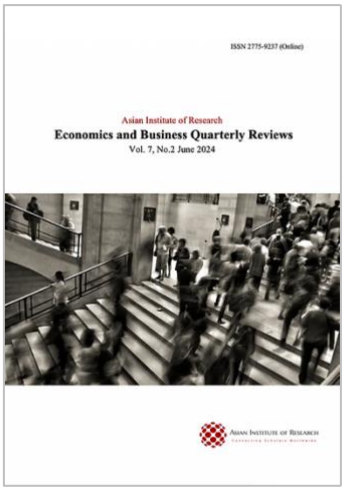

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Bank Risk-Taking and Monetary Policy: Empirical Results for Taiwan

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Abstract
Will bank risk-taking increase in response to monetary policy easing, especially when interest rates are low, and will banks increase their risk-taking in pursuit of profits? Using Z-score and non-performing loan ratio of Taiwan banking sector covered the period 2015-2020 as proxy variables for bank risk, the empirical analysis shows that there is no significant evidence to support bank risk-taking behavior in a loose monetary policy environment, implying the risk-taking channel of monetary policy not existing. However, after considering the impact of Basel III on bank capital regulations in Taiwan since 2013, bank risk-taking will increase with monetary policy easing as capital regulations become more stringent, which is consistent with the regulatory hypothesis. As for the impact of monetary regime change, banks' risk will increase with loosening monetary policy during the easing phase of monetary policy, while during monetary policy tightening stage, banks have no risk risking tendency. These inferences are valid after taking the effect of the 2008 financial crisis and considering the cross-effects of bank characteristics and monetary policy, indicating that not only banks' risk-taking is related to the strengthening of bank capital regulations, but the difference in the regime of monetary easing and tightening also affects bank risk-taking behavior.

Keywords: Bank Risk-Taking, Monetary Policy, Risk-Taking Channel

1. Introduction

The undue risk-taking behavior of banks is considered one of the causes of the 2008 global financial crisis. Therefore, discussing the relationship between monetary policy and bank risk-taking, analyzing whether monetary policy affects bank risk-taking, whether bank risk-taking acts as a transmission mechanism for monetary policy effects, and whether financial stability is negatively affected by loose monetary policy are among the topics discussed in recent literature.

For central banks, adjusting interest rates to respond to economic downturns is a common policy measure. However, past analyses of the effects of monetary policy have tended to overlook the relationship between bank risk-taking and loose monetary policy. One reason for this, according to the literature, is that central banks' macroeconomic policy objectives have shifted from controlling inflation to promoting economic growth. Additionally, financial innovation has allowed risks to be more effectively diversified, thereby increasing the flexibility of the financial system to adapt to market changes. Based on these perspectives, the issue of whether monetary policy affect financial stability has been less discussed. However, for banks, during periods of loose monetary policy, the drive to achieve expected profit targets may lead them to engage in higher-risk investment behavior. Furthermore, a prolonged environment of low interest rates may reduce banks' perception of risk in investment decisions, leading to an underestimation of actual risk levels. Therefore, while loose monetary policy cannot be solely blamed for the financial crisis, it could indeed be one of the causes. This is because in a persistently low-interest-rate environment, it can affect and reduce banks' and investors' perception of risk, potentially leading to financial imbalances.

The literature describes the mechanism through which monetary policy affects financial institutions' risk perception or risk tolerance as the "risk-taking channel." Why does bank risk-taking increase with low interest rates or loose monetary policy? Rajan (2005) argues that low-interest rates reduce banks' short-term funding costs and decrease their returns from financial assets like bonds, incentivizing financial institutions to increase their risk exposure in pursuit of higher yields. Adrian and Shin (2010) point out that low-interest rates influence banks' balance sheet structures, encouraging them to rely more on short-term funding, and to lend to riskier borrowers. Borio and Zhu (2012) suggest that loose monetary policy increases the value of assets on banks' balance sheets, leading them to adjust their expectations of default probabilities, losses from defaults, and price volatility, thereby affecting their assessment of expected risks. Consequently, as financial asset prices rise due to low-interest rates, banks' risk tolerance increases, leading to an expansion in lending or credit provision. Additionally, in a persistently low-interest-rate environment, the predictability of future policy directions increases, reducing market uncertainty through communication policies of central banks, thus enhancing banks' willingness to take on risk.

Empirical evidence suggests that a low-interest-rate environment does increase banks' expected default rates for corporate loans (Gaggl and Valderrama, 2010), leading banks to relax lending conditions (Jiménez et al., 2014) and engage in riskier lending activities (Altunbas et al., 2014). Additionally, factors such as pessimism about economic prospects (Montes and Scarpari, 2015), increased competition among banks (Ha and Quyen, 2018), and the rise of internet finance (Qiao et al., 2018) also contribute to increased bank risk-taking. Characteristics such as bank size, liquidity, and capitalization affect risk-taking behavior inversely; larger, more liquid, and better-capitalized banks tend to take on less risk (Özşuca and Akbostancı, 2016). Changes in banking regulation and monetary policy frameworks also influence bank risk-taking behavior. Stricter capital controls have been associated with increased bank risk-taking (Mujtaba et al., 2022, Dias, 2021), while differences in loose or tight monetary policy regimes affect bank risk-taking differently (Djatche, 2019).

In a low-interest-rate environment, influenced by factors such as banks' pursuit of profits, adjustments to risk perceptions, and decreased market uncertainty, do Taiwanese banks increase their risk tolerance and face higher risks? Does the bank risk-taking channel exist in the transmission process of Taiwan's monetary policy effects? This study focuses on Taiwanese domestic banks from 2006 to 2020, discussing whether bank risk-taking increases with declining interest rates and analyzing whether the strengthening of bank capital regulations and differences in monetary policy regimes affect bank risk-taking. The empirical evidence presented in the study suggests that, without considering the impact of Basel III capital controls and differences in monetary policy regimes, there is no clear and substantial evidence supporting the idea that bank risk increases with loose monetary policy, indicating the absence of a monetary policy bank risk-taking channel. However, after considering the impact of Basel III capital controls implemented in Taiwan in 2013, the evidence shows that bank risk increases with loose monetary policy, supporting the regulatory hypothesis. This conclusion holds true regardless of whether bank risk is represented by Z-scores or non-performing loan ratios. The analysis also demonstrates that bank risk-taking behavior varies with different monetary policy regimes. The empirical analysis indicates that bank risk-taking occurs during loose monetary policy phases, while banks show no risk-taking tendencies during tight monetary policy regimes. Even after considering the impact of the 2008 financial crisis and the interaction effects of bank characteristics and monetary policy, these conclusions remain valid. This suggests that bank risk-taking is influenced not only by the strengthening of bank capital regulations but also by differences in loose or tight monetary policy regimes.

Apart from the introduction, the second section of this paper discusses and reviews the literature, the third section introduces the research methodology, the fourth section explains the data and analyzes the empirical results, and finally, the conclusion is presented.

2. Literature review

Empirical research on bank risk-taking, Gaggl and Valderrama (2010), using Austrian bank lending data, analyzed that during the period of low interest rates from 2003 to 2005, there was an increase in expected default rates for corporate loans. Jiménez et al. (2014) analyzed Spanish banks from 1984 to 2006 and indicated that low interest rates environment reduce the default probability of existing loans and make banks reduce lending conditions and engage in riskier loans, expanding their lending to borrowers with poorer credit and higher risk.

Altunbas et al. (2014) discussed the impact of loose monetary policy on EU and US bank risks using individual bank expected default frequency from the KMV credit risk model. After controlling the effects of macroeconomic factors and bank characteristics, Altunbas et al. (2014) pointed out that a persistently low-interest rate environment increases bank risk. Therefore, from a financial stability perspective, monetary policy is not neutral.

Montes and Scarpari (2015) discussed whether central bank policy communication affects bank risk-taking. Analysis using Brazilian data showed that bank provisions increase with pessimistic views of future economic conditions by monetary authorities and decrease with policy rate cuts. This demonstrates that perceptions of future interest rates and the overall economic situation released through monetary policy affect bank strategies and risk-taking.

Ha and Quyen (2018) analyzed Vietnamese commercial banks from 2007 to 2016, using Z-scores to represent bank risk, and showed that bank risk-taking increases with loose monetary policy. Additionally, Ha and Quyen (2018) noted that bank risk-taking is also related to market power, with banks having more market power exhibiting lower risk-taking tendencies, indicating that bank risk-taking increases with market competition. Qiao et al. (2018) discussed the impact of internet finance on risk-taking in the Chinese banking industry using Z-scores and non-performing loan ratios as bank risk. Empirical evidence showed that bank risk-taking increases not only with loose monetary policy but also with the rise of internet finance, reinforcing the role of loose monetary policy in bank risk-taking.

Özşuca and Akbostancı (2016) demonstrated the impact of monetary policy changes on bank risk in Turkey from 2002 to 2012 using the deviation of policy rate from benchmark rate as monetary policy changes. Empirical results indicated that bank risk-taking increases with policy rates below the benchmark level. Regarding bank characteristics, risk-taking tends to be lower for larger, more liquid, and better-capitalized banks.

Paligorova and Santos (2017) discussed the existence of channels for bank risk-taking in corporate loans pricing in the United States. Empirical evidence showed that during loose monetary policy phases, for risk appetite banks, the risk premium for risky corporate loans is lower than the one in tight monetary policy phases, indicating that monetary policy affects bank risk-taking through these channels.

Furthermore, literature suggests that bank risk-taking is influenced by changes in bank capital regulation and shifts between loose and tight monetary policy regimes. Regarding the impact of bank capital regulation, literature indicates that the effect of increasing capital requirements on reducing bank risk is a controversial issue. On one hand, due to deposit insurance protection, banks may engage excessively in risky activities at the expense of depositors to maximize shareholder value. To prevent such moral hazard issues, Kim and Santomero (1988) suggest increasing capital requirements proportionally to the increasing risk undertaken by banks to internalize bank losses. The 'too big to fail' perspective also suggests a similar phenomenon, where government bailouts serve as a backstop, leading systemic banks to engage in excessive risk-taking behavior. Therefore, the regulatory hypothesis suggests that capital requirements should increase with the rising risk undertaken by banks, implying a positive relationship between capital requirements and bank risk. However, on the other hand, Anginer and Demirgüç-Kunt (2014) argue that increasing capital requirements can strengthen banks' ability to cope with unexpected adverse economic shocks, meet depositors' withdrawal demands, and allow bank owners to make investment choices more prudently. Therefore, stricter capital requirements can reduce banks' vulnerability, thus mitigating moral hazard issues caused by deposit insurance. Thus, policies that make banks have skin in the game through increased capital can enhance banks' risk monitoring and scrutiny attitudes, thereby reducing bank risk, indicating an inverse relationship between increased capital regulation and bank risk. Although the latter is conventional view, after the 2008 global financial crisis, there has been literature supporting the notion that capital regulation may increase bank risk-taking. Some literature even criticizes Basel II for insufficient risk-based capital requirements, leading to an inability to curb bank risk-taking. With the introduction of Basel III in 2010, which imposes risk-based capital regulations on banks, the main aim is to reduce incentives for bank risk-taking to enhance banking stability, but it also subjects banks to stricter capital regulations.

Related empirical studies like Mujtaba et al. (2022) and Dias (2021) indicate that increasing or tightening capital regulations lead to increased bank risk-taking. Mujtaba et al. (2022) analyzed Asian emerging markets from 2004 to 2017 using non-performing loan ratios and loan loss reserve ratios to represent bank risk. Their analysis showed a positive relationship between bank risk-taking and the ratio of own capital, supporting the regulatory hypothesis. Based on Calem and Rob (1999) models analyzing the effect of capital regulations on bank risk-taking, Dias (2021), covering over 1800 banks in more than 135 countries globally from 2011 to 2015, showed that the Z-score exhibits an inverted U-shaped relationship with increasing capital regulation, indicating a non-linear interaction between bank risk and capital regulation. Furthermore, Dias (2021) noted that stricter regulations weaken the effectiveness of reducing bank risk-taking through increased capital and risk-based capital requirements, whether for well-capitalized or undercapitalized banks, induce bank risk-taking at higher capital ratios.

Regarding the association between bank risk-taking and monetary policy regimes, Djatche (2019) pointed out that while studies suggest a low-interest-rate environment encourages bank risk-taking behavior, there are also studies indicating that low-interest rates are beneficial to banks and do not increase bank risk (Kane, 1989; Smith, 2002; Agur and Demertzis, 2012; Korinek and Simsek, 2016; Brummermeier and Koby, 2016). Therefore, Djatche (2019) believes that the impact of loose monetary policy on bank risk varies with different monetary policy regimes. Using Z-scores to represent bank risk and the deviation of policy rate from Taylor rule rate(Taylor gap) as a threshold variable, Djatche (2019) conducted empirical analysis on US banking data using the Hansen (1999) threshold model, showing that the impact of loose monetary policy on bank risk changes with different monetary policy regimes. When the Taylor gap is below the threshold, due to the relatively low market rates, the pursuit of profitable investments makes risky investments more attractive, thus loose monetary policy increases bank risk-taking. This aligns with Rajan (2005)'s view that banks pursue higher returns. Conversely, when the Taylor gap is above the threshold, loose monetary policy favors banking stability because rate cuts reduce bank costs.

3. Methodology

Whether the bank risk taking channel exists, as set forth by Altunbas et al. (2014), can be tested by following equation :

$$Risk_{i,t} = \alpha_0 + \alpha_1 Risk_{i,t-1} + \beta M_t + \lambda Size_{i,t} + \rho Cap_{i,t} + \delta Liq_{i,t} + \upsilon y_t + \omega \pi_t + \xi ex_t + \varepsilon_{i,t} \qquad (1)$$

where $Risk_{i,t}$ is the risk level of a bank, i is bank and t is time, and $\varepsilon_{i,t}$ is the independently and identical distributed error term. M_t stands for changes in monetary policy. $Size_{i,t}$、 $Cap_{i,}$ and $Liq_{i,t}$ represent the bank specific characteristics such as size, capitalization and liquidity, respectively. And y_t , π_t and ex_t are the major macroeconomic variables such as economic growth rate, inflation rate and exchange rate changes, for controlling the effects of economic environment on bank risks.

We use both the Z-score and nonperforming-loan ratio of the bank to represent the risk level of bank. The justification for using Z-score is to highlight the relationship between a bank's capital and the volatility of its returns, which reflects how much variability in returns could be absorbed by a bank's capital without putting the bank into insolvency. Z-score is the natural logarithm of the index which is calculated by the following equation:

$$Z_{it} = \frac{ROA_{it} + \frac{E_{it}}{A_{it}}}{\sigma(ROA_i)} \quad (2)$$

where ROA_{it} is the return on assets of bank, calculated by after-tax profit on eh total assets. E_{it} and A_{it} are the bank equity and total assets of the bank, respectively. $\sigma(ROA_i)$ is the standard deviation of the return on assets of bank. According to equation (2), Z-score rises as the increase in ROA_{it} and E_{it} , or decrease in $\sigma(ROA_i)$, therefore the bank risk will increase as Z-score falls. The nonperforming loan ratio is equal to the amount of nonperforming loans divided by the total number of loans, used to indicate the potential adverse impact of deteriorating loan quality on bank profitability and market value. The nonperforming loan ratio represents the loan portfolio risk or credit risk faced by banks. An increase in the nonperforming loan ratio indicates higher credit risk faced by banks, thus bank risk rises as the nonperforming loan ratio increases. [1]

This study uses the interbank overnight lending rate as the proxy of monetary policy. Regarding the demonstration of monetary policy changes, changes in interest rates (Djatche, 2019; Sarkar and Sensarma, 2019) or the gap between policy rates and the natural interest rate (Altunbas et al., 2014; Özşuca and Akbostancı, 2016) are utilized. Therefore, the research process will analyze these two settings separately to explore the similarities and differences in the results obtained.

About the three bank-specific characteristics, size, capitalization and liquidity, we use two approaches to get these variables. The first approach (referred to as "C1" in the text), following Ehrmann et al. (2003) and Gambacorta (2005), we define the bank characteristic variables as:

$$\begin{aligned} Size_{i,t} &= \log A_{i,t} - \frac{1}{N_t}\sum_i \log A_{i,t} \\ Cap_{i,t} &= \frac{C_{i,t}}{A_{i,t}} - \frac{1}{T}\sum_t \left(\frac{1}{N_t}\sum_i \frac{C_{i,t}}{A_{i,t}}\right) \\ Liq_{i,t} &= \frac{L_{i,t}}{A_{i,t}} - \frac{1}{T}\sum_t \left(\frac{1}{N_t}\sum_i \frac{L_{i,t}}{A_{i,t}}\right) \end{aligned} \quad (3)$$

where size is measured by the log of total assets, $A_{i,t}$. Liquidity is defined as the ratio of liquid assets $L_{i,t}$ (cash, interbank lending and securities) to total assets, and capitalization is given by the ratio of equity, C_{it}, to total assets. As seen, all three bank characteristics are normalized with respect to their average across all the banks in a given sample. To eliminate trend in size, the sample is normalized not only over the whole period but also over each single period (Ehrmann et al., 2003). The second approach ("C2") refers to the specification outlined by Dang and Dang (2020), where bank size is equal to the natural logarithm of total assets, capitalization level is calculated by dividing bank equity by total assets, and liquidity is defined as liquid assets divided by total assets. Since these bank characteristic variables may impact the risk of banks, higher levels of capitalization tend to reduce bank risk, while lower liquidity may increase the probability of bank failure. Moreover, larger bank size can provide protection against risks on one hand, but on the other hand, it may become too big to fail, thus increasing the risk the bank undertakes. Therefore, in the analytical process, bank characteristics such as capitalization, liquidity, and size are included in the regression equation to control for the influence of these factors on bank risk (Brana et al., 2019).

[1] Since Z-score is an inverse measure of bank risk, i.e., higher the value of Z-score lower the risk, we expect the opposite sign on the estimated coefficients when the Z-score replaces the nonperforming loan ratio as the dependent variable.

To further investigate whether the effects of bank characteristic variables on bank risk are affected by loose monetary policy and hence bank risk taking channel monetary transmission channel might be altered by bank characteristics, we add the interaction terms between each bank characteristic variable and monetary policy into equation (1):

$$\begin{aligned} Risk_{i,t} = {} & \alpha_0 + \alpha_1 Risk_{i,t-1} + \beta M_t + \lambda Size_{i,t} + \rho Cap_{i,t} + \delta Liq_{i,t} \\ & + \sigma M_t Size_{i,t} + \tau M_t Cap_{i,t} + \varsigma M_t Liq_{i,t} + \upsilon y_t + \omega \pi_t + \xi ex_t + \varepsilon_{i,t} \end{aligned} \tag{4}$$

According to equation (4), when the estimates of the interaction terms between the bank characteristic variables and monetary policy are positive and statistically significant, it implies that the role of banks in transmitting monetary policy through risk-taking is strengthened as capitalization level, liquidity, and size of banks increase.

Furthermore, considering potential changes in bank risk-taking due to alterations in banking capital regulations (Mujtaba et al., 2022; Dias, 2021) and differences in the phase of monetary policy easing or tightening (Djatche, 2019), these factors are also incorporated into the analytical framework. Concerning banking capital regulations, since the Taiwan Financial Supervisory Commission mandated banks to adhere to Basel III standards in 2013, thereby increasing bank capital, to account for the possible impact of these capital control regulations on bank risk, equation (1) can be rewritten as equation (5):

$$\begin{aligned} Risk_{i,t} = {} & \alpha_0 + \alpha_1 Risk_{i,t-1} + (\beta_1 + \beta_2 * \text{dummy}_{\text{Basel III}}) M_t \\ & + \lambda Size_{i,t} + \rho Cap_{i,t} + \delta Liq_{i,t} + \upsilon y_t + \omega \pi_t + \xi ex_t + \varepsilon_{i,t} \end{aligned} \tag{5}$$

where $\text{dummy}_{\text{Basel III}}$ represents a dummy variable indicating whether Basel III regulations are in effect, with value 0 before 2012 and 1 after 2013. Based on the specification of equation (5), the impact of monetary policy changes on bank risk is determined by the signs of β_1 and β_2. When the non-performing loan ratio reflects bank risk and banks engage in risk-taking behavior that increases with stricter Basel III capital regulations, the sign of β_2 should be negative, while the sum of β_1 and β_2 is less than zero. Alternatively, when using Z-scores to indicate the level of bank risk, the sign of β_2 should be positive, while the sum of β_1 and β_2 is greater than zero. If further considering the potential impact of interactions between bank characteristic variables and monetary policy on bank risk-taking, equation (5) can be rewritten as:

$$\begin{aligned} Risk_{i,t} = {} & \alpha_0 + \alpha_1 Risk_{i,t-1} + (\beta_1 + \beta_2 * \text{dummy}_{\text{Basel III}}) M_t + \lambda Size_{i,t} + \rho Cap_{i,t} + \delta Liq_{i,t} \\ & + (\sigma_1 + \sigma_2 * \text{dummy}_{\text{Basel III}}) M_t Size_{i,t} + (\tau_1 + \tau_2 * \text{dummy}_{\text{Basel III}}) M_t Cap_{i,t} \\ & + (\varsigma_1 + \varsigma_2 * \text{dummy}_{\text{Basel III}}) M_t Liq_{i,t} + \upsilon y_t + \omega \pi_t + \xi ex_t + \varepsilon_{i,t} \end{aligned} \tag{6}$$

Regarding the impact of changes in monetary policy regimes on bank risk, Djatche (2019) and Brana et al. (2019) have noted that the relationship between bank risk-taking and monetary policy changes varies depending on the state of monetary policy. To account for this, the research process employs the deviation of policy rate from the natural rate (q_t) to represent different phases of monetary policy. When this deviation is greater than zero or less than zero, it indicates that monetary policy is in a tightening or easing state, respectively. Therefore, the phenomenon of bank risk-taking varying with different states of monetary policy can be presented by reformulating equation (1) into equation (7):

$$\begin{aligned} Risk_{i,t} = {} & \alpha_0 + \alpha_1 Risk_{i,t-1} + \beta_1 M_t \mathrm{I}(q_t \le 0) + \beta_2 M_t \mathrm{I}(q_t > 0) \\ & + \lambda Size_{i,t} + \rho Cap_{i,t} + \delta Liq_{i,t} + \upsilon y_t + \omega \pi_t + \xi ex_t + \varepsilon_{i,t} \end{aligned} \tag{7}$$

where q_t represents the threshold variable indicating the state of monetary policy, and $\mathrm{I}(.)$ is the indicator function. β_1 and β_2 denote the effects of monetary policy easing or tightening intervals on the impact of monetary policy changes on bank risk. When using the non-performing loan ratio to indicate bank risk, if the phenomenon of increased bank risk-taking due to monetary easing only occurs during periods of loose monetary policy, then the signs of β_1 and β_2 should respectively be negative and positive. Conversely, when using Z-scores to indicate bank risk, the signs of β_1 and β_2 should respectively be positive and negative.

4. Results

Due to the interest rate hikes initiated by the United States since 2022, global interest rates have risen. Therefore, this study takes the longitudinal and cross-sectional data of 33 domestic banks in Taiwan from 2006 to 2020 as the analytical objects to discuss whether loose monetary policy in a low-interest-rate environment will increase bank risk and whether banks exhibit risk-taking behavior. The data necessary for calculating bank characteristics and bank risk are collected from the Statistical Database Query System of the Banking Bureau of the Financial Supervisory Commission.

Regarding the calculation of equation (3) for bank characteristic variables, total assets are derived from the balance sheet of domestic banks (asset-liability balance sheet), liquid assets are represented by cash and cash equivalents on the balance sheet, including deposits with central banks and interbank borrowings, which are combined as substitute variables, and bank equity is obtained from the equity item on the balance sheet. The calculation of the Z-score indicating bank risk, according to the content of equation (2), involves the asset return rate, which is net profit divided by total assets, with net profit data obtained from the pre-tax earnings item on the income statement of financial institutions, and total assets and bank equity are sourced separately from the asset and equity items on the balance sheet. The calculation of the standard deviation of asset return rates adopts a rolling method referenced from literature, calculating the standard deviation every three years, and then computing the Z-score based on the corresponding asset return rate and equity ratio. As for the data on the non-performing loan ratio, it is directly obtained from the Banking Bureau's statistical database.

The main macroeconomic variables include economic growth, inflation, and exchange rate fluctuations. Economic growth data is sourced from the Directorate-General of Budget, Accounting and Statistics, which publishes economic growth rate data. Inflation is represented by the annual growth rate of the Consumer Price Index, and exchange rate fluctuations are based on the movement of the New Taiwan Dollar against the US Dollar. These data are obtained respectively from the databases of the Directorate-General of Budget, Accounting and Statistics and the Central Bank of Taiwan.

As the proxy variables for monetary policy, the overnight interbank lending rate is used, and both the policy rate deviation from the natural rate and the changes in the lending rate represent the variables of monetary policy changes in the study. The natural interest rate will be estimated using the HP filter method.

Finally, regarding the estimation of the relationship between monetary policy changes and bank risk-taking, such as equations (1), (4) to (7), the endogeneity issues arise due to the dependent variables being related to their lagged values and the use of panel data of banks, which may face endogeneity issues such as the bank asset size expanding with loan growth and changes in the capitalization level accompanying changes in bank size. This could lead to biased estimation results.

To address this concern, the study employs the Generalized Method of Moments (GMM) system estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998), obtaining results through a two-step estimation process. When the selected instrumental variables are appropriate and the residuals exhibit no second-order serial correlation, the estimates will possess properties of consistency and efficiency. Regarding the selection of instrumental variables, lagged values of the dependent and explanatory variables are chosen. The study utilizes the Hansen over-identification test to examine whether the selected instrumental variables are correlated with the error term, verifying the appropriateness of the chosen instrumental variables.

4.1 Bank risk-taking analysis

Table 1 presents the results of estimating equation (1) using different bank characteristics calculation methods (C1 and C2), with bank risk represented by Z-scores and non-performing loan ratios(NPL), and different monetary policy variables (interest rate gap("M1") and interest rate changes("M2")). In the upper panel of Table 1, where Z-scores represent bank risk and the interest rate gap represents monetary policy changes, the estimated coefficients of β are positive for both C1 and C2. This indicates that Z-scores decrease with loose monetary policy, suggesting that bank risk increases with loose monetary policy, indicating a risk-taking behavior by banks. However, the estimated coefficient of β is statistically significant only at the 10% level for C1 and not significant for C2. When interest rate changes represent monetary policy changes, regardless of C1 or C2, the estimated coefficients of β are negative. This suggests that bank risk does not increase with loose monetary policy, indicating that banks do not exhibit a risk-taking tendency.

If bank risk is represented by non-performing loan ratios, as shown in the lower panel of Table 1, the estimated coefficients of β are positive and statistically significant regardless of the monetary policy variables and the method of calculating bank characteristics. This indicates that non-performing loan ratios do not increase with loose monetary policy, suggesting that banks do not engage in risk-taking behavior.

Regarding the impact of macroeconomic variables on bank risk, the effect of inflation on Z-scores and non-performing loan ratios is positive and negative, respectively, indicating that rising inflation is beneficial for reducing bank risk. The Hansen test and the second-order autocorrelation test for residuals for all estimation results show p-values greater than the 10% level, indicating the appropriateness of instrumental variable selection and the suitability of the estimation results.

In summary, based on the estimation results of equation (1), only when Z-scores represent bank risk and the interest rate gap represents monetary policy changes, along with bank characteristics calculated using C1, supports the conclusion that bank risk increases with loose monetary policy, suggesting a risk-taking behavior by banks. Other results either lack statistical significance or do not align with the expectations of banks exhibiting risk-taking behavior. Overall, the estimation of the impact of monetary policy changes on bank risk in equation (1) does not provide clear evidence to support the inference of banks engaging in risk-taking behavior.

In the research process, the impact of the 2008 global financial crisis is further considered by incorporating a dummy variable to represent the effect of the financial crisis. This dummy variable is included in equation (1) as an explanatory variable for estimation. Regarding the setting of the financial crisis dummy variable, the years 2008 and 2009 are considered as the stages affected by the financial crisis. Therefore, the dummy variable takes the value of 1 for these years and 0 for the remaining years. The estimation results are presented in Table 2.

Similar to the results in Table 1, only in the combination of Z-scores, interest rate gap, and C1, the estimated coefficient of β is significant and positive, supporting the notion that banks exhibit risk-taking behavior. The estimation results for other combinations using either Z-scores or non-performing loan ratios as explanatory variables do not support the hypothesis that bank risk-taking behavior increases with loose monetary policy.

Additionally, considering the interaction between bank characteristics and monetary policy on bank risk, as described in equation (4), the estimation results are presented in Table 3. Again, similar to the results in Table 1, only in the combination of Z-scores, interest rate gap, and C1, there is support for banks exhibiting risk-taking behavior.

In summary, regardless of considering the financial crisis or the interaction between bank characteristics and monetary policy on bank risk, all estimation results from Tables 1 to 3 only indicate banks exhibiting risk-taking behavior in the combination of Z-scores, interest rate gap, and C1. Thus, the support for the inference of banks exhibiting risk-taking behavior is not evident.

4.2 Capital Regulation, monetary policy regime and bank risk-taking

Might the oversight of changes in capital controls and variations in monetary policy intervals in equation (1) be why the empirical results do not support the hypothesis that banks do not possess risk-taking behavior? To delve deeper into this, the analytical approach is refined using equations (5) and (7) to explore the effects of changes in capital controls and differences in monetary policy regimes on bank risk-taking behavior.

In the analysis process using equation (5), a dummy variable is set to differentiate the impact of changes in capital control regulations by the Financial Supervisory Commission before and after 2013. The estimation results are shown in Table 4. According to the content of the table, before the implementation of Basel III, the results using Z-scores and non-performing loan ratios as the dependent variables indicate that the estimated coefficients of β_1 are negative and positive, respectively. This suggests that bank risk does not increase with loose monetary policy, indicating that banks do not exhibit risk-taking behavior. However, after the implementation of Basel III capital controls in 2013, the estimated coefficients of β_2 for Z-scores and non-performing loan ratios change to positive and negative, respectively. Further, when β_1 and β_2 are summed, the results for Z-scores and non-performing loan ratios are positive and negative, respectively. This indicates that after the implementation of Basel III capital control regulations, bank risk increases with loose monetary policy, suggesting that banks exhibit risk-taking behavior, implying that strengthened capital controls lead to increased bank risk, consistent with the regulatory hypothesis.

Furthermore, incorporating the effects of the global financial crisis and the interaction between bank characteristics and monetary policy into equation (5), the relevant estimation results are shown in Tables 5 and 6. The content of these two tables consistently indicates that when Z-scores represent bank risk, the estimated coefficients of β_1 and β_2 are negative and positive, respectively, in the upper half of the table. The former is partially statistically significant, while the latter is all statistically significant. Additionally, the sum of β_1 and β_2 is greater than zero, indicating that banks exhibit risk-taking behavior. Similarly, in the lower half of the tables, when bank risk is represented by non-performing loan ratios, the estimated coefficients of β_1 and β_2 are positive and negative, respectively, with both statistically significant, and the sum of β_1 and β_2 is less than zero. These results all support the hypothesis that banks exhibit risk-taking behavior.

Based on the content of Tables 4 to 6, regardless of whether considering the impact of financial crises and the interaction between bank characteristics and monetary policy, and whether using Z-scores or the loan-to-default ratio to represent bank risk, the estimates consistently indicate that bank risk does not increase with loose monetary policy before the implementation of Basel III. However, after the implementation of Basel III, bank risk increases with loose monetary policy. This implies that with the strengthening of bank capital regulation under Basel III, it changes banks' willingness to bear risk, leading to a positive relationship between bank risk and loose monetary policy. This finding is consistent with the regulatory hypothesis.

Regarding the impact of the difference between monetary policy regimes (loose or tight) on bank risk, the study utilizes the specification of equation (7) to examine the effects. The results of adopting the deviation of policy interest rates from the natural interest rate gap (q_t) to represent changes in monetary policy phases are presented in Table 7. The upper part of the table, with Z-scores as the dependent variable, indicates that when using the interest rate gap to represent changes in monetary policy, the signs of the estimates β_1 and β_2 are positive and negative, respectively. This shows that during periods of loose monetary policy, Z-scores decrease with loose monetary policy, indicating increased bank risk due to loose monetary policy, suggesting banks exhibit risk-taking behavior. However, the estimates are statistically significant under C1 but not under C2. When monetary policy is in a tightening phase, there is an inverse relationship between Z-scores and monetary policy, indicating that bank risk does not increase with loose monetary policy, suggesting banks do not exhibit risk-taking behavior. Results using interest rate changes as a proxy for monetary policy show that β_1 are negative regardless of the calculation method for bank characteristics, while β_2 is negative under C1 and positive under C2. This suggests that during periods of loose monetary policy, bank risk does not increase with loose monetary policy, indicating banks do not exhibit risk-taking behavior. As the estimate β_2 is positive under C2, it suggests that bank risk increases with loose monetary policy, and risk-taking behavior occurs during periods of monetary policy tightening. Results using the loan-to-default ratio to represent bank risk, as listed in the lower part of Table 7, show that when using the interest rate gap as a proxy for monetary policy changes, the signs of β_1 and β_2 are negative and positive, respectively, and both are statistically significant. This indicates that the phenomenon of increased bank risk with loose policy only occurs during periods of loose monetary policy; during periods of monetary policy tightening, banks do not exhibit risk-taking behavior. Results using interest rate changes as a proxy for monetary policy show that the signs of and are both positive, with only the latter being statistically significant. This indicates that bank risk does not increase with loose monetary policy regardless of the monetary policy regime, suggesting banks do not exhibit risk-taking behavior.

To verify the robustness of the inference from Table 7, the analysis further incorporates the impact of financial crises and the interaction between bank characteristics and monetary policy into equation (7). The relevant estimation results are presented in Tables 8 and 9. The content of Table 8 indicates that when using the interest rate gap as the variable representing monetary policy changes the signs of β_1 and β_2 in the upper panel are positive and negative, these estimates are negative and positive in lower panel of respectively, and all estimates are statistically significant. This implies that regardless proxy of bank risk, the phenomenon of bank risk increasing with loose monetary policy only occurs during the loose monetary policy reimge, and this phenomenon does not hold during the monetary policy tightening phase. When using interest rate changes as a proxy for the monetary policy variable, the signs of β_1 and β_2 in the upper panel are mostly negative, while in the lower panel, they are all positive. Additionally, only under Z-scores with C2, the sign of is positive, supporting the phenomenon of bank risk increasing with loose monetary policy. Similarly, the content of Table 9 shows that when using the interest rate gap to represent monetary policy changes, the signs of β_1 and β_2 are consistent with those shown Table 8. This indicates that the inference where bank risk increases with loose monetary policy can be sustained. However, the results using interest rate changes as a proxy for the monetary policy variable cannot support this inference.

Summarizing the findings from Tables 7 to 9, using positive or negative interest rate gap to demonstrate monetary policy tightening or loosening and regardless the proxy of bank risk, the estimates by adopting the interest rate gap as a measure for monetary policy changes consistently indicate that bank risk tends to rise only during periods of loose monetary policy. This suggests that banks exhibit the tendency for risk-taking behavior when monetary policy is easing. However, there's insufficient evidence to support the idea that bank risk increases with loose monetary policy during periods of monetary policy tightening. The results consistently reveal that bank risk-taking behavior varies with different monetary policy phases, aligning with the assertion that banks tend to take on more risk when monetary policy is loose, as suggested by Djatche (2019). This underscores the notion that in a low-interest-rate environment, banks may pursue higher returns, as highlighted by Rajan (2005). Nevertheless, when using interest rate changes as indicators of monetary policy changes, the evidence supporting the idea of increased bank risk during loose monetary policy periods is not conclusive. Only in the case of Z-scores with C2 in Tables 7 and 8 does it suggest that banks exhibit risk-taking behavior during periods of monetary policy tightening. The inference drawn from the remaining results contradicts this notion.

5. Conclusion

This study investigates whether banks tend to increase their risk-taking behavior with loose monetary policy, particularly in a low-interest-rate environment. Using panel data from 2006 to 2020 of the Taiwan banking sector before the global interest rate trend reversal in 2022, the analysis employs the GMM method of Arellano and Bover (1995) and Blundell and Bond (1998) to conduct empirical analysis.

The study employs Z-scores and the non-performing loan ratio to represent bank risk, while using the interest rate gap and interest rate changes to indicate the changes in monetary policy. The empirical findings suggest that without considering the impact of Basel III capital regulations and differences in monetary policy regimes, most estimates do not support the notion of banks exhibiting risk-taking behavior, and there's no sufficient evidence indicating that bank risk increases with loose monetary policy.

However, after considering the impact of strengthened capital controls under Basel III, the results show that bank risk does not increase with loose monetary policy before the implementation of Basel III. Yet, after Basel III implementation in 2013, loose monetary policy tends to increase bank risk, suggesting that banks exhibit risk-taking behavior in response to stricter bank capital regulations, aligning with the regulatory hypothesis. Regardless of whether bank characteristics are calculated using C1 or C2, and after taking the effects of financial crises and the interaction between bank characteristics and monetary policy into consideration, the inference that bank risk increases with strengthened capital regulations can still hold.

Moreover, when considering the influence of differences in monetary policy intervals on bank risk response to loose monetary policy, the findings suggest that the phenomenon of bank risk increasing with loose monetary policy only occurs during periods of loose monetary policy. During periods of monetary policy tightening, this phenomenon does not hold, indicating that banks do not exhibit risk-taking behavior. These conclusions are consistent whether using Z-scores or the loan-to-default ratio to represent bank risk, particularly evident when the loan-to-default ratio is utilized as a substitute variable for bank risk. Regardless of the calculation method for bank characteristics or additional considerations, such as financial crises and the interaction between bank characteristics and monetary policy, the results clearly indicate that bank risk-taking behavior varies with different monetary policy intervals, with banks exhibiting risk-taking behavior during loose monetary policy phases and not during periods of monetary policy tightening.

In terms of policy implications, with the Financial Supervisory Commission designating six banks as domestic systemically important banks (D-SIBs) and requiring these banks to increase their common equity Tier 1 capital ratio, Tier 1 capital ratio, and capital adequacy ratio annually, there's a concern raised by the inference obtained from this study regarding the relationship between increased bank capital regulation and bank risk-taking behavior. By requiring D-SIBs to enhance their capital as part of macroprudential policy, authorities aim to reduce market systemic risk and enhance the resilience of the financial system. However, there's a possibility that this requirement may inadvertently lead to increased risk-taking tendencies among these banks, potentially undermining their ability to cope with financial crises. This highlights the importance for authorities to closely observe and supervise the effects of such policies.

Furthermore, in terms of the transmission of monetary policy effects, with the implementation of Basel III bank capital regulation, the channel through which monetary policy affects bank risk-taking behavior emerges with loose monetary policy, enhancing the transmission of loose monetary policy effects. Additionally, in the loose monetary policy interval, there is also the emergence of the bank risk-taking channel in monetary policy transmission, which positively impacts the effectiveness of loose monetary policy. Therefore, in addition to traditional monetary policy transmission mechanisms such as the interest rate channel, balance sheet channel, and bank lending channel, monetary authorities need to consider the impact and role of the bank risk-taking channel when evaluating policy effectiveness, especially when implementing loose measures.

Table 1：Monetary policy and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	0.704(0.036)***	0.303(0.089)***	0.750(0.050)***	0.173(0.080)**
β	0.339(0.179)*	-0.826(0.237)***	0.111(0.180)	-1.186(0.196)***
λ	0.187(0.184)	1.209(0.460)***	0.252(0.229)	1.815(0.386)***

ρ	7.717(6.636)	46.58(22.79)**	8.496(6.586)	19.83(10.32)*
δ	1.050(1.566)	-0.025(6.581)	1.295(1.764)	1.009(1.731)
υ	-0.104(0.019)***	-0.117(0.018)***	-0.108(0.021)***	-0.117(0.015)***
ω	0.223(0.073)***	0.400(0.069)***	0.293(0.075)***	0.468(0.060)***
ξ	-0.032(0.017)*	-0.015(0.017)	-0.031(0.017)*	-0.007(0.014)
α_0	1.552(0.193)***	3.262(0.447)***	-2.944(2.959)	-22.32(5.290)***
Hansen test	0.140	0.186	0.132	0.182
AR(1)/AR(2)	0.000/0.151	0.002/0.193	0.000/0.190	0.001/0.218
	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	0.575(0.101)***	0.381(0.131)***	0.518(0.146)***	0.377(0.164)**
β	0.546(0.126)***	0.687(0.212)***	0.533(0.136)***	0.583(0.193)***
λ	-0.160(0.155)	-0.280(0.216)	-0.324(0.269)	-0.312(0.274)
ρ	-6.794(5.724)	-6.193(5.114)	-6.917(4.803)	-6.739(4.724)
δ	1.117(0.553)**	0.637(0.450)	0.409(0.566)	-0.183(0.496)
υ	-0.014(0.009)	-0.017(0.008)**	-0.016(0.009)*	-0.020(0.008)***
ω	-0.050(0.023)**	-0.117(0.062)**	-0.059(0.039)	-0.106(0.066)
ξ	-0.002(0.007)	-0.008(0.009)	-0.004(0.007)	-0.009(0.010)
α_0	0.276(0.099)***	0.202(0.095)**	5.173(4.110)	4.988(4.152)
Hansen test	0.162	0.166	0.196	0.176
AR(1)/AR(2)	0.249/0.363	0.245/0.371	0.248/0.355	0.242/0.351

Note: In the parentheses are standard deviations. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. AR(1) and AR(2) represent first-order and second-order autocorrelation tests on the regression residuals. The Hansen test and the AR(1)/AR(2) statistics correspond to the p-values of the tests.

Table 2: Monetary policy, financial crisis and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	0.857(0.069)***	0.821(0.089)***	0.927(0.085)***	0.213(0.083)***
β	0.487(0.273)*	-0.360(0.165)**	0.217(0.201)	-1.185(0.196)***
λ	-0.091(0.250)	-0.330(0.269)	-0.277(0.270)	1.761(0.356)***
ρ	8.477(19.34)	6.678(7.398)	5.779(8.408)	19.72(10.79)*
δ	3.264(6.227)	0.230(1.952)	1.627(2.137)	0.507(1.579)
υ	-0.023(0.028)	-0.055(0.029)*	-0.048(0.028)*	-0.079(0.030)***
ω	0.257(0.073)***	0.416(0.078)***	0.283(0.082)***	0.471(0.065)***
ξ	-0.014(0.015)	-0.019(0.018)	-0.029(0.017)*	-0.002(0.014)
Criss dummy	0.947(0.262)***	0.804(0.227)***	0.863(0.256)***	0.450(0.343)
α_0	0.587(0.398)	0.758(0.490)	3.380(3.529)	-21.82(4.947)***
Hansen test	0.331	0.123	0.138	0.215
AR(1)/AR(2)	0.000/0.203	0.000/0.340	0.000/0.202	0.001/0.287
	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	0.496(0.159)***	0.338(0.148)**	0.412(0.192)***	0.286(0.170)*

β	0.536(0.138)***	0.606(0.181)***	0.579(0.159)***	0.602(0.168)***
λ	-0.148(0.184)	-0.242(0.197)	-0.376(0.290)	-0.346(0.266)
ρ	-6.517(6.034)	-6.929(4.842)	-7.189(4.746)	-6.855(4.534)
δ	0.598(0.453)	-0.025(0.279)	-0.032(0.674)	-0.575(0.724)
υ	0.021(0.034)	0.014(0.023)	0.022(0.030)	0.012(0.019)
ω	-0.048(0.028)*	-0.100(0.053)*	-0.075(0.044)*	-0.113(0.060)*
ξ	0.001(0.003)	-0.004(0.006)	0.001(0.004)	-0.005(0.007)
Criss dummy	0.414(0.357)	0.385(0.247)	0.446(0.337)	0.378(0.216)*
α_0	0.167(0.043)***	0.100(0.055)*	5.869(4.362)	5.420(4.016)
Hansen test	0.179	0.156	0.175	0.159
AR(1)/AR(2)	0.241/0.341	0.242/0.360	0.244/0.339	0.245/0.353

Table 3: Monetary policy, bank characteristics and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	0.712(0.039)***	0.361(0.094)***	0.773(0.065)***	0.196(0.073)***
β	0.483(0.209)**	-0.648(0.293)**	-3.029(3.269)	-1.869(3.237)
λ	0.235(0.198)	0.958(0.439)**	0.006(0.265)	1.629(0.320)***
ρ	9.789(7.427)	43.17(28.53)	10.64(10.07)	21.22(13.36)
δ	1.292(1.457)	1.489(9.058)	0.835(0.215)	1.366(1.743)
σ	0.234(0.150)	0.061(0.139)	0.249(0.202)	0.095(0.204)
τ	5.576(2.749)**	-4.137(5.933)	1.262(13.38)	-2.526(9.548)
ς	-3.719(2.529)	-4.491(4.821)	-3.564(2.764)	-2.228(2.204)
υ	-0.100(0.021)***	- 0.117(0.020)***	-0.116(0.018)***	-0.117(0.015)***
ω	0.229(0.072)***	0.411(0.062)***	0.354(0.081)***	0.468(0.058)***
ξ	-0.034(0.016)**	-0.018(0.019)	-0.037(0.017)**	-0.007(0.015)
α_0	1.482(0.213)***	3.046(0.517)***	0.137(3.461)	-20.04(4.392)***
Hansen test	0.159	0.273	0.134	0.224
AR(1)/AR(2)	0.001/0.113	0.002/0.219	0.000/0.261	0.001/0.221
	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	0.573(0.115)***	0.387(0.138)***	0.539(0.140)***	0.357(0.159)**
β	0.458(0.115)***	0.592(0.209)***	2.176(1.137)*	2.530(1.087)**
λ	-0.157(0.148)	-0.208(0.196)	-0.269(0.243)	-0.278(0.241)
ρ	-8.228(6.865)	-7.394(6.257)	-4.671(3.942)	-6.964(5.514)
δ	1.459(0.697)**	0.061(0.477)	0.804(0.593)	-0.705(0.598)
σ	-0.162(0.085)*	-0.145(0.072)**	-0.153(0.074)**	-0.168(0.072)**
τ	0.699(2.295)	0.777(2.086)	-0.376(1.951)	-0.797(1.978)
ς	2.207(1.162)*	1.530(0.691)**	2.327(0.846)***	1.975(0.957)**
υ	-0.016(0.009)*	-0.018(0.008)**	-0.017(0.008)**	-0.019(0.008)**
ω	-0.049(0.030)	-0.103(0.065)	-0.056(0.038)	-0.098(0.060)
ξ	-0.003(0.005)	-0.006(0.008)	-0.002(0.005)	-0.006(0.008)
α_0	0.294(0.122)**	0.227(0.095)**	4.235(2.593)	4.668(3.760)
Hansen test	0.338	0.281	0.496	0.245
AR(1)/AR(2)	0.250/0.352	0.347/0.367	0.245/0.342	0.243/0.359

Table 4:Basel III regulation, monetary policy and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	0.368(0.078)***	0.167(0.095)*	0.668(0.056)***	0.273(0.119)**
β_1	-0.279(0.373)	-0.801(0.325)**	-0.781(0.202)***	-0.594(0.325)*
β_2	8.369(2.638)***	2.304(0.601)***	10.94(2.136)***	1.704(0.500)***
λ	1.577(0.367)***	1.525(0.495)***	0.006(0.376)	0.897(0.309)***
ρ	51.52(21.09)***	62.71(26.75)**	29.01(24.09)	28.04(14.84)*
δ	8.039(6.467)	7.374(6.549)	7.505(6.054)	3.378(5.798)
υ	-0.112(0.022)***	-0.094(0.022)***	-0.140(0.020)***	-0.096(0.017)***
ω	0.302(0.090)***	0.304(0.091)***	0.483(0.075)***	0.304(0.081)***
ξ	-0.046(0.026)*	-0.040(0.022)*	-0.091(0.019)***	-0.029(0.022)
α_0	2.411(0.398)***	3.476(0.514)***	-2.104(6.169)	-11.59(4.875)**
Hansen test	0.286	0.208	0.325	0.172
AR(1)/AR(2)	0.002/0.116	0.004/0.151	0.000/0.102	0.007/0.172
	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	0.503(0.126)***	0.285(0.164)*	0.449(0.164)***	0.148(0.187)
β_1	0.659(0.177)***	0.744(0.221)***	0.672(0.217)***	0.780(0.167)***
β_2	-3.924(1.680)**	-0.951(0.559)*	-3.782(1.489)**	-1.225(0.446)***
λ	-0.155(0.152)	-0.281(0.222)	-0.310(0.271)	-0.624(0.368)*
ρ	-7.489(5.598)	-6.065(4.380)	-7.831(5.310)	0.411(3.040)
δ	0.546(0.506)	0.464(0.360)	-0.095(0.581)	-0.510(0.719)
υ	-0.004(0.012)	-0.013(0.008)	-0.005(0.011)	-0.015(0.006)**
ω	-0.098(0.046)**	-0.134(0.061)**	-0.117(0.059)**	-0.162(0.062)***
ξ	0.014(0.005)***	0.005(0.003)*	0.014(0.004)***	0.005(0.004)
α_0	0.481(0.193)**	0.398(0.191)**	5.354(4.201)	9.006(5.327)*
Hansen test	0.211	0.172	0.314	0.200
AR(1)/AR(2)	0.260/0.402	0.276/0.516	0.263/0.404	0.301/0.700

Table 5: Basel III regulation, monetary policy, financial crisis and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	0.377(0.094)***	0.179(0.107)*	0.340(0.110)***	0.644(0.086)***
β_1	-0.318(0.475)	-0.782(0.380)**	-0.480(0.487)	-0.302(0.228)
β_2	8.099(2.635)***	2.299(0.595)***	7.138(2.972)**	1.773(0.477)***
λ	1.466(0.432)***	1.484(0.505)***	1.600(0.390)***	0.113(0.291)
ρ	57.44(20.17)***	62.19(27.69)**	55.71(23.76)**	23.14(21.59)
δ	8.295(6.198)	7.285(8.628)	11.21(7.605)	4.349(6.509)
υ	-0.106(0.036)***	-0.086(0.041)**	-0.080(0.036)**	-0.037(0.033)
ω	0.325(0.114)***	0.307(0.100)***	0.406(0.109)***	0.334(0.068)***
ξ	-0.045(0.025)*	-0.037(0.020)*	-0.032(0.029)	-0.039(0.020)*
Criss Dummy	0.099(0.306)	0.092(0.384)	0.344(0.342)	0.790(0.328)**
α_0	2.328(0.525)***	3.395(0.571)***	-24.92(6.015)***	-2.593(5.262)

Hansen test	0.210	0.175	0.169	0.160
AR(1)/AR(2)	0.004/0.127	0.004/0.148	0.005/0.123	0.000/0.139
	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	0.096(0.183)	0.246(0.142)*	0.270(0.149)*	0.198(0.158)
β_1	0.985(0.217)***	0.652(0.173)***	0.827(0.176)***	0.651(0.156)***
β_2	-7.687(2.585)***	-0.829(0.444)*	-4.841(1.301)***	-0.810(0.407)**
λ	-0.598(0.350)*	-0.270(0.195)	-0.387(0.261)	-0.355(0.263)
ρ	-3.605(3.356)	-7.571(4.032)*	-7.999(4.244)*	-7.185(3.648)**
δ	-0.786(0.948)	-0.206(0.404)	-0.630(0.770)	-0.808(0.767)
υ	0.119(0.047)**	0.020(0.017)	0.051(0.022)**	0.018(0.013)
ω	-0.180(0.048)***	-0.114(0.049)**	-0.161(0.053)***	-0.127(0.053)**
ξ	0.048(0.013)***	0.008(0.003)***	0.024(0.004)***	0.007(0.003)**
Criss Dummy	1.302(0.492)***	0.397(0.191)**	0.649(0.227)***	0.399(0.166)**
α_0	0.450(0.129)***	0.276(0.128)**	6.398(3.990)	5.768(3.972)
Hansen test	0.155	0.116	0.156	0.118
AR(1)/AR(2)	0.230/0.357	0.265/0.402	0.259/0.394	0.269/0.410

Table 6: Basel III regulation, monetary policy, bank characteristics and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	0.665(0.090)***	0.593(0.078)***	0.034(0.199)	0.052(0.153)
β_1	-0.681(0.642)	-0.526(0.249)**	-10.28(14.98)	-0.646(0.299)**
β_2	9.534(3.054)***	1.440(0.442)***	564.3(279.6)**	57.88(22.21)**
λ	0.032(0.523)	-0.106(0.338)	2.403(0.652)***	1.949(0.573)***
ρ	28.92(32.50)	8.022(17.39)	41.99(23.59)*	35.07(21.92)
δ	7.246(8.604)	2.852(2.733)	-1.686(10.83)	0.035(7.336)
σ_1	0.413(1.168)	0.057(0.189)	0.694(0.991)	-0.851(0.943)
σ_2	2.289(8.022)	0.525(0.683)	-44.81(22.25)	-3.966(1.885)**
τ_1	-17.09(24.87)	-2.444(8.922)	2.016(30.49)	-4.497(19.51)
τ_2	-334.2(412.9)	34.69(48.23)	486.6(731.9)	-46.42(94.93)
ς_1	-1.773(9.302)	-3.106(2.848)	3.050(12.69)	-3.275(6.429)
ς_2	-74.97(105.3)	-11.96(24.71)	56.69(146.4)	1.989(39.84)
υ	-0.129(0.031)***	- 0.126(0.018)***	-0.035(0.019)*	-0.081(0.018)***
ω	0.487(0.083)***	0.389(0.069)***	0.253(0.094)***	0.266(0.082)***
ξ	-0.082(0.022)***	- 0.053(0.018)***	0.013(0.036)	0.001(0.024)
α_0	1.189(0.431)***	1.831(0.438)***	-31.29(8.188)***	-24.76(7.605)***
Hansen test	0.326	0.210	0.666	0.397
AR(1)/AR(2)	0.001/0.253	0.000/0.223	0.011/0.137	0.037/0.405
	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	0.484(0.125)***	0.188(0.237)	0.367(0.187)**	0.107(0.210)

β_1	0.626(0.166)***	0.725(0.267)***	3.424(1.365)**	6.723(2.019)***
β_2	-3.931(1.874)**	-1.245(0.753)*	-50.42(26.45)*	-25.05(12.34)**
λ	-0.230(0.160)	-0.549(0.393)	-0.522(0.355)	-0.704(0.450)
ρ	-8.417(4.784)*	-5.408(6.420)	-10.16(6.558)	-4.149(9.338)
δ	0.584(0.697)	-1.580(1.766)	-0.085(0.730)	-1.805(1.608)
σ_1	-0.121(0.077)	-0.264(0.087)***	-0.216(0.091)**	-0.447(0.141)***
σ_2	0.919(0.895)	0.727(0.615)	3.094(1.761)*	1.501(0.795)*
τ_1	0.014(3.032)	-1.406(2.819)	-0.747(0.282)	-3.466(4.325)
τ_2	32.07(64.80)	17.78(21.83)	51.34(86.33)	33.14(22.38)
ς_1	1.962(1.399)	1.069(0.933)	1.499(1.051)	0.451(1.309)
ς_2	-0.934(20.53)	9.991(7.851)	2.538(29.04)	11.41(9.154)
υ	-0.004(0.012)	-0.012(0.008)	-0.007(0.011)	-0.018(0.007)***
ω	-0.107(0.047)**	-0.139(0.068)**	-0.144(0.067)**	-0.138(0.047)***
ξ	0.016(0.006)**	0.011(0.005)**	0.015(0.005)***	0.006(0.003)*
α_0	0.506(0.205)**	0.554(0.304)*	8.492(5.387)	10.58(6.52)
Hansen test	0.447	0.303	0.249	0.313
AR(1)/AR(2)	0.265/0.394	0.300/0.646	0.270/0.529	0.307/0.750

Table 7: Monetary policy regimes and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	0.328(0.082)***	0.644(0.060)***	0.249(0.079)***	0.203(0.070)***
β_1	0.836(0.351)**	-1.680(0.478)***	0.470(0.377)	-1.508(0.644)**
β_2	-1.979(0.359)***	-0.695(0.165)***	-1.866(0.438)***	1.025(0.227)***
λ	0.589(0.225)***	0.023(0.215)	1.006(0.254)***	1.603(0.332)***
ρ	15.86(8.788)*	8.462(7.431)	10.52(8.960)	22.31(9.794)**
δ	-1.480(2.099)	1.165(1.812)	-1.130(2.959)	1.210(1.694)
υ	-0.147(0.016)***	-0.116(0.017)***	-0.141(0.016)***	-0.113(0.016)***
ω	0.245(0.069)***	0.464(0.078)***	0.285(0.067)***	0.465(0.074)***
ξ	-0.039(0.017)**	-0.030(0.016)*	-0.028(0.016)*	-0.012(0.013)
α_0	3.336(0.392)***	1.898(0.307)***	-10.70(3.688)***	-19.79(4.607)***
Hansen test	0.117	0.102	0.415	0.161
AR(1)/AR(2)	0.000/0.382	0.000/0.437	0.000/0.346	0.002/0.179
	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	0.115(0.173)	0.426(0.122)***	-0.271(0.135)**	0.381(0.168)**
β_1	-1.634(0.860)*	0.709(0.533)	-2.119(0.502)***	0.543(0.457)
β_2	1.037(0.262)***	0.609(0.228)***	1.593(0.260)***	0.577(0.226)**
λ	-0.351(0.236)	-0.180(0.140)	-0.524(0.285)*	-0.309(0.256)
ρ	-3.910(2.461)	-6.241(3.395)*	-9.369(4.731)**	-6.450(4.577)
δ	-1.970(1.712)	0.292(0.407)	-1.683(1.362)	-0.102(0.594)

υ	-0.052(0.015)***	-0.018(0.009)**	-0.056(0.018)***	-0.021(0.008)***
ω	0.133(0.079)*	-0.102(0.075)	0.107(0.058)*	-0.101(0.080)
ξ	-0.010(0.007)	-0.008(0.008)	-0.011(0.009)	-0.009(0.009)
α_0	0.276(0.072)***	0.177(0.065)***	8.501(4.429)*	4.907(3.858)
Hansen test	0.276	0.158	0.182	0.189
AR(1)/AR(2)	0.285/0.379	0.242/0.368	0.399/0.346	0.241/0.352

Table 8: Monetary policy regimes, financial crisis and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	0.741(0.101)***	0.760(0.073)***	0.730(0.087)***	0.213(0.077)***
β_1	3.757(0.956)***	-1.256(0.512)**	3.914(0.840)***	-1.514(0.631)**
β_2	-2.351(0.578)***	-0.555(0.165)***	-2.484(0.463)***	1.057(0.208)***
λ	-0.117(0.296)	-0.213(0.237)	-0.127(0.277)	1.570(0.313)***
ρ	8.586(13.55)	4.884(8.949)	10.78(17.96)	21.84(10.06)**
δ	3.092(4.278)	0.473(1.421)	3.692(5.663)	1.049(1.672)
υ	0.138(0.048)**	-0.064(0.028)**	0.135(0.046)***	-0.104(0.029)***
ω	0.157(0.095)*	0.467(0.072)***	0.143(0.081)*	0.473(0.073)***
ξ	-0.009(0.016)	-0.025(0.015)*	-0.010(0.015)	-0.010(0.014)
Criss Dummy	3.224(0.531)***	0.707(0.211)***	3.261(0.516)***	0.095(0.367)
α_0	0.953(0.489)*	1.137(0.415)***	1.474(4.458)	-19.34(4.474)***
Hansen test	0.226	0.120	0.250	0.137
AR(1)/AR(2)	0.001/0.120	0.000/0.374	0.000/0.103	0.002/0.206
	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	0.142(0.163)	0.345(0.205)*	-0.275(0.146)*	0.264(0.185)
β_1	-2.689(1.303)**	0.648(0.594)	-1.465(0.748)**	0.986(0.705)
β_2	2.632(0.879)***	0.596(0.248)**	1.125(0.372)***	0.663(0.240)***
λ	-0.289(0.247)	-0.111(0.256)	-0.513(0.314)	-0.309(0.220)
ρ	-3.265(2.702)	-3.787(3.205)	-9.026(5.028)*	-6.483(3.639)*
δ	1.864(1.170)	2.203(1.985)	-1.637(1.213)	0.816(1.032)
υ	-0.114(0.053)**	0.001(0.020)	-0.021(0.032)	0.021(0.027)
ω	0.046(0.045)	-0.102(0.074)	0.090(0.061)	-0.135(0.086)
ξ	-0.009(0.011)	-0.008(0.009)	-0.010(0.009)	-0.003(0.004)
Criss Dummy	-1.393(0.702)**	0.193(0.241)	0.563(0.248)**	0.472(0.320)
α_0	0.393(0.136)***	0.161(0.087)*	8.287(4.858)*	4.873(3.275)
Hansen test	0.162	0.257	0.166	0.115
AR(1)/AR(2)	0.282/0.785	0.271/0.407	0.422/0.398	0.247/0.353

Table 9: Monetary policy regimes, bank characteristics and bank risk-taking

	Z-score and C1		Z-score and C2	
estimate	M1	M2	M1	M2
α_1	-0.196(0.098)**	0.611(0.076)***	0.387(0.143)***	0.656(0.066)***
β_1	1.622(0.882)*	-1.937(0.584)***	13.70(36.70)	18.16(29.27)

β_2	-1.253(0.490)**	-0.673(0.223)***	-15.37(24.91)	1.724(8.682)
λ	0.990(0.393)**	0.025(0.254)	0.661(0.545)	0.155(0.371)
ρ	31.51(12.72)**	11.33(14.32)	45.27(43.47)	16.05(17.05)
δ	-5.962(2.741)**	1.578(4.081)	2.785(11.30)	4.331(5.991)
σ_1	-3.992(2.022)**	-0.108(1.738)	-1.388(2.133)	-1.004(1.538)
σ_2	2.668(1.342)**	0.123(0.207)	1.327(1.635)	-0.089(0.553)
τ_1	-186.5(121.5)	-4.572(117.3)	43.35(111.8)	-60.97(140.0)
τ_2	106.0(56.43)*	1.363(7.877)	-27.18(58.89)	-4.283(14.70)
ς_1	-12.10(9.981)	6.380(26.79)	9.084(28.99)	-13.14(41.06)
ς_2	-5.471(17.34)	-2.508(4.295)	-10.69(16.50)	-5.467(5.133)
υ	0.021(0.023)	-0.122(0.018)***	-0.144(0.025)***	-0.118(0.018)***
ω	-0.108(0.081)	0.451(0.083)***	0.342(0.069)***	0.454(0.079)***
ξ	0.027(0.015)*	-0.036(0.016)**	-0.033(0.018)*	-0.034(0.019)*
α_0	5.280(0.578)***	2.052(0.397)***	-9.918(9.230)	-2.055(5.736)
Hansen test	0.662	0.158	0.468	0.145
AR(1)/AR(2)	0.192/0.106	0.000/0.487	0.021/0.281	0.000/0.360

	NPL and C1		NPL and C2	
estimate	M1	M2	M1	M2
α_1	-0.063(0.098)	0.411(0.137)***	-0.080(0.094)	0.366(0.155)**
β_1	-2.258(0.936)**	0.561(0.480)	-15.73(6.377)**	4.070(6.213)
β_2	1.552(0.397)***	0.538(0.211)**	16.91(5.442)***	2.521(1.051)**
λ	-0.355(0.250)	-0.183(0.193)	-0.334(0.363)	-0.265(0.202)
ρ	-0.051(5.498)	-7.792(8.388)	-0.430(6.433)	-5.623(4.408)
δ	-0.675(1.898)	-0.157(1.057)	-1.709(1.894)	-0.464(0.791)
σ_1	0.485(0.359)	-0.125(0.270)	1.004(0.478)**	-0.138(0.322)
σ_2	-0.475(0.394)	-0.154(0.076)**	-1.112(0.329)***	-0.163(0.069)**
τ_1	4.615(10.41)	-11.76(15.08)	4.168(20.24)	-22.89(25.46)
τ_2	-5.538(15.12)	0.008(3.510)	-13.96(13.03)	-1.581(2.268)
ς_1	4.215(9.280)	-0.427(5.651)	2.411(5.217)	-0.817(6.583)
ς_2	-0.669(10.63)	1.815(1.167)	0.147(6.177)	1.874(0.918)**
υ	-0.053(0.021)**	-0.019(0.009)**	-0.052(0.014)***	-0.020(0.008)**
ω	0.134(0.060)***	-7.792(8.388)	0.092(0.030)***	-0.094(0.069)
ξ	-0.007(0.011)	-0.157(1.057)	-0.012(0.010)	-0.006(0.007)
α_0	0.289(0.108)***	0.217(0.090)**	5.202(4.894)	4.364(3.068)
Hansen 検定	0.230	0.281	0.269	0.285
AR(1)/AR(2)	0.293/0.709	0.244/0.362	0.308/0.590	0.245/0.363

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