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# Does the Development of Money Market Funds in China Increase the Bank Liquidity Risk?

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## Abstract

This paper studies the relationship between money market funds (MMFs) and bank liquidity risk in China. Based on the unique feature of "liquidity stratification" in China, the paper proposes a model of interbank market that includes big banks, small banks, and MMFs. The model drives that the emergence of MMFs pushes up the interbank liability ratio of the banking system and raises the bank liquidity risk. Using unbalanced bank-level panel data from China for the period from 2014 to 2021, we find that the empirical results are consistent with the theory. It is shown that the expansion of MMFs significantly elevates the bank liquidity risk in general, but this effect varies significantly by bank type, bank size, and different capital adequacy ratio. Moreover, the interbank liability channel plays an important mediating transmission role in the process of MMFs affecting bank liquidity risk.

**Keywords:** Money market funds, Bank liquidity risk, Interbank liability channel.

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# 1. Introduction

Non-bank financial intermediaries represented by asset management products have developed rapidly in China. As of the end of June 2021, there were a total of 143,700 financial institutions' existing asset management products, with a combined asset amount of approximately RMB 92.6 trillion. Among all the asset management products, MMFs have grown most rapidly . Resulting from the tax-free advantages and accounting advantages of amortized cost method, MMFs in China have grown from less than RMB 600 billion at the beginning of 2012 to more than RMB 20 trillion at the end of October 2022. In China, MMFs contain not only the MMFs regulated by China Securities Regulatory Commission (CSRC), but also the cash management wealth management products (WMPs) regulated by the China Banking and Insurance Regulatory Commission(CBIRC), which were introduced in China in 2018. By the end of 2021, global MMFs were about USD 10 trillion[3], of which the MMFs in China accounted for about 30 percent and MMFs in United States accounted for nearly 50 percent. Due to the data transparency problem, the subsequent empirical analysis in this paper is mainly based on the MMFs regulated by the CSRC.

The distinctive feature of MMFs in China is more closely linked to commercial banks, which are the most important financial intermediaries in China. Firstly, the features of stable net asset values(NAVs) and "T+0"settlement make MMFs in China more "deposit-like", while the "T+0" settlement is supported by the commercial banks. In US and Europe, the use of amortized cost method is strictly limited and "T+0" settlement advance is uncommon. Secondly, the MMF sector is an important funding source for commercial banks, especially for regional small banks. The MMFs invest a lot of interbank deposits and interbank certificated of deposits (CDs). The MMFs hold about more than 20% of interbank deposits and interbank CDs that banks issue. Thirdly, commercial banks are also important institutional investors in MMFs. Since the indirect investment in interbank deposits and interbank CDs through MMFs has unique tax-free advantages, there are obvious arbitrage gains for commercial banks through issuing interbank CDs and investing in MMFs. Tax exemption is also an important reason for commercial banks to invest in MMFs.

[3] The data is based on " policy proposals to enhance money market fund resilience " publised by Financial stability board(FSB) in 2021 .But FSB's statistics omitted cash management WMPs in China.

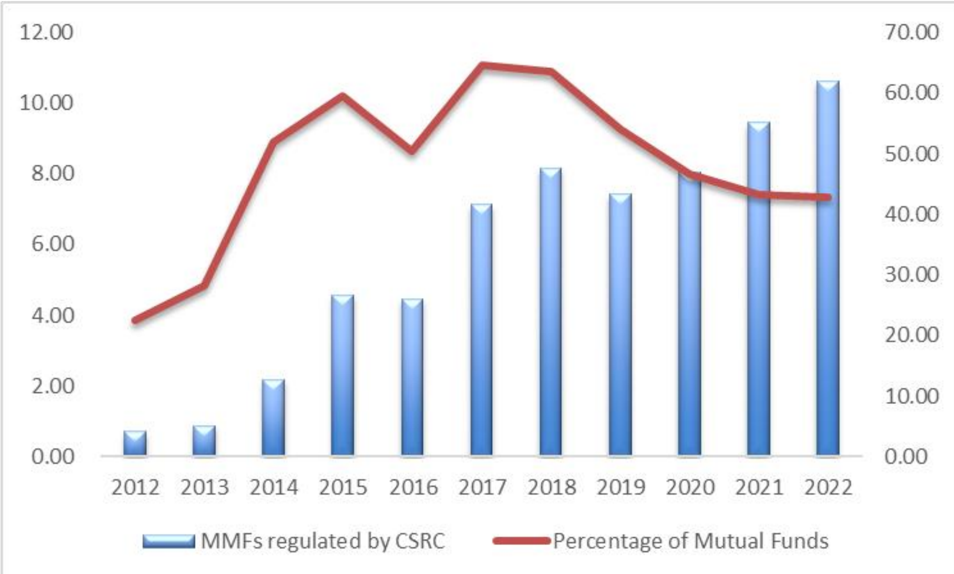


**Figure 1: Chinese MMFs scale and its fraction of Mutual Funds**

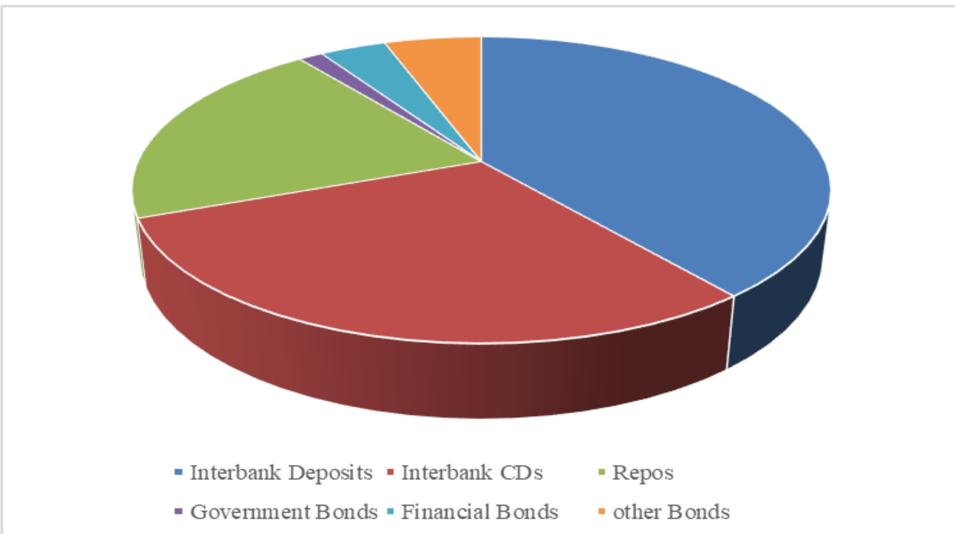


**Figure 2: MMFs holdings at the end of 2021**

Liquidity risk is known as the "deadliest risk of commercial banks" due to its high uncertainty and destructive impact. More seriously, the bank liquidity risk is highly contagious and can easily form a liquidity loss spiral, triggering systemic financial risk. With rapid development of the financial market, commercial banks are deeply integrated with financial markets and financial products, which brings new challenges for bank liquidity risk management and regulation. Just as Min Liao and Yuan-Yuan Yang (2008) said, the development of financial market is a doubleedged sword for China's banking system: on the one hand, it increases the diversity of banks' asset and liability portfolios, which helps improve liquidity risk management and better matches assets with liabilities; on the other hand, however, compared with retail deposits and traditional loans, capital market products are more volatile and more cyclical, exposing the banks to greater liquidity risk management challenges . Does the rapid development of MMFs in China increase the bank liquidity risk? How does the development of MMFs influence bank liquidity risk in China? How should we set the clear boundary between MMFs and bank deposits in order to promote the stability of the entire financial system? In this paper, we attempt to answer these questions.

Firstly, we start by presenting a new model of interbank market in China based on the theoretical studies of scholars such as Xia, Cong and Zhu (2022) and Hachem and Song (2017). The interbank market is an imperfectly competitive market with monopoly power and information asymmetry. Big banks and MMFs are the main suppliers of funds while small banks are the main demanders. Through model analysis, we find that the larger the MMFs, the higher the bank interbank liability ratio. As wholesale financing is much less stable than retail financing (Huang & Ratnovski, 2011), the high interbank liability ratio pushes up bank liquidity risk. Secondly, we empirically test the effect of MMFs development on bank liquidity risk using unbalanced bank-level panel date from China for the period from 2014 to 2021.We find robust evidence that the development of MMFs exacerbates bank liquidity risk in general. The heterogeneity analysis further indicates that the deterioration effect brought about by MMFs is more salient in banks with relatively limited business scope, small sizes and less capital adequacy. Thirdly, we use the mediating effect model to test whether the interbank liability channel plays an important mediating transmission role in the process of MMFs affecting bank liquidity risk. The results indicate that the mediating effect of interbank liability channel accounts for 19% of the total effect between MMFs and bank liquidity risk. Overall, the theoretical and empirical findings in the paper enrich the existing literature about the MMFs in China, which is an important part of shadow banking in China but gains little attention compared to WMPs. Also, this paper complements studies about the factors influencing bank liquidity risk. Insofar, this paper contributes to the understanding of how shadow banking such as MMFs may affect the stability of banks.

The rest of the paper is organized as follows. Section 2 presents literature review briefly. Section 3 presents a stylized model for interbank market in China. Section 4 describes data, variables and models. Section 5 describes main empirical results. Section 6 concludes the paper.

# 2. Literature Review

## 2.1 Bank Liquidity Risk and Influencing Factors

According to Min Liao and Yuan-Yuan Yang (2008), bank liquidity risk referred to the risk that banks were unable to provide sufficient funds to meet the increasing demand for assets or to meet their obligations. Decker (2000) indicated that liquidity risk can be divided into funding liquidity risk and market liquidity risk. Brunnermeier and Pedersen (2009) pointed out that funding liquidity risk and market liquidity risk can interact with each other and may lead to liquidity depletion of the entire financial system in times of crisis.

Previously, the related literature of bank liquidity risk mainly focused on bank run or failures. In the canonical model of Diamond and Dybvig (1983), bank failed because of liquidity demand by retail depositors. These depositors received exogenous liquidity shocks and demanded immediacy of payments precipitating bank runs. In the model of Acharya and Skeie (2011), bank failed because of liquidity demand by wholesale financiers. Acharya and Skeie (2011) proposed that rollover risk induced precautionary demand for liquidity in banks, causing interbank spreads to rise dramatically and interbank market frozen extremely.

Some scholars focused on the relationship between financial markets and bank liquidity risk. Some of them concluded that financial market development can help reduce bank liquidity risk. Franck and Krausz (2007) argued that capital market could serve a similar function as lender of last resort and could improve the bank's asset liquidity. Calomiris (1999) indicated that commercial banks could develop valuable investment opportunities by financing from the financial market without being constrained by local deposits supply. Calomiris and Kahn (1991) [10]pointed out that the financial market provided a venue for refinancing unanticipated withdrawals by retail banks, reducing liquidity risk. However, some scholars insisted that financial market development can increase bank liquidity risk. Ying (2002) indicated that the development of capital market in China had a negative impact on both the liability and asset liquidities of commercial banks. On one hand, it promoted the transformation of bank liabilities from stable retail deposits to unstable wholesale deposits. On the other hand, it promoted the use of bank assets for fixed-term and long-term purposes, which intensified the maturity mismatch of commercial banks' assets and liabilities and thus increased the bank liquidity risk. Wholesale financing had the dark side of poor stability and insufficient incentives for market discipline, and wholesale financers tended to ignore the counterparty credit risk due to short maturities and provide more funds for high-risk banks (Huang & Ratnovski, 2011; Myers & Rajan, 1998; Morrison & White, 2013). The dependency on wholesale financing increased the bank liquidity risk.

In a word, although the literature on bank liquidity risk and the influencing factors is plentiful, the scholars rarely take the development of MMFs into consideration.

## 2.2 MMFs Liquidity Risk and Influencing Factors

The liquidity risks of MMFs have been extensively described and documented, both in academic research and in official publications. Academic researchers were largely salient on MMFs risks until the Global Financial Crisis. However, the run on MMFs in 2008 prompted a wave of studies about factors that influence MMFs liquidity risk. Baba, McCauley et al. (2009), Kacperczyk and Schnabl (2013), Schmidt, Timmermann et al. (2016) based their study on the performance of MMFs during the Global Financial Crisis. Chernenko and Sunderam (2014) based their study on the performance of MMFs during the 2011 European Debt Crisis. Cipriani and La Spada (2020), Li, et al. (2021) analysed the MMFs runs at the outset of COVID-19 pandemic.

Bouveret, Martin et al. (2022) pointed that MMFs vulnerabilities had two fundamental sources: they performed liquidity transformation and they served as private money-like assets that can suddenly lose their" moneyness".

For the liquidity transformation function, the investors who redeemed first had significant "first mover advantages". Chen, Goldstein et al. (2010), Goldstein, Jiang et al. (2017) and Zeng (2017) had analysed both theoretically and empirically for non-MMF mutual funds. For MMFs, liquidity transformation may be particular stark. MMFs investors had incentives to redeem shares when liquidity is scarce, thus causing MMFs run in the crisis. For the money-like feature, when safe asset had proven to be risky, investors rushed to redeem (Schmidt, Timmermann, & Wermers, 2016). Once they no longer performed similar functions as "bank deposits", MMFs were vulnerable to runs.

Besides the two fundamental sources that caused MMFs liquidity risk, there were other factors that contribute to vulnerabilities. Some scholars found that vulnerabilities in MMFs could stem from the similarities of their portfolios. Bouveret and Danielli (2021) found that the Eurodollar MMFs and U.S. prime MMFs had a high degree of similarity. High portfolio overlaps and large market footprints indicated that when MMFs were subject to a common liquidity shock, they were likely to face acute challenges in disposing of their assets to meet redemptions. Some scholars found that threshold effects can contribute to MMFs liquidity risk. Li, et al. (2021) showed that liquidity restrictions on investors, like redemption gates and liquidity fees introduced in the 2016 MMF reform, exacerbated the run on the prime MMFs during the COVID-19 crisis.

## 2.3 Relationship between Shadow Banking and Bank Liquidity Risk

MMFs are part of shadow banking. The concept of shadow banking was first proposed by the American economist Paul McCulley in 2007. In 2011, the Financial Stability Board proposed that shadow banks were "credit intermediaries and credit intermediation activities outside the conventional banking system". Since 2016, the Financial Stability Board introduced the concept of economic functions (EFs), which subdivided narrow measure of shadow banking into five categories. MMFs, fixed income funds, hedge funds, etc. belonged to the first category and were categorized as "collective investment vehicles with features that make them susceptible to runs ".

In US and Europe, MMFs are the focus for analysis of shadow banking. Scholars such as Bouveret, Martin et al. (2022) and Baes, Bouveret et al. (2021) have argued that MMFs were key intermediaries in the short-term funding market. Baba, McCauley et al. (2009) insisted that a run on MMFs stressed global interbank markets because MMFs were the largest suppliers of dollar funding to non-US banks. Cipriani, Martin et al. (2013) found that a mechanism through which instability can arise in an MMF-intermediated financial system.

In China, WMPs and entrusted loans are the focus of shadow banking analysis. Liang (2016) pointed that shadow banking in China had contributed to credit expansion and credit-driven growth. However, such growth entailed significant financial risks and rendered the macro-economy financially fragile. Guo Ye and Zhao Jing (2017) showed that shadow banking significantly increased the risk of China's banking system by increasing interbank linkages and intensifying bank risk contagion.

Building on the existing research, we aim to study the impact of MMFs on bank liquidity risk.

# 3. Model

## 3.1 Benchmark Model

Our starting point is the micro model with interbank market developed in Xia Cong and Zhu Bo (2022), Hachem and Song (2017). In this section we disaggregate the banks into big banks and small banks. In the model, we portray the unique "liquidity stratification" phenomenon in China. Under the primary open market dealer system in China, the central bank’s low-cost funds are only available for big banks, while small banks can only rely on the interbank market to borrow funds from large banks. In the model, the big banks make loans to the non-financial sector funded primarily by depositors, while the small banks rely on the wholesale financing from big banks. The interbank market exists when big banks provide funding for small banks. The big banks and small banks are heterogeneous in the market power of interbank market. The small banks are price-taker in the interbank market. We use the Cournot Model to capture the market dominance of big banks in the interbank market. Assume that the number of big banks is $N$and they are homogeneous. The big bank can choose the amount of interbank assets $IB_j$ to maximize the profit. The decisions of the big banks will affect the equilibrium interest rate of the interbank market. Therefore, the supply function of interbank market is set as follows:

$$R_{IB} = a - \sum_{j=1}^{N} IB_j \tag{1}$$

In the formula (1), $a$ is set as constant number.

From the liability sides, big banks absorb deposits and liquidity injections by the central bank. The amounts of deposits for the *j*th(*j*=1,2,· · · , N) big bank is $D_j^B$. The deposit rate $R_d$ is regulated by central bank. We introduce the supply of external funds by central bank, $\psi_j = \psi R_{IB}$,where $\psi > 0$.

From the asset sides, big banks invest in both interbank assets $IB_j$ and loans $L_j^B$.

$$D_j^B = IB_j + L_j^B \tag{2}$$

Suppose that the interbank assets equal part of deposits plus central bank liquidity support:

$$IB_j = (1-\tau) * D_j^B + \psi_j \tag{3}$$

The profit the big bank can get from interbank assets is set as follows:

$$\Pi_j = IB_j * R_{IB} - (1-\tau) * D_j^B R_d \tag{4}$$

We can solve for the first-order condition of the big bank's profit maximization. The optimal solution for interbank investment is:

$$IB_j^* = \frac{a - R_d}{N+1} \tag{5}$$

The equilibrium interest rate of the interbank market is:

$$R_{IB} = a - \frac{N}{N+1}(a - R_d) \tag{6}$$

There is a continuum of risk-neutral, competitive small banks in the model. The small banks are heterogeneous with respect to their intermediation technology. Some banks are more efficient than others. The maximum rate of return that each small bank may achieve on its loans during the operating period is $R$. The effective gross return of loan is $\theta_i * R$ for small bank indexed by $i$. The $\theta_i$ s represent the intermediation skill of small bank indexed by $i$ . The $\theta_i$ s are distributed over the interval $[0,1]$ with cumulative distribution $u(\theta_i)$,satisfying $u(0)=0$, $u(1)=1$, $u'(\theta_i) > 0$.

From the liability side, small banks absorb deposits limited in the local areas and

finance from the interbank market. The interbank liability ratio, which is the ratio of interbank liabilities to deposits, is set as $\phi$ . $\phi$ is common and detectable.
From the asset side , small banks make loans to the non-financial companies.
The interbank market is subject to moral hazard and information asymmetry. For the moral hazard problem, small banks may be "lazy" after incorporating funds. The gross return of being "lazy" is set $r(1+\beta\phi)$ , where $\beta \in [0,1]$ . For the information asymmetry problem, small banks' intermediation skills are privately known, and lenders can neither observe them ex ante nor verify them ex post.
For the small banks, there is no incentive to finance from interbank market if their net return is less than the return on interbank investments. Then the constraints for small banks to borrow from the interbank market must satisfy:

$$\theta_i * R * (1+\phi) - \phi * R_{IB} \geq R_{IB} \tag{7}$$

In order to prevent borrowing banks from being "lazy", the level of interest rates in the interbank funding market should satisfy:

$$r(1+\beta\phi) - R_{IB}\phi \leq 0 \tag{8}$$

Then we can solve for the optimal solution of profit maximization subject to the budget constraint (7) (8).
Solve for the optimal solution of profit maximization subject to the budget constraint (4-9) (4-10).

$$\begin{aligned} &\max_{\phi} \theta_i * R * (1+\phi) - \phi * R_{IB} \\ &s.t \;\; r(1+\beta\phi) - R_{IB}\phi \leq 0 \\ &\quad\;\; \theta_i \geq R_{IB} / R \end{aligned} \tag{9}$$

Using the Lagrange function to solve the optimization problems, the optimization solution is as follows:

$$\phi^* = \frac{r}{R_{IB} - r\beta} \tag{10}$$

Under the set of the basic model, the total demand in the interbank market is

$$IB_D = (1 - \frac{R_{IB}}{R}) * \frac{r}{R_{IB} - r\beta} \tag{11}$$

### 3.2 Expanded Model

We now extend the benchmark model to include a Money Market Mutual Fund. As in China, MMF is allowed to invest in the interbank market. Depart from the deposits absorbed by both big banks and small banks, the return rate on MMF is unregulated by central bank. As the return rate on MMF is larger than the deposit rate regulated, the impact of MMF on banks is all-encompassing, hitting not only big banks, but also small smalls. When MMF enter the model, the deposits of both big banks and small banks decline. Suppose the degree of decline is set $\lambda$. Then we can get the new interbank lending constraint for big banks:

$$IB_{j,MMF} = (1-\tau)*(1-\lambda)D_j^B + \psi_j \tag{12}$$

The amount raised for a money market fund must satisfy the following condition:

$$M = \lambda\sum_{j=1}^{N} D_j^B + \lambda\sum_{i} D_i^S \tag{13}$$

Assume that the MMF invests all of its funds in the interbank market. Then, in the expanded model, the supply of funds in the interbank market is:

$$IB_{S,MMF} = \sum_{i=1}^{N} IB_{j,MMF} + M \tag{14}$$

According to the profit maximization principle of big banks, the optimal solution for the amounts of interbank assets of big banks is solved as:

$$IB_{j,MMF} = \frac{a - R_d - M}{N+1} \tag{15}$$

Then the supply of funds for the interbank market under the expanded model is:

$$IB_{S,MMF} = IB_S + \frac{M}{N+1} \tag{16}$$

The equilibrium interest rate in the interbank market is:

$$R_{IB,MMF} = R_{IB} - \frac{M}{N+1} \tag{17}$$

From formula (17), we can get the conclusion that under the expanded model, the equilibrium interest rate is lower than that in the basic model.
As small banks are price-takers in the interbank market, the total demand in the interbank market is adjusted to:

$$IB_{D,MMF} = (1 - \frac{R_{IB,MMF}}{R}) * \frac{r}{R_{IB,MMF} - r\beta} > IB_D \tag{18}$$

From equation (18), when introducing MMF in the model, the demand of small banks in the interbank market increases significantly. There are increasing availabilities of funds for small banks in the interbank market.
Under the expanded model, the interbank liability ratio of small banks is adjusted to:

$$\phi^*_{MMF} = \frac{r}{R_{IB,MMF} - r\beta} > \phi^* \tag{19}$$

From formula (19), it is indicated that the interbank liability ratio under the condition of bringing in MMF is much higher than that without MMF.
Deriving the equilibrium interest rate in the interbank market and the interbank liability ratio with respect to the size of the MMF, separately, we can get:

$$\frac{\partial R_{IB,MMF}}{\partial M} < 0 \tag{20}$$

$$\frac{\partial \phi^*_{MMF}}{\partial M} > 0 \tag{21}$$

As for the banking system, the quality of assets corresponding to a unit of wholesale interbank funding declined significantly as the equilibrium interest rate declined, where the interest rate is an important filtration mechanism for intermediation skills of small banks. As wholesale funds are usually raised on a short-term rollover basis , the decline in asset quality might make banks more vulnerable to the deterioration of asset-side returns, thus increasing the liquidity risk of banks. Then we can get our main hypothesises as follows:

**Theorem 3.1** *The larger the MMF, the higher the bank liquidity risk.*
**Theorem 3.2** *The larger the MMF, the higher the interbank liability ratio.*

# 4. Data and Methodology

## 4.1 Data

In this study, we build an unbalanced bank-level panel for the period from 2014 to 2021. We collect the bank-level data from Wind database. This paper finally selects 38 listed banks in China, including 6 state-owned commercial banks, 9 joint-stock banks, 15 urban commercial banks and 8 rural commercial banks. This paper selects these banks as the sample based on three main considerations. Firstly, the sample banks are representative for banking system in China. The total assets of the sample banks are RMB 225trillion, accounting for 65.5% of the total assets of banking industry in China. Secondly, the data is authoritative. As the sample banks are all listed banks, the financial data they released has been audited by third-party institutions. Thirdly, the data availability is better.

## 4.2 Variable Construction

We use the liquidity coverage ratio (LCR) to represent the bank liquidity risk, which is the dependent variable in the model. The Basel Ⅲ Accord contains the LCR that requires banks to hold sufficient high quality liquid assets to cover 30 days of estimated net cash outflows. We use the net growth ratio of MMFs to express the expansion degree of MMFs, which is the independent variable in our model.
Six bank-level variables are controlled since a wide range of the literature has confirmed their decisive roles in bank liquidity risk. We also control for a group of macro variables and use the interbank liability ratio as the mediating variable.

**Table 1: Description of variables**

| Variables | Description |
|---|---|
| $LCR$ | Reserves of high-quality liquid assets/net outflows for the next 30 days |
| $MMF$ | The growth rate of money market mutual funds |
| $IL$ | Interbank liability ratio=interbank liabilities/total liabilities |
| $nii$ | Non-interest income/total operating income |
| $npl$ | Non-performing loans/total loan balance |
| $car$ | Capital adequacy Ratio= Net capitalization/weighted risk assets |
| $size$ | Natural logarithm of total bank assets |
| $leverage$ | Leverage Ratio= total liabilities / total assets |
| $M_2$ | Quarterly year-on-year growth of money supply |
| $GDP$ | Quarterly year-on-year growth of gross domestic product |

## [1] Empirical Models

To test how MMFs growth affect bank liquidity risk, we first build the fix effects panel model. To control the model endogeneity, we test the relationship between MMFs growth in the current period and bank liquidity risk in the next period. The model is set as follows:

$$LCR_{i,t+1} = \beta_0 + \beta_1 MMF_t + \beta_2 X_{i,t+1} + \beta_3 Z_{t+1} + u_i + \varepsilon_{i,t+1} \tag{22}$$

Regarding above equation, the subscripts $t$ and $t+1$ represent the current period and next period, respectively. $X_{i.t+1}$ represent for bank-level control variables, which contain non-interest income ratio, non-performing loans ratio, capital adequacy ratio, the natural logarithm of total bank assets and leverage ratio. $Z_{t+1}$ represent for macro-level control variables, which contain quarterly year-on-year growth rate of money supply and gross domestic products.

Next, we build the Mediating effect model to test whether the interbank liability channel plays an important mediating transmission role in the process of MMFs affecting liquidity risk in the banking system. The mediating effect model is set as follows:

$$\begin{aligned} LCR_{i,t+1} &= \beta_0 + \beta_1 MMF_t + \beta_2 X_{i,t+1} + \beta_3 Z_{t+1} + u_i + \varepsilon_{i,t+1} \\ IL_{i,t+1} &= \gamma_0 + \gamma_1 MMF_t + \gamma_2 X_{i,t+1} + \gamma_3 Z_{t+1} + u_i + \varepsilon_{i,t+1} \\ LCR_{i,t+1} &= \rho_0 + \rho_1 MMF_t + \rho_2 LI_{i,t+1} + \rho_3 X_{i,t+1} + \rho_4 Z_{t+1} + u_i + \varepsilon_{i,t+1} \end{aligned} \tag{23}$$

According to mediating effects analysis method introduced by Wen et.al (2014),if $r_1$ and $\rho_2$ are both statistically significant , the mediating effects of Interbank Liability Channel is very significant. $|\gamma_1 \rho_2 / \rho_1|$ represents for the proportion of mediating effects to total effects.

# 5. Empirical Results

## 5.1 Descriptive Statistics

This paper collects data of listed banks from 2014 to 2021. Table 2 presents variable summary statistics. There are 698 observations in total. The mean of liquidity coverage ratio is 149.69% with the standard deviation of 56.82%. It is shown that bank liquidity risk varies across different banks and different dates. The average growth rate on MMFs is 5%. The largest growth rate is 52%, while the lowest growth rate is -9%.

**Table 2: Summary Statistics**

| Variables | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| $LCR$ (%) | 698 | 149.67 | 56.82 | 74.44 | 515.81 |
| $MMF$ | 698 | 0.05 | 0.11 | -0.09 | 0.52 |
| $nii$ (%) | 698 | 26.98 | 9.67 | -14.62 | 52.79 |
| $npl$ (%) | 698 | 2.19 | 0.41 | 1.18 | 3.81 |
| $car$ (%) | 698 | 13.46 | 1.85 | 0 | 18.02 |
| $size$ | 698 | 19.32 | 1.48 | 16.38 | 21.99 |
| $leverage$ (%) | 698 | 5.50 | 2.49 | 0 | 8.72 |
| $M_2$ (%) | 698 | 9.59 | 1.52 | 8 | 14.7 |
| $GDP$ (%) | 698 | 9.26 | 4.32 | -3.25 | 20.73 |

Sources: Wind Database

## 5.2 Main Results

The regression results of the fix effects panel model are shown in Table 3. Firstly, we run the regression without control variables. The results are shown in the column (1) of Table 3. Next, we run the regression containing control variables. The results are shown in the column (2) of Table 3. Under these two conditions, the coefficients on MMF are negative at the 1% level of significance. Then we can get the main conclusion that the faster the growth rate of MMFs, the lower the bank liquidity risk in the next term. Specifically, for every 1% increase in the size of MMFs, commercial bank liquidity risk increases by 0.58%. As for the control variables, the coefficient on capital adequacy ratio is significantly negative, which indicates that the higher the capital adequacy ratio, the lower the bank liquidity risk. The coefficient on bank size is significantly negative, which indicates that the correlation between bank size and bank liquidity risk is negative. The coefficient on leverage is significantly positive, which means that the higher the leverage ratio, the higher the bank liquidity risk. The coefficient on GDP is significantly negative, which means that the economic down cycle will increase bank liquidity risk.

**Table 3: Regressions of bank liquidity risk on MMFs growth rate**

| | (1)<br>*LCR* | (2)<br>*LCR* |
|---|---|---|
| *MMF* | -68.69***<br>（14.48） | -58.48***<br>（19.03） |
| *nii* | | 0.04<br>（0.33） |
| *npl* | | 2.48<br>（6.99） |
| *car* | | -4.60***<br>（1.52） |
| *size* | | -10.72***<br>（3.84） |
| *leverage* | | 2.85**<br>（1.36） |
| $M_2$ | | -0.31<br>（1.61） |
| *GDP* | | -0.68*<br>（0.40） |
| Bank fixed effect | Yes | Yes |
| Quarter fixed effect | Yes | Yes |
| Constant terms | 159.77***<br>（7.79） | 284.99***<br>（73.35） |
| Observations | 579 | 541 |
| Adjusted $R^2$ | 0.03 | 0.20 |

Note: standard deviation is bracketed below each coefficient, ***、**、* indicate coefficient is significant under 1%、5%、10% level.

Next, we run the regressions of the mediating effect model to test whether the interbank liability channel plays an important mediating transmission role in the process of MMFs affecting bank liquidity risk. The results are shown in Table 4. Firstly, we perform a regression analysis of the interbank liability ratio on the growth rate of MMFs. The results are shown in the column (1) of table 4. The coefficient on MMF is significantly positive under the 5% level of significance. It indicates that the development of MMFs contributes to pushing up the bank interbank liability ratio. Next, we perform a regression analysis of bank liquidity risk on both the interbank liability ratio and growth rate of MMFs. The coefficients of MMF and IL are both significantly negative. According to mediating effects analysis method introduced by Wen et.al (2014), the regression results can verify that the development of MMFs push up bank liquidity risk through interbank liability channel. The mediating effect of the interbank liability channel accounts for 19% of the total effects.

**Table 4: Results of the mediating effect model**

| | (1)<br>*IL* | (2)<br>*LCR* |
|---|---|---|
| *MMF* | 0.09**<br>（0.013） | -32.25*<br>（17.10） |
| *IL* | | -68.25*<br>(46.35) |
| Control Variables | Yes | Yes |
| Bank fixed effect | Yes | Yes |
| Quarter fixed effect | Yes | Yes |
| Constant terms | 1.00***<br>（0.11） | 243.61**<br>（79.81） |
| Observations | 541 | 541 |
| Adjusted $R^2$ | 0.25 | 0.21 |

Note: standard deviation is bracketed below each coefficient, ***、**、* indicate coefficient is significant under 1%、5%、10% level

## 5.3 Robust Tests

A series of robustness tests are applied to check whether the baseline results are consistent after adopting alternative measure of bank liquidity risk, different econometric methodologies and instrument variables.

First, we re-estimate our model using alternative indicators of bank liquidity risk. We construct the " liquidity mismatch index " ($LMI$) according to the indicators proposed by Bai, Krishnamurthy et al. (2018). $LMI$ is a measurement to gauge the mismatch between the market liquidity of assets and the funding liquidity of liabilities. The definition of $LMI$ is as follows:

$$LMI_{it} = \frac{\sum_k \lambda_{t,a_k} a_{i,t,k} - \sum_{k'} \lambda_{t,l_{k'}} l_{i,.t,k'}}{\sum_k a_{i,t,k}} = \frac{\sum_k \lambda_{t,a_k} a_{i,t,k}}{\sum_k a_{i,t,k}} - \frac{\sum_{k'} \lambda_{t,l_{k'}} l_{i,t,k'}}{\sum_k a_{i,t,k}} \quad (24)$$
$$= LMIA_{it} - LMIL_{it}$$

Where $LMIA_{it}$ and $LMIL_{it}$ are the asset and liability mismatch indexes for bank $i$ at time $t$ ,respectively. $\lambda_{t,a_k}$ and $\lambda_{t,l_{k'}}$ are the asset-side weights and the liability-side weights, respectively, where $\lambda_{t,a_k} > 0$ and $\lambda_{t,l_{k'}} > 0$ . $a_{i,t,k}$ and $l_{i,t,k'}$ are assets and liabilities for bank $i$ at time $t$ across classes $k$ and $k'$ ,respectively. Higher levels of $LMI$ indicate a sound liquidity position and low liquidity mismatch, whereas low or even negative values imply liquidity stress.

Table 5 describes the calculation methods respect to the liquidity weights and details of the asset and liability classes.

**Table 5: LMI liquidity weights and balance sheet classes**

| **Assets Category** | **Asset Weights** | **Liabilities category** | **Liability Weights** |
|---|---|---|---|
| Cash and deposits with the central bank | 100% | Deposits from interbank and other financial institutions | 100% |
| Deposits with interbank and other financial institutions | 100% | Repos | 90% |
| Repos | 90% | Borrowing from the central bank | 75% |
| Financial assets at fair value through profit or loss | 85% | Loans from other banks | 75% |
| Available-for-sale financial assets | 75% | Bonds Payable | 75% |
| Held-to-maturity financial assets | 50% | Derivative financial liabilities | 50% |
| Derivative financial assets | 50% | Financial liabilities at fair value through profit or loss | 50% |
| Financial Investment | 50% | Other liabilities (including tax payable and deferred income tax liabilities) | 50% |
| Other financial assets | 50% | Deposits | 10% |
| Loan disbursement and advances | 20% | | |
| Long-term equity investments | 10% | | |
| Other Assets | 10% | | |

It is shown in column(1) and column(2) of Table 6 that the coefficient on $MMF$ is significantly negative, indicating that bank liquidity risk could be strengthened by the growth of MMFs, in line with our baseline findings. It is shown in column(3) and column(4) of Table 6 that the interbank liability channel plays an important intermediate transmission role in the process of money market funds affecting liquidity risk in the banking system.

Secondly, we apply the dynamic panel models to re-estimate the results. Considering that bank liquidity risk has the feature of continuity, we absorb two lags of the dependent variables as the independent variables. The model is set as follows:

$$LCR_{it+1} = \alpha + \beta_1 LCR_{i,t} +_1 \beta_2 LCR_{i,t-1} + \beta_3 MMF_t + \beta_4 X_{i,t+1} + \beta_5 Z_{t+1} + u_i + \varepsilon_{i,t+1} \quad (25)$$

The literature has usually applied both differential GMM and systematic GMM methods to estimate dynamic panel models. In this paper, the models are estimated with the two methods, differential GMM and systematic GMM, respectively. The prerequisite for the implementation of these two methods is that there is no autocorrelation among the perturbation terms. The models may also suffer from over-identification problems due to the introduction of too many instrumental variables. Therefore, this subsection also verifies the validity of serial correlation and instrumental variables. Further, we test the model for over-identification and find the Sargan statistic is not significant at the 5% level of significance, indicating that the original hypothesis of "all instrumental variables are valid" can be rejected. This indicates that the prerequisites of differential GMM and systematic GMM are valid and the results of the dynamic panel models are reliable. The results of differential GMM methods are shown in column (5) of Table 6. The results of systematic GMM methods are shown in column (6) of Table 6. The coefficients on *MMF* are significantly negative. Moreover, the absolute values of the coefficients of the dynamic model are smaller than those of the static model, suggesting that growth rate of MMFs play a smaller role in bank liquidity risk after excluding the inertial adjustment effect of the dependent variable.

Thirdly, the values of the independent variables averaged over two lags are included in the model as instrumental variables. It is shown in column (7) and column (8) of Table 6 that the coefficients on instrument variables are significantly negative. The regressions represented by column (7) do not contain control variables, while the regressions represented by column (8) contain control variables.

**Table 6: Results of the robust tests**

| | (1) *LMI* | (2) *LMI* | (3) *IL* | (4) *LMI* | (5) *LCR* | (6) *LCR* | (7) *LCR* | (8) *LCR* |
|---|---|---|---|---|---|---|---|---|
| *MMF* | -17.26*** (2.42) | -11.86*** (2.74) | 0.09** (0.013) | -12.75*** (2.54) | -15.26** (6.28) | -31.54*** (10.03) | | |
| *IL* | | | | -80.56*** (7.35) | | | | |
| *L.LCR* | | | | | 0.13* (0.074) | 0.34*** (0.06) | | |
| $L_2$.*LCR* | | | | | -0.011* (0.056) | 0.05 (0.04) | | |
| Instrument variable | | | | | | | -104.09*** (18.28) | -101.88*** (23.16) |
| Control Variables | No | Yes | Yes | Yes | Yes | Yes | No | Yes |
| Bank and quarter fixed effect | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 579 | 541 | 541 | 541 | 465 | 508 | 533 | 508 |
| Adjusted $R^2$ | 0.06 | 0.15 | 0.25 | 0.53 | 0.20 | 0.25 | 0.04 | 0.22 |

### 5.4 Heterogeneity Analysis

Having found that developed MMFs increase bank liquidity risk, we next examine the relevant factors contributing to the heterogeneity of the MMF-bank liquidity risk nexus. In this section, we test whether the effect of MMFs development on bank liquidity risk varies across banks' features.

First, we divide the sample of banks based on bank type. We divide the sample into national commercial banks and regional commercial banks. National commercial banks include state-owned commercial banks and joint-stock commercial banks, which own outlets throughout the country and a wide range of income sources. Regional commercial banks include urban commercial banks and rural commercial banks. Therefore, being involved in the MMFs wave, regional commercial banks are more sensitive due to their limited deposits sources and lower capacities to resist risk. Column(1) and (2) of Table 7 present the results, showing that the coefficient on MMF is statistically larger for regional commercial banks. This finding indicates that regional commercial banks are more vulnerable to MMFs development than national commercial banks.

Secondly, we divide the sample of banks based on bank size. With reference to He et al. (2021), we further divide the sample into large banks and small banks based on the size of the banks, which cut off at the 75% quantile of commercial banks' assets size. We perform regression analysis for each of the two subsamples. The impact of MMF on bank liquidity risk can differ between large and small banks. For one thing, large banks often participate in issuing WMPs which are similar as MMFs. The issuance of WMPs can mitigate the impact of MMFs. For another, large banks have brand advantages, which may attract lots of stable investors with low risk appetite. Column (3) and (4) of Table 7 present the results, showing that the coefficient on MMF is statistically larger for small banks. This finding indicates that small banks are more vulnerable to MMFs development than big banks.

Thirdly, we add a cross term combined with the growth rate of MMFs and the capital adequacy ratio of banks in the model. We first perform a regression analysis without the control variables. The results are shown in the column(5) of Table 7. Then we perform a regression analysis containing all the control variables. The results are shown in column (6) of Table 7. The coefficient on the cross term is significantly positive, which indicates that higher capital adequacy ratio will weaken the negative effect of MMFs on bank liquidity risk. Diamond and Rajan (2001) found that there was a strong link between capital adequacy ratio and bank liquidity risk. The higher the capital adequacy ratio, the lower the bank liquidity risk.

**Table 7: Results of heterogeneity analysis**

| | (1) National Banks | (2) Regional Banks | (3) Large Banks | (4) Small Banks | (5) $LCR$ | (6) $LCR$ |
|---|---|---|---|---|---|---|
| $MMF$ | -41.31*** (12.04) | -73.48* (39.1) | -46.32*** (15.57) | -65.00*** (25.05) | -229.68** (92.28) | -448.00*** (162.37) |
| $MMF * car$ | | | | | 12.15* (6.88) | 29.09** (12.05) |
| Control Variables | Yes | Yes | Yes | Yes | No | Yes |
| Bank and quarter fixed effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant terms | -168.18 (128.43) | 84.95 (193.02) | -226.23 (304.54) | 310.10*** (113.43) | 159.77*** (7.79) | 296.57*** (74.34) |
| Observations | 282 | 259 | 142 | 395 | 579 | 541 |
| Adjusted $R^2$ | 0.15 | 0.04 | 0.10 | 0.22 | 0.03 | 0.21 |

Note: standard deviation is bracketed below each coefficient, ***、**、* indicate coefficient is significant under 1%、5%、10% level

## 6. Conclusions

This paper has attempted to examine the crucial question of whether MMFs development has an impact on the liquidity risk of traditional commercial banks in China, a country that experienced phenomenal growth of MMFs from 2012 to 2021.With a dataset comprising a panel of all the listed banks in China, we find robust evidence that the development of MMFs intensifies the bank liquidity risk. Moreover, the heterogeneity analysis demonstrates that the above nexus is heterogeneous among banks with different characteristics, such as bank type, size and capital adequacy ratio. Further we find that the interbank liability channel is the main mediating channel for the nexus between MMFs and bank liquidity risk. As wholesale financing is less stable than deposits taking, making banks more dependent on wholesale financing is a threat to the healthy development of traditional commercial banks.

The deposit-like features of MMFs in China make MMFs extremely competitive in China. Especially under the new regulations on asset management[4], the regulators prohibited banks from guaranteeing a rate of return on WMPs, which were competitors of MMFs. Since the establishment of new regulations on asset management, MMFs have grown fast. MMFs have expanded by nearly RMB 14 trillion, which contain MMFs regulated by CSRC of nearly RMB 4 trillion and cash

[4] In April 2018, the people's bank of China and four financial regulatory agencies jointly issued rules to eliminate implicit guarantees, regulatory arbitrage and maturity mismatch in the asset management sector.

management WMPs regulated by CSIRC of nearly RMB 10 trillion. Based on the analysis in this paper above, the excessive growth of MMFs is not conducive to the stability of the banking system. The close "entanglement" of MMFs with the traditional commercial banks allows the funds to take full advantage of its risk association with banks and indirectly take up the central bank's liquidity support and deposit insurance, which triggers emergency intervention of the central bank and breeds moral hazard in times of crisis.

In order to promote the healthy development of banks in China, we should limit the irrational expansion of MMFs. Firstly, the scope of the use of the amortized cost method should be limited. The MMFs whose major investments are non-sovereign securities with credit risk should be valued with a flexible end-of-day net asset value (NAV) method. The change of valuation method will make MMFs apart from deposits provided by traditional banks. Secondly, whether to allow banks to make advances to MMFs should be assessed. If we allow banks to provide liquidity advances for MMFs, the liquidity risk of MMFs can be quickly transmitted to banking system through the funds advance channel in the event of MMFs runs. Thirdly, whether there should be tax advantages when participating in the interbank market through MFMs mediating channel should be further considered. The tax advantages may make traditional banks become the main institutional investors of MMFs, which attributes the vulnerabilities of MMFs.

For traditional banks, we should intensify the efforts to reform in order to enhance their capacities to resist risk aroused by MMFs. Firstly, we should strengthen the supervision of interbank business in banks. The banks should avoid over-reliance on interbank liabilities, especially not on the interbank liabilities supported by MMFs. Secondly, we should promote interest rate liberalization. We should encourage banks to further improve their independent pricing capabilities and strengthen supervision of irrational pricing behavior. Next, attention should be paid to the impact of non-bank financial intermediaries such as MMFs. A systemic risk monitoring mechanism for the integration of traditional banks and new wealth management products should be designed to guard the bottom line of "no systemic financial risk".

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