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Shadow banking, macroprudential policy, and bank stability: Evidence from China's wealth management product market☆

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ABSTRACT

This study examines whether shadow banking activities reduce the stability of 269 commercial banks in China, and if they do, whether a tightening macroprudential policy could mitigate this negative effect. A quarterly bank level, unbalanced panel data of wealth management products (WMPs) from 2006 to 2018 measured China's shadow banking activities. The results show that China's shadow banking activities weaken the stability of banks, especially for principal-floating WMPs, long-term WMPs, and WMPs issued to individual investors. China's macroprudential supervision improves the soundness of banks and eases the negative effects of shadow banking on banking stability. Our results suggest the necessity to design specific macroprudential policies based on different kinds of shadow banking activities and different types of banks.

1. Introduction

Since the 2007–2008 global financial crisis, the shadow banking sector and its potential risk for the regular banking system have received much attention from regulatory authorities and academia. The definition of the term "shadow banking" varies. Although the Financial Stability Board (FSB) re-named traditional "shadow banking" as "non-bank financial intermediation (NBFI)" (Financial Stability Board (FSB), 2019), the People's Bank of China (PBOC) summarized China's shadow banking system as a credit intermediation system outside the regular banking sector. It is composed of institutions and businesses with liquidity and credit conversion functions and may lead to systemic risk or regulatory arbitrage (PBOC, 2013).

China's shadow banking system differs from that of developed countries (Ehlers, Kong, & Zhu, 2018; Lu, 2014). In particular, the shadow banking in the United States and Europe is mainly concentrated on non-bank financial institutions, such as securities companies, asset management companies, and hedge fund companies, whereas China's shadow banking system is dominated by commercial banks. The shadow banking system of China is often characterized by a low degree of asset securitization with a simple structure of financial products. It is more like a substitute for banks' regular deposit and loan business. According to Moody's (2019), by the end of 2018, the total value of China's shadow banking activities reached 61.3 trillion RMB, with wealth management products (WMPs) and asset management plans accounting for the majority of the shadow banking sector's components. They contributed 24.4 trillion RMB (including 15.8 trillion RMB of off-balance-sheet investment products). Meanwhile, entrusted loans are the second-largest

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component, contributing 12.4 trillion RMB.

The impact of shadow banking activities on banks' stability must be examined, as shadow banking's complexity and highly leveraged property often make it a regulatory arbitrage tool to circumvent government supervision, thereby exacerbating financial risks and increasing the fragility of the financial system. According to China Banking and Insurance Regulatory Commission, China's shadow banking problems are severe, which have greatly increased the level of macro-leverage, blown up the asset bubble, and dispersed the expected functions of financial institutions. Among the shadow banking activities in China, WMP is often regarded as an important supplement to bank deposits as traditional banking activities are restricted by strict requirements, such as loan-deposit ratio, capital adequacy ratio, and regulated deposit rates. However, maturity mismatch, regulatory arbitrage, and nested structural and highly leveraged properties of WMPs also make them a potential threat to the banking system stability (Acharya, Qian, Su, & Yang, 2020; Michalak & Uhde, 2012; Pozsar, Adrian, Ashcraft, & Boesky, 2013). To prevent financial systemic risks, China's regulatory authorities issued a series of regulations to manage the development of the WMPs market.[1] They also introduced macroprudential policies into the original regulatory framework.[2] Therefore, this study examines the effect of shadow banking activities on the stability of 269 commercial banks in China. Primarily, we aim to determine if shadow banking activities tend to reduce the stability of Chinese banks, and if they do, whether a tightening macroprudential policy could mitigate this negative effect. So far, only a few empirical studies have examined the effect of WMPs on the stability of Chinese banks and the role of macroprudential policies. This is the gap we want to fill.

This study used the quarterly unbalanced WMP panel data of 269 Chinese banks from 2006 to 2018 to proxy China's shadow banking activities. We focus on China's WMPs market because it is deemed China's largest shadow banking segment (Ba, 2013). To construct bank-level data, we aggregated the quantity of WMPs for each bank in each quarter. Using bank-level data allowed us to investigate the effect of banks' shadow banking behavior on bank stability under macroprudential policies at different levels of strictness. More importantly, we examined whether this effect was heterogeneous due to different kinds of WMPs or different characteristics of banks. We derived four main findings. First, in general, banks' shadow banking behavior of issuing WMPs tends to damage their own stability, especially for principal-floating WMPs, long-term WMPs and WMPs issued to individual investors. Second, the effect of WMPs on the stability of different types of banks is heterogeneous. Although issuing WMPs impairs the stability of large-sized banks (i.e., state-owned and joint-stock banks), it has much less influence on the stability of small and medium-sized banks (i.e., urban and rural commercial banks). This may be because, on average, large-sized banks issue much more WMPs than small and medium-sized banks. Fourth, tightening macroprudential policies have mitigated the negative effects of shadow banking activities on bank stability, emphasizing macroprudential regulations' importance.

The remainder of this article is organized as follows. Section 2 reviews the relationship between shadow banking and bank stability and the policy effectiveness of macroprudential policies. Section 3 presents the empirical model and the construction of the bank stability index. Section 4 discusses the empirical results. Finally, Section 5 concludes the paper.

2. Literature review

International Monetary Fund (IMF) and the Bank for International Settlements (BIS) have repeatedly warned against the risk of shadow banking in China in the past decade, believing that interbank investment, trust loans and off-balance WMPs have posed a serious threat to the security and stability of China's financial system. The growth of China's shadow banking sector was triggered mainly by the 4 trillion RMB economic stimulus plan in 2008. It was accelerated due to the credit crunch and monetary tightening period from 2009 to 2015 (Acharya et al., 2020; Chen, Ren, & Zha, 2018). Since 2014, WMPs have surpassed entrusted loans and become the largest component of China's shadow banking sector (Moody's, 2019).

Two forces drive the growth of China's WMP market: the strict supervision of interest rates and the regulatory arbitrage behavior of banks. Before October 2015, deposit rates had long been rigidly controlled in China. The issuance of WMPs allowed banks to attract funds by bypassing deposit rate caps and offering higher investment returns (Wang, Wang, Wang, & Zhou, 2019). Wealth management products are also popular with investors because WMPs are usually sold at the bank counter. Investors tend to regard WMPs as a safe investment asset with relatively high returns. They think the banks guarantee the principal and proceeds (Dang, Wang, & Yao, 2014). The other force is the regulatory arbitrage behavior of banks. Chinese commercial banks often issue WMPs to circumvent the limit on the loan-to-deposit (LDR) and capital ratio requirements (Cai, Garcia-Herrero, & Xia, 2016; Hachem & Song, 2016). For example, Acharya et al. (2020) described how WMPs can help banks attract more deposits and/or cut on-balance-sheet lending. This ensures that the LDR stays below the 75% threshold. The authors argued that banks can provide loans without increasing on-balance-sheet assets on the asset side by investing funds raised from WMPs in loan assets originated by themselves and/or packaged by other financial institutions. Meanwhile, they found that many WMPs are short-term products with an average maturity of three to four months on the liability side. They usually mature on the last date of a quarter which is consistent with the date on which the China Banking Regulatory Commission (CBRC) monitors the LDR ratio. In other words, the maturity structure of WMPs can be set to boost the banks'

[1] The supervision documents include "Notice on Regulating Investment and Operational Issues Related to Commercial Bank Wealth Management Products Business from the China Banking Regulatory Commission (CBRC)" (March 2013), "Notice on Regulating the Business of Transferring Usufruct of Credit Assets of Banking Financial Institutions" (August, 2016), "The Administrative Procedure for Wealth Management Business of Commercial Banks" (September, 2018), and "The Administrative Procedure for the Commercial Bank Wealth Management Subsidiary" (December, 2018).

[2] See the report to the 19th National Congress of the Communist Party of China (CPC).

deposit balance when the LDR is calculated. Therefore, many studies have found that China's shadow banking activities are increasingly active and complex. Their scale, structure and risks are constantly developing, making supervision increasingly challenging (Ehlers et al., 2018; Li, 2016).

Current literature presents different opinions on whether shadow banking activities damage the stability of banks. Some studies suggest that shadow banking activities can serve as diversified and efficient credit risk management tools for banks. The expansion of shadow banking activities helps banks improve their business model and, thus, banks stability (Wang & Shen, 2014; Zhang, 2012). However, even more studies have argued the following negative impact of shadow banking on the stability of banks for the following reasons.[3]

(1) *The maturity mismatch of shadow banking products.* Acharya et al. (2020) found that the growth of WMPs imposes rollover risks for issuing banks because WMPs were mostly short-term and loans were mostly the opposite. Such a maturity mismatch may force the issuers to pay higher yields on new WMPs or borrow at higher rates in the interbank market when more WMPs mature.
(2) *The sudden shortage of funds in shadow banking.* Pozsar et al. (2013) studied the characteristics of the shadow banking business and its capital flow, and they found that a sudden shortage of funds in the shadow banking system will cause a large amount of capital outflow and increase the risk of a run on the bank. He and Zhang (2009) also argued that a highly-leveraged shadow banking business can bring disaster to the entire financial system especially when the financial market goes into a depression.

The effectiveness of China's macroprudential policies in limiting the effect of shadow banking activities on bank stability is also unclear. The financial crisis has made Chinese regulators aware of the importance of macroprudential policies, which are aimed at maintaining the overall stability of the financial system rather than being focused on individual financial institutions. To manage the risks of financial system, China established the Bureau of Macroprudential Administration in 2019 and introduced macroprudential policies coordinated with monetary policy to form a two-pillar framework for financial regulations. Many empirical studies have found that macroprudential policies can effectively mitigate the pro-cyclical characteristics of credit growth and real estate prices (Cerutti, Claessens, & Laeven, 2017; Fendoğlu, 2017; Lim, Columba, & Costa, 2011). However, when affected by the risk characteristics of different financial institutions, the effectiveness of macroprudential policies is often heterogeneous (Akinci & Olmstead-Rumsey, 2018; Claessens, Kose, Laeven, & Valencia, 2013; Song & Li, 2019).

Although macroprudential regulation aims to improve the soundness of the overall financial system, including banks, the regulation itself may affect the development of shadow banking (Acharya et al., 2020; Zhou, 2011).[4] Conversely, implementing macroprudential policies may increase the regulatory arbitrage behavior of banks by issuing more WMPs to circumvent interest rate restrictions and prudential indicator regulations.[5] Alternatively, the regulatory arbitrage behavior of banks may, in turn, hamper the effectiveness of monetary and macroprudential policies. Ba (2013), Qiu and Zhou (2014), and Chen et al. (2018) argued that a contractionary monetary policy or tight macroprudential policies during the credit boom often caused shadow banking loans to rise rapidly. This offsets the original intention of the policy and weakened the effectiveness of monetary and macroprudential policies.

3. Empirics

3.1. Empirical model

This study used the quarterly non-balanced panel data of 269 Chinese banks from 2006 to 2018 to examine the influence of shadow banking activities on bank stability. We also examine the effectiveness of macroprudential policies in reducing this influence. We adopted the following instrumental variable (IV) model that controls bank fixed effects.

$$BSI_{i,t} = \beta_0 + \beta_1 WMP_{i,t} + \beta_2 \left(WMP_{i,t} \times MPP_{t-1}\right) + \beta_3 MPP_{t-1} + \theta Control_{i,t} + \alpha_i + \epsilon_{i,t} \quad (1)$$

Where, $BSI_{i,t}$ is the bank stability index of each bank i in each quarter t (see Section 3.2 for a detailed description of the index construction). The variable $WMP_{i,t}$ is used to measure the intensity of banks' shadow banking activities. Using WMPs to proxy China's shadow banking activities has at least three advantages. First, WMP data are representative because it has been the largest component of China's shadow banking sector since 2014, accounting for almost 40% of the total value of China's shadow banking activities.

[3] Asset securitization is also a reason that shadow banking activities may reduce bank stability, mostly occurring in developed countries. Hakenes and Schnabel (2010) argued the tendency for asset securitization to reduce loan standards of banking industry and the screening standards that banks apply to borrowers. They also pointed out that banks can more easily transfer inferior loans to investors. Moreover, Michalak and Uhde (2012) indicated that asset securitization increases the volatility of bank profits by complicating financial products. This reduces the transparency of the financial system and, thus, makes banking supervision more difficult.

[4] For example, improving the capital adequacy ratio aims to reduce bank risks; however, Jones (2000) found that banks can sometimes meet the capital adequacy ratio through financial innovation, i.e., shadow banking activities, without reducing bank risks.

[5] The evolution of China's WMPs market and banks' regulatory arbitrage behavior in response to policy regulations can be found in Acharya et al. (2020).

Second, WMP is a product that is linked to the banking sector. Our focus is on bank stability rather than the overall economy; therefore, using WMPs to examine the effect of shadow banking on bank stability is directly on the topic and can avoid double-counting problem.[6] Third, compared to other shadow banking activities, WMP data are easier to obtain and can be matched with bank data. We can further extend our research questions by studying the effects of WMP heterogeneity and bank heterogeneity. Generally, we find that WMP data appear to have more advantages in sample size and data structure than other macro- or industry-level shadow banking measures that have been used in past literature.

To improve the cross-sectional comparison, we scaled the total number of new WMP issuances within the quarter by the natural logarithm value of total bank assets. We used the quantity of WMPs rather than the value for two reasons. First, WMPs are an investment product and their value changes over time. Whether the change in WMP value has resulted from banks' shadow banking activity or from a price change is difficult to determine. Second, the banks rarely disclose the total amount that is raised through WMPs. The only available data are the range of the amount that banks plan to raise through WMP issuance. Hence, we have also replaced the total number of new issuance WMPs with the upper (lower) bound of the amount that banks plan to raise through WMPs as a robustness check. The upper (lower) bound value is calculated as the sum of the upper (lower) bound value of the planned issuance of all WMPs issued by each bank in each quarter. The term during which shadow banking and macroprudential policies interact is used to analyze how these two factors simultaneously influence the stability of banks.

MPP_{t-1} is the lagged cumulative macroprudential policy index. We use the lagged value of the macroprudential index to mitigate the endogeneity concerns, and, in addition, apply an instrumental variable generalized method of moments (IV-GMM) approach to address reverse causality explicitly. Both China's Gini coefficient and financial development index are used as instruments for the macroprudential index.[7] As Beck, Levine, and Levkov (2010) specified, income distributional considerations frequently exert the dominant influence on bank regulation. Moreover, in a country with better quality of financial development, people are more likely to have access to financial market and all sorts of information. Consequently, a country with better financial development is more likely to adopt state-of-the-art and appropriate regulation schemes. Noteworthily, because we use bank-level bank stability index data to proxy the stability of a single bank, the soundness of a single bank is less likely to influence the macroprudential policy decision aiming at the overall financial stability.

To measure the extent of macroprudential policy implementation in China, we used a new cross-country macroprudential policy database constructed by Cerutti et al. (2017). We also followed the same method to extend China's index into the last quarter of 2018 because the database only contains data from 2000 to 2014.[8] The updated index is constructed based on the information published in the *China Monetary Policy Implementation Report* issued quarterly by the PBOC. Among the commonly used prudential tools, China most frequently uses loan-to-value (LTV) ratio, capital requirement, reserve requirement for foreign-exchange deposits, and reserve requirement for local-currency deposits. We constructed this index by recording the changes in each prudential tool with $+1$ indicating tightened policies in a given quarter, -1 denoting loosened policies, and 0 otherwise. The index is not limited to ± 1 if the tool is used more than once in the same quarter. The aggregate macroprudential index is the sum of the indices from these four tools. This study used a cumulative aggregate macroprudential index to capture the tightness (or looseness) of the macroprudential policy implemented in the economy. The macroprudential policy may influence bank stability with a time lag; hence, the cumulative value from 2004 and 2005 was selected as the initial value.[9]

$Control_{i,t}$ is a set of control variables. Bank stability can be affected by the macroeconomic conditions and government policies, such as deleveraging and stabilizing leverage policies aimed at real and financial sectors. Considering this, we included quarterly annual real gross domestic product (GDP) growth and the macroeconomic leverage ratio, that is, the ratio of total debt to GDP, in the regression, where total debt is the aggregation of debts from the household, non-financial enterprise, and government sectors. Given that WMPs are mainly invested in stocks and bonds, the stability of banks is directly or indirectly related to the volatility of the stock market and the level of government debt. Hence, we included the fiscal deficit over GDP ratio and the Shanghai A-share index volatility, that is, the three-month rolling average of the standard deviation of the Shanghai A-share index closing quotation, as the control. The bank's size, leverage ratio and profitability can influence its stability; thus, we also include the total assets, financial leverage ratio (the ratio of earnings before interest and taxes over operating profit), and net interest margin (the difference between the average yield of interest-bearing assets and the average yield of interest-bearing liabilities) as control variables. All the control variables are quarterly data. α_i is the fixed effect for banks, whereas $\epsilon_{i,t}$ is a random error term.

Bank stability may depend on the past; thus, we have also applied a two-step system GMM estimation to address the inconsistency of the least-squares parameter estimates issue that results from the combination of fixed effects and lagged dependent variables (Arellano & Bond, 1991; Blundell & Bond, 1998). Moreover, the GMM technique mitigates some of the endogenous concerns. In our

[6] The double-counting problem may originate from the financing-nesting characteristics of shadow banking products. It refers to the problem that the same transaction may be counted repeatedly on the asset side or liability side of the balance sheet in different financial institutions or the same product may appear as different types of financial products.

[7] China's Gini coefficient and financial development index are taken from WIND Database and Svirydzenka (2016), respectively.

[8] The database in Cerutti et al. (2017) contains a change in the intensity of the usage of nine commonly-used prudential tools from 2000 to 2014 at a quarterly frequency for 64 economies. Noteworthily, these indices do not capture the actual magnitude of policy changes, so they should be used with caution when making cross-sectional comparisons. The updated index is constructed based on information published in the *China Monetary Policy Implementation Report* issued quarterly by the PBOC. Updated macroprudential policy summaries, classifications and coding table are available upon request.

[9] Even with 0 or 1 as the initial value, the results are still robust.

estimation, WMP quantity, macroprudential policy, and their interaction terms are treated as endogenous.[10] Our sample also meets the requirements of system GMM for "small T and large N" characteristics. The model is as follows:

$$BSI_{i,t} = \eta_i + \sum_{k=1}^{p} \rho_k BSI_{i,t-k} + \gamma_1 WMP_{i,t} + \gamma_2 \left(WMP_{i,t} \times MPP_{t-1}\right) + \gamma_3 MPP_{t-1}$$

$$+ \theta Control_{i,t} + e_{i,t} \quad (2)$$

where $BSI_{i,t-k}$ is the lagged k quarter dependent variable. Here we set $k = 2$.

3.2. Construction of the bank stability index

We followed Wu (2002) and Zhang and Peng (2014) and used a mapping method to measure the degree of bank stability in China. We chose some financial and macroeconomic indicators that can be used to proxy bank stability, mapped them into different score intervals, and used the weighted average method to construct a composite index. All financial data for banks were taken from the Wind database. Some banks commonly have only annual and semi-annual reports. If this was the case, we used the interpolation method to fill in the missing data in the first and third quarters. Several other methods can be used to proxy bank stability, but they are difficult to apply in the context of China. For example, expected default probability (EDF), Z index, the variance of bank profits and other variables can be used to measure the operating risk or bankruptcy risk of banks, but these methods are difficult to use for China due to the poor quality of the data from China's small- and medium-sized banks.[11] Some studies, such as Li and Xue (2014), also use the CoVaR method to measure banks' systemic risk and risk spillover, but this method needs stock price information, which applies only to listed banks. Moreover, due to the confidentiality of the data, only regulatory authorities can commonly conduct bank stress tests.

We referred to the internationally accepted CAMELS rating method and the "Internal Guidelines on Commercial Bank Regulatory Rating" (hereinafter the "Guidelines") issued by the CBRC. We selected four categories and nine subclasses of indicators to measure China's bank stability index. The composite index is constructed by the weighted average method, and the weight is determined based on the official "Guidelines."[12] For the mapping score interval, we followed the method of Wu (2002), Zhang and Peng (2014), and the "Guidelines," but we have reversed the meanings of the scores. Now the greater the score, the higher the stability of the bank. Specifically, (80, 100] stands for "safe", (50, 80] for "normal", (20, 50] for "attention" and [0,20] for "dangerous".[13] Table 1 lists the specific mapping score intervals and their weight distribution in detail.

When constructing the index, we first mapped the original value of the indicator to the corresponding mapping interval and assigned it based on its position within the original interval to get the index value or mapping value for each indicator. For example, if a bank has a capital adequacy ratio of 9%, the number is located within the original interval of (8, 10] and classified as "normal." We then mapped the number to the larger mapping interval ranging from (50, 80] based on its position within the original interval. The capital adequacy ratio is positively correlated with bank stability index (BSI); thus, the index value for capital adequacy ratio of 9% is 65 (i.e., $50 + (80 - 50) \times (9 - 8)/(10 - 8)$). In another example, if a bank's non-performing loan ratio (NPL) is 11%, which locates within the interval of $(10, +\infty]$, its corresponding mapping interval is [0,20] and is classified as "Dangerous." The maximum value of NPL in our sample is 23.57, and the NPL ratio is negatively correlated with BSI; therefore, the index value of NPL of 11% is 18.53 (i.e., $0 + (20 - 0) \times (23.57 - 11)/(23.57 - 10)$). Then, after getting the mapping values of nine sub-indicators using the aforementioned method, we applied the weighted average approach to calculate the quarterly value of each bank's BSI by using the formula $\sum\{$ *weights of* 4 *big categories* $\times \sum($*weights of* 9 *sub* $-$ *indicators* $\times$ *the index value of each indicator*$)\}$. For example, the index values are as follows: for capital adequacy ratio, 70; for core capital adequacy ratio, 80; for NPL ratio, 70; for provision coverage, 80; for return on assets, 70; for return on equity, 80; for cost-income ratio, 90; for liquidity ratio, 70; and for loan-deposit ratio, 80. After obtaining all these index values for nine sub-indicators of a bank in one quarter, we can obtain a BSI of 74.9 ($BSI = 30\% \times (50\% \times 70 + 50\% \times 80) + 30\% \times (60\% \times 70 + 40\% \times 80) + 15\% \times (40\% \times 70 + 40\% \times 80 + 20\% \times 90) + 25\% \times (60\% \times 70 + 40\% \times 80)$). Considering a few extreme data values—for example, the maximum value of provision coverage in our sample was 25,818.62, much higher than the average value of 286.02—we winsorized the provision coverage at the 99% level. After obtaining the mapping values of nine sub-indicators, we used the weighted average approach to calculate the quarterly value of BSI for each bank.

Fig. 1 shows the evolution of the bank stability of state-owned, joint-stock, and urban and rural commercial banks in China. This was measured by the average bank stability index of each type of bank within a quarter. The bank stability index fluctuated greatly during the global financial crisis from 2007 to 2009 and became relatively stable from 2010 to 2014, which may be attributed to

[10] Those endogenous regressors are instrumented with their lags and with the lags of their first differences. The limit of lag is 2.

[11] Due to the poor credit rating system and data quality in China, EDF data are often missing. Some studies, such as Michalak and Uhde (2012) and Song and Li (2019), also used Z scores to measure the stability of banks, but the calculation of the Z-score needs a high-quality return on average assets before taxes (ROAA) and equity ratio data, which are difficult to obtain for small- and medium-sized banks in China.

[12] We argue that our weighted average method based on industry experience is better than the principal component analysis (PCA) method and arithmetic average method. On the one hand, the PCA method tends to reduce the data dimension. When the signs of the factors are positive and negative, the economic meaning becomes ambiguous. On the other hand, the arithmetic average method tends to amplify the impact of secondary indicators on bank stability.

[13] The notation "( )" stands for open interval and "[ ]" means closed interval. For example, (80, 100] means greater than 80 and less than or equal to 100.

Table 1
Bank stability index.

Bank stability index (BSI)		Dangerous	Attention	Normal	Safe
Mapping interval		[0,20]	(20, 50]	(50, 80]	(80, 100]
Capital Adequacy (30%)	Capital Adequacy Ratio (50%)	[0,4]	(4, 8]	(8, 10]	(10, + ∞)
	Core Capital Adequacy Ratio (50%)	[0,2]	(2, 4]	(4, 6]	(6, + ∞)
Asset Quality (30%)	Non-performing Loan Ratio (60%)	[10, + ∞)	[5, 10)	[3, 5)	[0, 3)
	Provision coverage (40%)	[0,80]	(80, 100]	(100, 150]	(150, + ∞)
Earning Performance (15%)	Return on Assets (40%)	(-∞, 2]	(2, 6]	(6, 10]	(10, + ∞)
	Return on Equity (40%)	(-∞, 5]	(5, 10]	(10, 15]	(15, + ∞)
	Cost-income Ratio (20%)	[80, + ∞)	[60, 80)	[50, 60)	(-∞, 50)
Liquidity Condition (25%)	Liquidity Ratio (60%)	[0,10]	(10, 25]	(25, 40]	(40, + ∞)
	Loan-deposit Ratio (40%)	[85, + ∞)	[75, 85)	[50, 75)	[0, 50)

Note: Percentage number in parentheses represents the weight of each indicator. Under the original value and mapping intervals, the notation "( )" and "[ ]" stands for open interval and closed interval, respectively. For example, (80, 100] means greater than 80 and less than or equal to 100.

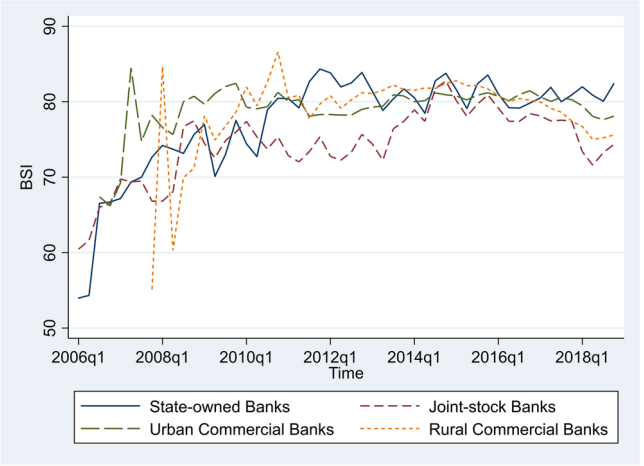

Fig. 1. Bank stability index.
Source: Authors' calculation.

China's economic stimulus policy and real estate development. Meanwhile, the most significant increase was in the bank stability index of joint-stock banks. From 2015 to 2018, the overall degree of bank stability declined slightly due to macroeconomic downturns, the policy of cleaning up "zombie enterprises" and the increase in the non-performing loans of state-owned enterprises. In the sample period, the stability of state-owned banks was the highest, followed by urban and rural commercial banks, and then joint-stock banks. Moreover, a sharp fluctuation occurs in the stability level of rural commercial banks during the financial crisis period. This may be due to the impact of the financial crisis, or it may be related to the fact that the rural commercial banks in China have fewer data available that was vulnerable to extreme values. The figure also shows an obvious characteristic of seasonal fluctuations for bank stability indices, which may be related to the "window dressing" of financial statements or the seasonal fluctuation of the overall economic situation. We included the control variables with similar seasonal fluctuations and time dummies to control for this seasonal effect.

3.3. Data and descriptive statistics

Our sample contains 269 Chinese commercial banks, including six state-owned banks, 11 joint-stock banks, 109 urban commercial banks and 143 rural commercial banks.[14] We used quarterly data from the sample period of 2006–2018. The total number of newly-issued WMPs within a quarter scaled by banks' total assets was used as a proxy for their shadow banking activities. All the WMP information was obtained from the "Compendium of Wealth Management Product" section on the *ChinaWealth.com* website and from the Wind database. Financial indicators for banks were taken from the Bank's Financial Database, Bank's Special Database and the Bank's Important Business Indicators in the Wind database.

[14] The state-owned banks include the Industrial and Commercial Bank of China, the China Construction Bank, the Agricultural Bank of China, the Bank of China, and the Bank of Communications and Postal Savings Bank of China. Meanwhile, the joint-stock banks include Guangfa Bank, China Minsheng Bank, Huaxia Bank, China Everbright Bank, Hengfeng Bank, China Merchants Bank, China Civic Bank, Zheshang Bank, Industrial Bank, Bohai Bank and Ping'an Bank. The classification of bank categories is based on Wind database.

The descriptive statistics of the main financial indicators of state-owned, joint-stock, and urban and rural commercial banks is presented in Table 2. Among these four types of banks, the average bank stability level of joint-stock banks is the lowest, implying that joint-stock banks have a more aggressive operating style than the other three types. The median leverage ratio of joint-stock banks is also higher than for the others. Concerning WMP issuance, state-owned banks account for the largest part of the total issuances of WMPs and of the issuance of principal-floating WMPs. They are followed in order by joint-stock banks, urban commercial banks, and rural commercial banks. This is consistent with the size of total assets of these four types of banks. Finally, listed state-owned and joint-stock banks have a higher financial leverage ratio than the non-listed urban and rural commercial banks.

Fig. 2 shows the total number of WMPs issued by the four different types of banks. We added up the number of WMPs issued by the different banks in each quarter. The number of WMPs issued by a state-owned or a joint-stock bank is much larger than that of an urban or a rural commercial bank. However, since 2016, urban and rural commercial banks have surpassed state-owned and joint-stock banks, becoming the bank types with the largest WMP issuance. The figure also shows that the WMP issuance had dropped sharply by the end of 2017, which may be related to the policies aimed at restricting the WMP market.[15]

The total issuance of different types of WMPs is shown in Fig. 3. We added up all the WMPs issued by the different revenue-types of all banks in each quarter. Principal-floating WMPs account for the largest proportion of all WMPs, and this proportion is far greater than the number of the other two kinds of principal-guaranteed WMPs. According to China's regulatory requirements, principal-guaranteed WMPs are treated as bank deposits in calculating the LDR and the capital adequacy ratio, whereas principal-floating WMPs are treated as off-balance-sheet investment products. Principal-floating WMPs are considered to be more closely related to shadow banking activities (Acharya et al., 2020).

Fig. 4 shows the cumulative value of the four most frequently used macroprudential instruments in China (i.e., capital requirements, LTV limits, foreign-exchange deposit reserve requirements, local-currency deposit reserve requirements) and their aggregate value (i.e., the aggregate macroprudential index). These indices are used to capture the relevance of the overall macroprudential policy in the economy. The upward trend of the macroprudential index from 2006 to 2012 indicates gradual policy-tightening during this period. However, the index became relatively stable between 2012 and 2015, and the policy has loosened since then. It can be seen that the macroprudential policy is counter-cyclical. When the economy is overheated (depressed), it adopts a tightening (loosening) policy. The reserve requirement for local-currency deposits is the macroprudential instrument most frequently used by the PBOC, and the change in the reserve requirement is also most consistent with the movement of the aggregate macroprudential index.

4. Empirical analysis

4.1. The first-order effect of shadow banking activities and macroprudential policies on bank stability

We first apply IV-GMM approach with robust standard errors to examine the first-order effect of shadow banking activities and macroprudential policies on the stability of Chinese banks without adding their interaction term. As the equation is overidentified, the IV-GMM estimates will be more efficient than the robust two-stage least square estimates. Both F-test and Hansen J test are used to examine the weak instrument problem and the validity of overidentification restrictions, respectively. The results of both tests in Table 3 suggest that the instrumental variables we selected are exogenous and have explanatory power.

The estimated coefficients of WMPs indicate the effect of banks' shadow banking activities on their own stability when macroprudential supervision is at an average level (Table 3). The results of the first two columns show that banks' shadow banking activities (i.e., the issuance of WMPs) tends to harm the stability of banks. However, the estimation significance of WMPs may vary with different control variables. To test whether the results are affected by the heterogeneity of WMPs, we investigate different types of WMP according to their revenue types, maturity periods, and the intended recipients, respectively. The results of Columns 3 and 4 show that compared with principal-guaranteed WMPs (i.e., $WMP\_PG_{i,t}$), principal-floating WMPs (i.e., $WMP\_PF_{i,t}$) tend to do more damage on bank stability. Based on the results of Columns 5 and 6, the WMPs with terms greater than 1 year (i.e., $WMP\_LM_{i,t}$) have more significant negative effect on bank stability than the WMPs with terms of less than 1 year (i.e., $WMP\_SM_{i,t}$). Moreover, the results of the last three columns also show that the WMPs issued to institutions (i.e., $WMP\_INT_{i,t}$) tend to harm bank stability, whereas those issued to VIPs (i.e., $WMP\_VIP_{i,t}$) have the exact opposite effect, which significantly improved the stability of Chinese banks.

Our results suggest that although issuing WMPs tend to worsen the stability of banks on average, not all types of WMP have a negative effect. WMPs with floating principal, longer-term maturity, and those issued to institutional investors tend to damage the stability of Chinese banks more when macroprudential supervision is at an average level. Additionally, our results also show that the estimated coefficients of the lagged macroprudential policies in most regressions are positive and statistically significant, indicating that China's tightening macroprudential regulation has effectively enhanced banks' stability.

[15] In April 2018, the People's Bank of China, the China Banking & Insurance Regulatory Commission, the China Securities Regulatory Commission and the State Administration of Foreign Exchange jointly issued the Guidance on Regulating the Asset Management Business of Financial Institutions (referred to as the "New Regulation on Asset Management"). In July 2018, the China Banking & Insurance Regulatory Commission issued the Draft Measures on the Supervision and Administration of Commercial Banks' Wealth Management Business (hereinafter "New Regulation on Wealth Management"). In December 2018, the Banking & Insurance Regulatory Commission issued the "Measures for the Administration of Commercial Banks' Wealth Management Subsidiaries."

Table 2
Descriptive statistics.

	Obs.	Mean	Median	1st percentile	99th percentile	SE
State-owned Banks						
Bank Stability Index	273	78.50	80.84	48.55	89.16	7.87
# of WMPs	297	533.05	277.00	4.00	3496.00	720.96
# of Principal-floating WMPs	297	415.02	171.00	0.00	3371.00	656.82
Total Asset (Trillions)	266	12.13	10.81	2.10	27.30	6.39
Financial leverage	266	17.40	15.62	11.75	60.61	7.90
Joint-stock Banks						
Bank Stability Index	499	74.87	75.99	43.08	86.58	8.23
# of WMPs	600	219.67	129.00	1.00	1248.00	260.30
# of Principal-floating WMPs	600	172.29	93.00	0.00	1174.50	240.67
Total Asset (Trillions)	460	2.27	1.78	0.04	6.56	1.79
Financial leverage	460	14.87	18.02	11.00	43.37	216.58
Urban Commercial Banks						
Bank Stability Index	2782	79.92	80.41	58.22	90.38	6.31
# of WMPs	3409	64.82	38.00	1.00	600.00	98.05
# of Principal-floating WMPs	3461	45.67	24.00	0.00	468.00	77.67
Total Asset (Trillions)	2252	0.24	0.13	0.02	1.81	0.32
Financial leverage	2230	14.95	14.87	7.73	22.99	3.08
Rural Commercial Banks						
Bank Stability Index	1962	79.32	81.13	51.79	90.73	8.12
# of WMPs	5661	25.01	12.00	1.00	181.00	44.31
# of Principal-floating WMPs	5705	13.13	2.00	0.00	133.00	29.68
Total Asset (Trillions)	1178	0.08	0.03	0.01	0.75	0.14
Financial leverage	1171	13.41	12.87	7.75	24.37	4.17

Note: # of WMPs is the total number of WMPs issued by banks. # of Principal-floating WMPs is the total number of principal-floating WMPs issued by banks.

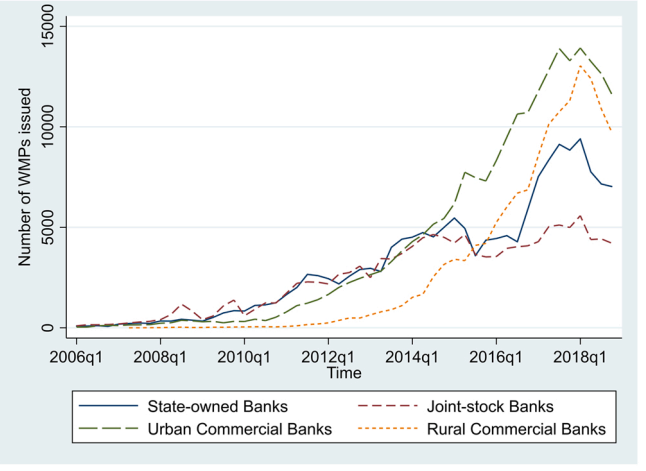

Fig. 2. Total number of WMPs issued—based on bank type.
Source: Authors' calculation.

4.2. Baseline model with macroprudential policies at different time lags

We then examine the effectiveness of macroprudential policies in reducing the negative effect of shadow banking activities by adding their interaction term back to the model, as shown in Eq. (1). Moreover, to test whether a time lag in the effectiveness of macroprudential regulations, we use different length of the lagged macroprudential index in the model. The results in Table 4 show that regardless of the length of the lagged period of macroprudential policies, the estimated coefficients of WMP issuance on bank stability are always negative and statistically significant. This suggests that our baseline result, that is, the bank's shadow banking activities tend to damage its stability, is robust. The positive and statistically significant estimated coefficients of the interaction term between WMPs and macroprudential policy also prove that macroprudential policy in different periods can mitigate the negative effect of shadow banking activities on bank stability.

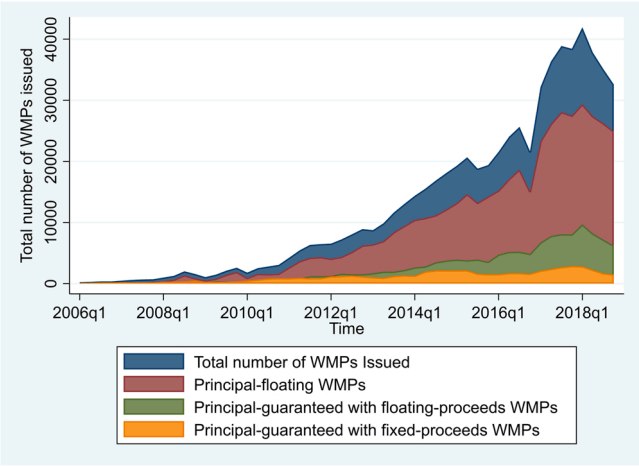

Fig. 3. Total number of WMPs issued—based on revenue type.
Source: Authors' calculation.

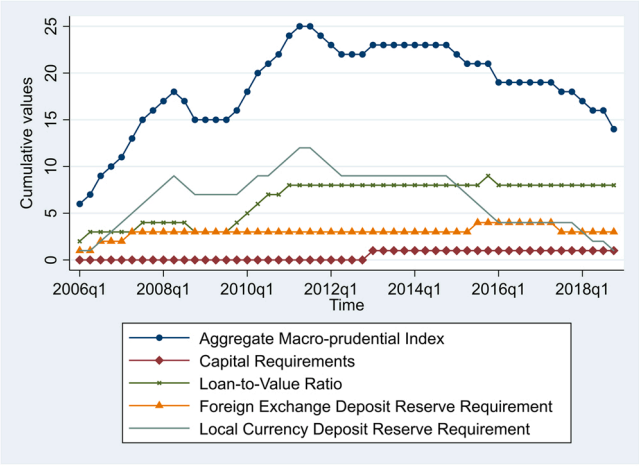

Fig. 4. Aggregate macroprudential index and its components.
Source: Authors' calculation.

4.3. Heterogeneity of WMPs

To examine whether our baseline results will be affected by the heterogeneity of WMPs, we re-estimate Eq.(1) using different WMP samples according to their revenue types, maturity periods and the intended recipients, respectively.

(1) **By Revenue Type**

Based on the WMP revenue type, we divided the WMPs into principal-guaranteed and principal-floating WMPs. Then, we re-ran the baseline regression for each sub-sample. Again, these WMP variables are all scaled according to the natural logarithm of total bank assets. Table 5 presents the results.

The regression result of Column 1 shows that the effect of principal-guaranteed WMPs on bank stability is negative, but not statistically significant, whereas the result of Column 2 indicates different conclusions. That is, principal-floating WMPs significantly weaken the stability of banks. Moreover, compared with the estimated coefficient of overall WMPs of Column 1 in Table 4, the results show that the principal-floating WMPs have a greater weakening effect on bank stability than the average effect of overall WMPs. This finding is consistent with the argument of Acharya et al. (2020) that principal-guaranteed WMPs are normally treated as bank deposits and recorded on the balance sheet. The capital requirement and loan-to-deposit cap strictly regulate them. However, principal-floating WMPs are off-balance-sheet investment products. These are associated more with banks' shadow banking activities and are difficult to regulate due to its regulatory arbitrage property. These products tend to do more damage to bank stability. Nevertheless, tightening macroprudential supervision can still mitigate the negative effect of principal-floating WMPs on bank stability to some extent.

Table 3
First-order effect of shadow banking activities and macroprudential policies.

	Dep. Variable: $BSI_{i,t}$								
	All WMPs		By revenue type		By maturity period		By customer type		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$WMP_{i,t}$ =	$WMP\_T_{i,t}$	$WMP\_T_{i,t}$	$WMP\_PG_{i,t}$	$WMP\_PF_{i,t}$	$WMP\_SM_{i,t}$	$WMP\_LM_{i,t}$	$WMP\_IND_{i,t}$	$WMP\_INT_{i,t}$	$WMP\_VIP_{i,t}$
$WMP_{i,t}$	-0.0203**	-0.0120	0.0279	-0.0189*	0.0209	-0.163*	0.00115	-0.0561***	0.386***
	(0.00959)	(0.00910)	(0.0259)	(0.0101)	(0.0192)	(0.0835)	(0.0214)	(0.0145)	(0.117)
MPP_{t-1}	0.319***	0.349***	0.344***	0.347***	-0.184	0.336***	0.347***	0.351***	0.328***
	(0.0563)	(0.0612)	(0.0620)	(0.0609)	(0.181)	(0.0612)	(0.0632)	(0.0610)	(0.0621)
$RGDPG_t$	0.135	0.238	0.240	0.239	-0.463	0.243	0.239	0.247	0.261
	(0.187)	(0.211)	(0.210)	(0.211)	(0.371)	(0.211)	(0.210)	(0.211)	(0.210)
$MacroLev_t$	0.0311**	0.0228*	0.0195	0.0230*	0.00509	0.0244*	0.0201	0.0229*	0.0189
	(0.0122)	(0.0137)	(0.0132)	(0.0135)	(0.0209)	(0.0135)	(0.0145)	(0.0131)	(0.0130)
$StockVol_t$	0.000874	0.00151	0.00160	0.00151	0.00409**	0.00153	0.00156	0.00162	0.00160
	(0.000862)	(0.00101)	(0.00100)	(0.00100)	(0.00185)	(0.000995)	(0.00100)	(0.000991)	(0.000992)
$TAssets_{i,t}$	0.422***	0.338**	0.302**	0.351***	0.880***	-0.359***	0.303**	0.372***	0.323**
	(0.123)	(0.132)	(0.133)	(0.133)	(0.233)	(0.0884)	(0.129)	(0.135)	(0.135)
$BankLev_{i,t}$	-0.283***	-0.358***	-0.359***	-0.359***	0.944***	0.335**	-0.359***	-0.358***	-0.370***
	(0.0562)	(0.0884)	(0.0882)	(0.0885)	(0.238)	(0.133)	(0.0878)	(0.0885)	(0.0886)
$NIM_{i,t}$	—	0.00340	0.00416	0.00343	-0.0236	0.00329	0.00391	0.00332	0.00428
		(0.0217)	(0.0217)	(0.0217)	(0.0326)	(0.0216)	(0.0217)	(0.0215)	(0.0216)
$Deficit_t$	—	0.111***	0.110***	0.112***	0.0729	0.111***	0.109***	0.111***	0.109***
		(0.0293)	(0.0292)	(0.0293)	(0.0524)	(0.0292)	(0.0293)	(0.0293)	(0.0291)
Constant	87.46***	83.80***	84.14***	83.82***	-16.60***	83.54***	84.06***	83.78***	84.77***
	(8.675)	(8.548)	(8.545)	(8.570)	(1.080)	(8.527)	(8.381)	(8.599)	(8.576)
1st stage F-test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Shea's partial R-square	0.498	0.510	0.504	0.509	0.508	0.501	0.503	0.509	0.502
Hansen J Test (p-value)	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Observations	3495	2655	2655	2655	2655	2655	2655	2655	2655

Note for Tables 3–9: *, **, and *** represent 10%, 5%, and 1% significance levels. The robust standard errors are reported in parentheses. Bank fixed effects are considered in all regression. We also reported the p-value of the weak instrument test in the first-stage regression for the null hypothesis that instruments are weak and the Hansen J test for null hypothesis of over-identifying restrictions.

Table 4
Baseline model with macroprudential policies at different time lags.

	Dep. Variable: $BSI_{i,t}$			
	(1)	(2)	(3)	(4)
	$j = 1$	$j = 2$	$j = 3$	$j = 4$
$WMP_{i,t}$	-0.191***	-0.195***	-0.347***	-0.111*
	(0.0474)	(0.0555)	(0.107)	(0.0574)
$WMP_{i,t} \times MPP_{t-j}$	0.00937***	0.0102***	0.0179***	0.00588**
	(0.00252)	(0.00287)	(0.00566)	(0.00296)
MPP_{t-j}	0.250***	0.160*	-0.0762	0.262**
	(0.0789)	(0.0907)	(0.176)	(0.108)
Controls	√	√	√	√
1st stage F-test (p-value)	0.000	0.000	0.000	0.000
Shea's partial R-square	0.376	0.294	0.286	0.390
Hansen J Test (p-value)	1.000	1.000	1.000	1.000
Observations	2655	2552	2498	2428

Note: The control variables are the same as those in Column 2 of Table 3.

(2) **By Maturity Period**

We further divided the WMPs into samples with maturity periods of less than 1 year and more than 1 year. The results in Table 6 show that both short-term and long-term WMPs harm bank stability. However, the WMPs with terms longer than 1 year have greater negative effects on bank stability than the WMPs with terms within 1 year, indicating that long-term WMPs tend to

Table 5
WMP heteroscedasticity by revenue type.

	Dep. Variable: $BSI_{i,t}$	
	(1) Principal-guaranteed WMPs ($WMP\_PG_{i,t}$)	(2) Principal-floating WMPs ($WMP\_PF_{i,t}$)
$WMP_{i,t}$	-0.417	-0.642***
	(0.308)	(0.156)
$WMP_{i,t} \times MPP_{t-j}$	0.0201	0.0345***
	(0.0138)	(0.00843)
MPP_{t-j}	0.307***	-0.287
	(0.0748)	(0.192)
Controls	√	√
1st stage F-test (p-value)	0.000	0.000
Shea's partial R-square	0.399	0.394
Hansen J Test (p-value)	1.000	0.138
Observations	2655	2655

Note: The control variables are the same as those in Column 2 of Table 3.

Table 6
WMP heteroscedasticity by maturity period.

	Dep. Variable: $BSI_{i,t}$	
	(1) Within 1 year ($WMP\_SM_{i,t}$)	(2) Greater than 1 year ($WMP\_LM_{i,t}$)
$WMP_{i,t}$	-0.224***	-2.117***
	(0.0574)	(0.538)
$WMP_{i,t} \times MPP_{t-j}$	0.0110***	0.106***
	(0.00304)	(0.0286)
MPP_{t-j}	0.261***	0.244***
	(0.0775)	(0.0763)
Controls	√	√
1st stage F-test (p-value)	0.000	0.000
Shea's partial R-square	0.385	0.390
Hansen J Test (p-value)	1.000	1.000
Observations	2655	2655

Note: The control variables are the same as those in Column 2 of Table 3.

reduce banks' stability more. In general, banks need to pay a higher risk premium to cover the liquidity and maturity risk of long-term WMP, which may have greater negative effects on the stability of banks. Although short-term WMPs has less such concern, it may lead to a maturity mismatch problem because the funds raised by the WMPs are often invested in loans or corporate bonds with maturity dates longer than 1 year. This may raise a rollover risk of WMPs and weaken the stability of banks.[16] Moreover, banks often transfer funds to the investors' saving/deposit accounts after the short-term WMPs mature to meet the regulatory requirements on the capital requirement and loan-to-deposit ratio at the end of the months, quarters, and years. This may beautify banks' financial situation. The results in Table 6 also show that a tightened macroprudential policy improves the stability of banks and reduces the negative effect of WMPs on bank stability regardless of the duration of the term.

(3) **By Customer Type**

Finally, based on various customers of WMPs, we investigate the influence of WMPs issued to individual investors, institutional investors, and VIP customers on bank stability. Among them, VIP customers are determined by the value of asset under management, which is usually the weighted market value of all financial investments in the bank from an individual or an entity. Both individual and institutional investors could be VIP customers.

The results in Table 7 show that without the macroprudential regulation, the WMPs issued to individual or institutions will damage the stability of banks, but the former tend to have greater negative effect on bank stability. This finding is again consistent with that of Acharya et al. (2020), who found that institutional investors have more bargaining power on WMP pricing (i.e., expected rate of

[16] Although banks can also meet redemption of funds by issuing new WMPs and/or raising funds from the interbank market, the empirical findings of Acharya et al. (2020) show that the growth of WMPs not only raises the funding cost of newly issued WMPs, but also increases banks' financing cost in the interbank market.

Table 7
WMP heteroscedasticity by intended customer.

	Dep. Variable: $BSI_{i,t}$		
	(1) Individual investors ($WMP\_IND_{i,t}$)	(2) Institutional investors ($WMP\_INT_{i,t}$)	(3) VIP customers ($WMP\_VIP_{i,t}$)
$WMP_{i,t}$	-0.432***	-0.279**	2.475***
	(0.0952)	(0.126)	(0.806)
$WMP_{i,t} \times MPP_{t-j}$	0.0214***	0.0115*	-0.0969***
	(0.00457)	(0.00648)	(0.0370)
MPP_{t-j}	0.207**	0.325***	0.359***
	(0.0814)	(0.0683)	(0.0645)
Controls	√	√	√
1st stage F-test (p-value)	0.000	0.000	0.000
Shea's partial R-square	0.350	0.454	0.472
Hansen J Test (p-value)	1.000	0.138	1.000
Observations	2655	2655	2655

Note: The control variables are the same as those in Column 2 of Table 3.

return) and risk controls than individual investors. Individual investors also tend to have less knowledge about the underlying assets, interest rates, and risk management of WMPs. This encourages them to take more risks and further weakens the stability of banks. Regardless of customer type, a tightened macroprudential policy significantly reduce the negative effect of these WMPs on bank stability. Contrary to the previous cases, the WMPs issued to VIP have a positive and statistically significant effect on bank stability, suggesting that WMP issuing to high-quality customers will not damage the bank's stability but improve it. The interaction term's negative and significant estimated coefficient indicates that a tightened regulation may also reduce the WMPs issued to VIP and damage bank stability.

4.4. Heterogeneity of banks

To investigate the influence of shadow banking activities on the stability of different types of banks, we divided the banks into large-sized banks, which included six state-owned banks and 11 joint-stock banks, and small- and medium-sized banks, which included 109 urban commercial banks and 143 rural commercial banks. Then we re-ran the baseline regressions based on the model specification of Column 1 in Table 4. The empirical results are listed in Columns 1 and 2 in Table 8, respectively.

The roles of WMPs for different types of banks vary. The results show that the issuance of WMPs has a negative and statistically significant effect on the stability of large-sized banks. This may because state-owned banks and joint-stock banks account for the largest part of the total issuance of WMPs and of the issuance of principal-floating WMPs. The Chinese regulatory authorities are also aware of the risks of WMPs. At the end of 2018, they published the "Measures for the Management of Wealth Management Subsidiaries of Commercial Banks." These measures require large-sized banks to set up wealth management subsidiaries and take the WMP business away from the parent companies. This is a policy aimed at isolating the WMP business risk from the regular business of the banks. It was applied to the state-owned banks first. In contrast, the issuance of WMPs has a positive, but statistically insignificant effect on bank stability for small- and medium-sized banks. On the one hand, considering that both urban and rural commercial banks have significantly fewer branches than large-sized banks, their ability to attract deposits is not comparable to that of large-sized banks. Hence, WMPs may provide important supplemental funds for these banks. On the other hand, the threat of WMPs may not be so severe for small- and medium-sized banks because they issue significantly less WMPs than that of large-sized banks.

Concerning macroprudential policies, the results show that a tightened macroprudential policy is more effective in reducing the negative effect of shadow banking activities on the stability of large-sized banks. WMPs can be an important channel for small- and medium-sized banks to supplement their capital in lieu of deposits. Tightened macroprudential supervision will increase the complexity of shadow banking activities, enhance small- and medium-sized banks' regulatory arbitrage behavior, and then damage the stability of the banks. Therefore, we found that the same macroprudential policy could have different policy effects on banks' shadow banking activities and the following effects on bank stability, depending on the type of bank. This further emphasizes the importance of designing specific regulations for different types of banks.

4.5. Robustness tests

To check the robustness of the empirical results, we used four different tests and presented the results in Table 9. First, due to the lack of data before 2009 and the sharp fluctuation of economic variables caused by the economic crisis, we used post-crisis data from 2009 to 2018 for the robustness check. The results in Column 1 are consistent with our previous findings in general. Second, we replaced the number of WMP issuances with the upper and lower bound values of the planned issuance of all WMPs, respectively. The actual sales amounts of WMPs are rarely disclosed; therefore, the planned sales amount of WMPs was the only available data we could obtain from the Wind database. We added up the planned sales amounts of WMPs issued by each bank in each quarter and scaled it by banks' total assets. The actual sales amount of WMPs should be located between the upper and lower limits of the planned sales

Table 8
Bank heteroscedasticity by bank type.

	Dep. Variable: $BSI_{i,t}$	
	(1) Large-sized banks ($WMP\_LB_{i,t}$)	(2) Small- and medium-sized banks ($WMP\_SM_{i,t}$)
$WMP_{i,t}$	-0.376***	0.220
	(0.0972)	(0.146)
$WMP_{i,t} \times MPP_{t-j}$	0.0199***	-0.0105
	(0.00514)	(0.00764)
MPP_{t-j}	-0.279	0.487***
	(0.210)	(0.0919)
Controls	√	√
1st stage F-test (p-value)	0.000	0.000
Shea's partial R-square	0.174	0.651
Hansen J Test (p-value)	0.098	1.000
Observations	612	2043

Note: The control variables are the same as those in Column 2 of Table 3.

Table 9
Robustness tests.

	Dep. Variable: $BSI_{i,t}$			Dep. Var.: $BadLoan_{i,t}$
	After the GFC (1)	Upper limits (2)	Lower limits (3)	(4)
$WMPs_{i,t}$	-0.310***	-0.0289***	-0.0986***	1.345***
	(0.0873)	(0.00774)	(0.0309)	(0.209)
$WMPs_{i,t} \times MPP_{t-1}$	0.0160***	0.00140***	0.00501***	-0.0717***
	(0.00467)	(0.000394)	(0.00150)	(0.0107)
MPP_{t-1}	-0.0497	0.308***	0.227***	-0.324*
	(0.191)	(0.0707)	(0.0743)	(0.171)
Controls	√	√	√	√
1st stage F-test (p-value)	0.000	0.000	0.000	0.000
Shea's partial R-square	0.732	0.576	0.422	0.323
Hansen J Test (p-value)	1.000	1.000	1.000	1.000
Observations	2534	2563	2511	2335

Note: The control variables are the same as those in Column 2 of Table 3.

amounts of WMPs. The actual amount and the planned amount should be positively correlated. The results in Columns 2 and 3 are consistent with our previous findings, suggesting the robustness of our results. Third, we replace the dependent variable BSI with non-performing loans (in billion,) and use it to proxy the risk losses that banks are about to incur. This variable is an opposite indicator of BSI, representing the instability of banks. The results in Column 4 show that issuing WMPs tends to increase banks' non-performing loans, which is not conductive to bank stability. A tightening macroprudential policy can curb the risk resulting from banks' shadow banking activities. The result is still consistent with our previous findings.

Finally, we applied a two-step system GMM estimation model. As mentioned earlier, the dynamic GMM technique mitigates some of the endogenous concerns and addresses the inconsistency estimation issue due to the combination of fixed effects and lagged dependent variables. Table 10 show the results of GMM estimation, which are consistent with our previous results; that is, although the shadow banking activities of banks harm bank stability, a tightened macroprudential policy consistently improves bank stability and migrates the negative effect induced by the shadow banking activities. The results also show that our GMM estimation passes both the AR(2) test and the Hansen J test, indicating that the estimation is proper without autocorrelation and overidentification problems.

5. Conclusion

WMPs make up the largest component of China's shadow banking system and they are its main provider of funds. This study used quarterly bank level unbalanced panel data of WMPs issued by 269 commercial banks in China from 2006 to 2018 to measure China's shadow banking activities We examined the influence of shadow banking activities on the stability of Chinese banks and how macroprudential policies affect it. The empirical results show that the shadow banking activities represented by WMPs significantly reduce bank stability, but this effect is heterogeneous depending on the type of WMP. Compared with principal-guaranteed WMPs, principal-floating WMPs weaken bank stability to a greater extent. Both short-term and long-term WMPs reduce bank stability, but the latter tends to do more damage. The WMPs issued mainly to individual investors significantly harm the stability of banks, but those issued to VIP customers do not. Moreover, the effect of WMPs issued by different types of banks on bank stability is heterogeneous. Although

Table 10
System GMM estimates.

	Dep. Variable: $BSI_{i,t}$	
	(1)	(2)
$BSI_{i,t-1}$	0.760***	0.877***
	(0.0380)	(0.0470)
$BSI_{i,t-2}$	—	-0.101***
		(0.0342)
$WMP_{i,t}$	-0.0432**	-0.0443**
	(0.0217)	(0.0211)
$WMPs_{i,t} \times MPP_t$	0.00273**	0.00291**
	(0.00126)	(0.00128)
MPP_t	0.0856*	0.0578
	(0.0453)	(0.0426)
$RGDPG_t$	0.340***	0.274***
	(0.112)	(0.0954)
$MacroLev_t$	0.00952	0.00315
	(0.00717)	(0.00635)
$StockVol_t$	-0.000220	-0.000296
	(0.000571)	(0.000565)
$TAssets_{i,t}$	0.0494*	0.0434*
	(0.0255)	(0.0234)
$BankLev_{i,t}$	-0.0275	0.00133
	(0.0491)	(0.0549)
$NIM_{i,t}$	0.0470	0.0593
	(0.0493)	(0.0561)
$Deficit_t$	0.162***	0.157***
	(0.0171)	(0.0188)
$Shibor_t$	-0.239***	-0.210**
	(0.0909)	(0.0906)
Constant	13.03***	13.49***
	(3.650)	(3.220)
Observations	2554	2445
Number of Banks	249	249
Instrument number	458	503
Ar(1) Test (p-value)	0.00005	0.00008
Ar(2) Test (p-value)	0.0740	0.129
Hansen J Test (p-value)	1.000	1.000

Note: *, **, and *** represent 10%, 5%, and 1% significant levels, respectively. The robust standard errors are reported in parentheses. We also reported the p-value of Arellano-Bond tests for the null hypothesis of no first-order and second-order autocorrelation and the Hansen J test for the null hypothesis of over-identifying restrictions.

shadow banking activities damage the stability of large-sized banks, they have no significant influence on the stability of small- and medium-sized banks. This may because most WMPs are issued by large banks.

Overall, a tightening macroprudential policy improves the soundness of banks and eases the negative effects of shadow banking activities on banking stability. This may result from the reduced issuance of WMPs and may therefore enhance bank stability. However, tightened regulation may instead harm banks' stability by limiting the issuance of WMPs to high-quality customers. This emphasizes the importance and necessity for regulatory authorities to design specific macroprudential policies according to different kinds of shadow banking activities and different types of banks. For state-owned banks, WMP business can be separated from regular business. This prevents the risk created by WMPs from spreading to the parent company. Excessive prudential standards may force small- and medium-sized banks to circumvent regulations and turn their regular business into off-balance-sheet business, which may not be conducive to the healthy development and stability of banks.

Data availability

Data will be made available on request.

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