncertainty and bank risk-taking are positive. Bank risks come from all aspects, including operation risk, liquidity risk, financing risk, profit risk and credit default risk. Due to the infectious risk, the risks of banks affect each other. When the uncertainty of economic policies increases and the risk of credit default increases, banks will issue more short-term loans and guaranteed loans and recover long-term loans, Reduce the loss of non-performing loans, but banks sometimes fail to correctly understand the situation and make mistakes in operation and management, resulting in the wrong issuance of credit structure, which leads to the rise of bank credit risk and the rise of non-performing loan rate. It can be seen from the previous literature that the research on bank risk-taking mainly focuses on the uncertainty of economic policy and the choice of two monetary policy tools. In addition, the previous literature has inconsistent directions in discussing the relationship between monetary policy uncertainty and bank risk-taking level. Therefore, the relationship between specific monetary policy uncertainty and bank risk-taking is still unclear and needs to be further studied.

Generally speaking, the previous literature focuses on the direct impact of economic policy uncertainty, and there is little research on the indirect impact between monetary policy uncertainty and loan default. Therefore, this paper aims to deeply analyze the impact of monetary policy uncertainty in the face of the impact of monetary policy uncertainty through the Chinese monetary policy uncertainty index constructed by Baker et al. (2016), How the two channels of loan cost and bank risk-taking affect loan default provides new ideas for preventing greater systemic financial risk.

2. Methodology

This paper comprehensively analyzes the indirect impact mechanism of monetary policy uncertainty on bank non-performing loan ratio, and verifies how monetary policy uncertainty affects bank non-performing loan ratio through two indirect impact mechanisms: loan cost and bank risk-taking through empirical regression results.

2.1. Fixed Panel Model

In order to estimate the total effect of monetary policy uncertainty on loan default, the following benchmark model is set:

$$npl_{it} = \beta_0 + \beta_1 lnmpu_t + \beta_2 X_{it} + \beta_3 M_t + a_i + u_{it} \quad (1)$$

NPL represents the non-performing loan ratio of banks, lnmpu represents the uncertainty of monetary policy, and the annual index is taken as logarithm, β_0 is intercept term, coefficient β_1 represents the impact of the uncertainty index of monetary policy on the non-performing loan ratio. X_{it} is a bank level control variable that changes with time, M_t controls a series of macro level factors, and a_i is a bank fixed effect that controls the individual characteristics that do not change with time. u_{it} is a random error term.

2.2. Intermediary Effect

In order to analyze how the uncertainty of monetary policy affects loan default through the two channels of bank risk-taking and loan cost, we need to expand the benchmark model of panel data and analyze the intermediary effect of intermediary variables. The intermediary effect can effectively test the role of intermediary variables. We need to test whether the intermediary effects of bank risk-taking and loan cost exist and their proportion in the total effect. We can judge whether the intermediary effect exists by gradually testing the regression coefficient. The extended model is as follows:

$$r_{it} = \varphi_0 + \varphi_1 lnmpu_t + \varphi_2 X_{it} + \varphi_3 M_t + a_i + u_{it} \quad (2)$$

$$Z_{it} = \alpha_0 + \alpha_1 lnmpu_t + \alpha_2 X_{it} + \alpha_3 M_t + a_i + u_{it} \quad (3)$$

$$npl_{it} = \omega_0 + \omega_1 lnmpu_{it} + \omega_2 r_{it} + \omega_3 X_{it} + \omega_4 M_t + a_i + u_{it} \quad (4)$$

$$npl_{it} = \gamma_0 + \gamma_1 lnmpu_{it} + \gamma_2 Z_{it} + \gamma_3 X_{it} + \gamma_4 M_t + a_i + u_{it} \quad (5)$$

"R" represents the floating range of loan interest rate, "Z" represents the bank's risk-taking level, and other variables have the same meaning as those in the benchmark model. Consider two intermediary effects, namely indirect effects. The first intermediary effect considers the cost of enterprise loans, that is, the uncertainty of monetary policy increases the cost of enterprise loans, which in turn leads to the default of enterprise loans. Models (1), (2) and (4) are used to test the uncertainty of monetary policy - loan cost - loan default. Firstly, we test the effect of monetary policy uncertainty on loan default $\beta_1$in the total effect model (1). Then test the impact of monetary policy uncertainty on loan cost, and investigate $\varphi_1$in model (2). Finally, test the influence of monetary policy uncertainty, loan default and loan interest rate and cost at the same time, and investigate the coefficients $\omega_1$and $\omega_2$in model (4). The second intermediary effect considers bank risk-taking. Firstly, it examines the impact of monetary policy uncertainty on loan default, then examines the impact of monetary policy uncertainty on bank risk-taking, and finally tests the impact of monetary policy uncertainty and bank risk-taking on loan default at the same time. Here, models (1), (3) and (5) are used to test the transmission mechanism of monetary policy uncertainty - bank risk-taking - loan default. First, test the total impact of monetary policy uncertainty on loan default, and investigate$\beta_1$in model (1). Then test the impact of monetary policy uncertainty on bank risk-taking, and investigate the effect of α_1 in model (3). Finally, test the impact of monetary policy uncertainty, bank risk-taking and bank loan default at the same time, and investigate the impact of γ_1 and γ_2 in model (5).

2.3. Data Source and Variable Selection

Huang and Luk (2020) measured the monthly data of the monetary policy uncertainty index in China. They can be found from the official website of the economic policy uncertainty index. The macro level data involved in the construction of loan default indicators comes from guotai'an database, and the enterprise level data comes from China bond information network and Dongfang wealth network. The data of listed banks comes from guotai'an database. Combined with the required data of listed banks, excluding other lack of listed banks, 15 listed banks with complete data range are finally obtained including 10 joint-stock banks and 5 large state-owned commercial banks, and finally obtained the balanced panel data of 15 listed banks from 2011 to 2020. Compared with the previous literature, this data covers a wide range of data and involves many types of data at all business levels of banks. Therefore, this paper uses the data of 15 listed commercial banks from 2011 to 2020 as samples for empirical analysis.

The dependent variable is the bank's non-performing loan rate. The proxy variable of monetary policy is generally the market interest rate, but China's market interest rate is not perfect. At the same time, China mostly uses quantitative monetary policy to regulate the economy, such as the growth rate of broad money supply, the deposit reserve ratio and the benchmark interest rate of one-year loan. Here, we refer to most literatures and select the monetary policy uncertainty index obtained from the official website for empirical analysis. It is made by extracting key words about monetary policy and uncertainty from well-known newspapers and periodicals. It is calculated by comprehensively considering many indicators of monetary policy, including macro-control, monetary policy means of the central bank, open market operation, deposit reserve ratio, benchmark interest rate, money liquidity, interest rate, interest, money supply, lending tools, inflation rate, quantitative easing and tightening, etc. We average the monthly data to obtain the annual data, which is used as the main explanatory variable for empirical analysis. The control variables at the bank level include the ROA of listed banks, deposit loan ratio, total asset turnover rate, net profit growth rate, sustainable development rate, total asset growth rate, banking profitability and banking prosperity, which in turn represent the development ability, operation ability and profitability of banks. As for the indicators of bank risk-taking, we refer to Xu and Chen (2012) to measure the overall risk of the bank with Z-value. It is a direct measure of the bank's bankruptcy probability, taking into account the bank's operating status, profitability, financial status, etc. For the enterprise loan cost index, the floating range of loan interest rate is selected as the index. The classification of bank nature refers to the classification of listed banks in guotai'an database, which is divided into two categories: large state-owned commercial banks and joint-stock commercial banks.

3. Results

We usually assume that the mean value of the disturbance term is independent of all explanatory variables and is not affected by internal factors. There is no problem of missing variables in the model, but if there is a problem of missing variables, the estimated value of variables will be too high or too low. Therefore, we need to test the robustness of the model

and variables before empirical analysis. In order to test the role of the two intermediary variables, bank risk-taking and loan cost, between the uncertainty of monetary policy and loan default, we need to test the intermediary effect and judge the proportion of the intermediary effect in the total effect. In addition, in order to investigate the different impact of banks with different property rights on loan default in the face of monetary policy uncertainty, we distinguish between state-owned banks and joint-stock banks to test bank heterogeneity.

3.1. Model Robust Test

Instrumental variable method is a common method to solve endogenous problems. It introduces an exogenous variable, which is independent of random disturbance term and related to endogenous variable. In fact, the over identification test is to test the exogenous nature of instrumental variables, that is, instrumental variables are not related to disturbance terms. Weak instrumental variable test is to test the correlation between instrumental variables and endogenous explanatory variables.

Table 1. Instrumental variable method

variable	**npl**
lnmpu	1.030746 *** （5.25）
adjusted R^2	0.7695
sample size	150
over identification test	3.402(0.0651)
weak instrumental variable test	0.9303(0.0000)

The superscript ***,**,* are significant at the level of 1%, 5% and 10%, respectively. The t-statistic is in brackets.

There are many methods of robustness test, including missing variables, changing dependent variables, core independent variables, instrumental variables, etc. Referring to the practice of Wang (2014), this paper selects the U.S. monetary policy uncertainty index and Monetary Policy Perception Index as instrumental variables, and uses the method of replacing the core explanatory variables to test the robustness of panel data. Through two-stage least squares regression, the results show that the instrumental variables we selected are effective. The panel model has good robustness.

3.2. Intermediary Effect Test

Firstly, hosman test is used to determine whether the panel model is suitable for fixed effect or random effect. The results show that the panel model in this paper is suitable for fixed effect. The hosman test results are omitted here. Then the total effect of monetary policy uncertainty and loan default is tested by Stata software. Model 1 is the regression result of the total effect. The results in Table 2 show that the value of the test statistics of the core explanatory variable lnmpu is less than the critical value, and the p value is 0. Therefore, the uncertainty of monetary policy after taking logarithm is significant at the significance level of 0.05. Therefore, the uncertainty of monetary policy has a significant impact on loan default, and the total effect is significant. The positive coefficient indicates that when the uncertainty of monetary policy increases, the loan default behavior of banks increases. It also controls the

bank level and macro level variables, including bank deposit loan ratio, ROA, total asset growth rate, net profit growth rate, sustainable development rate, total asset turnover rate, M0 growth rate and CPI growth rate.

Table 2. Total effect regression results

npl	Model (1)	
	fixed effect	random effect
lnmpu	0.78700***(5.56)	0.6334818***(4.15)
deposit loan ratio	-1.07687***(-6.05)	-0.670975***(-4.55)
Roa	-155.6282***(-7.03)	-124.3342***(-5.84)
Growth rate of total assets	-0.70727***(-2.72)	-0.952839***(-3.31)
Net profit growth rate	-0.04549(-0.45)	-0.0281298(-0.29)
Sustainable development rate	-1.66787*(-1.85)	-2.831056***(-3.30)
Total asset turnover	12.82201(1.21)	21.10358**(2.17)
M0 growth rate	-0.05840***(-7.09)	-0.0510332***(-5.66)
Consumer retail price index growth	-0.01231**(-2.15)	-0.0138502**(-2.17)
Constant	0.91502*(1.86)	0.7314408(1.35)
Observations	150	150
R^2	0.5222	0.6098

The superscript ***,**,* are significant at the level of 1%, 5% and10%, respectively. The t-statistic is in brackets.

The method of stepwise testing regression coefficient is divided into three steps. First, test the total effect of independent variable x on dependent variable y, and the coefficient is a. Second, test the relationship between independent variable x and intermediary variable m, and the coefficient is B. Third, after controlling the intermediate variable m, test the coefficient C of the core explanatory variable and the coefficient D of the intermediate variable. When the coefficients a, B and D are significant, the mediating effect is significant. When the coefficient C is not significant, it is a complete intermediary. When C is less than a, it is partial mediation.

Dependent variable R, core explanatory variable lnmpu, control variable deposit loan ratio, M0 growth rate, M1 growth rate, M2 growth rate, CPI growth rate, banking prosperity and bank profit index constitute model 2.

Table 3. Regression results of lnmpu and loan cost

r	Model (2)	
	fixed effect	random effect
Lnmpu	14.68339*** (9.36)	14.74255*** (9.91)
deposit loan ratio	-0.1761649 (-0.68)	-.0431235 (-0.35)
M0 growth rate	-1.437453*** (-9.65)	-1.443444*** (-10.22)
M1 growth rate	0.1082267*** (3.52)	0.1094503*** (3.76)
M2 growth rate	0.6246675*** (14.54)	0.6241975*** (15.29)
Consumer retail price index growth	-0.1623461*** (-7.66)	-0.1608086*** (-8.04)
Prosperity banking index	1.70574*** (7.63)	1.719066*** (8.14)
Bank profit index	-1.079227*** (-6.33)	-1.090572*** (-6.78)
Constant	-94.10628*** (-8.73)	-94.68211*** (-9.28)
Observation	150	150
R^2	0.9872	0.9873

The superscript ***,**,*,are significant at the level of 1%, 5% and 10%, respectively. The t-statistic is in brackets.

Dependent variable Z, core explanatory variable lnmpu, control variable deposit loan ratio, ROA, total asset growth rate, net profit growth rate, sustainable development rate, total asset turnover rate, M0 growth rate, CPI growth rate, banking prosperity and bank profit index constitute model 3.

Table 4. Regression results of lnmpu and Z

Z	**Model (3)**	
	fixed effect	**random effect**
lnmpu	0.0615389* (1.93)	0.0495106 (1.49)
deposit loan ratio	-0.0107933 (-0.66)	-0.0132385 (-0.82)
Roa	-23.82271*** (-10.80)	-23.02328*** (-10.27)
growth rate of total assets	-0.045203* (-1.92)	-0.0409833* (-1.67)
net profit growth rate	0.0165214* (1.79)	0.023647* (2.50)
sustainable development rate	-0.1288618 (-1.46)	-0.1390081 (-1.54)
total asset turnover	-0.8137681 (-0.83)	-0.1683032 (-0.17)
M0 growth rate	-0.003772* (-1.74)	-0.0029327 (-1.30)
consumer retail price index growth	-0.0024034*** (-2.87)	-0.0020059* (-2.31)
prosperity banking index	0.0005043 (0.17)	0.0002299 (0.07)
bank profit index	0.001598 (0.62)	0.0015954 (0.59)
Constant	0.0388958 (0.23)	0.0869708 (0.50)
Observations	150	150
R^2	0.3024	0.3371

The superscript***,**,*,are significant at the level of 1%,5%and10%, respectively. The t-statistic is in brackets.

Dependent variable NPL, core explanatory variable lnmpu, control variable R, deposit loan ratio, ROA, total asset growth rate, net profit growth rate, sustainable development rate, total asset turnover rate, M0 growth rate and CPI growth rate constitute model 4.

Table 5. Test of intermediary effect of loan cost

npl	**Model (4)**	
	fixed effect	**random effect**
lnmpu	0.5698241*** (4.31)	0.5052124*** (3.80)
r	-0.0679363*** (-5.73)	-0.0758525*** (-6.67)
Deposit loan ratio	-1.050897*** (-6.60)	-0.6937231*** (-5.27)
Roa	-98.74781*** (-4.46)	-79.03743 *** (-3.95)
Growth rate of total assets	-0.4664896* (-1.97)	-0.6586843*** (-2.64)
Net profit growth rate	0.0441789 (0.48)	0.0550549 (0.64)
Sustainable development rate	-0.2474846 (-0.29)	-1.094317 (-1.39)
Total asset turnover	29.74063*** (3.01)	31.1346 *** (3.56)
Consumer retail price index growth	-0.009584* (-1.86)	-0.0097352* (-1.77)
M0 growth rate	-0.0413281*** (-5.21)	-0.0370297*** (-4.59)
Constant	1.732409*** (3.75)	1.578605*** (3.28)
Observations	150	150
R^2	0.6364	0.6997

The superscript ***,**,* are significant at the level of 1%, 5%and 10%, respectively. The t-statistic is in brackets.

Dependent variable NPL, core explanatory variable lnmpu, control variable Z, deposit loan ratio, ROA, total asset growth rate, net profit growth rate, sustainable development rate, total asset turnover rate, M0 growth rate and CPI growth rate constitute model 5.

Table 6. Intermediary effect test of bank risk taking

npl	Model (5)	
	fixed effect	random effect
Lnmpu	0.8070487*** (5.84)	0.6361135*** (4.19)
z	-2.524276*** (-2.76)	-0.6982436 (-0.98)
Deposit loan ratio	-1.087181*** (-6.26)	-0.7042696*** (-4.71)
Roa	-205.6704*** (-7.30)	-138.8544*** (-5.53)
Growth rate of total assets	-0.8015908*** (-3.13)	-0.9466838*** (-3.32)
Net profit growth rate	0.0131696 (0.13)	0.0148919 (0.14)
Sustainable development rate	-1.657554* (-1.89)	-2.897372*** (-3.34)
Total asset turnover	13.56764 (1.32)	22.414** (2.25)
M0 growth rate	-0.0560069*** (-6.94)	-0.0503604*** (-5.58)
Consumer retail price index growth	-0.0117763** (-2.10)	-0.0131003** (-2.06)
Constant	1.659577*** (3.02)	0.9721898* (1.65)
Observations	150	150
R^2	0.4699	0.6016

The superscript ***,**,* are significant at the level of 1%, 5% and 10%, respectively. The t-statistic is in brackets.

First, we examine the relationship between the uncertainty of monetary policy and the non-performing loan ratio of banks, as shown in Table 2, $\beta_1$significant. Then through the regression results of monetary policy uncertainty and loan cost, as shown in Table 3, the uncertainty of monetary policy is significant at the 95% significance level, and the coefficient is significant φ_1 is positive, which indicates that when the uncertainty of monetary policy increases, the floating range of loan interest rate becomes larger and the loan cost increases. When considering both monetary policy uncertainty and loan cost, as shown in Table 5, the coefficient φ_1 and ω_2 were significant at 95% significance level, and ω_1 less than β_1. Therefore, there are some intermediary effects $\frac{\varphi_1\omega_2}{\beta_1}$. Similarly, the relationship between bank risk-taking and monetary policy uncertainty is investigated. As shown in Table 4, the uncertainty of monetary policy is at the significance level of 90% α_1 is significant, and the coefficient is positive. It shows that when the uncertainty of monetary policy increases, the risk of bank bankruptcy increases and the Z value becomes larger. When considering the uncertainty of monetary policy and bank risk-taking at the same time, it can be seen from the results of empirical analysis that, as shown in Table 6, the p value is still significant at the 95% level, $\alpha_1$and $\gamma_2$are significant, and $\gamma_1$not less than β_1. So, there are some mediating effects $\frac{\alpha_1\gamma_2}{\beta_1}$.

Through the intermediary effect results, it can be seen that the loan cost and bank risk-taking have some intermediary effects on loan default when the uncertainty of monetary policy increases. Therefore, when considering the impact of monetary policy uncertainty on bank loan default, we need to pay attention to the two default risk transmission channels of enterprise loan cost fluctuation and bank risk-taking. For the enterprise loan cost channel, when the uncertainty of monetary policy rises, we should pay attention to how the uncertainty affects the enterprise loan cost and control the sunk cost. Generally, enterprises have policy lag and lag in cost adjustment. Therefore, we need to focus on the renewal of cost control means to prevent the loan default caused by the rise of loan cost. For the risk-taking

channels of banks, when the uncertainty of monetary policy rises, the adjustment of uncertainty also lags behind. Therefore, it is necessary to prevent the risk of loan default caused by the rise of the overall risk of banks. We should reduce the default risk of credit loans by controlling other risks, such as liquidity risk, management risk and policy risk

3.3. Bank Heterogeneity Test

Table 7. Bank heterogeneity test

npl	**Joint stock bank**		**state-owned bank**	
	Fixed effect	**Random effect**	**Fixed effect**	**Random effect**
Lnmpu	0.65236***	0.4986255***	1.4361***	1.048157***
	(3.51)	(2.76)	(7.28)	(4.75)
Deposit loan ratio	-1.201761***	-0.9588634***	1.176877	0.7092313**
	(-6.21)	(-6.96)	(1.92)	(2.02)
Roa	-149.6731***	-128.8045***	-251.73***	-106.6937***
	(-6.26)	(-5.94)	(-4.05)	(-2.69)
Growth rate of total assets	-0.4802444*	-0.4039017	-2.822009**	-1.850375
	(-1.79)	(-1.46)	(-2.65)	(-1.46)
Net profit growth rate	-0.0421021	0.1037302	-0.2921297	-0.648162***
	(-0.38)	(1.13)	(-1.03)	(-3.17)
Sustainable development rate	-1.432817	-2.132364***	0.2957409	-2.891566
	(-1.50)	(-2.60)	(0.12)	(-1.08)
Total asset turnover	19.23747	22.45357**	-19.10937	-5.835748
	(1.62)	(2.46)	(-0.87)	(-0.24)
M0 growth rate	-0.064852***	-0.0594472***	-0.0799793***	-0.0488822***
	(-6.10)	(-5.63)	(-5.01)	(-3.10)
Consumer retail price index growth	-0.0097125	-0.0100577	-0.0390256***	-0.0463385***
	(-1.38)	(-1.40)	(-3.24)	(-4.26)
Constant	1.339463**	1.550186**	-2.791941***	-2.146565**
	(2.12)	(2.41)	(-2.80)	(-2.53)
Observations	100	100	50	50
R^2	0.7771	0.8036	0.5831	0.7374

The superscript ***,**,* are significant at the level of 1%, 5% and 10%, respectively. The t-statistic is in brackets.

Through the analysis of 15 listed banks divided into two types of banks with different properties, we can see from the empirical results, as shown in Table 7. The impact of monetary policy uncertainty on the non-performing loan ratio of state-owned banks and joint-stock banks is significantly positive, and the impact coefficient on the non-performing loan ratio of state-owned banks is greater than that of joint-stock banks, indicating that when the uncertainty of monetary policy increases, compared with joint-stock banks, the uncertainty of monetary policy has a greater impact on state-owned banks. As the equity nature of state-owned banks belongs to state-owned holding, the influence of government policies is more direct, comprehensive and profound, so the coefficient is large. At the same time, other control variables, bank deposit loan ratio, ROA level, total asset growth rate, M0 growth rate and consumer price index growth rate are also significant. Comparing the development ability, operation ability and profitability of state-owned banks and joint-stock banks, it is concluded that the coefficients of state-owned banks are greater than joint-stock banks. It shows that the non-performing loan rate of state-owned banks with strong

profitability and development ability is lower than that of joint-stock banks. Therefore, the problem of non-performing loan ratio of joint-stock banks cannot be ignored.

4. Discussion and Conclusions

This paper studies the relationship between monetary policy uncertainty and loan default, and comprehensively analyzes how the two intermediary variables of loan cost and bank risk-taking transfer uncertainty and then affect loan default. Based on the panel data of 15 listed banks in China from 2011 to 2020, three conclusions can be drawn: (1) when other variables are controlled unchanged, monetary policy uncertainty significantly affects bank loan default, and when monetary policy uncertainty increases, loan default will increase. (2) Considering the intermediary effect, we find that there are some intermediary effects in both loan cost and bank risk-taking. Therefore, when the uncertainty of monetary policy increases, we should focus on how the uncertainty will affect loan default through the two transmission channels of loan cost and bank risk. (3) Considering the heterogeneity of banks with different equity properties, we find that the impact of monetary policy uncertainty on the non-performing loan ratio of state-owned banks is greater than that of joint-stock banks.

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References

Apergis, N., & Miller, S. M. (2007). Total factor productivity and monetary policy: evidence from conditional volatility. *International Finance*, *10*(2), 131-152. https://doi.org/10.1111/j.1468-2362.2007.00200.x

Bekaert, G., Hoerova, M., & Duca, M. L. (2013). Risk, uncertainty and monetary policy. *Journal of Monetary Economics, 60*(7), 771–788. https://doi.org/10.1016/j.jmoneco.2013.06.003

Bolton, P., Wang, N., & Yang, J. (2019). Investment under uncertainty with financial constraints. *Journal of Economic Theory, 184*. https://doi.org/10.1016/j.jet.2019.06.008

Brana, S., Campmas, A., & Lapteacru, I. (2019). (un)conventional monetary policy and bank risk-taking: a nonlinear relationship. *Economic Modelling, 81*, 576–593. https://doi.org/10.1016/j.econmod.2018.07.005

Cook, T., & Korn, S. (1991). The reaction of interest rates to the employment report: the role of policy anticipations. *FRB Richmond Economic Review, 77*(5), 3–12.

Christiano, L. J., Motto, R., & Rostagno, M. (2016). Risk shocks. *American Economic Review, 104*, 27–65. https://doi.org/10.1257/aer.104.1.27

Cogley, T., Paoli, B. D., Matthes, C., Nikolov, K., & Yates, T. (2011). A bayesian approach to optimal monetary policy with parameter and model uncertainty. *Journal of Economic Dynamics & Control, 35*(12), 2186–2212. https://doi.org/10.1016/j.jedc.2011.02.006

Francis, B. B., Hasan, I., & Zhu, Y. (2014). Political uncertainty and bank loan contracting. *Journal of Empirical Finance, 29*, 281–286. https://doi.org/10.1016/j.jempfin.2014.08.004

Huang, Y., & Luk, P. (2020). Measuring economic policy uncertainty in China. *China Economic Review*, *59*, 101367. https://doi.org/10.1016/j.chieco.2019.101367

Husted, L., Rogers, J., & Sun, B. (2019). Monetary policy uncertainty. *Journal of Monetary Economics, 115*, 20–36. https://doi.org/10.1016/j.jmoneco.2019.07.009

Fernández-Villaverde, J., Guerron-Quintana, P.A., Kuester, K., & Rubio-Ramírez, J. F. (2015). Fiscal volatility shocks and economic activity. *CEPR Discussion Papers*, *105*(11), 3352–3384. https://doi.org/10.1016/10.2139/ssrn.1908676

Kurov, A., & Stan, R. (2017). Monetary policy uncertainty and the market reaction to macroeconomic news. *Journal of Banking & Finance, 86*, 127–142. https://doi.org/10.2139/ssrn.2776357

Li, J. (2016). Research on credit risk prevention of commercial banks under uncertain macroeconomic background. Reform and Strategy (02), 50-53. https://doi.org/10.16331/j.cnki.issn1002-736x.2016.02.013

Lu, P. P. (2012). Research on the fluctuation of interest rate and non-performing loan ratio of commercial banks. *Southwest finance, 6*, 50–53.

Liu, Y., & Hou, M. (2020). An empirical study on the relationship between economic policy uncertainty, bank credit behavior and risk taking. *Statistics and decision making, 1,* 141–145.

Li, L., & Huang, X. (2021). Research on the uncertainty of monetary policy and the risk-taking of commercial banks. *System engineering theory and Practice,* 1–25.

Li, C., Yu, H., & Li, Y. (2021). An empirical study on the impact of monetary policy uncertainty on macro economy. *Statistics and decision making*, *18*, 128–132.

Ma, X., & Shen, Y. (2017). Policy uncertainty, monetary policy and bank risk taking. *East China Economic Management*, *5*, 100–106.

Matthys, T., Meuleman, E., & Vander Vennet, R. (2020). Unconventional monetary policy and bank risk taking. *Journal of International Money and Finance, 109*, 102233. https://doi.org/10.1016/j.jimonfin.2020.102233

Nam, E. Y., Lee, K., & Jeon, Y. (2021). Macroeconomic uncertainty shocks and households' consumption choice. *Journal of Macroeconomics, 68*(2), 103306. https://doi.org/10.1016/j.jmacro.2021.103306

Song, Q., Li, X., & Qian, L. (2019). Economic policy uncertainty and enterprise loan cost. *Financial Research*, *7*, 57–75.

Tan, X., & Zhang, W. (2017). Analysis on the channels of economic policy uncertainty affecting enterprise investment. *World economy*, *12*, 3–26.

Wu, W., Tiwari, A. K., Gozgor, G., & Leping, H. (2021). Does economic policy uncertainty affect cryptocurrency markets? Evidence from twitter-based uncertainty measures. *Research in International Business and Finance, 58*, 101478. https://doi.org/10.1016/j.ribaf.2021.101478

Wang, L., & Wang, S. (2020). Research Progress on uncertainty of monetary policy. *Economic dynamics*, *6*, 109–122.

Xie, B. (2009). Analysis of macroeconomic factors affecting non - performing loans of commercial banks. *Financial theory and Practice, 6*, 22–25.

Xu, M., & Chen, X. (2012). Monetary Environment, Capital Adequacy Ratio and Commercial Bank Risk Taking. *Financial Research*, (07), 489+50-62. https://kns.cnki.net/kcms/detail/detail.aspx?FileName=JRYJ201207007&DbName=CJFQ2012

Zhou, L., Sun, N., Zhang, S., & Zhang, J. (2021). Monetary policy uncertainty, financial friction and economic tightening effect - an analysis based on BGG-DSGE model. *Exploration of economic issues, 4*, 145–156.