Benefits and Risks of Shadow Money: Evidence from Chinese WMP Market

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Abstract

We study banking competition in presence of shadow money. Investors choose between insured deposits and uninsured off-balance sheet shadow money. Banks compete for investors by setting corresponding interest rates and default endogenously. Our approach allows to quantitatively examine the benefits and risks inherent in shadow money across time and states. We calibrate our model to Chinese banking sector data using wealth management products (WMPs) as proxy for shadow money. Implicit guarantees inherent in WMPs incentive banks to issue more shadow money. The resulting supply of credit boosts economic growth but also builds up financial fragility that potentially hampers economy. Multiple equilibria emerge which may lead to severe financial distress with large welfare losses. Further, we show that banks are more fragile if adjusting rates on shadow money is costly and that imposing capital requirements on shadow money is not a suitable policy to enhance stability.

Keywords: banking competition, financial stability, shadow banking, wealth management products

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1. Introduction

The boom and bust of the shadow banking system have played a central role in the expansion and contraction of the economy in the past years. While shadow money can increase economic growth by providing easily accessible funding during an expansion period, it can also lead to increasing fragility of the banking system as it is mostly unregulated and amplifies leverage. A modest negative shock in the shadow banking boom can cause liquidity to evaporate and set off a cascade of adverse events: shadow banks go bust, retail banks suffer, capital investments fall and the economy enters a recession. The latest global financial crisis (GFC) recorded such an episode in the business cycle. The rapid growth of the shadow banking sector in China since 2010 has attracted particular attention by researchers and policymakers. While there has been substantial research focussing on regulatory arbitrage and the effects of monetary policy interventions, the systemic role of the shadow banking sector has been investigated much less though. The heavy reliance on shadow financing, however, also substantially increases the odds of a systemic financial crisis originating in the shadow banking sector with spillover effects to the whole banking system and real economy.

In this paper we examine the benefits and risks inherent in shadow money to the banking system and the real economy across time and states. To this end, we adopt a banking model from Egan et al. [2017] where banks compete for uninsured and insured depositors, and default endogenously. Our setting deviates from their model to account for several stylized facts on shadow money. Firstly, in our model banks compete for insured deposits and uninsured off-balance sheet shadow money. Banks seek to raise funding through shadow money because of the regulatory arbitrage opportunities represented by off-balance-sheet shadow money relative to traditional deposits (e.g. Acharya et al. [2013b]). Secondly, in our model retail banks contract with shadow banks who manage the shdaow money instruments. Profits on shadow money are split between retail and shadow banks. When retail banks can retain a larger fraction of the profits, this indicates a higher bargaining power when contracting with shadow banks and thus more incentives for retail banks to issue shadow money. A similar approach is used, for example, in He and Milbradt [2014] to model the profit split for bond traders. Thirdly, shadow money investors as well as retail banks assume that shadow money is implicitly guaranteed by issuing shadow banks or directly by the government. The value of such an implicit guarantee is a good measure for the prosperity and risk of shadow money. Incorporating these features into a model for banking competition enables us to study the impact of shadow money on the financial system and the real economy in equilibrium.

We estimate and calibrate our model to a unique data set of China's retail banks with insured deposits on the balance sheet and shadow money off the balance sheet. In China so-called wealth management products (WMPs) consistute a large fraction of all shadow banking instruments. Abusing notations, we interchangeably use shadow money and WMP in the sequel. We determine demand for WMPs and for deposits by a difference-in-difference specification as in Egan et al. [2017] and Berry et al. [1995]. The estimated market share of WMPs declines with bank distress while that of deposits is left unaffected. This feature implies a feedback loop between financial distress and demand for shadow money. We further calibrate the supply-side parameters, i.e. the means and variances of asset returns as well as the premium for implicit guarantees on WMPs for all banks, through banks' optimal rate setting on deposits and shadow money given demand elasticities. The premium for implicit guarantees or bailout rate is mainly driven by the rate spread, i.e. the WMP rate net the deposit rate, and the markup spread which is given by the marginal demand rate on WMPs net the marginal demand rate on deposits. Hachem and Song [2016] document that banks strongly believe in the implicit guarantee and Dang et al. [2015] provide theoretical evidence that China's shadow banking system heavily relies on such an implicit guarantee. Within our model setup, we are able to explicitly quantify the bailout rate on WMPs.

The expected returns and standard deviations of banks' assets throughout Q2/2008-Q1/2017 ranged reasonably between 3.5%–6% and between 15%–60%, respectively. Their dynamics capture the global financial crisis of 2007/2008 and the Chinese equity market crash in 2015. The bailout rate was flat at about 4% prior to 2012. It moved upward since 2012 and peaked on the burst of China's equity market crash in 2015. Bian et al. [2018] document that a big portion of China's 2008-2009 economic stimulus plan of RMB 4 trillion had to be rolled over in 2012. To finance these rollovers institutions strongly relied on shadow money instruments as demand on deposits was low in response to the low deposit rates. Banks learned that government would intervene to bail out financial market. Thus, banks relied on the implicit government guarantee, which incentivized them to issue more shadow money.[2] Compared with the systemically important banks, the non-systemically important banks had much less deposit financing and hence they acted more aggressively in offering WMP rates. Their bailout rates were higher than those of the systemically important banks from 2012, reflecting that they relied on and valued the implicit government guarantee more than the systemically important banks.

Our results indicate that the bailout rate is a robust predictor of economic activities since economy expands with the rising supply of credit. We find that an increase in the bailout rate predicts a rise in real estate investment and GDP, inflation, a drop in unemployment rate and an increase in both sale and purchasing power over one quarter. While shadow money constitutes an easily accessable source of funding to the economy, it also builds up financial fragility over time. All else equal, the increased WMP rate relative to deposit rate not only incentivizes banks to issue shadow money but also raises banks' default risks as their profit margins drop. The increased default risk, however, lowers the markup spread. We find that the economic growth suffers setback while the markup spread increases. Furthermore, a shock of one standard deviation of the bailout rate, which is independent of the endogenous variables, causes persistent and substantial impact on economic activities over 4 or 5 quarters. Although macroeconomic variables respond to innovations to the markup spread negatively, the net effect of responding to the bailout rate is positive because the bailout rate is driven mainly by the rate spread in our sample. Our findings are different to results for the corporate bond market in Gilchrist and Zakrajšek [2012], who find that an increase in the corporate bond spread reduces the supply of credit and causes economy to contract.

Further, we examine financial fragility and shadow money by comparing the realized banking system and the alternative equilibrium in spirit of Egan et al. [2017]. We compute multiple equilibria of interest rates, default probabilities and market shares under the same bank fundamentals as of Q3/2015 in our baseline model for the four systemically important banks. We rank equilibria according to banks' relative welfare and group them into good equilibria with low probability of default and positive welfare, and bad equilibria with high probability of default and negative welfare.

[2] Similar moral hazard problems have been studied in Cordella and Yeyati [2003], Gorton and Huang [2004], Kacperczyk and Schnabl [2013] and Dam and Koetter [2012].

We find that the observed Chinese banking system is comparable to the best equilibrium that has the lowest probability of default and highest positive welfare. Across good equilibria, banks reduce demand for deposits but keep strong demand for WMPs: the observed cumulative market share for deposits, 43.09%, drops and the observed cumulative market share for WMPs, 28.07%, rises slightly compared to the alternatives. Given that WMP financing is lower than deposit financing, the high elasticity of demand for WMPs from customers and the absence of capital requirements on WMPs drive banks to raise WMP rates in order to lift demand for WMPs given that probability of default is low in good states. Moreover, as long as banks gain more bargaining power to obtain higher profits from lending out shadow money in good states, they improve profitability and become more stable. In other words, shadow money can stabilize the banking system in the good states.

In bad states, however, shadow money builds up fragility which may causes severe financial distress and large welfare losses. Several facts stand out. First, even in good equilibria, banks are socially optimal but fragile. The banks' average default probability is 0.22% in the best equilibrium and thus higher than the observed one of 0.16%. Second, asymmetric and concentric bad equilibria indicate instabilities of the banking system. Banks default with an average probability of 50% in some bad equilibria in contrast to the observed 0.16%, leading to welfare losses of more than 50 trillion RMB. Either a single bank or even all banks, which seem stable, could be extremely vulnerable although the fundamental risks for banks are unchanged. China Construction Bank (CCB), a systemically important bank and the wolrd's second largest bank by assets, has an observed default probability of 0.20%. It defaults with probability 22.45% in one bad equilibrium[3] while the other banks' default probabilities are as low as 0.05%–0.4%. In this equilibrium, distressed CCB values the implicit guarantee and raises deposit and WMP rates. CCB's competitors raise rates as well to compete, cutting off profit margins and increasing financial fragility of the whole banking system. Third, gain in welfare and financial stability in the good equilibria when banks have more bargaining power with shadow banks are sacrificed for loss in the bad equilibria. Indeed, more bargaining power causes more swings in financial distress and welfare loss. The interaction between banks and shadow banks as well as the competition between deposits and WMPs generate and transmit ex-

[3]Given the same fundamentals for CCB, depositors could believe that CCB defaults with the observed default probability 0.20% in one equilibrium or with a higher default probability of 22.45% in another equilibrium.

tensive risks from the shadow banking to the retail banking. This leads to a fragile banking sysmem although WMP financing relative to deposits and the bargaining power of banks in our sample are low. Fourth, our alternative equilibria exhibit left skewness: welfare losses in the bad equilibria are much more substantial than welfare gains in the good equilibria. Fifth, we observe that risk concentration on the unstable banks may effectively drive some banks out of the insured deposit market in some of the bad equilibria. Last, we also find asymmetric and concentric equilibria for the non-systemically important banks with welfare losses in the same order of magnitude as for the systemically important banks. This is different from the view that Chinese non-big 4 banks are less important for the stability of the banking system.

We extend our model to study bank runs on WMPs. Therefore, we introduce a liquidity cost function when banks adjust WMP rates. Borrowing is costly in the economic downturn in which interbank lending is frozen (compare e.g. Acharya et al. [2011] or Diamond and Rajan [2011]). Note that unregulated WMPs are much more run-prone compared to the uninsured deposits in Egan et al. [2017]. When it is costly for banks to adjust WMP rates, the profit margins on WMPs could quickly become negative and use up equity, speeding up bank failures. While we observe some weak runs on WMPs in the baseline model, we find that the accumulated market share in the bad equilibria drops dramatically in the specification with liquidity costs, generating more welfare losses and higher default probabilities compared with those in the baseline model.

In the aftermath of the financial crisis 2007/2008, capital requirements have been commonly imposed for many kinds of shadow money instruments. A corresponding policy became effective in China in the beginning of 2018. We incorporate its implementation in our model to study its effectiveness. We find that increasing capital requirements to deposits and/or WMPs reduces financial fragility and increases social welfare. However, the banking system is still fragile if the capital requirements to deposits and/or WMPs are at rather low levels as suggested in current regulations. We define the optimal level of capital requirement as the one at which the financial distress and welfare in the worst equilibrium are almost as good as those in the best equilibrium. Our results indicate that the optimal capital requirement needs to be as high as 30% in order to stabilize the banking system. Thus, our findings show that the currently implemented regulatory rules are not as effective as anticipated by policy makers.

Our paper relates to the literature on banking competition and financial stability. While Egan et al. [2017] study competition between insured and uninsured deposits, we emphasize competition in the presence of shadow money and analyse the effects of shadow money on the real economy and the banking sector. In this sense, our model offers empirical evidence to the work of Moreira and Savov [2017], Gertler and Kiyotaki [2010] and Gertler and Kiyotaki [2015]. Moreira and Savov [2017] show that shadow money expands liquidity provision and boosts economic growth in good times but also builds up fragility over time that may cause a recession in bad times. Their model does not consider banking competition but instead focusses on the liquidity channel and shadow money. Another closely related work is Shu [2017]. The author studies how a representative shadow bank competes for deposits with a representative retail bank and predicts that the shadow bank offers higher rates on deposits than the retail bank. To the best of our knowledge, our work is the first that models how a pool of banks compete for deposits and shadow money simultaneously, and uses the endogenous model-implied quantities to empirically study how shadow money affects the real economy and financial stability. In contrast, Shu [2017] employs a regression model to justify his model predictions. Our model further relates to the early banking literature on bank runs and financial stability that include Diamond and Dybvig [1983], Postlewaite and Vives [1987], Peck and Shell [2003], Goldstein and Pauzner [2005], and latest examples that include Gertler and Kiyotaki [2015], Brunnermeier and Sannikov [2014], Gennaioli et al. [2013] and many others. Runs on shadow money in our extended model where we incorporate the liquidity cost show an even more unstable banking system than the observed one.

Moreover, our paper contributes to a large literature on regulatory arbitrage and implicit guarantees associated with shadow banking. Gorton et al. [2010], Acharya et al. [2013b], and Harris et al. [2014] document that regulatory arbitrage is the key driver for the prosperity of shadow banking. Absent capital requirements to shadow money provide incentives for banks to maintain a high demand for WMPs across equilibria in our baseline model. With respect to implicit guarantee, our work relates to Gorton and Souleles [2007] and Dang et al. [2015]. Specifically, banks value the implicit guarantee and interact with shadow banks in our model. We empirically quantify the value of the implicit guarantee, which supports the view in Dang et al. [2015] that the Chinese shadow banking is bank-centric[4] and driven by asymmetric perception of the implicit guarantee. Besides, our paper relates to a fast growing literature on shadow banking and financial fragility in India and China such as Acharya et al. [2013a], Hachem and Song [2016], Acharya et al. [2017] and Chen, Ren and Zha (2016). These studies analyse how banks' characteristics are associated with the use of shadow instruments such as WMPs and entrusted loans. One of the key findings is that banks' risk characteristics such as stock price volatilities increase with rates offered on these instruments. We endogenously determine equilibrium quantities, accounting for not only interest rates on but also demand sensitivities for WMPs (shadow money) with respect to interest rates. In this way, we can capture the feedback loop that essentially implies benefits and risks of shadow money.

The remaining paper is structured as follows. In Section 2 we provide a brief overview over the shadow banking system in China to which we calibrate our model later on. In Section 3 we describe the model setup and the solution to the banks' optimization problem in setting interest rates for deposits and WMPs. Here we also discuss the deviations from the approach in Egan et al. [2017]. Section 4 describes the data and calibration procedure while empirical results and model implications are discussed in Section 5. Section 6 is devoted to a policy analysis testing the effectiveness of capital requirements on shadow money. Finally, Section 7 concludes.

2. Shadow Banking in China

Shadow banking generally refers to financial institutions and markets that conduct traditional banking functions but do not fall under the normal banking regulations. For example, financial intermediaries or shadow banks transform illiquid risky assets into short-term money-like instruments. These instruments are called *shadow money* and can be considered as substitutes for traditional bank deposits. Hence, shadow money refers to funding that financial intermediaries provide to the real economy e.g. sponsoring investments in infrastructure or the industrial sector.

Financial intermediaries (or shadow banks) often contract with commercial or retail banks who sell the corresponding shadow banking assets to their clients. Commercial or retail banks distribute shadow banking assets to individual and institutional investors while shadow banks manage shadow money on behalf of banks. Profits earned on shadow money are split between both counterpar-

[4] That is shadow banks perform many traditional banking functions of credit intermediation.

ties. In good times with low uncertainties, banks interact with financial intermediaries in order to raise unregulated shadow money and earn high returns. In this way, shadow money can stimulate economic growth by providing easily accessible funding. However, as shadow money generally is not due to regulation[5], it can crowd out the traditional deposits and breed fragility in the banking system over time. A modest negative shock to the shadow banking system can cause liquidity to evaporate and set off a cascade of adverse events: shadow banks go bust, retail banks suffer, capital investments decrease and the economy enters a recession. The latest global financial crisis (GFC) recorded such episode in the business cycle.

In China, so-called wealth management products (WMPs) constitute a large part of shadow money instruments. These are off-balance sheet and short-dated derivative-like money instruments offering higher rates than deposits. WMPs in general are no in the government guaranteed scheme and thus are uninsured instruments. As such, financial intermediaries and banks take no responsibility to compensate investors whenever the underlying investments fail to deliver the required return. However, investors purchasing WMPs strongly assume the existence of an implicit guarantee (see, e.g. Dang et al. [2015] and Hachem and Song [2016]). A famous example of a government intervention in case of a failed WMP is the "2010 China Credit-Credit Equals Gold #1 Collective Trust Product", where the Chinese government forced the retail bank which sold the WMP to take the losses although it was not the issuing institution. Funds raised through this high-yield WMP, that was sold by Industrial and Commercial Bank of China (ICBC), were invested by China Credit Trust in some unlisted coal mining company that defaulted in 2012. As the Chinese regulator feared a liquidity crisis if investors in other WMPs suddently become aware of the default risk inherent in these products, they urged ICBC to repay customers.

[Figure 1 about here.]

In the last decade, the shadow banking system in China has grown rapidly with shadow financing accounting for about 80% of China's GDP today as opposed to less than 10% before the financial crisis of 2007/2008.[6] In particular, the market for wealth management products (WMPs)

[5]For example, banks are not required to hold capital requirements for shadow money instruments.

[6]Compare the article „China's shadow finance time-bomb could trigger market collapse.“ in Financial Times, June 26, 2017.

has increased rapidly with a current trading volume of about $4tn. As shown in Figure 1 investments in WMPs have especially increased during the time period 2008–2014 in which the Chinese central bank, People's Bank of China, has set ceilings on deposit rates which usually were below market rates. Thus, WMPs allowed investors to benefit from the spread between market rates and capped deposit rates. Besides, WMPs were particularly attractive as they represent off-balance sheet positions. Thus, banks investing in WMPs do not have to hold regulatory capital for these positions. Additionally regulatory rules prohibited loan-to-deposit ratios above 75% which in turn led banks to search for investment products in less regulated markets, such as WMPs. Hence, banks were able to exploit regulatory arbitrage through investments in WMPs.

More recently, on November 17, 2017, however, the People's Bank of China has issued new draft guidelines which impede the intermediation of the WMPs between retail banks and financial intermediaries. The guidelines require financial institutions to provision 10 percent of their management fee income from asset management products as risk reserves and forbid financial institutions from conducting asset pools to manage funds raised through asset management products. Besides, institutions would be punished (e.g. through cancellation of practicing qualifications) for providing implicit guarantees for asset management products. When these guidelines become effective, they might potentially cause a run on WMPs and as a consequence liquidity dry ups in the financial system which will not only harm banks' profitability but also the whole asset market. 10 banks including China Merchants Bank and China Citic Bank have allied and called for a longer transition period of 3 years. Moreover, these guidelines do not prevent banks from creating new instruments such as yield enhancement products to bypass regulation. In fact, such yield enhancement products have been more and more prosperous since the guidelines have been announced.[7] In light of this, the rapid growth of the shadow banking sector in China since 2010 and its effect on the stability of the banking system is still attracting particular attention by regulators, policymakers and researchers.

[7] Compare e.g. articles on https://www.bloomberg.com/view/articles/2018-08-23/china-s-mid-tier-banks-structured- deposits-on-the-rise or https://www.vantageasia.com/structured-deposits-new-asset-management-rules/ or https://www.caixinglobal.com/2018-03-16/structured-deposits-wax-as-wealth-management-products-wane-101222352.html

3. Model for Banking Competition in Presence of Shadow Money

In the following we build on Egan et al. [2017] in constructing a model for banking competition. In contrast to their approach, however, our model is adapted to a setting where banks can raise shadow money besides classical deposits. Later on we apply our model to the Chinese banking system where wealth management products (WMPs) constitute a large part of all shadow money instruments. Therefore, we will use the terms WMP and shadow money interchangeably in the sequel.

We consider K banks, indexed by $k = 1, \dots, K$ which are financed by deposits, WMPs (shadow money), long-term debt and equity. Debt is a consol bond with fixed coupon b_k each period for bank k. Each bank k optimally sets the interest rates $i^D_{k,t}$ for insured deposits and $i^W_{k,t}$ for uninsured WMPs in each period t. While banks can retain the profits on invested deposits completely, profits earned on WMPs needs to be split between banks distributing WMPs to investors and financial intermediaries managing WMPs. We assume that deposits and WMP funds of each bank are eventually invested in the same risky asset.[8] Each bank internalizes gains and losses from investing deposits and WMP funds. This is motivated by the fact that banks can pool the unregulated WMP funds and apply a netting scheme to offset debts and receivables. For instance, a bank can use gains from one WMP to compensate investors in another defaulting WMP. Moreover, banks employ a Ponzi scheme, i.e. they can issue new WMPs and use their proceeds to compensate investors in defaulting WMPs. We denote the return of bank k in period t by $R_{k,t}$. Returns are i.i.d. across time but can be correlated among banks and are normally distributed $R_{k,t} \sim \mathcal{N}(\mu_k, \sigma_k)$ under the risk-neutral measure. After profit shocks are realized, each bank chooses whether to repay depositors, WMP investors and long-term debt holders or to default. A bank stays solvent as long as equity and capital reserves can absorb a potential shortfall and defaults otherwise.

3.1. Demand for Deposits and Shadow Money

In order to build borrowing and lending relationships between depositors, WMP investors and banks, we specify the depositors' and WMP investors' preferences as in Egan et al. [2017]. The

[8] If WMP funds are invested in other riskier but more productive assets, it significantly complicates banks' default decisions and makes the model intractable.

insured depositor j's indirect utility from bank k at time t is given by

$$u^D_{j,k,t} = \alpha^D i^D_{k,t} + \delta^D_k + \varepsilon^D_{j,k,t}, \tag{3.1}$$

where α^D measures the depositors' sensitivity to interest rates $i^D_{k,t}$ on insured deposits. Bank k's fixed effects δ^D_k reflect differences in bank quality and services and $\varepsilon^D_{j,k,t}$ denotes i.i.d. utility shocks that reflect differences in consumer preferences. Note that the bank's default probability has no impact on the insured depositor's utility.

The WMP investor j's indirect utility from bank k at time t is given by

$$u^W_{j,k,t} = \alpha^W i^W_{k,t} - \gamma p_{k,t} + \delta^W_k + \varepsilon^W_{j,k,t}, \tag{3.2}$$

where α^W denotes the investors' sensitivity to interest rates $i^W_{k,t}$ paid on WMPs offered by bank k. δ^W_k and $\varepsilon^W_{j,k,t}$ have the same interpretation as above for insured depositors. When bank k defaults, which happens with risk-neutral probability $p_{k,t}$ in period t, investors in WMPs suffer a utility loss of $\gamma p_{k,t}$, where γ denotes the investors' sensitivity to banks' probability of default $p_{k,t}$.

Next, we construct demand for the insured deposits and uninsured WMPs. Similar to Berry et al. [1995] and Egan et al. [2017], given that utility shocks are realized, demand for insured deposits of bank k, i.e. the share of consumers choosing insured deposits with bank k, is given by

$$S^D_{k,t}(i^D_{k,t}, \mathbf{i^D_{-k,t}}) = \frac{\exp\{\alpha^D i^D_{k,t} + \delta^D_k\}}{\sum_{l=1}^K \exp\{\alpha^D i^D_{l,t} + \delta^D_l\}}, \tag{3.3}$$

while demand for uninsured WMPs of bank k is given by

$$S^W_{k,t}(i^W_{k,t}, \mathbf{i^W_{-k,t}}, p_{k,t}, \mathbf{p_{-k,t}}) = \frac{\exp\{\alpha^W i^W_{k,t} - \gamma p_{k,t} + \delta^W_k\}}{\sum_{l=1}^K \exp\{\alpha^W i^W_{l,t} - \gamma p_{l,t} + \delta^W_l\}}. \tag{3.4}$$

$\mathbf{i^D_{-k,t}}$ and $\mathbf{i^W_{-k,t}}$ and $\mathbf{p_{-k,t}}$ denote the vectors of interest rates offered from banks other than k and their expected default probabilities.

Each period we assume that a mass of M^D consumers invests in insured deposits. Thereby, they choose among the K banks in the system. Thus, the product $M^D S^D_{k,t}$ gives the portion of consumers investing in insured deposits of bank k at time t. Analogously, $M^W S^W_{k,t}$ denotes the portion of consumers investing in WMPs of bank k at time t.

3.2. Bank Default

Bank k defaults if equity value drops below zero, i.e., if the value of keeping the bank alive is lower than the funds that need to be injected in order to avoid bankruptcy. When at any time t the bank's profits are lower than the payments to depositors, WMP investors, and long-term debt holders, equity holders have to bear the losses. At time t, bank k's profits net of interest payments and costs equal

$$\pi_{k,t} \quad = \quad M^D S^D_{k,t}(R_{k,t} - i^D_{k,t}) + M^W S^W_{k,t} \eta_k (R_{k,t} + c_{k,t} - i^W_{k,t}) - b_k. \tag{3.5}$$

Here, η_k is the fraction of profit margin $R_{k,t} - i^W_{k,t}$ that bank k retains and hence models the profit split between banks and financial intermediaries. Thus, η_k reflects the Nash-bargaining power weight of bank k and $1 - \eta_k$ the weight of the financial intermediary who manages WMP funds. Such a linear rule of splitting profits has been used in the literature, e.g. in Duffie et al. [2007] and He and Milbradt [2014]. Although returns on WMPs solely depend on the performance of the underlying investments, investors nevertheless assume that either the issuing bank or the financial intermediary managing WMPs or ultimately the government will cover the shortfall if the underlying WMP fails. The parameter c_k in our model reflects a premium for such an implicit guarantee. The guarantee can be interpreted as a contingent claim that pays off when WMPs perform poorly. c_k is the value of this contingent claim. We assume the premium is distributed to bank k proportional to the WMP outstanding $M^W S^W_k$ multiplied by η_k.

We denote by κ the capital ratio representing the capital reserve requirement on the bank's liabilities. As WMPs are off-balance sheet, banks only need to hold capital reserves for the long-term debt and insured deposits. Hence, $\kappa(b_k + M^D S^D_{k,t})$ represents the total capital reserve of bank k which is invested at the risk-free interest rate. As this yields a zero net return, this term does not appear in the banks net profits in equation (3.5).

Bank k's equity value at the beginning of every period is denoted by E_k. We can skip the time index here because of stationarity. Bank k loses capital reserve if it defaults. Therefore, bank k stays alive whenever its franchise value next period evaluated today $\frac{1}{1+r}E_k$ plus capital reserve $\kappa(b_k + M^D S^D_{k,t})$ and bailout/guarantee value $M^W S^W_{k,t}\eta_k c_k$ exceeds the shortfall which equals

$$b_k - M^D S^D_{k,t}(\bar{R}_k - i^D_{k,t}) - M^W S^W_{k,t}\eta_k(\bar{R}_k - i^W_{k,t})$$

when positive. Note that in practice the guarantee is only paid (if at all) in case the WMP fails. In our setting this coincides with the event when the bank defaults, since we assume that banks can internalize gains and losses from capital investments. Thus, when a particular WMP should underperform, the bank can use gains on other WMPs or on investments financed through deposits to pay off WMP investors. When the overall profits are insufficient to pay off depositors and WMP investors, the bank will default. In that case the financial intermediary or the government might step in to cover the payments to WMP investors. Thus, the guarantee would actually only be paid at default time of the bank. However, to keep the analysis tractable, we assume that the guarantee is paid proportionally every period.

Equity holders' default decision then suggests a Leland-type default threshold $\bar{R}_k$ (Leland [1994]). When the bank's return $R_{k,t}$ falls below $\bar{R}_k$, the equity holders will cease to finance and let the bank default. The threshold $\bar{R}_k$ is determined by the level of bank profitability at which equity holders are indifferent between keeping the bank alive or defaulting, i.e.

$$\frac{1}{1+r}E_k + \kappa(b_k + M^D S^D_{k,t}) + M^W S^W_{k,t}\eta_k c_{k,t} = b_k - M^D S^D_{k,t}(\bar{R}_k - i^D_{k,t}) - M^W S^W_{k,t}\eta_k(\bar{R}_k - i^W_{k,t}) \quad (3.6)$$

In Appendix A we solve for the endogenous default threshold $\bar{R}_k$ which in turn indicates the equilibrium default probability

$$p_{k,t} = \Phi\left(\frac{\bar{R}_k - \mu_k}{\sigma_k}\right).$$

Obviously, the capital reserve $\kappa(b_{k,t} + M^D S^D_{k,t})$ and the expected bailout package $M^W S^W_{k,t}\eta_k c_{k,t}$ delay default. As banks do not need to hold capital reserves for WMP funding since the latter are off-balance sheet, banks have incentives to issue more WMPs. If the underlying asset is profitable in good times, issuing more WMPs can improve profitability and lead to a decrease in the default probability, especially when banks have high bargaining power η. However, it creates fragility that potentially causes the instability of banking system and welfare losses in bad times when the underlying asset is under performing.

3.3. Equilibrium in Benchmark Model

Banks compete for deposits and WMPs by setting the corresponding interest rates, i.e. before the beginning of each period, every bank k chooses the interest rates $i^D_{k,t}$ and $i^W_{k,t}$ on deposits and WMPs, resp., such as to maximize its equity value

$$
\begin{aligned}
E_k = \max_{i^D_{k,t}, i^W_{k,t}} \mathbb{E}\Big[\Big(& M^D S^D_{k,t}(R_{k,t} - i^D_{k,t}) + M^W S^W_{k,t}\eta_k(R_{k,t} + c_{k,t} - i^W_{k,t}) \\
& -b_k + \tfrac{1}{1+r}E_k\Big) 1_{\{R_{k,t} > \bar{R}_k\}} - \kappa(b_{k,t} + M^D S^D_{k,t})1_{\{R_{k,t} \le \bar{R}_k\}}\Big]
\end{aligned}
\tag{3.7}
$$

If $R_{k,t} > \bar{R}_k$, equity holders keep the bank's franchise value next period evaluated today $E_k/(1+r)$ and cash in the bank's current period profits net of interest payments and costs, and they are also willing to finance any potential shortfall in the current period in order to keep the bank solvent. If $R_{k,t} \le \bar{R}_k$, the bank defaults and equity holders lose the invested capital reserve. The first order conditions for the optimal deposit rate $i^D_{k,t}$ and for the optimal WMP rate i^W_k, respectively, are given by[9]

$$
\mu_k + \sigma_k m\left(\frac{\bar{R}_k - \mu_k}{\sigma_k}\right) - i^D_k = \frac{1}{(1 - S^D_k)\alpha^D} + \kappa \frac{\Phi\left(\frac{\bar{R}_k - \mu_k}{\sigma_k}\right)}{1 - \Phi\left(\frac{\bar{R}_k - \mu_k}{\sigma_k}\right)}, \tag{3.8}
$$

$$
\mu_k + \sigma_k m(\frac{\bar{R}_k - \mu_k}{\sigma_k}) + c_k - i^W_k = \frac{1}{(1 - S^W_k)\alpha^W}. \tag{3.9}
$$

Note that bank k's bargaining power, measured by the parameter η_k proportional to the WMP outstanding, does not impact the rates setting directly as can be seen from the FOCs (3.8) and (3.9). It affects bank's profitability in that it changes the bank's default decision. A higher bargaining power η_k increases bank's profitability and reduces bank's default risk as long as the margin $R_k - i^D_k$ is positive but the opposite happens if the the margin $R_k - i^D_k$ is negative.

Banks' expected return can be directly calculated from equation (3.8) while the premium c_k

[9] Here $m(\cdot) = \phi(\cdot)/(1 - \Phi(\cdot))$ is the inverse Mills ratio.

for the implicitly assumed guarantee can be expressed as difference between (3.8) and (3.9). In Appendix B we further solve for banks' standard deviation such that bank k's equilibrium triplet (μ_k, σ_k, c_k) is given by

$$\mu_k = i_k^D + \frac{1}{(1-S_k^D)\alpha^D} + \frac{\kappa p_k}{1-p_k} - \sigma_k m\left(\Phi^{-1}(p_k)\right) \quad (3.10)$$

$$\sigma_k = \frac{1+r}{p_k+r} \frac{b_k - \frac{\kappa r(b_k+M^D S_k^D)}{1+r} - \left(\frac{M^D S_k^D}{(1-S_k^D)\alpha^D} + \frac{\kappa p_k M^D S_k^D}{1-p_k}\right) - \frac{M^W S_k^W \eta_k}{(1-S_k^W)\alpha^W}}{(M^D S_k^D + M^W S_k^W \eta_k)\left(\Phi^{-1}(p_k) - m\left(\Phi^{-1}(p_k)\right)\right)} \quad (3.11)$$

$$c_k = \frac{1}{(1-S_k^W)\alpha^W} - \frac{1}{(1-S_k^D)\alpha^D} + i_k^W - i_k^D - \frac{\kappa p_k}{1-p_k}. \quad (3.12)$$

Note that c_k increases when the WMP rate i_k^W increases with all else equal. This is because the rate spread $i_k^W - i_k^D$ and markup spread $\frac{1}{(1-S_k^W)\alpha^W} - \frac{1}{(1-S_k^D)\alpha^D}$ increase with i_k^W under moderate default probability. When the premium c_k is high, banks have more incentives to issue WMPs. The liquidity injections through WMPs in turn support economic growth. In the mean time, the probability of default increases with deposit and WMP rates whereas the demand for WMPs is reduced with increasing probability of default. In summary, the markup spread $\frac{1}{(1-S_k^W)\alpha^W} - \frac{1}{(1-S_k^D)\alpha^D}$ increases with i_k^W but declines with financial distress that is caused by increased i_k^W. Overall, an increase in WMP rate increases demand for WMPs but at the same time increases banks' financial distress and causes financial fragility.

3.4. Introducing Liquidity Costs

As an alternative to the benchmark model described above, we model runs on WMPs through imposing liquidity costs on setting the WMP rate. WMPs are prone to run as they are off-balance-sheet and usually short-term instruments. We assume the costs to set WMP rates are quadratic, i.e. $\frac{1}{2}\xi(i_k^W)^2$. Hence, banks set the rate for deposits and WMPs to maximize the expected return to equity holders in presence of a quadratic liquidity cost as follows

$$E_k = \max_{i_{k,t}^D, i_{k,t}^W} \mathbb{E}\left[\left(M^D S_{k,t}^D(R_{k,t} - i_{k,t}^D) + M^W S_{k,t}^W \eta_k(R_{k,t} + c_{c,t} - i_{k,t}^W - \tfrac{1}{2}\xi(i_k^W)^2)\right.\right.$$
$$\left.\left. - b_k + \tfrac{1}{1+r} E_{R_k}\right) 1_{\{R_{k,t} > \bar{R}_k\}} - \kappa(b_{k,t} + M^D S_{k,t}^D) 1_{\{R_{k,t} \leq \bar{R}_k\}}\right].$$

The corresponding first order conditions for setting rates are given by

$$\begin{aligned} \mu_k + \sigma_k m\left(\frac{\bar{R}_k - \mu_k}{\sigma_k}\right) - i_k^D &= \frac{1}{(1-S_k^D)\alpha^D} + \kappa \frac{\Phi\left(\frac{\bar{R}_k-\mu_k}{\sigma_k}\right)}{\left(1-\Phi\left(\frac{\bar{R}_k-\mu_k}{\sigma_k}\right)\right)} \\ \mu_k + \sigma_k m(\frac{\bar{R}_k-\mu_k}{\sigma_k}) + c_k - i_k^W - \frac{1}{2}\xi(i_k^W)^2 &= \frac{1+\xi i_k^W}{(1-S_k^W)\alpha^W}. \end{aligned} \tag{3.13}$$

Expected return μ_k and premium c_k can be directly extracted from the FOC. The standard deviation σ_k can be calculated similarly to the benchmark case and is given by

$$\sigma_k = \frac{1+r}{p_k+r} \frac{b_k - \frac{\kappa r(b_k + M^D S_k^D)}{1+r} - \left(\frac{M^D S_k^D}{(1-S_k^D)\alpha^D} + \frac{\kappa p_k M^D S_k^D}{1-p_k}\right) - \frac{(1+\xi i_k^W) M^W S_k^W \eta_k}{(1-S_k^W)\alpha^W}}{(M^D S_k^D + M^W S_k^W \eta_k)\left(\Phi^{-1}(p_k) - m\left(\Phi^{-1}(p_k)\right)\right)}. \tag{3.14}$$

4. Data and Calibration

4.1. Data

Our data set contains information on a total of 455 Chinese banks. From these, we consider the sixteen largest commercial banks in China as our sample banks. These include, in particular, the big four, systemically important banks (Agriculture Bank of China, Bank of China, China Construction Bank and Industrial and Commercial Bank of China) and 12 other listed banks. Their names and stock codes are reported in Table 1. The sample period is Q2/2008–Q1/2017. The RESSET financial database reports volumes, rates, durations and other characteristics of WMPs of each bank on daily basis. WMP volumes and volume-weighted WMP rates are calculated for each bank by quarter. Daily stock prices for each bank, quarterly deposit volumes, quarterly balance sheet data of each bank as well as quarterly one-year government bond rates are taken from the China Stock Market&Accounting Research (CSMAR) database. In addition, we went through every bank's announcements on deposit rates from its official website, extracted the deposit rates for the 16 largest banks and aggregated in the quarterly series. Overall, banks' total deposit volume and WMP volume in the sample account for 65% of all deposits and 84% of all WMPs in the Chinese banking system.

We estimate the one-year risk neutral probabilities of default of each bank using the distance to default model in Merton [1974]. This produces a quarterly time series of annual probabilities of default. We implement an iterative procedure introduced in Bharath and Shumway [2008] and

Vassalou and Xing [2004] which provides reasonable estimates for banks' default probabilities. In particular, this methodology takes into account that excessive volatility can cause large variations in market leverage.

[Table 1 about here.]

[Table 2 about here.]

Table 2 provides summary statistics about our sample data. The average big 4 banks' quarterly WMP volume is with 1.31 trillion RMB significantly larger than the average WMP volume of the sample banks which equals roughly 0.99 trillion RMB. The big 4 banks' and the sample banks' average deposit volumes are 11.12 and 3.97 trillion RMB, respectively. Both big 4 banks and non big 4 banks offer higher WMP rates than deposits rates. The average WMP rate is 4.3% in contrast to the average deposit rate 2.9%. The standard deviation of WMP rate and deposit rate is 0.9% and 0.7%, respectively, when calculated over the entire sample of banks. This indicates that the WMP market is more volatile than the deposit market. However, for the big 4 banks rates on WMPs and deposits both have a standard deviation of 0.7%. Hence, big 4 banks are more stable in this respect. The average market share of the sample banks is about 6% for WMP and 4% for deposits. The total market share for WMPs and deposits for the big 4 banks amounts to roughly 33% and 50% (average market share per bank times 4), respectively, which justifies why they are considered to be systemically important. The cumulative market share of the outside banks is 9.2% and 30.1%, resp., for WMPs and deposits. These values are used to estimate elasticities of demand. Given there are 439 outside banks, their market shares per bank are quite small. Indeed, their volumes per bank are small and not used in our estimations. Thus, we do not report them here. The average and median one-year probabilities of default are 0.4% and 0.004% for the 16 largest banks. The maximum one-year probability of default is up to 7% and the standard deviation of default probability is rather large with 1%. This indicates that the Chinese banking system is stable over most periods but has experienced large fluctuation in some periods. Our estimated probabilities of default are similar in magnitude to corresponding estimates in Ahn et al. [2015]. The risk free rate r is set to the one year government bond rate.

From discussions with various securities and trust companies, we conclude that banks gain a net profit of $0.2 - 0.4$ cents out of one unit of WMP outstanding. The majority of WMP funds is invested in the corporate bond market. We estimate the corporate bond index return as approximately $6\% - 8\%$ in our sample period. The average WMP rate is 4%. Thus, we set $\eta_k = 10\%$ which produces a net profit equal to $0.2 - 0.4$ out of profit margin $2\% - 4\%$ for every unit of WMP outstanding. For simplicity, we assume the bargaining power is the same for banks.

Further, we set the capital requirement $\kappa = 10\%$. The China Banking Regulatory Commission (CBRC) first introduced a minimum capital adequacy ratio of 8% similarly to the Basel I requirements.[10] The CBRC then increased capital ratios to 9.5% for systemically important banks and 8.5% for all other banks after 2013. In accordance with the higher capital requirements under Basel III, capital ratios will be further raised to 11.5% and 10.5%, respectively, by the end of 2018 while the average capital ratio across Chinese banks has already been significantly larger in the past years.[11] Therefore, we consider an intermediate level of $\kappa = 10\%$ in our analysis.

4.2. Demand Estimation and Supply Calibration

We apply our model to the sixteen largest banks in our data set such that these banks compete against each other in order to attract depositors and WMP investors. The remaining banks in our data set are designated as outside banks, which we index by 0. We follow Egan et al. [2017] and use banks' market shares on WMPs and deposits described in Section 4.1 to estimate the demand elasticity parameters α^D, α^W and γ according to specifications (C.3) and (C.4) provided in Appendix C. The resulting estimates are reported in Table 3. We observe that demand for WMPs rises with WMP rates but declines with probabilities of default. Demand for deposits is sensitive to variations in deposit rates but insensitive to changes in probabilities of default. This is in correspondence with the fact that deposits are insured while WMPs are uninsured.

[Table 3 about here.]

We calibrate the supply-side parameters by using estimated demand elasticities of banks. More specifically, we calibrate bank k's equilibrium triplet (μ_k, σ_k, c_k) such that it characterizes its optimal pricing behavior and default decision described by equations (3.10), (3.11) and (3.12) for

[10] See Article 7 in Regulation Governing Capital Adequacy of Commercial Banks at `http://www.cbrc.gov.cn/EngdocView.do?docID=558`.

[11] Compare footnote 9 in Hachem and Song [2016].

expected return μ_k, standard deviation σ_k, and premium c_k, respectively. Here we use the previously determined risk neutral probabilities of default, as well as levels, shares, rates and demand elasticities for WMPs and deposits of each bank.

[Figure 2 about here.]

We report the average bank fundamental triplet (μ, σ, c) for the big 4 banks and non-big 4 banks in Figure 2 where quantities are averaged across big 4 and non-big 4 banks separately in each quarter. The asset average return is 3%–6% and standard deviation varies between 15%–60%. The non-big 4 banks have lower returns in the whole sample period but higher standard deviation over most of the sample period. In particular, since Q3/2009 their standard deviation was significantly higher than that of big 4 banks indicating that non-big 4 banks experienced more distress in that period.

Due to this increasing financial distress and the competition pressure on the deposits from the big 4 banks, the non-big 4 banks have raised WMP rates aggressively in order to increase demand for WMPs. This observation is confirmed in Table 2 which reports higher mean and median WMP rates for non-big 4 banks than for big 4 banks. Besides, reliance on WMP funding increased especially after 2012. Chen et al. [2017] argue that China's four trillion RMB stimulus package triggered the rapid growth in shadow banking after 2012 where a big portion of the bank loans of the 2009 package faced a massive rollover. Both higher WMP rates and heavy reliance on WMP funding imply a higher premium for implicit guarantees (compare equation (3.12) and the following discussion) when default probability is moderate. In fact the realized financial distress in the Chinese banking sector has not been severe in the past years and Figure 1 indeed shows that the premium for implicit guarantees in our calibrated model is larger for the non-big 4 banks compared to the big 4 banks since 2012.

[Figure 3 about here.]

Figure 3 illustrates the evolution of the rate spread and markup spread. Interestingly, these behave oppositely especially since 2012. For example, during the period 2015/2016 when the Chinese equity market crashed, the rate spread spiked but the markup spread bottomed. The rational is that financial distress impacts the demand on WMP and hence the markup spread negatively while it also leads to higher competition pressure and thus to increased WMP rates. This effect is more pronounced for the non-big 4 banks than for big 4 banks.

5. Macroeconomics, Financial Fragility and Shadow Money

In this section we study risks and benefits of shadow money by associating the time series variations of bank fundamentals with economic activities. Further, we examine financial fragility by analyzing multiple equilibria supported by the same bank fundamentals.

5.1. Macroeconomics and Shadow Money

Based on a theoretical study on the Chinese shadow banking system since 2008 Dang et al. [2015] show that China's shadow banking system is bank-centric and driven by an asymmetric perception of implicit guarantees. In our model the premium c_k values the implicit guarantee inherent in WMPs. Therefore, we estimate the value of the expected bailout package as the expectation of the discounted future (total) bailout costs of WMPs given by

$$\sum_{i=0}^{\infty} \frac{1}{(1+r)^i} M^W S_k^W c_k \quad = \quad c_k \frac{1+r}{r} M^W S_k^W. \tag{5.1}$$

The package reflects WMP investors' belief on the implicit guarantee to bail out distressed WMPs. Note that the premium can be expressed as the rate spread plus the markup spread minus the capital loss given default as follows

$$c_k \quad = \quad \underbrace{i_k^W - i_k^D}_{rate\ spread} + \underbrace{\frac{1}{(1-S_k^W)\alpha^W} - \frac{1}{(1-S_k^D)\alpha^D}}_{markup\ spread} - \frac{\kappa p_k}{1-p_k}.$$

An increase in WMP rate will cause the rate spread to rise but does not necessarily increase the markup spread. On the one hand it increases demand for WMPs and on the other hand it increases probability of default, which in turn decreases demand for WMPs (compare equation (3.4)). The probability of default, however, rises more strongly with WMP rate because the increased WMP rate reduces profit margin. Given that the markup spread is an increasing function in demand for WMPs, it might increase or decline with WMP rate which is determined by the trade-off between consumer's utility from WMP rate and disutility from financial distress. In good times, however, increasing the WMP rate has only a mild effect on the probability of default. As a result the increased WMP rate in good times will increase the premium c_k and hence the expected bailout package in (5.1). A higher bailout package can provide incentives for banks to issue more WMPs. We conjecture that the prosperous shadow money suggested by a high premium.[12] This is indicated also by Figure 3 which shows that the markup spread stays flat while the rate spread increases implying an increasing premium c_k. In this way, shadow money representing easy accessible funding can boost economic growth but also builds up fragility over time. To test our hypothesis, we follow the approach from Gilchrist and Zakrajšek [2012]. Therefore, we first calculate the average premium, rate spread and markup spread weighted by total WMP outstanding for each bank.[13] We then regress the macroeconomic variables onto the premium, rate spread or markup spread

$$Y_t = a + b_1 X_{t-1} + \sum_{k=1}^{p} b_2' Y_{t-k} + b_3' Z_{t-1} + b_4 Q_{t-1} + e_t. \tag{5.2}$$

Here the dependent variable Y is one of the following macroeconomic variables: investment rate in real estate REAL_EST, gross domestic product GDP, unemployment rate EMPLOY, consumer price index CPI, retail price index RPI, and purchasing managers' index PMI. The explanatory variable X is the premium, the rate spread or the markup spread. The control variables Z are lags in dependent variables such as 7-day repo rate (central bank funding rate), term spread (calculated as the premium between 10 year government bond and 1 year government bond yield) and credit spread (calculated as the difference between the yield on a 10 year corporate bond index from China Securities Index and the 10 year government bond rate). The time dummy Q is a quarter dummy. In particular, lag p in the macroeconomic variables is optimally determined by the AIC.

[Table 4 about here.]

The results in Table 4 provide evidence that shadow money stimulated economic growth over Q3/2008-Q2/2017. A higher premium c_k indicates that banks intermediate more shadow money as the deposit rate is relatively flat and hence c_k increases mainly because i_k^W is increased which in turn corresponds to an increased reliance on WMP financing. Our results show that a 1% increase in the premium in a quarter leads to an increase of 2.8% of real estate investment, 0.4% of GDP, 0.8% of inflation, 1.2% retail price, 0.8% of purchasing power, and a deduction of 5.9% of unemployment rate. Interestingly, the rate spread and the markup spread predict economic activities more significantly but their predictions are opposite. In addition, the predictions are more

[12]Moreira and Savov [2017] prove a similar conjecture theoretically.
[13]The results are left unchanged if we calculate the equally weighted premium, rate spread and markup spread.

significant for the non-big 4 banks with the larger coefficients compared to the big 4 banks. The former applied more aggressive rate-setting strategies and held stronger belief in shadow bank or government intervention (compare also Figure 3).

These predictions justify the hypothesis that shadow money provides benefits to the real economy as it enhances supply of credit. In the mean time, it builds up fragility since shadow money is usually invested in more risky projects. This in turn can potentially cause significant distress for banks and impair the whole economy if the underlying investments fail to produce the required return. Our results not only support the model predictions in Moreira and Savov [2017] but also document new evidence about China's shadow banking. While most of the recent studies about Chinese shadow banking focuses on WMP rates, we use the endogenous quantities accounting for the feedback effect between demand for shadow money and financial distress.

We further examine the macroeconomic consequence of shocks to the premium for the implicit guarantee. Therefore, we add the premium, rate spread or markup spread to a standard VAR that includes the following endogenous variables: (i) the rate of real-estate investments (REAL_EST), (ii) the real GDP rate, (iii) the unemployment rate EMPLOY; (iv) the rate of inflation measured by the rate of the consumer price index CPI, (v) the retail price index RPI, (vi) the purchasing managers' index PMI. A shock to the premium, the rate spread, or the markup spread, respectively, affects economic activities with lags. We estimate the VAR over the full sample period with the optimal lags determined by the AIC. The shocks are independent from the endogenous variables, i.e. since we consider one macroeconomic variable at a time, in each estimation the shock will be independent of one of these variables.

[Figure 4 about here.]

[Figure 5 about here.]

[Figure 6 about here.]

Figures 4–6 show the impulse response functions of the endogenous macroeconomic variables to an orthogonalized shock to the premium, the rate spread and the markup spread. An increase of one standard deviation in the premium - about 79 basis points - causes a significant rise in economic activity over the next three to four quarters: real-estate investment rises 2%, GDP increases by 0.3%, retail price rises by 1% and purchasing power increases by about 0.6%. At the same time it lowers unemployment rate by 0.04% and increases inflation by 0.5%. As anticipated, shocks to the rate spread have opposite consequences than shocks to the markup spread. As documented in Figure 5 economic activities expand substantially when the rate spread increases by one standard deviation corresponding to about 56 basis points. By contrast, Figure 6 shows that economic activities suffer a setback when the markup spread rises by one standard deviation, i.e. roughly 19 basis points.

Our findings provide empirical support for the theoretical work of Moreira and Savov [2017] in showing that shadow money can expand the supply of credit and has large, positive, persistent and independent effects on the real economy in good times while it accumulates risks into the banking system that can have severe consequences in bad times. In this respect, our results for shadow financing are contrary to findings in Gilchrist and Zakrajšek [2012] and Gertler and Kiyotaki [2010] for corporate bond markets. The authors argue that an increase in the corporate bond spread causes a contraction in economic activities because it reduces the supply of credit. We conclude that the rising premium for implicit guarantees in WMPs, which is mainly driven by the rate spread, promotes credit supply differently than increasing corporate bond spreads. In particular, this indicates that shadow money is invested mainly in riskier but productive investments in China.

5.2. Financial Fragility and Shadow Money

Financial distress embedded in the markup spread limits economic growth since it makes the banking system unstable. In this section we examine how fragile the banking system could be by analysing different but unrealized states of the banking system. The same bank fundamental triplet (μ_k, σ_k, c_k) can support an alternative equilibrium of deposit rates, WMP rates and probabilities of default that differs from the observed one. For instance, if WMP investors' belief that a bank's default probability is much higher than the observed one, this can reduce the demand for WMPs which in turn lowers the bank's profitability and hence increases default risk. In this way, a pessimistic equilibrium with high probability of default can be generated based on the same values of bank fundamentals. We calculate multiple equilibria in the baseline model and in the model with liquidity cost as of Q3/2015 when China's equity market crashed. We classify these into good and bad equilibria in terms of positive and negative welfare and we report four equilibria in each group. Two equilibria are associated with the lowest and highest welfare, respectively, while the other two in each group are related to intermediate welfare levels.

First, we perform this analysis for the systemically important big 4 banks and we report the good equilibria in Table 5. Our results reveal that China's banking system was comparable to the best equilibrium (stated in column 4 of Table 5) of our baseline model. In the best equilibrium banks have an average probability of default of 0.22% which is only slightly higher than the observed default probability of 0.16%. The welfare gain in the best equilibrium is 1.2 trillion RMB which is rather small compared to the substantial welfare loss in the worst equilibria (provided in Table 6). A similar pattern can be observed for the alternative specification with liquidity cost. Further, our results document that in all good equilibria banks' cumulative deposit share is lower than the observed one while the cumulative WMP share stays roughly unchanged or even slightly increases. WMP rates net deposits rates in every good equilibrium on average are comparably equal to the counterparts in the observed equilibrium, approximately at 220-240 basis points. This suggests that investors and banks hold a strong belief on the implicit guarantee/bailout even in the good states, under which banks intermediate more WMPs relative to deposits. In the meanwhile, fragility is built up. In fact, WMP investors are over optimistic about financial distress in contrast to what was realized because the realized average default probability was smaller than the observed one in all good equilibria, resulting in a negative flow to capital.[14] This finding is different to corresponding results for the US banking sector provided in Egan et al. [2017], indicating that the Chinese banking system is more fragile. However, it should be noted here that the analysis in Egan et al. [2017] does not include shadow banking instruments and hence results are not fully comparable.

[Table 5 about here.]

Financial fragility rises even further when competition between deposits and shadow money drives pessimistic WMP investors' beliefs to settle in the alternative equilibrium. We report bad equilibria with and without liquidity cost, respectively, in Table 6. These equilibria are associated

[14]Flow to capital is calculated as the difference between equity value in the alternative equilibrium and in the realized one. Hence, the smaller realized probability of default implies a higher equity value in the observed state and hence flow to capital is negative.

with high default probabilities and significant welfare losses. The average default probabilities range between 5.8% and 55.7%, far above the observed 0.16%. Welfare losses vary between 21–55 trillion RMB. They feature risk concentration and asymmetry that give rise to several interesting facts.

[Table 6 about here.]

Firstly, risk concentration on the unstable banks in the equilibrium 3 in Table 6 in the baseline model, effectively drives some banks out of the insured deposit market. To see this, observe that financial distress is concentrated on ICBC China (Industrial and Commercial Bank of China) and CCB (China Construction Bank) in this equilibrium. Both have probabilities of default of about 50% whereas their competitors, ABC (Agricultural Bank of China) and Bank of China, have default probabilities of only 0.4%. As the stressed ICBC China and CCB highly value the explicit and implicit guarantees in WMPs, they raise their deposit rates to 19% and WMP rate to 34%. In this way these two banks not only take the whole deposit market share but also keep their WMP market share at a constant level. In contrast, ABC and Bank of China appear safe and stable in this equilibrium with probabilities of default at roughly 0.4%. They can manage keeping their market share on WMPs at 7.54% and 11.96%, respectively, which equals the observed market share. However, they lose their market share on deposits completely. This documents that some banks' responses to the risk concentration on shadow money cause deposit runs on other banks. Consequently, this can turn a seemingly stable banking system in a highly unstable system with high average default probabilities and enormous welfare losses.

Secondly, in our model CCB is the systemically most unstable bank. Its probabilities of default across all bad equilibria are higher than 22% (compare equilibria 1–4 in the baseline model in Table 6) and hence substantially above the observed default probability of 0.20%. We note that CCB has the lowest WMP share among all banks. The rational is as follows. CCB like any other bank values implicit guarantees in WMPs in bad states and hence is willing to offer higher WMP rates to increase demand on WMPs. However, default risk increases with higher WMP rates as profit margins are reduced. Our findings are in line with the fact that throughout 2015 Q1, Q2 and Q3, Vlab from the Volatility Institute NYU continuously puts CCB (China Construction Bank) top 2 of the systemically riskiest banks along with Mitsubishi UFJ Financial Group in the Asian-Pacific area.

Finally, the contagious bad equilibria spill over risks due to banking competition. For instance, CCB's probability default is 22% in one equilibrium (compare equilibrium 4 of Table 6 in the baseline model) and hence much higher than the observed default probability of 0.20%. As discussed above, CCB sets both deposit and WMP rates high in order to attract a large market share on deposits and to maintain a decent market share on WMPs. In response, CCB's competitors raise deposit and WMP rates, by approximately 31 basis points and 15 basis points on average, respectively, relative to the observed state. The decreased profit margins exacerbate financial fragility. The presence of liquidity costs limits spillover effects because raising interest rates to lift demand is restricted by the incurred liquidity cost. Correspondingly, in our model specification with liquidity costs we observe that WMP rates as well as deposit rates significantly decrease compared to the bad equilibrium 4 in the benchmark model.

5.3. Bank Runs

WMPs are run prone because the short-matured WMPs are invested in long-term risky asset. If investors are worried about whether or not they can redeem WMPs in case of an adverse shock, adjusting WMP rates becomes difficult and costly for banks. In the worst case, adjusting costs can quickly deplete bank's equity and speed up bank's default. Runs on WMPs do not occur in our benchmark model, however, they do emerge in our model specification with liquidity cost. For instance, in the worst equilibrium with the largest welfare loss (see equilibrium 1 of Table 6 in the specification with liquidity costs) the cumulative WMP share declines to 0.43% from the observed 28.07% while the welfare loss rises from 55 trillion RMB to 70 trillion RMB. Especially, the negative consumer surplus indicates that investors are to pay less than the observed market price to purchase WMPs. Overall, the banking system becomes much more fragile due to high financial distress and large welfare losses in the bad equilibria in presence of liquidity costs.

5.4. Banks' Bargaining Power

Our calibrated model assumes a uniform bargaining power such that each bank has the same parameter $\eta = 10\%$. If banks have more bargaining power, reflected in a higher value of η, banks are able to contract more profits on WMPs with shadow banks. In Panel A of Table 7 we report the worst equilibrium with the largest welfare loss, the interim equilibrium with large welfare losses, and the best equilibria with the highest welfare gain averaged over the big 4 banks for different values of η ranging from 10% over 20% to 30%. We find that banks improve welfare and strengthen stability of the banking system in the best equilibria given that they gain more power to collect profits on WMPs. When η rises in that equilibrium, the average probability of default drops from 0.2% to 0.1% and then to 0.0% while welfare gains increase from 1.2 trillion RMB to 1.6 trillion RMB and then to 1.8 trillions RMB. The worst equilibrium, in contrast, is rather stable w.r.t. banks' bargaining power as varying η has only a minor effect on equilibrium quantities. In case of the interim equilibrium with negative welfare, increasing η increases the probability of default from 5.8% to 6.4% and then to 7.1% while causing an additional welfare loss of 1.0 trillion RMB for $\eta = 20\%$ and additional 2.5 trillion RMB for $\eta = 30\%$. This indicates that the banking system becomes more unstable if banks interact more aggressively with shadow banks on intermediating shadow money. Corresponding results for the worst and best equilibrium averaged over the non-big 4 banks for different levels of η are provided in Panel B of Table 7. While results for the best equilibrium are comparable to those for the big 4 banks, the worst equilibrium is highly sensitive to the choice of η. When bargaining power increases from 10% to 20%, the average default probability of non-big 4 banks increases from 8.5% to 55.9% while welfare losses rise from 3.9 trillion RMB to 52.8 trillion RMB. Increasing η further to 30% results in an extremely high average default probability of 87.5% and welfare losses of 70.4 trillion RMB. This documents that non-big 4 banks act more aggressively in setting WMP rates to exploit regulatory arbitrage when they have more bargaining power.

[Table 7 about here.]

5.5. Financial Fragility and The Non-big 4 Banks

Next, we examine the non-big 4 banks under multiple equilibria. For ease of presentation, we consider only the largest five joint-stock commercial banks including Shanghai Pudong Development Bank (SPD), China Minsheng Bank (CMBC), China Merchants Bank (CMB), China CTTIC Bank (CTTIC) and China Industrial Banks. Results for the good and bad equilibria are presented in Tables 8 and 9, respectively. The main findings are comparable to those for the big 4 banks. The realized banking system is close to the best equilibrium and the centric and asymmetric bad equilibria justify financial fragility. In comparing with the results for the big 4 banks, we observe several interesting facts, though.

Firstly, the non-big 4 banks are more aggressive than the big 4 banks in setting WMP and deposit rates. The average probability of default in the realized state equals 0.43% and hence is higher than the average default probability of 0.29% in the best equilibrium (see equilibrium 4 in the baseline model in Table 8). Consequently, the observed deposit and WMP rates are higher than the counterparts in the best equilibria, which is different from the results for the big 4 banks. The rationale is as follows. For the non-big 4 banks, the market share on WMPs dominates the market share on deposits. The opposite is true for the big 4 banks. Thus, the non-big 4 banks are keen to exploit the unregulated WMP market and act aggressively in setting interest rates but rely heavily on the implicit guarantee. The empirical analysis approves that the bailout of the non-big 4 banks has more variation to explain economic activities. Secondly, also the non-systemically important banks can incur large welfare losses. The equilibria in columns 1 and 2 of Table 9 in the baseline model and the alternative specification with liquidity costs, impose massive financial distress and welfare losses of up to 30 trillion RMB. Lastly, when adjusting WMP rats is costly, the cumulative WMP share decreases indicating that WMPs are run prone.

[Table 8 about here.]

[Table 9 about here.]

6. Capital Requirements

China's financial regulators launched the "Guidance Opinions Concerning Standardisation of Asset Management Operations by Financial Institutions" on 27 April, 2017. One of the main goals requires banks to provision 10 percent of their management fee income from WMPs as risk reserves. We investigate if such a policy is effective to eliminate the large welfare losses in the unstable equilibria and we analyse what level of capital requirements can stabilize the banking system. In addition to the baseline model we include different model specifications: imposing a 10% capital requirement to WMPs, imposing liquidity costs in adjusting WMP rates, imposing a 10% capital requirement on WMPs as well as incorporating liquidity cost in adjusting WMP rates. These specifications and their calibrations are detailed in Section 3.4 and Appendix D. As each alternative changes the optimal pricing of deposit and WMP rates as well as the determination of the optimal default threshold, each specification needs to be calibrated accordingly. Specifically, we use the calibrated parameters (μ, σ, c) in each model specification and compute equilibria for each level of capital requirements. We apply a rate ceiling requiring deposit rates to be positive in order to rule out the equilibria with negative deposit rates.[15]

We use the mean risk-neutral probability of default of all banks to measure the stability of the banking sector and rank equilibria according to this measure. Figure 7 plots financial distress and welfare against capital requirements where banks do not provide capital to WMPs whereas Figure 8 plots them where banks provide capital to WMPs. First, we observe that increasing capital requirements reduces instability of the banking system. Both financial distress and welfare losses in the worst equilibrium decline because increasing capital requirements to deposits and/or WMPs forces equity holders to invest a larger share into safe assets and thereby reduces the severity of the bad and unstable equilibria. Second, imposing 10% capital requirement on WMPs improves welfare in both the worst and best equilibrium. For example, the loss in welfare is reduced from 58 trillion RMB to 48 trillion RMB in the worst equilibrium and the gain in welfare rises in the best equilibrium. It, however, does not change the stability of banking system much because no significant drop in the average probability of default in the worst equilibrium can be observed. In fact, the worst equilibrium and the best equilibrium in the model specification with 10% capital requirement on WMPs still deviate substantially with a difference of about 50% in financial distress and about 50 trillion RMB change in welfare, indicating a highly fragile banking system.

[Figure 7 about here.]

[Figure 8 about here.]

We define the level of capital requirement at which the financial distress and welfare in the worst equilibrium are almost as good as those in the best equilibria. Thereby we aim at determining a stable banking system in which differentials between the worst and best are negligible. Results in Table 10 show that the capital requirements must be lifted extremely high in order to achieve the stability of the banking system in the model perturbations. Specifically, in order to eliminate fragility in the banking system, equity holders need to capitalize more than 30% in deposits and/or WMPs. In this respect, our results show that a capital requirement of 10% on shadow money does not stabilize the system as effectively as regulators expect.

[15] Effectively, we simply exclude those equilibria with negative deposit rates.

[Table 10 about here.]

7. Conclusion

In this paper we examine the benefits and risks inherent in shadow money. We incorporate several stylized features of shadow money into the banking competition model of Egan et al. [2017] and then estimate and calibrate the resulting model to China's banking system. The model endogenizes and implies the value of the government guarantee on shadow money using not only interest rates but also elasticities of demand with respect to interest rates. The model possesses multiple equilibria supported by the same bank fundamentals. We use the bailout rate, reflecting belief on the government guarantee that depositors and WMP investors hold, as a measure of prosperity of shadow money. We compare the realized banking system with the alternative equilibria to measure financial fragility.

Associating the bailout rate with macroeconomic variables, we find that the bailout rate is mainly driven by the rate spread and represents a robust predictor of future economic activities. This suggests that the intermediation of shadow money can boost economic growth as one way of supply of credit. The component of the bailout rate - the markup spread - makes the economy suffer setback since it contains default risks of banks that likely cut off supply of credit. Moreover, innovations to the bailout rate and the rate spread, respectively, that are orthogonal to the current macroeconomic conditions are shown to cause large and persistent expansion in economic activities. Innovations to the markup spread cause large and persistent contraction in economic activities.

Studying the stability of the banking system in presence of shadow money, China's banking system is shown to be close to the best equilibrium but is highly fragile. In China, WMP financing is relatively low compared with deposit financing. Banks interact with shadow banks for profits on shadow money under the low bargaining power. However, competition between deposits and shadow money can lead to bad equilibria resulting in severe financial distress and large welfare losses. Some banks that appear safe are not stable. In particular, some banks such as CCB are much more unstable than other banks. The banking system is exposed to even more fragilities caused by WMP runs when adjusting WMP rates is costly, which is the case provided that banks are distressed.

We also examine whether or not providing capital to shadow money can ease financial fragility by cutting regulatory arbitrage opportunities. The policy is effective but it turns out that the effectiveness of this policy is limited. We show that very high capital requirements are needed to achieve a stable banking system.

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Appendix A. Endogenous Default Threshold

As shown in Hortacsu et al. [2011] and Egan et al. [2017] the discounted future value of keeping the bank solvent can be computed as

$$\begin{aligned} E_k &= \int_{\bar{R}_k}^{\infty} \left\{ M^D S_k^D (R_k - i_k^D) + M^W S_k^D \eta_k (R_k + c_k - i_k^W) - b_k + \frac{E_k}{1+r} + \kappa (b_k + M^D S_k^D) \right\} d\mathbb{P}_{R_k} \\ &\quad - \int_{-\infty}^{\bar{R}_k} \kappa (b_k + M^D S_k^D) d\mathbb{P}_{R_k} \end{aligned} \tag{A.1}$$

with boundary condition

$$M^D S_k^D (\bar{R}_k - i_k^D) + M^W S_k^W \eta_k (\bar{R}_K + c_k - i_k^W) - b_k + \frac{1}{1+r} E_k + \kappa (b_k + M^D S_k^D) = -\kappa (b_k + M^D S_k^D).$$

Inserting the boundary condition in equation (A.1) yields

$$\begin{aligned} E_k &= (M^D S_k^D + M^W S_k^W \eta_k) \cdot \mathbb{E}[R_k - \bar{R}_k | R_k > \bar{R}_k] \cdot \mathbb{P}(R_k > \bar{R}_k) - \kappa (b_k + M^D S_k^D) \\ &= (M^D S_k^D + M^W S_k^W \eta_k) \left(1 - \Phi\left(\frac{\bar{R}_k - \mu_k}{\sigma_k}\right)\right) \cdot \left(\mu_k - \bar{R}_k + \sigma_k m \left(\frac{\bar{R}_k - \mu_k}{\sigma_k}\right)\right) \\ &\quad - \kappa (b_k + M^D S_k^D), \end{aligned} \tag{A.2}$$

where $m(\cdot) \equiv \frac{\phi(\cdot)}{1-\Phi(\cdot)}$ is the inverse Mills ratio. Inserting (A.2) in (3.6) yields an endogenous default threshold $\bar{R}_k$ characterized by the following equation

$$\begin{aligned} & b_k - \kappa(b_k + M^D S^D_{k,t}) - M^D S^D_{k,t}\left(\bar{R}_k - i^D_{k,t}\right) - M^W S^W_{k,t}\eta_k(\bar{R}_k + c_{k,t} - i^W_{k,t}) \\ = \quad & \tfrac{1}{1+r}\Big\{M^D S^D_{k,t}\left(1-\Phi\left(\tfrac{\bar{R}_k-\mu_k}{\sigma_k}\right)\right)\cdot\left(\mu_k - \bar{R}_k + \sigma_k m\left(\tfrac{\bar{R}_k-\mu_k}{\sigma_k}\right)\right) \\ & +M^W S^W_{k,t}\eta_k\left(1-\Phi\left(\tfrac{\bar{R}_k-\mu_k}{\sigma_k}\right)\right)\cdot\left(\mu_k - \bar{R}_k + \sigma_k m\left(\tfrac{\bar{R}_k-\mu_k}{\sigma_k}\right)\right) - \kappa(b_k + M^D S^D_{k,t})\Big\}. \end{aligned} \tag{A.3}$$

The LHS is the shortfall at the threshold level after capital reserve is exhausted. The RHS is the (discounted) continuation value of the bank from the next period. The first term of the RHS is the expected value of the deposits invested in the bank's assets in the next period, i.e. the total insured deposits times survival probability times expected return on risky assets. The second term of the RHS is the expected value of the WMPs invested in the bank's assets in the next period and distributed to the bank. The last term of the RHS is the capital reserve the bank needs to hold in the next period. The premium $\sigma_k m(\frac{\bar{R}_k-\mu_k}{\sigma_k})$ reflects the default risk in the next period and accounts for equity holders' limited liability.

Appendix B. Equilibrium Quantities in Baseline Model

We will drop the time subscript in the equilibrium due to stationarity. Since R_k is normally distributed, we can write the optimal interest rate setting problem (3.7) as

$$\begin{aligned} E_k = \quad & \max_{i^D_k, i^W_k}\Big[\Big(M^D S^D_k(\mu_k + \sigma_k m\left(\tfrac{\bar{R}_k-\mu_k}{\sigma_k}\right) - i^D_k) + M^W S^W_k \eta_k(\mu_k + \sigma_k m\left(\tfrac{\bar{R}_k-\mu_k}{\sigma_k}\right) + c_k - i^W_k) \\ & -b_k + \tfrac{1}{1+r}E_k\Big)\left(1-\Phi\left(\tfrac{\bar{R}_k-\mu_k}{\sigma_k}\right)\right) - \kappa(b_k + M^D S^D_k)\Phi\left(\tfrac{\bar{R}_k-\mu_k}{\sigma_k}\right)\Big] \end{aligned}$$

and calculate the first order conditions for the optimal deposit rate $i^D_{k,t}$ as

$$\mu_k + \sigma_k m\left(\frac{\bar{R}_k-\mu_k}{\sigma_k}\right) - i^D_k = \frac{1}{(1-S^D_k)\alpha^D} + \kappa\frac{\Phi\left(\frac{\bar{R}_k-\mu_k}{\sigma_k}\right)}{1-\Phi\left(\frac{\bar{R}_k-\mu_k}{\sigma_k}\right)}, \tag{B.1}$$

and correspondingly for the optimal WMP rate i^W_k as

$$\mu_k + \sigma_k m(\frac{\bar{R}_k-\mu_k}{\sigma_k}) + c_k - i^W_k = \frac{1}{(1-S^W_k)\alpha^W}. \tag{B.2}$$

Inverting the default probability

$$\frac{\bar{R}_k - \mu_k}{\sigma_k} = \Phi^{-1}(p_k)$$

allows us to rewrite equation (A.3) for the endogenous default threshold as

$$\begin{aligned} & b_k - \kappa(b_k + M^D S^D_{k,t}) - M^D S^D_{k,t}\left(\bar{R}_k - i^D_{k,t}\right) - M^W S^W_{k,t}\eta_k\left(\bar{R}_k + c_k - i^W_{k,t}\right) \\ = \quad & \tfrac{M^D S^D_k + M^W S^W_{k,t}\eta_k}{1+r}(1-p_k)\left(-\sigma_k\Phi^{-1}(p_k) + \sigma_k m(\Phi^{-1}(p_k))\right) - \tfrac{\kappa(b_k + M^D S^D_k)}{1+r}. \end{aligned} \tag{B.3}$$

Further, we can express the FOCs (B.1) and (B.2) in terms of margin as

$$\begin{aligned} \bar{R}_k - i^D_k \quad &= \quad \tfrac{1}{(1-S^D_k)\alpha^D} + \tfrac{\kappa p_k}{1-p_k} + \sigma_k\left(\Phi^{-1}(p_k) - m\left(\Phi^{-1}(p_k)\right)\right) \\ \bar{R}_k + c_k - i^D_k \quad &= \quad \tfrac{1}{(1-S^W_k)\alpha^W} + \sigma_k\left(\Phi^{-1}(p_k) - m\left(\Phi^{-1}(p_k)\right)\right). \end{aligned} \tag{B.4}$$

Substituting (B.4) for margin into equation (A.3), we obtain

$$\begin{aligned} & \sigma_k\tfrac{p_k+r}{1+r}\left(M^D S^D_k + M^W S^W_{k,t}\eta_k\right)\left(\Phi^{-1}(p_k) - m\left(\Phi^{-1}(p_k)\right)\right) \\ = \quad & b_k - \tfrac{\kappa r(b_k + M^D S^D_k)}{1+r} - \left(\tfrac{M^D S^D_k}{(1-S^D_k)\alpha^D} + \tfrac{\kappa p_k M^D S^D_k}{1-p_k}\right) - \tfrac{M^W S^W_k\eta_k}{(1-S^W_k)\alpha^W}. \end{aligned}$$

This determines the standard deviation of bank k's asset return

$$\sigma_k = \frac{1+r}{p_k+r}\frac{b_k - \frac{\kappa r(b_k+M^D S^D_k)}{1+r} - \left(\frac{M^D S^D_k}{(1-S^D_k)\alpha^D} + \frac{\kappa p_k M^D S^D_k}{1-p_k}\right) - \frac{M^W S^W_k\eta_k}{(1-S^W_k)\alpha^W}}{\left(M^D S^D_k + M^W S^W_k\eta_k\right)\left(\Phi^{-1}(p_k) - m\left(\Phi^{-1}(p_k)\right)\right)}.$$

Finally, we express the bailout rate c_k as difference between (B.1) and (B.2)

$$c_k \quad = \quad \tfrac{1}{(1-S^W_k)\alpha^W} - \tfrac{1}{(1-S^D_k)\alpha^D} + i^W_k - i^D_k - \tfrac{\kappa p_k}{1-p_k},$$

and determine the expected return on the bank's assets from (B.1) as

$$\mu_k \quad = \quad i^D_k + \tfrac{1}{(1-S^D_k)\alpha^D} + \tfrac{\kappa p_k}{1-p_k} - \sigma_k m\left(\Phi^{-1}(p_k)\right).$$

Appendix C. Demand Estimation

We follow the procedure described in Egan et al. [2017] to estimate demand parameters. Therefore, denote by $\xi^D_{k,t}$ resp., $\xi^W_{k,t}$ the effect of time-varying quality in bank k. Benefits that consumers derive from the outside good are set to zero, so that $\delta_0^D + \xi_{0,t}^D = \delta_0^W + \xi_{0,t}^W = 0$. This implies the following linear regression specification of WMP demand.

$$\ln S_{k,t}^W - \ln S_{0,t}^W = \alpha^W (i_{k,t}^W - i_{0,t}^W) - \gamma(p_{k,t} - p_{0,t}) + \delta_k^W + \xi_{k,t}^W, \tag{C.1}$$

and of deposit demand

$$\ln S_{k,t}^D - \ln S_{0,t}^D = \alpha^D (i_{k,t}^D - i_{0,t}^D) + \delta_k^D + \xi_{k,t}^D. \tag{C.2}$$

As we do not observe any data on the outside good, we include quarter fixed effects δ_t^D and δ_t^W which absorb the unobserved quantities $i_{0,t}^D$, $i_{0,t}^W$, and $p_{0,t}$ so that we estimate a differences in differences specification of the form

$$\ln S_{k,t}^W = \alpha^W i_{k,t}^W - \gamma p_{k,t} + \delta_t^W + \delta_k^W + \xi_{k,t}^W, \tag{C.3}$$

for WMP demand and

$$\ln S_{k,t}^D = \alpha^D i_{k,t}^D + \delta_t^D + \delta_k^D + \xi_{k,t}^D \tag{C.4}$$

for deposit demand.

Appendix D. WMP and Capital Requirements

When WMPs are secured, bank k is required to co-invest κ fraction of $M^W S_k^W \eta_k$ in the risk-free asset. The default condition becomes

$$M^D S_{k,t}^D (\bar{R}_k - i_{k,t}^D) + M^W S_{k,t}^W \eta_k (\bar{R}_k + c_{k,t} - i_{k,t}^W) - b_k + \frac{1}{1+r} E_k + \kappa(b_k + M^D S_{k,t}^D + M^W S_k^W \eta_k) = 0.$$

The endogenous default threshold $\bar{R}_k$ is characterized by

$$\begin{aligned} & b_{k,t} - \kappa(b_k + M^D S_{k,t}^D + M^W S_k^W \eta_k) - M^D S_{k,t}^D \left(\bar{R}_k - i_{k,t}^D\right) - M^W S_{k,t}^W \eta_k (\bar{R}_k + c_{k,t} - i_{k,t}^W) \\ = \quad & \tfrac{M^D S_{k,t}^D}{1+r} \left(1 - \Phi(\tfrac{\bar{R}_k - \mu_k}{\sigma_k})\right) \left(\mu_k - \bar{R}_k + \sigma_k m(\tfrac{\bar{R}_k - \mu_k}{\sigma_k})\right) \\ & + \tfrac{M^W S_{k,t}^W \eta_k}{1+r} \left(1 - \Phi(\tfrac{\bar{R}_k - \mu_k}{\sigma_k})\right) \left(\mu_k - \bar{R}_k + \sigma_k m(\tfrac{\bar{R}_k - \mu_k}{\sigma_k})\right) - \tfrac{\kappa(b_k + M^D S_{k,t}^D + M^W S_k^W \eta_k)}{1+r}. \end{aligned}$$

The addition of risk-free capital requirements on WMPs also impacts a bank's optimal deposit rate decision through its effect on the cost of default. Banks set the rate for deposits and WMPs to maximize the expected return to equity holders which is given by

$$E_k = \max_{i^D_{k,t}, i^W_{k,t}} \mathbb{E}\Big[\Big(M^D S^D_{k,t}(R_{k,t} - i^D_{k,t}) + M^W S^W_{k,t}\eta_k(R_{k,t} + c_{c,t} - i^W_{k,t}) \\ -b_k + \tfrac{1}{1+r}E_{R_k}\Big) 1_{\{R_{k,t} > \bar{R}_k\}} - \kappa(b_{k,t} + M^D S^D_{k,t} + M^W S^W_k \eta_k)) 1_{\{R_{k,t} \leq \bar{R}_k\}}\Big].$$

The corresponding first order conditions for setting rates are given by

$$\begin{aligned} \mu_k + \sigma_k m(\tfrac{\bar{R}_k - \mu_k}{\sigma_k}) - i^D_k &= \tfrac{1}{(1-S^D_k)\alpha^D} + \kappa\Phi(\tfrac{\bar{R}_k - \mu_k}{\sigma_k}) / \Big(1 - \Phi(\tfrac{\bar{R}_k - \mu_k}{\sigma_k})\Big) \\ \mu_k + \sigma_k m(\tfrac{\bar{R}_k - \mu_k}{\sigma_k}) + c_k - i^W_k &= \tfrac{1}{(1-S^W_k)\alpha^W} + \kappa\Phi(\tfrac{\bar{R}_k - \mu_k}{\sigma_k}) / \Big(1 - \Phi(\tfrac{\bar{R}_k - \mu_k}{\sigma_k})\Big) \end{aligned} \quad \text{(D.1)}$$

and the standard deviation equals

$$\sigma_k = \frac{1+r}{p_k + r} \frac{b_k - \frac{\kappa r(b_k + M^D S^D_k + M^W S^W_k \eta_k)}{1+r} - \Big(\frac{M^D S^D_k}{(1-S^D_k)\alpha^D} + \frac{\kappa p_k M^D S^D_k}{1-p_k}\Big) - \Big(\frac{M^W S^W_k \eta_k}{(1-S^W_k)\alpha^W} + \frac{\kappa p_k M^W S^W_k \eta_k}{1-p_k}\Big)}{(M^D S^D_k + M^W S^W_k \eta_k)\left(\Phi^{-1}(p_k) - m\left(\Phi^{-1}(p_k)\right)\right)}. \quad \text{(D.2)}$$

Appendix E. Welfare

In order to keep the paper self contained, we provide the definition of welfare as in Egan et al. [2017] here. Consumer welfare equals

$$CS = \frac{M^D}{\alpha^D}\left(\ln \sum_{l=1}^{K} \exp(\alpha^I i^D_l + \delta^D_k + \xi^D_l) + \frac{M^W}{\alpha^W} \ln \sum_{l=1}^{K} \exp(\alpha^W i^W_l - \gamma p_k + \delta^W_l + \xi^W_l)\right), \quad \text{(E.1)}$$

where we normalize the Euler-Mascheroni constant to zero. The annualized flow to capital (equity value) of all banks is

$$\text{Flow to Capital} = \sum_{l=1}^{K} r E_l, \quad \text{(E.2)}$$

where the equity value of bank l is inverted from the the bank's default condition

$$E_k = (1+r)\left(b_k - M^D S^D_k(\bar{R}_k - i^D_k) - M^W S^W_l(\bar{R}_k + c_k - i^W_k) - \kappa(b +^D S^D_k)\right). \quad \text{(E.3)}$$

The expected payout of the government is

$$EC = 0.6 \sum_{l=1}^{K} p_k (M^D S_l^D + M^W S_l^W c_l \frac{1+r}{r}), \tag{E.4}$$

where we assume the WMPs are bailed out under an implicit guarantee and the recovery rate 40%. The bankruptcy cost is:

$$EC = 0.2 \sum_{l=1}^{K} (M^D S_l^D + M^W S_l^W) \tag{E.5}$$

where we assume the dead weight bankruptcy cost 20%.

Table 1: Stock code and name of sixteen banks in data sample

Stock Code	Bank Name
000001	Pingan Bank
002142	Ningbo Bank
600000	Shanghai Pudong Development Bank
600015	Huaxia Bank
600016	China Minsheng Bank
600036	China Merchants Bank
601009	Nanjing Bank
601166	China Industrial Bank
601169	Beijing Bank
601288	Agricultural Bank of China
601328	Bank of Communications
601398	Industrial and Commercial Bank of China
601818	Everbright Bank of China
601939	China Construction Bank
601988	Bank of China
601998	China CITIC Bank

Table 2: Summary statistics on banks' deposits, WMPs, and probabilities of default
The table reports summary statistics for the sixteen largest Chinese banks over Q2/2008 - Q1/2017. Banks are divided into the big 4 systemically important banks and the 12 remaining non-big 4 banks. Observations are per bank by quarter: 576. WMP volumes, rates and market shares are extracted from the RESSET WMP Database. We aggregate the WMP volumes and volume-weighted WMP rates for each bank from daily series. Deposit volumes and market shares of the sample banks are taken from the CSMAR database. Deposit rates are hand collected from banks' official websites and aggregated to the quarterly series. Risk neutral probabilities of default for each bank are estimated based on the distance to default model. The one year government rate is from the CSMAR database. Moreover, the table provides summary statistics for the cumulative WMP and deposit shares of the 439 smaller outside banks in our data set.

	Mean	Median	Max	Min	Std.Dev
WMP volume (CNY tr)	0.993	0.640	5.413	0.005	1.007
WMP volume, big 4 (CNY tr)	1.306	1.076	5.413	0.005	1.215
Deposit volume (CNY tr)	3.970	1.943	18.565	0.056	4.524
Deposit volume, big 4 (CNY tr)	11.117	11.102	18.565	4.928	3.145
WMP rate	0.043	0.043	0.065	0.023	0.009
WMP rate, big 4	0.042	0.042	0.059	0.031	0.007
Deposit rate	0.029	0.03	0.039	0.018	0.007
Deposit rate, big 4	0.028	0.03	0.039	0.018	0.007
WMP share	0.057	0.05	0.219	0.005	0.033
WMP share, big 4	0.082	0.077	0.219	0.008	0.041
Deposit share	0.044	0.021	0.188	0.001	0.049
Deposit share, big 4	0.124	0.121	0.187	0.087	0.022
Cum. WMP share, outside banks	0.092	0.098	0.128	0.062	0.022
Cum. Deposit share, outside banks	0.301	0.298	0.393	0.220	0.058
Probability of default	0.004	0.00004	0.070	0.000	0.010
1 year government rate	0.026	0.028	0.042	0.010	0.008

Table 3: Demand estimates

The table provides demand estimates for WMPs and deposits. The dependent variable in each regression is the log of a bank's market share. Each demand specification is estimated using an unbalanced panel of sixteen Chinese banks with quarterly observations over the period Q1/2008-Q3/2017. The standard errors are clustered in firm level and are adjusted for the heteroscedasticity. Robust standard errors are given in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

	WMP share	Deposit share	Deposit share
WMP rate	20.92***		
	(3.52)		
Deposit rate		54.90***	55.75***
		(6.38)	(6.46)
Probability of default	−13.06***	-1.38	
	(−2.65)	(-1.46)	
Quarter fixed effect	X	X	X
Bank fixed effect	X	X	X
Observations	576	576	576.00
R-squared	0.92	0.99	0.98

Table 4: Predictability of macroeconomic variables
The table documents the effectiveness of the bailout premium, rate spread and mark-up spread to predict macroeconomic variables. The data sample consists of the sixteen largest Chinese banks over Q2/2008 - Q1/2017. The dependent variables are the investment rate in real estate (REAL_EST), gross domestic product (GDP), unemployment rate (EMPLOY), consumer price index (CPI), retail price index (RPI), and purchasing managers' index (PMI), respectively. The independent variable in each specification is the aggregate bailout premium (resp. rate spread or mark-up spread) weighted by each bank's market share for WMPs. In addition to the independent variable in quarter t, each specification also includes a constant and p lags of dependent variables, where p is determined by the AIC. The control variables also include the repo rate (central bank funding rate), term spread, credit spread and a time dummy. The t-statistics reported in brackets are computed according to Hodrick [1992] while robust standard errors are given below. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

	REAL_EST	GDP	EMPLOY	CPI	RPI	PMI
Panel A. All banks						
c	2.770*	0.406**	-5.907**	0.783*	1.246*	0.754*
	(1.912)	(2.263)	(-2.666)	(1.815)	(1.860)	(1.838)
R^2	0.489	0.473	0.351	0.462	0.473	0.334
Rate spread	3.554***	0.494***	-7.413***	1.006***	1.521***	0.939***
	(4.400)	(5.697)	(-3.311)	(3.277)	(4.206)	(3.240)
R^2	0.517	0.502	0.409	0.489	0.493	0.364
Mark-up spread	-39.373***	-4.113**	37.073***	-11.867***	-13.297**	-9.725**
	(-3.109)	(-2.623)	(2.944)	(-3.096)	(-2.614)	(-2.583)
R^2	0.562	0.477	0.314	0.543	0.481	0.391
Pane B. Big 4 vs. Non Big 4						
c (big 4)	2.303*	0.349**	-4.889**	0.635*	0.957*	0.636*
	(1.728)	(2.107)	(-2.405)	(1.896)	(1.742)	(1.778)
R^2	0.479	0.463	0.328	0.450	0.456	0.323
c (non big 4)	4.099**	0.541**	-8.059***	1.264**	2.333***	1.063**
	(2.386)	(2.544)	(-3.132)	(2.488)	(3.047)	(2.212)
R^2	0.516	0.491	0.392	0.502	0.547	0.361
Rate spread (big 4)	3.211**	0.453**	-6.717***	0.889**	1.279*	0.858**
	(2.282)	(2.599)	(-3.163)	(2.113)	(1.938)	(2.147)
R^2	0.510	0.495	0.395	0.479	0.477	0.356
Rate spread (non big 4)	4.153***	0.552***	-8.112***	1.268***	2.221***	1.061***
	(5.559)	(6.744)	(-4.303)	(3.640)	(5.033)	(4.332)
R^2	0.527	0.505	0.418	0.512	0.546	0.371
Mark-up rate (big 4)	-18.272**	-2.523**	22.971*	-5.096*	-4.102*	-4.495*
	(-2.099)	(-2.234)	(1.918)	(-1.889)	(-1.747)	(-1.761)
R^2	0.472	0.441	0.247	0.445	0.426	0.304
Mark-up rate (non big 4)	-40.419***	-4.898**	40.379***	-16.178***	-17.197***	-15.165***
	(-3.214)	(-2.652)	(3.179)	(-3.223)	(-3.566)	(-4.898)
R^2	0.576	0.479	0.327	0.586	0.492	0.408

Table 5: Good Multiple Equilibria
This table states the good equilibria for the big 4 banks. Column (Obs) gives the observed equilibrium as of Q3/2015. Columns (1)-(4) in panel "No Liquidity Cost" refer to the good equilibria with the welfare gains while columns (1)-(4) in panel "Liquidity Cost" refer to the corresponding good equilibria when raising WMP rates is costly. Equilibria are ranked w.r.t. welfare. A definition for welfare relative to its respective values in the observed equilibrium is provided in Appendix E. Consumer surplus is calculated as the difference between welfare in the alternative and the realized equilibrium.

		No Liqudity Cost				Liquidity Cost			
	Obs.	1	2	3	4	1	2	3	4
Deposit rate %									
ICBC China	2.50	3.11	3.13	2.62	2.61	3.14	3.15	2.60	2.59
ABC	2.50	2.92	2.61	2.95	2.60	2.99	2.58	3.00	2.57
Bank of China	2.50	2.54	2.53	2.53	2.52	2.43	2.43	2.43	2.43
CCB	2.57	2.76	2.75	2.75	2.74	2.74	2.74	2.73	2.73
WMP rate %									
ICBC China	4.97	5.65	5.68	5.04	5.03	5.33	5.35	4.99	4.99
ABC	4.83	5.27	4.91	5.32	4.89	5.10	4.85	5.11	4.85
Bank of China	5.05	5.04	5.04	5.04	5.04	4.99	4.99	4.99	4.99
CCB	4.71	4.88	4.88	4.87	4.87	4.79	4.79	4.79	4.79
Probability of Default %									
ICBC China	0.05	0.76	0.79	0.11	0.11	0.76	0.79	0.10	0.09
ABC	0.08	0.49	0.14	0.55	0.13	0.56	0.11	0.58	0.10
Bank of China	0.30	0.29	0.29	0.29	0.29	0.19	0.19	0.19	0.20
CCB	0.20	0.36	0.36	0.36	0.36	0.34	0.34	0.34	0.34
Mean Def. probability	0.16	0.48	0.39	0.33	0.22	0.46	0.36	0.30	0.18
Deposit share %									
ICBC China	12.78	13.35	13.67	10.50	10.64	13.53	13.92	10.43	10.62
ABC	10.52	9.87	8.48	10.39	8.70	10.26	8.35	10.69	8.63
Bank of China	9.05	6.89	6.98	7.08	7.21	6.50	6.63	6.73	6.89
CCB	10.74	8.90	9.01	9.14	9.30	8.81	8.97	9.09	9.29
Cumulateive share	43.09	39.01	38.13	37.10	35.85	39.11	37.88	36.94	35.44
WMP share %									
ICBC China	5.90	6.18	6.20	5.92	5.93	5.82	5.81	5.90	5.90
ABC	7.15	7.37	7.17	7.42	7.18	7.11	7.16	7.10	7.15
Bank of China	11.62	11.54	11.56	11.57	11.59	11.64	11.64	11.63	11.63
CCB	3.40	3.42	3.43	3.43	3.44	3.40	3.39	3.39	3.39
Cumulateive share	28.07	28.52	28.37	28.33	28.14	27.97	28.00	28.03	28.07
Welfare tn RMB									
Consumer surplus		-0.16	-0.24	-0.31	-0.42	-0.24	-0.31	-0.36	-0.45
Flow to capital		-0.24	-0.23	-0.22	-0.21	-0.25	-0.24	-0.23	-0.21
Bailout cost		0.11	0.08	0.05	0.01	0.45	0.33	0.27	0.13
Bankruptcy cost		-0.96	-1.21	-1.48	-1.83	-1.03	-1.34	-1.57	-1.95
Change of welfare		0.45	0.66	0.90	1.20	0.10	0.47	0.71	1.16

Table 6: Bad Multiple Equilibria
This table reports the bad equilibria for the big 4 banks. Column (Obs) states the observed equilibrium as of Q3/2015. Columns (1)–(4) in the panel "No Liquidity Cost" refer to the equilibria with welfare losses in the benchmark model while columns (1)-(4) in the panel "Liquidity Cost" refer to the corresponding bad equilibria when raising WMP rates is costly. Equilibria are ranked w.r.t. welfare. A definition for welfare relative to its respective values in the observed equilibrium is provided in Appendix E. Consumer surplus is calculated as the difference between welfare in the alternative and the realized equilibrium.

		No Liqudity Cost				Liquidity Cost			
	Obs.	1	2	3	4	1	2	3	4
Deposit rate %									
ICBC China	2.50	20.89	20.39	19.01	2.97	22.37	2.99	2.98	2.93
ABC	2.50	21.78	3.02	3.00	2.84	23.69	23.54	21.38	2.67
Bank of China	2.50	21.66	21.13	2.74	2.61	24.56	24.36	2.32	2.33
CCB	2.57	20.89	20.49	19.25	8.75	13.56	21.93	20.74	8.79
WMP rate %									
ICBC China	4.97	36.83	36.13	34.34	5.26	18.03	5.02	5.06	5.09
ABC	4.83	38.18	5.14	5.13	5.03	18.64	18.59	17.79	4.83
Bank of China	5.05	38.59	37.79	5.09	5.02	19.41	19.34	4.81	4.87
CCB	4.71	36.52	35.92	34.32	18.70	22.69	17.62	17.12	11.06
Probability of Default %									
ICBC China	0.05	54.11	52.95	49.94	0.33	55.48	0.27	0.26	0.28
ABC	0.08	54.70	0.38	0.37	0.26	56.10	55.84	51.90	0.08
Bank of China	0.30	55.53	54.27	0.36	0.27	56.48	56.15	0.00	0.03
CCB	0.20	54.36	53.37	50.70	22.45	78.34	55.42	52.87	22.21
Mean Def. probability	0.16	54.67	40.24	25.34	5.83	61.60	41.92	26.26	5.65
Deposit share %									
ICBC China	12.78	23.60	34.29	51.89	3.75	19.74	0.00	0.00	3.64
ABC	10.52	31.64	0.00	0.01	2.88	33.51	36.26	59.07	2.59
Bank of China	9.05	25.54	36.39	0.00	2.18	46.62	48.95	0.00	1.86
CCB	10.74	19.21	29.30	48.06	72.63	0.13	14.78	40.91	73.55
Cumulateive share	43.09	100.00	99.99	99.96	81.44	100.00	100.00	99.99	81.63
WMP share %									
ICBC China	5.90	4.24	4.21	4.19	6.03	0.09	7.44	6.55	6.04
ABC	7.15	6.51	7.71	7.54	7.25	0.12	0.11	0.14	7.34
Bank of China	11.62	10.15	10.01	11.96	11.55	0.21	0.20	12.83	11.92
CCB	3.40	2.38	2.36	2.34	3.45	0.01	0.05	0.05	0.74
Cumulateive share	28.07	23.28	24.28	26.02	28.29	0.43	7.80	19.57	26.04
Welfare tn RMB									
Consumer surplus		1.12	1.31	1.62	1.51	-16.70	-3.75	0.35	1.15
Flow to capital		-0.99	-0.97	-0.92	-0.46	-1.04	-1.03	-0.96	-0.47
Bailout cost		42.19	41.19	38.50	12.47	43.66	43.40	40.27	12.98
Bankruptcy cost		13.62	13.80	14.12	9.82	9.36	10.73	12.92	9.45
Change of welfare		-55.67	-54.64	-51.93	-21.23	-70.76	-58.90	-53.80	-21.75

Table 7: Bargaining Power and Multiple Equilibria
This table gives the averaged rates, the averaged probabilities of default and the accumulated market shares (in %) and welfare (in trillion RMB) for the big 4 and non-big 4 banks when banks' bargaining power η varies. A definition of welfare relative to its respective values in the observed equilibrium is provided in Appendix E.

	Deposit rate	WMP rate	Default of probability	Deposit share	WMP share	welfare
Panel A. Big 4						
Worst equilibrium						
η=0.10	21.3	37.5	54.7	100.0	23.2	-55.7
η=0.20	21.3	37.8	55.1	100.0	23.2	-56.0
η=0.30	21.4	38.0	55.5	100.0	23.2	-56.4
Interim equilibrium						
η=0.10	4.3	8.5	5.8	83.2	28.4	-21.2
η=0.20	4.7	9.0	6.4	83.2	29.2	-22.2
η=0.30	4.9	9.5	7.1	85.2	29.2	-24.7
Best equilibrium						
η=0.10	2.6	5.0	0.2	36.4	28.4	1.2
η=0.20	2.5	4.8	0.1	34.2	28.0	1.6
η=0.30	2.4	4.7	0.0	33.6	27.6	1.8
Panel B. Non Big 4						
Worst equilibrium						
η=0.10	3.5	6.8	8.5	4.3	5.0	-3.9
η=0.20	5.7	22.2	55.9	15.9	5.5	-52.8
η=0.30	15.5	28.3	87.5	20.0	4.0	-70.4
Best equilibrium						
η=0.10	2.6	5.1	0.6	2.0	5.7	0.2
η=0.20	2.3	4.8	0.0	1.8	5.6	0.4
η=0.30	2.3	4.8	0.0	1.8	5.6	0.6

Table 8: Good Multiple Equilibria

This table documents the good equilibria for the non-big 4 banks. Column (Obs) gives the observed equilibrium as of Q3/2015. Columns (1)–(4) in the panel “No Liquidity Cost” refer to the equilibria with welfare losses in the benchmark model while columns (1)-(4) in the panel “Liquidity Cost” refer to the corresponding bad equilibria when raising WMP rates is costly. Equilibria are ranked w.r.t. welfare. A definition for welfare relative to its respective values in the observed equilibrium is provided in Appendix E. Consumer surplus is calculated as the difference between welfare in the alternative and the realized equilibrium.

		No Liqudity Cost				Liquidity Cost			
	Obs.	1	2	3	4	1	2	3	4
Deposit rate %									
SPD bank	2.67	2.97	2.98	2.66	2.66	2.60	3.18	2.60	2.60
CMBC	2.67	2.62	2.82	2.83	2.62	2.53	3.05	2.53	2.53
CMB	2.58	2.61	2.33	2.33	2.32	2.82	2.25	2.82	2.25
China CITIC Bank	2.67	2.66	2.41	2.41	2.41	2.88	2.33	2.33	2.33
China Industrial Bank	2.67	2.64	2.64	2.64	2.64	2.58	2.58	2.58	2.58
WMP rate %									
SPD bank	4.74	5.09	5.10	4.73	4.73	2.88	3.26	2.88	2.88
CMBC	5.30	5.25	5.48	5.49	5.25	3.16	3.49	3.16	3.16
CMB	5.23	5.26	4.94	4.94	4.94	3.37	3.00	3.37	3.00
China CITIC Bank	5.40	5.39	5.12	5.11	5.11	3.45	3.09	3.09	3.09
China Industrial Bank	5.31	5.28	5.28	5.28	5.28	3.20	3.20	3.20	3.20
Probability of Default %									
SPD bank	0.16	0.57	0.59	0.15	0.15	0.08	0.90	0.08	0.08
CMBC	0.21	0.17	0.39	0.40	0.16	0.07	0.70	0.07	0.07
CMB	0.43	0.46	0.14	0.14	0.14	0.75	0.06	0.75	0.06
China CITIC Bank	0.48	0.47	0.16	0.16	0.16	0.80	0.07	0.07	0.07
China Industrial Bank	0.89	0.85	0.84	0.83	0.83	0.72	0.72	0.72	0.72
Mean Def. probability	0.43	0.50	0.42	0.34	0.29	0.48	0.49	0.34	0.20
Deposit share %									
SPD bank	2.34	2.59	2.61	2.20	2.20	2.11	2.89	2.12	2.14
CMBC	2.07	1.88	2.11	2.12	1.89	1.79	2.38	1.80	1.81
CMB	2.70	2.55	2.20	2.20	2.21	2.87	2.10	2.89	2.13
China CITIC Bank	2.42	2.24	1.97	1.98	1.98	2.54	1.88	1.89	1.90
China Industrial Bank	1.92	1.77	1.77	1.78	1.78	1.71	1.71	1.72	1.74
Cumulateive share	11.45	11.03	10.66	10.28	10.06	11.02	10.96	10.42	9.72
WMP share %									
SPD bank	3.89	3.97	3.98	3.89	3.90	2.94	2.86	2.93	2.93
CMBC	6.00	5.97	6.08	6.09	5.99	4.31	4.25	4.30	4.30
CMB	6.73	6.74	6.59	6.59	6.60	4.82	4.88	4.81	4.87
China CITIC Bank	5.62	5.61	5.52	5.52	5.53	3.95	4.03	4.02	4.02
China Industrial Bank	4.62	4.62	4.63	4.63	4.64	3.35	3.35	3.35	3.34
Cumulateive share	26.86	26.91	26.79	26.73	26.65	19.36	19.37	19.42	19.47
Welfare bn RMB									
Consumer surplus		-76.79	-175.44	-269.08	-332.67	-1546.23	-1555.57	-1660.65	-1811.67
Flow to capital		-14.70	-12.32	-10.34	-8.75	-17.21	-16.16	-13.79	-9.73
Bailout cost		24.16	-31.20	-69.15	-103.05	-29.10	-57.59	-98.67	-177.75
Bankruptcy cost		-146.73	-262.90	-370.23	-441.25	-1556.97	-1569.25	-1697.06	-1867.36
Change of welfare		31.09	106.34	159.96	202.88	22.63	55.11	121.30	223.70

Table 9: Bad Multiple Equilibria

This table gives bad equilibrium for the non-big 4 banks. Column (Obs) gives the observed equilibrium as of Q3/2015. Columns (1)–(4) in the panel "No Liquidity Cost" refer to the equilibria with welfare losses in the benchmark model while columns (1)-(4) in the panel "Liquidity Cost" refer to the corresponding bad equilibria when raising WMP rates is costly. Equilibria are ranked w.r.t. welfare. A definition for welfare relative to its respective values in the observed equilibrium is provided in Appendix E. Consumer surplus is calculated as the difference between welfare in the alternative and the realized equilibrium.

		No Liqudity Cost				Liquidity Cost			
	Obs.	1	2	3	4	1	2	3	4
Deposit rate %									
SPD bank	2.67	10.95	10.68	2.92	2.71	2.83	10.80	3.15	3.17
CMBC	2.67	2.74	2.71	2.90	2.60	11.66	3.10	2.52	3.05
CMB	2.58	2.41	2.37	2.67	2.31	2.96	2.91	2.85	2.25
China CITIC Bank	2.67	2.60	2.59	2.69	2.42	2.55	2.55	2.33	2.88
China Industrial Bank	2.67	6.89	0.49	6.32	6.31	6.59	6.49	5.90	2.58
WMP rate %									
SPD bank	4.74	21.68	21.26	5.02	4.77	3.00	10.65	3.24	3.26
CMBC	5.30	5.34	5.30	5.56	5.22	11.76	3.49	3.15	3.49
CMB	5.23	4.98	4.94	5.32	4.91	3.41	3.39	3.38	3.00
China CITIC Bank	5.40	5.28	5.27	5.41	5.11	3.20	3.21	3.09	3.45
China Industrial Bank	5.31	14.11	26.34	12.55	12.52	7.47	7.30	6.52	3.20
Probability of Default %									
SPD bank	0.16	32.37	31.47	0.49	0.21	0.34	32.28	0.85	0.89
CMBC	0.21	0.27	0.23	0.49	0.14	32.77	0.72	0.06	0.70
CMB	0.43	0.20	0.16	0.54	0.12	0.88	0.82	0.79	0.06
China CITIC Bank	0.48	0.36	0.35	0.50	0.17	0.30	0.30	0.07	0.80
China Industrial Bank	0.89	28.36	67.53	22.87	22.79	28.50	27.08	20.93	0.72
Mean Def. probability	0.43	12.31	19.95	4.98	4.69	12.56	12.24	4.54	0.63
Deposit share %									
SPD bank	2.34	64.53	65.00	2.25	2.03	0.63	63.16	2.62	2.87
CMBC	2.07	0.63	0.72	1.96	1.68	70.55	0.81	1.64	2.36
CMB	2.70	0.72	0.82	2.36	1.97	0.81	1.00	2.68	2.08
China CITIC Bank	2.42	0.68	0.79	2.04	1.78	0.56	0.70	1.72	2.52
China Industrial Bank	1.92	5.69	0.20	11.88	11.97	4.05	4.84	9.71	1.70
Cumulateive share	11.45	72.24	67.52	20.50	19.44	76.60	70.51	18.37	11.54
WMP share %									
SPD bank	3.89	2.13	2.21	4.08	4.05	3.14	0.24	2.95	2.86
CMBC	6.00	6.38	6.41	6.31	6.18	0.39	4.50	4.43	4.26
CMB	6.73	7.00	7.03	6.98	6.81	5.15	5.09	4.95	4.88
China CITIC Bank	5.62	5.91	5.95	5.80	5.72	4.31	4.25	4.14	3.95
China Industrial Bank	4.62	0.86	0.07	1.23	1.24	0.23	0.27	0.49	3.35
Cumulateive share	26.86	22.28	21.66	24.40	24.00	13.22	14.35	16.96	19.30
Welfare bn RMB									
Consumer surplus		3445.87	3164.99	927.06	728.74	1256.53	1431.74	-946.96	-1450.47
Flow to capital		-7.12	-4.47	-33.04	-26.42	-20.05	-19.82	-31.41	-19.52
Bailout cost		18674.70	16841.94	2599.45	2432.23	18814.64	16782.14	1654.29	10.98
Bankruptcy cost		14595.73	13278.66	1800.18	1453.82	14018.06	12677.19	-127.79	-1433.14
Change of welfare		-29831.69	-26951.14	-3505.61	-3183.74	-31556.13	-28047.41	-2504.87	-47.83

Table 10: Financial Fragility and Optimal Capital Requirement

This table gives the optimal capital requirement in four model specifications as of Q3/2018. The optimal capital requirement is determined as the level at which the worst equilibrium is comparable to the best equilibrium in terms of welfare. We calibrate the alternative model specifications, in addition to the baseline model, as follows. First, we calibrate the model to existing capital requirements of 10%. Second, we calibrate the model where adjusting WMP rate is costly. Third, we calibrate the model where banks are required to provide capital on WMPs at 10%. Fourth, we calibrate the model where adjusting WMP rate is costly as well as banks are required to provide capital on WMPs at 10%. With the calibrated values of bank fundamentals, we analyse the worst and best equilibria by varying capital requirements. The alternative model specifications and their calibration are given in Appendix E.

Model	Optimal capital req.
Baseline	32%
Baseline, WMP Capital Req. 10%	30%
Baseline, liquidity cost	33%
Baseline, liquidity cost, WMP Capital Req. 10%	33%

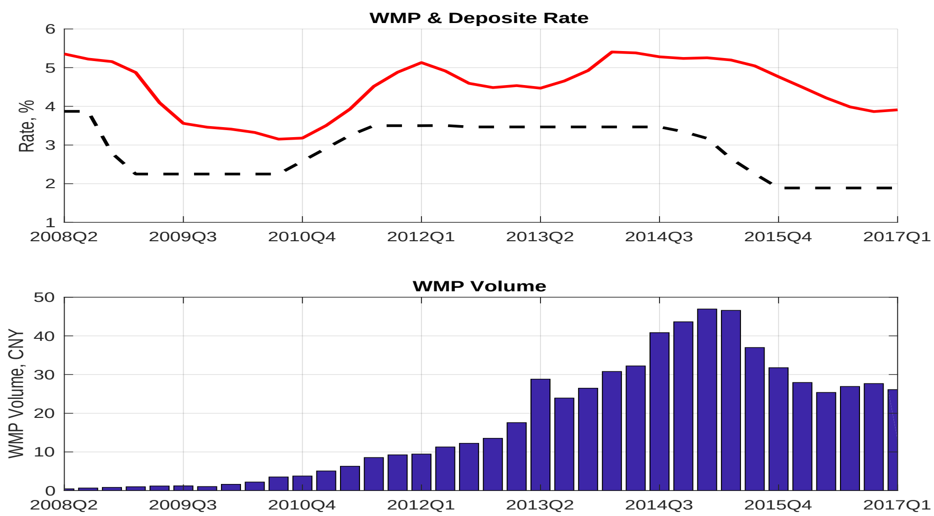

Figure 1: The figure shows the average WMP and deposit rate (upper panel) and the WMP volume over the time period Q2/2008-Q1/2017. The WMP rate is the average of the whole sample banks and the deposit rate the average of the 16 largest banks.

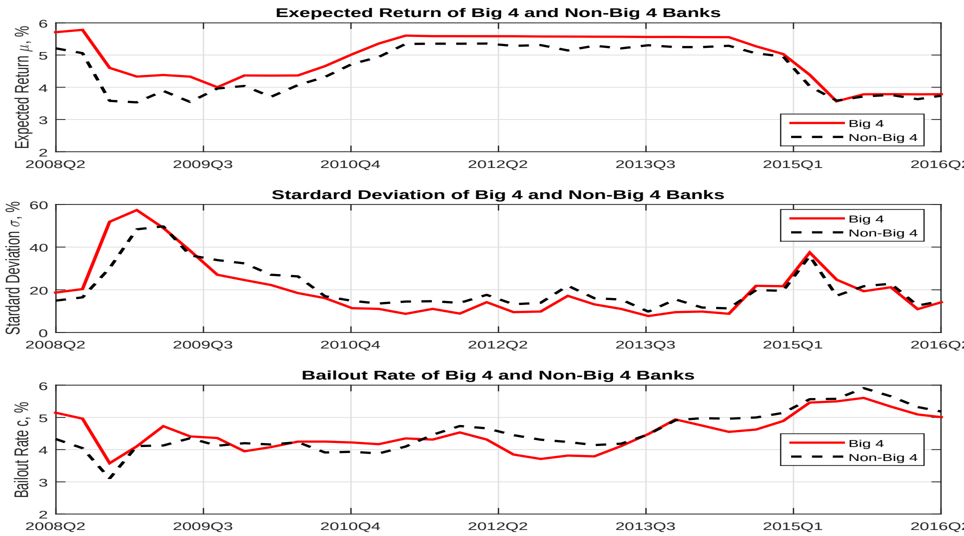

Figure 2: The figure shows the calibrated average bank fundamental triplet (μ, σ, c) over time. It is averaged across banks for each group of banks in each quarter. Data is quarterly, Q2/2008Q2–Q1/2017.

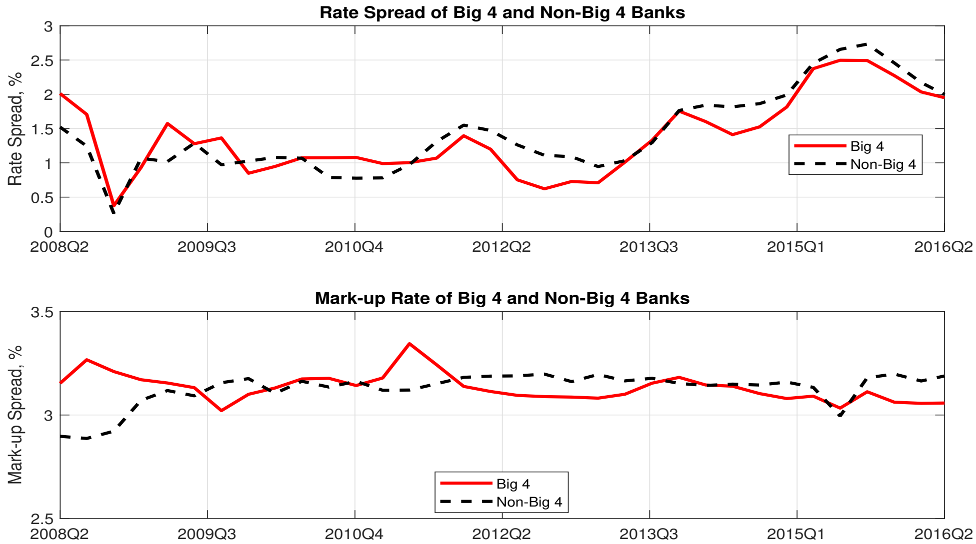

Figure 3: The figure shows the calibrated average bank rate spread $i^W - i^D$ and markup spread $\frac{1}{(1-S_k^W)\alpha^W} - \frac{1}{(1-S_k^D)\alpha^D}$ over time. It is averaged across banks for big 4 and non-big 4 bank separately in each quarter. Data are quarterly for the period Q2/2008Q2–Q1/2017.

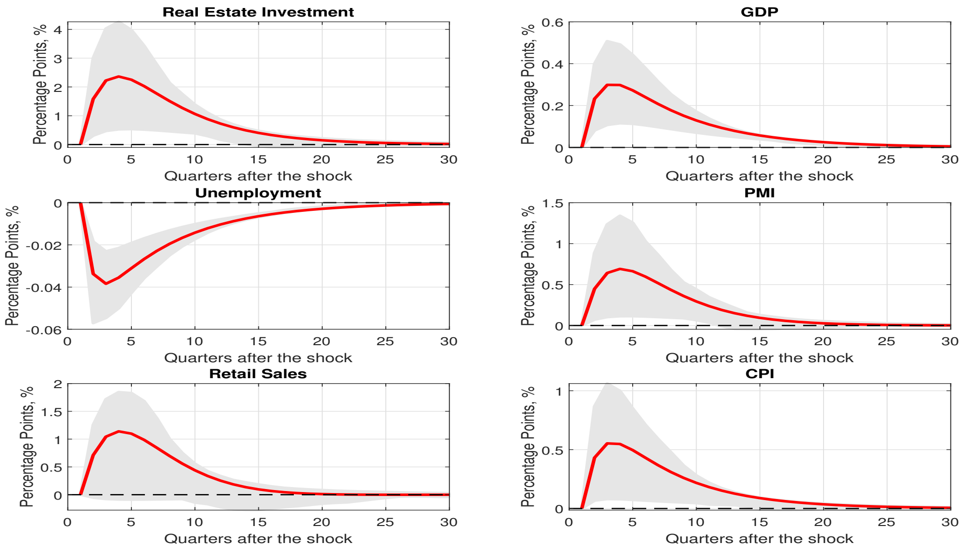

Figure 4: The figure depicts the impulse responses to a one-standard-devation orthogonalized shock to the premium c. The responses of real estate investment, GDP, unemployment rate, PMI, retail sales and CPI have been accumulated. Shaded bands denote 95% confidence intervals based on 2.000 bootstrap replication.

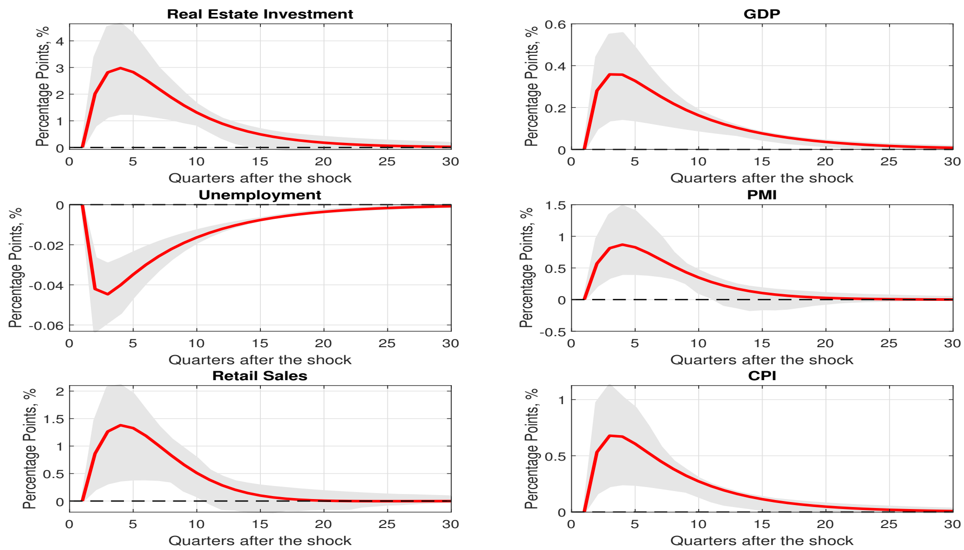

Figure 5: The figure depicts the impulse responses to a one-standard-devation orthogonalized shock to the rate spread. The responses of real estate investment, GDP, unemployment rate, PMI, retail sales and CPI have been accumulated. Shaded bands denote 95% confidence intervals based on 2.000 bootstrap replication.

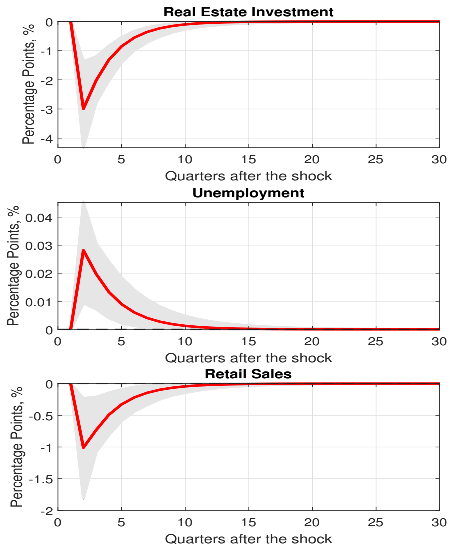

Figure 6: The figure depicts the impulse responses to a one-standard-devation orthogonalized shock to the markup spread. The responses of real estate investment, GDP, unemployment rate, PMI, retail sales and CPI have been accumulated. Shaded bands denote 95% confidence intervals based on 2.000 bootstrap replication.

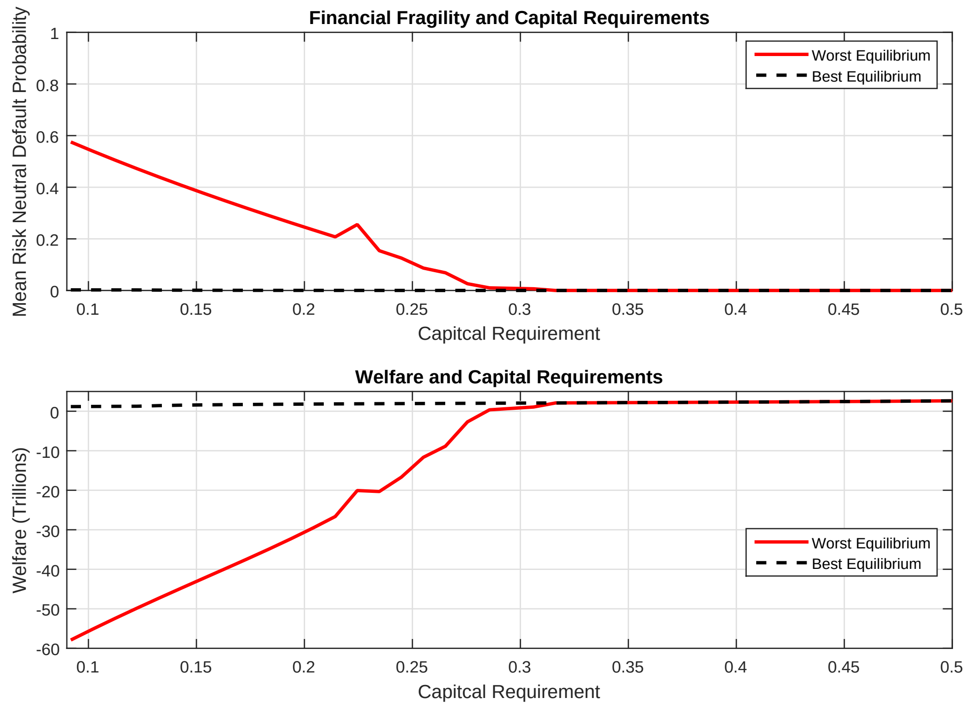

Figure 7: Banking fragility and welfare without capital requirements on WMPs
This figure plots the probability of default (averaged across banks) and welfare in the worst and best equilibrium where banks do not provide capital requirement to WMPs as of Q3/2015. Equilibria are ranked in terms of the probability of default and welfare, respectively. Appendix E gives the definition of welfare relative to their respective values in the observed equilibrium.

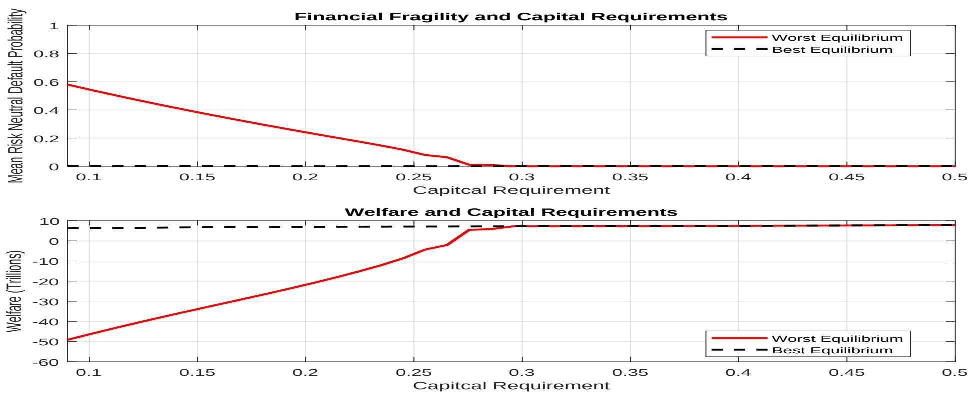

Figure 8: Banking fragility and welfare with capital requirements on WMPs
This figure plots the probability of default (averaged across banks) and welfare in the worst and best equilibrium where banks provide capital requirement on WMPs as of Q3/2015. Equilibria are ranked in terms of the probability of default and welfare, respectively. Appendix E gives the definition of welfare relative to their respective values in the observed equilibrium.