NBER WORKING PAPER SERIES

THE NEXUS OF MONETARY POLICY AND SHADOW BANKING IN CHINA

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Working Paper 23377
http://www.nber.org/papers/w23377

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 2017

This research is supported in part by the National Science Foundation Grant SES 1558486 through the NBER and by the National Natural Science Foundation of China Project Numbers 71473168, 71473169, and 71633003. We thank Dean Corbae, Marty Eichenbaum, Sergio Rebelo, Richard Rogerson, Wei Xiong, and seminar participants at Federal Reserve Bank of Richmond, 2016 NBER Chinese Economy Working Group Meeting, International Monetary Funds, University of Virginia, 2016 Society of Economic Dynamics Meetings, North Carolina State University, Tsinghua University, Bank of Canada, Princeton University, and Federal Reserve Bank of San Francisco for helpful discussions. Karen Zhong provided outstanding research assistance. The current version of this paper draws heavily from the two unpublished manuscripts ``What We Learn from China's Rising Shadow Banking: Exploring the Nexus of Monetary Tightening and Banks' Role in Entrusted Lending'' and ``China Pro-Growth Monetary Policy and Its Asymmetric Transmission.'' The views expressed herein are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of Atlanta, the Federal Reserve System, or the National Bureau of Economic Research.

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NBER Working Paper No. 23377
May 2017, Revised August 2017
JEL No. E02,E5,G11,G12,G28

ABSTRACT

We estimate the quantity-based monetary policy system in China. We argue that China's rising shadow banking was inextricably linked to banks' balance-sheet risk and hampered the effectiveness of monetary policy on the banking system during the 2009-2015 period of monetary policy contractions. By constructing two micro datasets at the individual bank level, we substantiate this argument with three empirical findings: (1) in response to monetary policy tightening, nonstate banks actively engaged in intermediating shadow banking products; (2) these banks, in sharp contrast to state banks, brought shadow banking products onto the balance sheet via risky investments; (3) bank loans and risky investment assets in the banking system respond in opposite directions to monetary policy tightening, which makes monetary policy less effective. We build a theoretical framework to derive the above testable hypotheses and explore implications of the interaction between monetary and regulatory policies.

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I. Introduction

In the aftermath of the unprecedented stimulus of four trillion RMBs injected by the Chinese government to combat the 2008 financial crisis, the People's Bank of China (PBC) pursued contractionary monetary policy by tightening M2 supply between 2009 and 2015. The policy of persistent monetary tightening resulted in a simultaneous fall of bank deposits and bank loans. During this period of monetary contractions, shadow banking rose rapidly. As noted in various reports by the Financial Stability Board and the central government of China, shadow banking products bear more risk than traditional bank loans in China.[1] But there has been little academic research on how China's monetary policy interacted with banking regulations to affect the banking system, how China's banking system reacted to monetary policy tightening by exploiting shadow banking products and by bringing these risky products into its balance sheet, and how the rapid rise of shadow banking hampered the effectiveness of monetary policy on the banking system. Answers to these questions will not only deepen our understanding of how quantity-based monetary policy works in China but also provide a broad perspective on the effectiveness of monetary policy on the banking sector when shadow banking is an important part of the financial system.

This paper aims to answer each of these three questions and consists of four contributions. First, we provide institutional details on China's quantity-based monetary policy, its regulations on commercial banks, and the relationship between shadow banking and traditional banking. One unique feature of monetary policy in China is to use M2 growth as a policy instrument to stabilize macroeconomic fluctuations. In 1999, the PBC officially switched monetary policy from controlling bank credit to controlling M2 growth. In fact, M2 growth is the only instrument used regularly (on a quarterly basis) by the central government.[2] Against this institutional background, we explicitly model the quantity-based monetary policy system and estimate exogenous M2 growth rates that are used for our subsequent empirical analysis.

China's quantity-based monetary policy works through the bank lending channel that is supported by two major regulations specific to China's banking system: the legal ceiling on

[1] In 2009 the G20 countries created the Financial Stability Board from their previous financial stability forum to promote the goal of achieving global financial stability.

[2] Since the beginning of 2016, there have been serious discussions within the central government about gradually moving from quantity-based monetary policy to interest rate policy. One major issue is whether one particular interest rate or a set of interest rates should be used by the PBC as a policy instrument. The issue has not been completely settled.

the ratio of bank loans to bank deposits imposed by the PBC on each commercial bank, which we call the LDR regulation where LDR stands for the loan-to-deposit ratio, and the regulation issued by the Chinese Banking Regulatory Commission (CBRC) prohibiting commercial banks from expanding bank loans to risky industries such as real estate, which we call the *safe-loan regulation*. These two regulations had different consequences on two different groups of banks.

One of the most unique features in China's banking system is an institutional division of state and nonstate commercial banks. State banks are state owned and the remaining commercial banks are nonstate banks. Nonstate banks as a whole represent almost half the size of the entire banking system. In 2015, the share of their assets was 47.38% and the share of their equity was 47.22%. State banks, directly controlled by the central government, adhere to the government's own policy against actively bringing shadow banking products into their balance sheet. This is not true of nonstate banks, however. During the period of 2009-2015, monetary tightening gave nonstate banks a strong incentive to take advantage of the lax regulatory environment by bringing shadow banking products into a special investment category on the asset side of their balance sheet. This special investment category, called account-receivable investment (ARI), is not subject to the safe-loan and LDR regulations.

To understand China's institutional elements within a clear conceptual framework, we develop a simple theory of banks' optimal portfolio problem subject to China's unique safe-loan and LDR regulations. The theoretical model, constituting a second contribution, is made tractable enough for one to obtain intuitive results and testable hypotheses. One key result is that the nonstate bank, in response to an exogenous fall in M2 supply, optimally increases investment in risky assets that are not counted as part of safe bank loans and thus not subject to the safe-loan and LDR regulations. A higher return on such risky investments than the return on bank loans effectively offsets the extra cost of attracting additional deposits when monetary policy tightens unexpectedly. The ability to reallocate bank loans to risky investments on the balance sheet gives nonstate banks an incentive to promote shadow banking so that off-balance-sheet products can be brought onto the balance sheet. These theoretical results deliver the testable hypotheses that nonstate banks, in response to monetary tightening, will first increase their activities in shadow banking and then their investment in risky assets other than bank loans on their balance sheet.

As a third contribution of the paper, we construct two micro datasets at the level of individual banks and use these data to test the aforementioned hypotheses. The first dataset, named the entrusted loan dataset, covers new entrusted loans between nonfinancial firms for the period 2009-2015. The dataset enables us to identify the name of a financial trustee that facilitated each entrusted loan. We use this information in our panel analysis and find that entrusted lending facilitated by nonstate banks increased significantly in response to a contraction of M2 growth, while there is no evidence of an increasing off-balance-sheet activity by state banks. This finding holds even after we control for bank-specific attributes such as LDR, size, liquidity, and profitability.

The second dataset, named the bank asset dataset, covers the two major categories on the asset side of an individual bank's balance sheet: bank loans and ARI excluding central bank bills (ARIX). Bank loans are subject to the safe-loan and LDR regulations and ARIX holdings are not. The principal component of ARIX is in the form of the beneficiary rights of entrusted loans funneled by banks, which we call the entrusted rights; the rest of ARIX consists of risky investments brought onto the balance sheet from other shadow banking products. Based on the bank asset data, our panel analysis finds no evidence of an increase of ARIX holdings in state banks in response to a fall in M2 growth but strong evidence that nonstate banks increased their ARIX holdings significantly. This finding of nonstate banks' risk-taking behavior on the balance sheet, consistent with the previous finding of their behavior off balance sheet, implies that these banks bear the risk of shadow banking products in the form of ARIX on their balance sheet.

A fourth contribution of the paper is to analyze how the rapid rise of shadow banking affects the effectiveness of quantity-based monetary policy on the banking system. The total credit in the banking system combines both bank loans and ARIX holdings. For monetary policy to be effective through the bank lending channel, it is the total credit that matters. We address this issue by both theoretical model simulation and empirical model estimation. After extending our simple theory to a dynamic equilibrium model, we simulate the dynamic model and find that bank loans and risky investments move in opposite directions in response to a fall of money growth so that the total credit in the model (the sum of bank loans and risky investments) rises, not falls, over time. Thus, contractionary monetary policy is ineffective when there is no regulatory restriction on banks' investment in risky assets. We provide a counterfactual exercise to show a different implication on the effectiveness of monetary policy when restrictions on banks' risky investment assets are imposed.

The theoretical prediction is confirmed by our empirical result. Using the bank asset dataset, we estimate a quarterly dynamic panel model. We impose an identifying restriction consistent with the theoretical framework and allow bank loans and ARIX to be determined simultaneously as in the theory. Despite the simultaneity, the econometric model is globally identified. Our estimation indicates that in response to a one-standard-deviation fall of M2 growth, bank loans fall persistently. The estimated dynamics are statistically significant. If one were to use bank loans as the only criterion, monetary policy would be rendered effective. But the estimated response of ARIX rises and more than offsets the decline of bank loans. The rise of ARIX, therefore, makes monetary policy ineffective on the total bank credit.

Although these theoretical and empirical findings are specific to China, their broad policy implications as well as our empirical methodology for analyzing the banking data can be useful for studies on other economies in which the interactions between monetary and regulatory policies and between shadow banking and traditional banking may constitute an important ingredient in assessing the strength of the bank lending channel for monetary policy.

The rest of the paper is organized as follows. Section II reviews the literature relevant to our paper. Section III presents the institutional details of China's banking system and monetary policy. The institutional background serves as a foundation for subsequent theoretical and empirical analyses. Section IV develops a simple theoretical framework and uses its implications to derive the key hypotheses for subsequent empirical testing. Section V estimates China's quantity-based monetary policy system. Section VI discusses the two new datasets we construct and provides robust empirical evidence on banks' risk-taking behavior both off and on the balance sheet. Section VII builds a dynamic equilibrium model to demonstrate how banks' risk-taking behavior on the balance sheet makes monetary policy ineffective. In support of theoretical predictions, a dynamic simultaneous-equation panel model is estimated to show how the rise of ARIX affects the effectiveness of monetary policy on the banking system as a whole. Section VIII concludes the paper.

II. Literature review

The empirical analysis in this paper is based on the testable hypotheses derived from our theoretical framework. This framework is largely inspired by and based on Bianchi and Bigio (2014), who develop a theoretical framework for evaluating the tradeoff faced by the ex-ante homogeneous bank between profiting from more loans on the one hand and incurring the liquidity risk exposure associated with a potential reserve shortfall on the other hand.[3]

[3]In other banking works such as Gertler and Kiyotaki (2010) and Christiano and Ikeda (2013), shocks to the bank equity, coupled with the credit constraint, affect the supply of bank loans, as these shocks

Our theoretical work builds on Bianchi and Bigio (2014) by taking into account the unique Chinese institutional characteristics. In particular, bank loans are subject not to reserve shortfalls but to deposit shortfalls during the period of monetary tightening. The problem facing Chinese banks, especially nonstate banks, is not a reserve requirement, but two other regulations specific to China—the safe-loan and LDR regulations. Another new feature of our theoretical model is that Chinese banks face a tradeoff between the regulation risk associated with bank loans and the default risk associated with shadow banking products brought onto the balance sheet as risky investments.

Our empirical work is influenced by Jiménez, Ongena, Peydró, and Saurina (2014), who utilize millions of transaction-based Spanish loan data to study the effect of interest rate policy on the supply of traditional bank loans to risky firms. While such valuable data are not publicly available in China, we are able to construct the two banking panel datasets at a level of individual banks to study the impact of changes in monetary policy on shadow banking activities, the link between shadow banking loans and risky investment assets on the balance sheet, and the different roles of nonstate versus state banks during the period of monetary policy tightening.

China's unique institutional arrangements play a critical role in the close relationships between monetary policy, traditional bank loans, and risky shadow loans. One unique arrangement is the quantity-based monetary policy system. We estimate this system and obtain a measure of exogenous monetary policy changes that are used for our theoretical and empirical analyses. To our knowledge, our work is the first to estimate the quantity-based monetary policy system and provide a theoretical framework for the bank lending channel of such monetary policy.

There are other works on China's shadow banking, but not on monetary policy, that emphasize different issues. He, Lu, and Ongena (2015) investigate the reaction of stock prices of both issuing and receiving firms to an announcement of a particular shadow banking product: entrusted lending between nonfinancial firms. Allen, Qian, Tu, and Yu (2015) explore which types of lending firms tend to make entrusted loans and their motives in making affiliated and unaffiliated entrusted loans. Qian and Li (2013) provide an analysis of entrusted lending as an alternative way of external funding to bank loans when the borrower and the lender have an affiliated relationship. Hachem and Song (2016) examine the "unintended

exacerbate the incentive problem of banks. Accordingly, the focus of those papers is to explain the effects of policies to recapitalize the banks.

consequences of higher liquidity standards" on credit boom and volatile interest rates in the interbank market. Our work has a different emphasis. We focus on the effectiveness of monetary policy on the total bank credit in the context of rapidly rising shadow banking in China.[4]

III. China's banking system and monetary policy

In this section we provide a narrative of China's institutional background on unique features of China's monetary policy, banking system, and banking regulations, all of which are pertinent to the subsequent theoretical and empirical analysis in the paper. The discussion centers on three issues: (a) how quantity-based monetary policy works in China, (b) facts about rising shadow banking during the 2009-2015 period of monetary policy tightening, and (c) institutional asymmetry between nonstate and state banks in shadow banking and in practices of bringing off-balance-sheet products onto the balance sheet.

III.1. **Quantity-based monetary policy.**

III.1.1. *The main instrument of monetary policy.* Before 1993, the PBC directly controlled bank loans and their allocations; in 1993, it began to publish the index of supply of various monetary aggregates; and in 1996, it began to use money supply as an instrument of monetary policy in conjunction with directly controlling bank loans. In 1998 the PBC officially abandoned direct control of bank loans and explicitly made M2 supply the main policy instrument. Open market operations were subsequently resumed in May of that year.

According to the Chinese law, the PBC must formulate and implement monetary policy under the leadership of the State Council. At the end of each year, M2 growth for the next year is carefully planned by the central government. The PBC adjusts M2 growth on a quarterly basis to influence the credit volume in the banking system. As a result, growth rates of M2 supply and bank loans move closely together (the top left panel of Figure 1). This bank lending channel is supported and reinforced by banking regulations.

III.1.2. *The bank lending channel of monetary policy.* Quantity-based monetary policy affects the banking system in both quantity and quality of bank loans through two separate regulations. One regulation is a 75% ceiling on the ratio of bank loans to bank deposits for

[4]In a recent paper, Brunnermeier, Sockin, and Xiong (Forthcoming) discuss how the interactions between market participants and government policies affect financial development in China.

each commercial bank as a way to manage the quantity of bank loans. The LDR regulation was established in 1994.

To see how monetary policy interacts with the regulatory LDR constraint to influence the quantity of bank lending, consider the following episode. At the end of 2009, the PBC began to tighten M2 supply for fear of an overblown bank credit expansion during the 2008 financial crisis. As M2 growth continued to slow down, banks became more vulnerable to sudden and unexpected deposit withdrawals, which exposed banks to the risk of violating the LDR regulation.[5]

To meet unexpected deposit shortfalls against the LDR ceiling, the bank attracted additional deposits by offering a much higher price than the official deposit rate imposed by the PBC. The government used the phrase "the last-minute rush (*chongshidian* in Chinese)" to refer to the last-minute actions taken by banks to pay high prices to increase deposits in order to recoup deposit shortfalls.[6] Such high prices during the last-minute rush decreased the net return on bank loans and thus banks reduced issuance of new bank loans. As a result, growth in M2 and bank loans declined simultaneously (the top left panel of Figure 1).

In addition to controlling the quantity of bank loans, the PBC used another regulation to control the quality of bank lending. In 2006 the State Council, concerned with potential financial risks associated with bank credit to real-estate and overcapacity industries, issued a notice to accelerate the restructuring process of these industries. The CBRC took concrete steps in 2010 to curtail expansion of bank credit to these industries.[7] These actions were reinforced by the State Council in its 2013 Guidelines. In the introduction, we term this quality-control regulation the *safe-loan regulation.* A combination of quantity-based monetary policy, the LDR regulation, and the safe-loan regulation contributes to China's unique bank lending channel that forms an essential ingredient for building our theoretical framework in Sections IV and VII.1.

III.1.3. *Implementation of monetary policy.* Two major policy tools that the PBC uses to adjust M2 supply are open market operations and changes in the reserve requirement. The

[5]For detailed discussions of such a risk, see the PBC's various "Financial Stability Reports" published in the early 2010s.

[6]See the proclamation "Number 236 Notice on Strengthening Commercial Banks Deposit Stability Management" jointly announced on 12 September 2014 by the CBRC, the Ministry of Finance, and the PBC.

[7]The 2010Q1 monetary policy report stated that "in the next stage, the PBC will tightly control lending to new projects, strictly restrain lending to high energy-consuming, heavily-polluting industries, and industries with excess capacity ..."

system for open market operations was established by the PBC in May 1998. Over the past 20 years, it has matured rapidly to become the main tool for the PBC to manage money supply on a regular basis. Initially the primary dealers in open market operations were commercial banks that could undertake a large number of bond transactions. Over time, primary dealers have been extended to include security companies and other financial institutions. In May 2015, there were a total of 46 primary dealers.

Bond trading in open market operations includes spot trading, repurchase trading, and issuance of central bank bills (short-term bonds issued by the PBC). Repurchase transactions are divided into "repurchase" (repo) and "reverse repurchase" (reverse repo) categories.[8] In 2010 and 2011, for example, the PBC used issuance of both central bank bills and repos to tighten M2 supply: issuance of central bank bills totaled about 4.3 trillion RMBs in 2010 and 1.4 trillion RMBs in 2011, and repo operations totaled about 2.1 trillion RMBs in 2010 and 2.5 trillion RMBs in 2011.

The system for reserve requirements was established in 1984. Changes in the reserve requirement are used by the PBC to influence money supply but irregularly. During the period from 2008Q4 to 2009Q4, for example, the PBC ramped up annual M2 growth from 14.8% to 25.4% to combat the effect of the 2008 financial crisis while the reserve requirement ratio remained unchanged. In 2010, the PBC raised the reserve requirement ratio by 3 percentage points in six successive increases with an increment of 0.5 percentage point each time. But the reserve requirement did not change at all during the period from 2012Q2 to 2014Q4. These examples illustrate the irregular nature of adjusting the reserve requirement as a tool to influence money supply.

Because both policy tools are used by the PBC to control M2 growth in response to economic fundamentals (endogenous monetary policy), an important question is which of the two tools is mainly responsible for carrying out exogenous monetary policy? The answer is provided in Section V, where we find that our estimated series of exogenous M2 growth is uncorrelated with changes in the reserve requirement and thus reflects only the outcome of open market operations. This empirical evidence allows us to build a theoretical framework that abstracts from reserve requirements and focuses on how exogenous changes in money supply affects the banking system.

[8]In January 2013, the PBC launched short-term liquidity operations (SLOs) to supplement regular open market operations each Tuesday and Thursday. SLOs, intended to be used when the banking system experiences a large fluctuation in liquidity, are repurchase agreements and reverse repurchase contracts with a maturity of less than seven days.

III.2. **Facts about the rising shadow banking during the period of monetary policy tightening.** In contrast to slowdowns of growth in both M2 and bank loans since late 2009, shadow banking activities sprang up with a rapid increase of the loan volume in the shadow banking industry (see top row of Figure 1). Shadow banking loan volume is the sum of entrusted lending, trusted lending, and bank acceptances, all of which are off balance sheet. The share of shadow banking loans in the sum of shadow banking loans and bank loans increased steadily to around 20% in 2013-2015 (see bottom left panel of Figure 1). All these loans are outstanding amounts. A similar time series pattern holds true for newly originated loans as well. In particular, new bank loans between 2010 and 2015 declined by an average rate of 7% relative to the 2009 value, but the total new credit as the sum of new bank loans and new shadow banking loans moved in an opposite direction, increasing by an average rate of 4.2% during the same period.

III.2.1. *Entrusted lending.* From 2009 to 2015, entrusted loans became the second largest financing source of loans after traditional bank loans, and there share in entrusted and bank loans combined reached over 10% in 2015 (see bottom right panel of Figure 1).[9] In that year, the amount of outstanding entrusted lending accounted for over 49% of total outstanding shadow banking lending. Given the importance of entrusted lending in the shadow banking industry, we provide a detailed discussion of this particular shadow banking product.

In 1996 the PBC issued "General Rules for Loans" that allowed entrusted lending. In May 2000 the PBC provided formal operational guidelines for commercial banks to be trustees of entrusted lending in its "Notice on Issues Related to Practices of Commercial Banks in Entrusted Lending" (No. 100 Notice). The key requirement in these guidelines was the mandatory participation of a financial institution acting as a trustee to facilitate a loan transaction between two nonfinancial firms. This regulation required the participating financial institution to verify that all lending practices met various legal forms and requirements. An entrusted lending transaction between nonfinancial firms with a commercial bank or a nonbank financial company acting as a trustee is summarized as

Lender (Firm A) ⟶ Trustee ⟶ Borrower (firm B)

On paper, a trustee is a middleman in the transaction of an entrusted loan. If the trustee is a commercial bank, it is commonly assumed that "the bank earns a fee for its service, but

[9] As discussed in Section III.2.2, the share of entrusted loans intermediated by nonstate banks would be much higher.

does not bear the risk of the investment" (Allen, Qian, Tu, and Yu, 2015). In Sections III.2.2 and VI.4, however, we show that the risk was brought onto the balance sheet: entrusted loans were first facilitated by banks and then their beneficiary rights (entrusted rights) were in turn purchased by banks as risky investments on the asset side of banks' balance sheet.[10]

Entrusted lending activity, as well as other shadow banking activities, did not really blossom until after 2009, a period when monetary policy tightened. One important piece of direct evidence from our entrusted loan data discussed in Section VI.1.2 reveals that most entrusted loans ended up in real-estate and overcapacity industries. These industries were classified by the Ministry of Industry and Information Technology as risky industries. Table 1 reports both maturities and rates of bank loans and entrusted loans. The average maturity of entrusted loans is shorter than that of bank loans, but the interest rate is higher. These facts confirm the risky nature of entrusted loans relative to bank loans.

III.2.2. *The asset side of banks' balance sheet.* We now describe how banks brought off-balance-sheet products into their balance sheet. ARIX holdings on the asset side of banks' balance sheet are not counted as part of bank loans; they conceal risky investment assets brought onto the balance sheet from shadow banking products. One principal component is entrusted rights, which are the beneficiary rights of entrusted lending facilitated by banks off balance sheet. Other components of the ARI category include trusted rights (associated with trusted loans) and various wealth management products (WMPs). Because most of ARIX is risky investments brought onto the balance sheet from shadow banking products, we use the two terms—ARIX holdings and risky assets—interchangeably.

As frequently discussed in the previous sections, one distinctive feature of China's banking system is a division of state and nonstate commercial banks. There are five state banks controlled and protected directly by the central government: the Industrial and Commercial Bank of China, the Bank of China, the Construction Bank of China, the Agricultural Bank of China, and the Bank of Communications.[11] The rest of commercial banks are nonstate banks, including China CITIC Bank, China Everbright Bank, China Merchants Bank, Shanghai Pudong Development Bank, the Industrial Bank of China, and the Bank of Beijing.

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[10]For other arguments that banks bore the risk of entrusted loans, see various Financial Stability Reports published by the PBC.

[11]The Bank of Communications, initially listed in the Hong Kong Stock Exchange, has officially become the fifth largest state-owned bank since May 16, 2006.

During the process of constructing our bank asset dataset (SectionVI.1.2), we discover that the shadowy nature of ARIX has become clearer in recent years as the CBRC regulations have been increasingly enforced over time. For example, commercial banks were not required to report the detailed products within ARIX until recently. During 2014-2015, the average share of entrusted rights in ARIX was 78.04% for nonstate banks and 43.64% for state banks. For nonstate banks, therefore, a majority of ARIX holdings were entrusted rights and thus bore the risk of entrusted leanding.

The contrast of nonstate banks to state banks in their off-balance-sheet entrusted lending activities is manifested by the findings in Table 2, which reports the correlations of entrusted lending channeled by banks off balance sheet and ARIX on the balance sheet. During the 2009-2015 period of monetary policy tightening, the correlation between new entrusted loans and changes in ARIX is significantly positive for nonstate banks, while the same correlation is statistically insignificant for state banks. A similar result holds for the correlation between entrusted lending and $\frac{\text{ARIX}}{\text{ARIX}+B}$ where B stands for bank loans. These facts suggest that nonstate banks had a penchant for bringing shadow banking products into their balance sheet as investment assets in the form of ARIX.

The correlation evidence presented in Table 2 is further substantiated by the share of ARIX in the sum of ARIX and bank loans on the balance sheet of state banks. Figure 2 shows that the share for state banks was unimportant (below 3% for most of the period 2009-2010). By contrast, the share of ARIX for nonstate banks was substantial, increasing rapidly during the period 2009-2015 until it reached almost 30% in 2015.

III.3. **State versus nonstate commercial banks.** The most conspicuous fact from our entrusted loan data is that nonstate banks play a dominant role in channeling entrusted loans between nonfinancial firms (Appendix A). In this section, we present a list of key regulatory requirements and analyze which one is likely to contribute to the difference between state and nonstate banks in their roles of promoting shadow banking activities.

III.3.1. *The usual suspects.* There were three major regulatory requirements of commercial banks: capital requirement, reserve requirement, and LDR requirement. We provide evidence on whether there was a notable difference between state and nonstate banks in meeting each of the three requirements for the 2009-2015 period.

First, both state and nonstate banks met the capital requirement by a comfortable margin as shown in Table 3. One can see from the table that the difference in the capital adequacy ratio between state and nonstate banks is statistically insignificant and economically inconsequential because both ratios are far above the capital requirement ratio of 8%.

Second, nonstate banks had more cushion than state banks in meeting the reserve requirement with a considerably higher *excess* reserve ratio than state banks. The numbers reported in Table 3 are based on the panel data that are not available in electronic format. We read the annual reports of 16 publicly listed commercial bank through pdf files downloaded from WIND (a pdf file for each bank has over 100 pages) and find the values for excess reserves and total deposits in the chapter called "Notes of Financial Statement." We compute the excess reserve ratio of each bank for every year, take a weighted average of these ratios for all the banks within each group (the state group and the nonstate group) for each year, and then average these ratios across years. As clearly shown in Table 3, nonstate banks were more cautious than state banks in managing their reserves to meet the reserve requirement.

Third, both state and nonstate banks met the LDR requirement of 75% on average during the period 2009-2015 and the difference in the LDR between state and nonstate banks is statistically insignificant.[12] During 2009-2015, the LDR of state banks increased steadily over time. By 2015, their LDR reached 74.22%, almost indifferent from 73.65% of nonstate banks. Therefore, the issue for banks is not the LDR ceiling per se, but rather the risk of hitting the ceiling due to unexpected deposit shortfalls. Such a risk is another important ingredient in our theory developed in Sections IV and VII.1.

In summary, both state and nonstate banks met the three major policy requirements during 2009-2015 and in this respect there was no difference between them. It is therefore not any of these regulatory requirements that helps explain the different roles played by state and nonstate banks in promoting shadow banking products. Our empirical findings in later sections of the paper indicate that nonstate banks, not state banks, play a dominant role in shadow banking activities *after* controlling for a host of bank-specific attributes such as LDR, size, liquidity, and profitability. In the next section we argue that the difference between state and nonstate banks is mainly *institutional* in the sense that the central government's direct control makes state banks behave differently than nonstate banks.

[12]Since only the PBC (not central banks in other countries) requires a bank to report the LDR and since Bankscope collects variables that are common across countries, a direct measure of the LDR is not provided by Bankscope. We construct this measure as the ratio of "gross loans" to "total customer deposits." For a listed bank, we verify this measure with the reported LDR published by the bank's own annual report and they match. The published ratio must comply with the PBC's requirement by law.

III.3.2. *The institutional asymmetry.* State banks, controlled directly by the central government, adhere to the government's regulations for promoting the healthy banking system rather than undermine the soundness of the banking system by circumventing the regulations. In 2010, the PBC and the CBRC issued a joint notice to reinforce the 2006 announcement made by the State Council that banks shall not partake in risky investments themselves to maintain "the soundness of the banking system." State banks did not circumvent the safe-loan regulation imposed by their own government and therefore did not bring shadow banking products into their balance sheet in ways inconsistent with the behavior of safe bank loans as the evidence in Figure 2 shows.

The institutional structure for nonstate banks is different. The government does not have direct control of them. Despite the regulations intended for limiting the risk on the balance sheet, nonstate banks had largely benefitted from China's lax regulatory system for shadow banking until the end of 2015.[13] On November 12, 2012, for example, the PBC governor Zhou Xiaochuan told a news conference that "Like many countries, China has shadow banking. But the scale and problem of China's shadow banking are much smaller compared with the its counterpart for the developed economies that was exposed during the latest financial crisis."[14] Indeed, before 2015 the government viewed the development of shadow banking as a new way to diversify financial services. The PBC's 2013Q2 Monetary Policy Report (MPR) stated that rapid growth of entrusted and trusted lending was viewed positively by the PBC because "the financing structure continues to diversify." Therefore, a combination of contractionary monetary policy and the lax regulatory system allowed nonstate banks to take advantage of regulatory arbitrage by increasing ARIX that was not subject to the LDR and safe-loan regulations.

IV. Simple theoretical framework

We construct, in this section, a one-period theoretical framework to illustrate key theoretical predictions and gain economic intuition behind these predictions.[15] These predictions

[13]Since late 2015, the government has gradually enforced various stricter guidelines to restrict fast growing off-balance-sheet products that eventually showed up on the ARIX category of nonstate banks. At the beginning of 2016, for example, the government incorporated the so-called Macro Prudential Assessment System, which requires that the "broad credit" growth rate should not deviate from the targeted growth rate of M2 by more than 22%.

[14]Reported in the Chinese edition of 15 January 2014 Wall Street Journal.

[15]An extension to a complicated dynamic model is discussed in Section VII.1.

are used to set up four main hypotheses for subsequent empirical testing of the effects of monetary policy on shadow banking products as well as risky assets on banks' balance sheet.

IV.1. **Monetary policy.** Monetary policy consists of two components: endogenous growth of money supply in response to economic fundamentals and an exogenous change in money growth. To determine the extent to which monetary policy causes a rapid rise of shadow banking in China, it is necessary to extract from the data a series of changes in exogenous money growth (i.e., unexpected monetary policy shocks) as in the empirical macroeconomic literature (Christiano, Eichenbaum, and Evans, 1996; Leeper, Sims, and Zha, 1996; Christiano, Eichenbaum, and Evans, 1999, 2005; Sims and Zha, 2006). In Section V, we estimate both endogenous and exogenous components of China's quantity-based monetary policy and show that exogenous shifts in money supply are carried out through open market operations, not through changes in the reserve requirement. Denote exogenous money growth by $\varepsilon_{m,t} = \Delta \log M_t^{\text{exog}}$, where M_t^{exog} represents exogenous money supply. Changes in $\varepsilon_{m,t}$, therefore, affect bank deposits directly through open market operations.[16]

The economy is populated by a continuum of banks whose identity is indexed by $j \in [0, 1]$. All banks live for only one period and are subject to idiosyncratic withdrawal shocks to deposits with a fraction ω_t of deposits withdrawn in the economy. We follow Bianchi and Bigio (2014) in modeling the shock process of ω_t. Specifically, the idiosyncratic shock ω_t is continuously distributed with the probability density function $\mathfrak{f}(\omega_t)$ that is uniformly distributed with the support of $[\mu(\varepsilon_{m,t}), 1]$, where $\mu(\varepsilon_{m,t})$ is a function of $\varepsilon_{m,t}$. Bianchi and Bigio (2014) provide an informative discussion of why the support of the idiosyncratic withdrawal shock should lie in $[-\infty, 1]$. In our framework, the lower bound is influenced by monetary policy and we derive the functional form of $\mu(\cdot)$.

Denote the deposits of bank j at the beginning of period t by $D_t(j)$. The deposits of bank j *after* the realization of an idiosyncratic withdrawal shock to deposits, therefore, is $D_t(j)(1-\omega_t)$. To understand the mechanism of how changes in monetary policy cause banks to adjust their balance-sheet portfolio, one should note that $\varepsilon_{m,t}$ has direct impact on

[16]For example, when the PBC tightens money supply by selling government bonds to a primary dealer, the dealer's deposits at its clearing bank typically fall.

aggregate deposits in the banking system.[17] That is,

$$\begin{aligned}
\varepsilon_{m,t} &= \Delta \log M_t^{\text{exog}} \\
&= \log \int_0^1 \int_{\mu(\varepsilon_{m,t})}^1 D_t\left(j\right)\left(1-\omega_t\right) \mathfrak{f}(\omega_t)\, d\omega_t\, dj - \log \int_0^1 D_t\left(j\right) dj \\
&= \log \left[\int_0^1 D_t\left(j\right) dj \int_{\mu(\varepsilon_{m,t})}^1 \left(1-\omega_t\right) \mathfrak{f}_t(\omega_t)\, d\omega_t\right] - \log \int_0^1 D_t\left(j\right) dj \\
&= \log\left(1 - E\left[\omega_t \mid \mu\left(\varepsilon_{m,t}\right)\right]\right) \\
&\simeq -(1+\mu\left(\varepsilon_{m,t}\right))/2,
\end{aligned}$$

which leads to

$$\mu\left(\varepsilon_{m,t}\right) \simeq -(2\varepsilon_{m,t}+1).$$

The above approximation is accurate as long as the range of variations for $\varepsilon_{m,t}$ is small. The estimated results reported in Section V indicate that annual changes of $\varepsilon_{m,t}$ are between -0.05 and 0.05. Because the variation of $\varepsilon_{m,t}$ is very small in practice, we use this approximation for the rest of our analysis. To keep the notation simple and transparent, we remove the subscripts t and j in the following discussion of our model. The subscript j can be removed without confusion because banks are all symmetric and it suffices to analyze the representative bank's behavior.

IV.2. **The bank's balance-sheet decision.** The representative bank has three types of assets to choose: (i) cash represented by C, (ii) traditional (safe) bank loans, B, subject to the safe-loan regulation as well as LDR regulation risks resulted from unexpected deposit shortfalls, and (iii) risky investment assets, I^r, subject to default risks of these assets but not to regulation risks as I_t^r is not regarded as part of bank loans. Given the deposits, the bank makes an optimal portfolio choice between safe loans and risky assets. Within the period, the banking activity involves two stages as in Bianchi and Bigio (2014): lending and balancing stages. At the end of the period, the bank sells its assets, pays off its liabilities, and consumes its proceeds. This one-period simplification allows us to obtain the intuition behind the bank's optimal portfolio choice. In the dynamic model developed in Section VII.1, we extend the simple model by allowing banks to choose equity and dividend in addition to portfolio choice.

[17]We thank a referee for bringing out this important point to us. As Anna J. Schwartz succinctly stated, absent movements of currency in circulation, "deposits and M2 move together almost by definition" (http://www.econlib.org/library/Enc/MoneySupply.html).

IV.2.1. *Lending stage.* At the lending stage, the bank decides the amount of deposits to demand and how to allocate the three types of assets. Bank loans (B) purchased at a discount price $0 < q < 1$ are subject to the safe-loan and LDR regulations; risky investment assets (I^r) purchased at a discount price $0 < q^r < 1$ have a default probability p^r. The interest rate on deposits is R^D.

In each period, the bank's balance-sheet constraint is

$$\underbrace{D/R^D}_{\text{liabilities}} = \underbrace{C}_{\text{cash}} + \underbrace{q^r I^r + qB}_{\text{assets}} \tag{1}$$

and the standard credit constraint is[18]

$$D/R^D \leq \kappa. \tag{2}$$

IV.2.2. *Balancing stage.* In the balancing stage, two random events occur: an idiosyncratic withdrawal shock to deposits and a default shock to risky assets. When the first random event occurs, the amount of bank loans is constrained by the LDR regulation as

$$qB \leq \theta \frac{(1-\omega)\, D}{R^D},$$

where θ is the LDR ceiling set by the government. Denote

$$x = qB - \theta \frac{(1-\omega)\, D}{R^D} \tag{3}$$

and

$$\chi(x) = \begin{cases} r^b x & \text{if } x \geq 0 \\ 0 & \text{if } x < 0 \end{cases},$$

where $r^b > 0$ is an extra cost of acquiring additional deposits x.

When the default on I^r does not occur (the no-default state), the bank's liability is reduced at the end of the period with more dividend. If I^r is defaulted (the default state), the bank's net profit and therefore dividend are reduced. We use the stochastic variable ε to denote this default contingency:

$$\varepsilon = \begin{cases} 1 & \text{with probability } 1 - p^r \text{ (the no-default state)} \\ 0 & \text{with probability } p^r \text{ (the default state)} \end{cases}.$$

[18]The credit constraint is generalized to a leverage ratio constraint in our dynamic model. Basel III guidelines explicitly state that a leverage ratio serves “as a backstop to the risk-based capital requirement.”

Accordingly, the dividend at the end of the period is

$$\mathrm{DIV} = \underbrace{C - \omega D}_{\text{cash}} + \underbrace{B + \varepsilon R^D I^r}_{\text{assets}} - \underbrace{[(1-\omega)D + \chi(x)]}_{\text{liabilities}}. \tag{4}$$

IV.3. **The bank's optimizing problem.** The bank takes $\mu(\varepsilon_m), r^b, q, q^r, R^D$ as given when solving its problem. The constraint

$$C \geq 0 \tag{5}$$

is used to reflect the liquidity requirement imposed by the government.[19] Combining lending and balancing stages leads to the bank's overall optimization problem as choosing (D, C, B, I^r) to solve

$$\max E_{\omega,\varepsilon}\left[U(\mathrm{DIV}) \mid \varepsilon_m\right] \tag{6}$$

subject to (1), (2), (3), (4), and (5), where $E_{\omega,\varepsilon}$ is the mathematical expectation with respect to the (ω, ε) measure. The utility function is assumed to be

$$U(\mathrm{DIV}) = \frac{\mathrm{DIV}^{1-\gamma}}{1-\gamma}. \tag{7}$$

Substituting out (6) by (3), (4), and (7), we rewrite the bank's problem as

$$\max E_{\omega,\varepsilon}\left[\frac{\left[C + B + \varepsilon R^D I^r - D - \chi\left(qB - \theta(1-\omega)D/R^D\right)\right]^{1-\gamma}}{1-\gamma}\right] \tag{8}$$

subject to (1), (2), and (5).

Define the two asset returns as

$$R^I = \frac{\varepsilon R^D}{q^r},\ R^B = \frac{1}{q},$$

and the equity return after dividend payout as

$$R^E\left(\omega, \varepsilon; \varepsilon'_m, \varepsilon_m\right) = w_c + R^I w_i + R^B w_b - R^D w_d - R^x,$$

where

$$w_c = C,\ w_i = q^r I^r,\ w_b = B,\ w_d = D/R^D,\ R^x = \chi\left(w_b - \theta(1-\omega)w_d\right).$$

The optimization problem (8) is for the bank to choose $\{w_c, w_i, w_b, w_d\}$ and maximize

$$E_{\omega,\varepsilon}\frac{\left[w_c + R^I w_i + R^B w_b - R^D w_d - R^x\right]^{1-\gamma}}{1-\gamma}$$

[19] In our dynamic model, the liquidity requirement is generalized to requiring C to be equal to or greater than a fraction of bank assets.

subject to

$$0 = w_c + w_i + w_b - w_d,$$

$$w_d \leq \kappa,\ w_c \geq 0.$$

The solution to this optimality problem leads to the no-arbitrage asset pricing equation between safe loans and risky assets as

$$E_\varepsilon(R^I) - \underbrace{\left[-\frac{\mathrm{Cov}_\varepsilon\left(R^I, E_\omega(R^E)^{-\gamma}\right)}{E_\varepsilon\left[E_\omega(R^E)^{-\gamma}\right]} \right]}_{\text{default risk premium}} = R^B - \underbrace{E_\omega\left[R_b^x(w_b, w_d; \omega)\right]}_{\text{expected regulation cost}} - \underbrace{\frac{\mathrm{Cov}_\omega\left(R_b^x, E_\varepsilon(R^E)^{-\gamma}\right)}{E_\omega\left[E_\varepsilon(R^E)^{-\gamma}\right]}}_{\text{regulation risk premium}}, \quad (9)$$

where $R_b^x(w_b, w_d; \omega)$ is the partial derivative of $R^x(w_b, w_d; \omega)$ with respect to B:

$$R_b^x(w_b, w_d; \omega) = \frac{\partial R^x(w_b, w_d; \omega)}{\partial w_b} = \begin{cases} r_b \text{ if } \omega > 1 - w_b/(w_d\,\theta) \\ 0 \text{ otherwise} \end{cases}.$$

It can be seen that the expected regulation cost is always positive. The term reflects the expected marginal cost of subjecting the lending amount B to the LDR regulation and captures an extra cost of recovering deposit shortfalls. To understand how monetary tightening affects the bank's decisions on risky investment assets, consider the case in which the bank is risk neutral ($\gamma = 0$). It can be shown (Appendix B) that as monetary policy tightens (i.e. ε_m decreases), the bank's optimal decision on risky assets is such that $\frac{\partial I^r}{\partial \varepsilon_m} < 0$.

IV.4. **Theoretical predictions.** Intuitively, the above result holds because banks can avoid regulatory costs by investing in risky assets that are not on the books of the safe-loan and LDR regulations and that have a higher return than bank loans. Clearly, this result applies to nonstate banks only. Because state banks, owned and controlled directly by the government, do not operate against the government's own regulatory policies by manipulating I^r in response to monetary tightening, the derivative $\frac{\partial I^r}{\partial \varepsilon_m}$ should be zero. Based on these results, we postulate four testable hypotheses:

Hypothesis I: Entrusted lending intermediated by state banks does not increase in response to monetary policy tightening.

Hypothesis II: Entrusted lending intermediated by nonstate banks increases in response to monetary policy tightening.

Hypothesis III: Risky assets on state banks' balance sheet do not increase in response to monetary policy tightening.

Hypothesis IV: Risky assets on nonstate banks' balance sheet increase in response to monetary policy tightening.

Hypotheses I and II must be a first set of hypotheses to test because risky investment assets would not have shown up in banks' balance sheet had banks not engaged in off-balance-sheet activities in the first place. The reason that nonstate banks brought shadow banking products onto the balance sheet as risky investments, according to our theory, is to circumvent the two strict regulations. Hypotheses III and IV are important because the way in which risky investment assets respond to monetary policy tightening not only reflects the risk-taking behavior of nonstate banks through their balance-sheet activities but also influences the effectiveness of monetary policy on the banking system (a topic to be discussed in Section VII).

V. Estimating the quantity-based monetary policy system

To test these hypotheses implied by our theory, our first task is to model explicitly the quantity-based monetary policy system of China and obtain estimation of exogenous M2 growth rates to be used for our subsequent empirical analysis.

V.1. **Estimating the monetary policy rule.** The original interest rule of Taylor (1993), called the Taylor rule, is inapplicable to the Chinese economy for two reasons. First, China is a transitional economy and its transitional path is characterized by unbalanced growth with the rising share of investment in GDP since the late 1990s (Chang, Chen, Waggoner, and Zha, 2016). For such an economy, it is practically difficult, if not impossible, to define what constitutes potential output or trend growth. Second, financial markets in China have yet to be fully developed and interest rates have not been a main instrument of monetary policy.[20] The main instrument of China's monetary policy has been to control M2 growth in support of rapid economic growth.

The PBC's Monetary Policy Committee (MPC) is an integral part of the policymaking body.[21] At the end of each year, the central government outlines overall M2 growth consistent

[20]See Appendix D and Taylor (2000) for further discussions.

[21]The MPC is composed of the PBC Governor, two PBC Deputy Governors, a Deputy Secretary-General of the State Council, a Deputy Minister of the NDRC, a Deputy Finance Minister, the Administrator of the State Administration of Foreign Exchange, the Chairman of China Banking Regulatory Commission, the Chairman of China Securities Regulatory Commission, the Chairman of China Insurance Regulatory Commission, the Commissioner of National Bureau of Statistics (NBS), the President of the China Association of Banks, and experts from academia (three academic experts in the current MPC).

with targeted GDP growth for the next year. Within each year, the MPC meets at the end of each quarter t (or the beginning of the next quarter) to decide on a policy action for the next quarter (i.e., quarterly M2 growth $g_{m,t+1} = \Delta M_{t+1}$) in response to CPI inflation $\pi_t = \Delta P_t$ and to whether GDP growth ($g_{x,t} = x_t - x_{t-1}$) in the current quarter meets the GDP growth target ($g^*_{x,t}$).[22] As discussed in Appendix C, the GDP growth target set by the State Council serves as a lower bound for monetary policy. When actual GDP growth in each quarter is above the target, therefore, M2 growth increases to accommodate such output growth as long as inflation is not a serious threat (see various MPC's quarterly monetary policy reports).

The above description of China's monetary policy can be formalized as

$$g_{m,t} = \gamma_0 + \gamma_m g_{m,t-1} + \gamma_\pi (\pi_{t-1} - \pi^*) + \gamma_{x,t} \left(g_{x,t-1} - g^*_{x,t-1} \right) + \varepsilon_{m,t}, \tag{10}$$

where $\varepsilon_{m,t}$ is a serially independent random shock that has a normal distribution with mean zero and time-varying standard deviation $\sigma_{m,t}$. Every quarter the PBC adjusts M2 growth in response to inflation and output growth in the previous quarter, a practice consistent with the PBC's decision making process. The inflation coefficient γ_π is expected to be negative.[23] Since GDP target serves as a lower bound, we allow the output coefficient to be time-varying with the form

$$\gamma_{x,t} = \begin{cases} \gamma_{x,a} & \text{if } g_{x,t-1} - g^*_{x,t-1} \geq 0 \\ \gamma_{x,b} & \text{if } g_{x,t-1} - g^*_{x,t-1} < 0 \end{cases},$$

where the subscript "a" stands for "above the target" and "b" for "below the target". These coefficients represent two states for policy response to output growth: the normal state when actual GDP growth meets the target as a lower bound and the shortfall state when actual GDP growth falls short of the government's target. During the period when GDP growth is above the target, we expect the coefficient $\gamma_{x,a}$ to be positive. On the other hand, when actual GDP growth is below its target, we expect the coefficient $\gamma_{x,b}$ to be negative. This asymmetric response reflects the central government's determination in making economic

[22] All the three variables, M_t, P_t, and x_t, are expressed in natural log.

[23] Discussions in the MPRs indicate that the annual CPI inflation target is around $3\% - 4\%$. We set π^* at 3.5% (an annualized quarterly rate).

growth an overriding priority.[24] Accordingly, the heteroskedasticity is specified as

$$\sigma_{m,t} = \begin{cases} \sigma_{m,a} & \text{if } g_{x,t-1} - g^*_{x,t-1} \geq 0 \\ \sigma_{m,b} & \text{if } g_{x,t-1} - g^*_{x,t-1} < 0 \end{cases} .$$

The sample period for estimation is from 2000Q1 to 2016Q2. This is a period in which the PBC has made M2 growth an explicit policy instrument. The endogenous-switching rule is estimated with the maximum likelihood approach of Hamilton (1994). Table 4 reports the results, which show that all the estimates are significant statistically with the p-value much than 1%. The persistence coefficient for M2 growth is estimated to be 0.39%, implying that monetary policy is somewhat inertial. When GDP growth is above the target, annualized M2 growth is estimated to rise by 0.72% (0.18×4) in support of a 1% annualized GDP growth rate above its target. When GDP growth falls short of the target, the estimate of $\gamma_{x,b}$ shows that annualized M2 growth rises by 5.20% (1.30×4) in response to a 1% annualized GDP growth short of its target. Thus, the negative sign of $\gamma_{x,b}$ and its estimated magnitude reveal that monetary policy takes an unusually aggressive response to stem a shortfall in meeting the GDP growth target. The asymmetry in China's monetary policy is also reflected in the volatility of its policy shocks (0.10 vs 0.005). Our estimate of the inflation coefficient in the monetary policy rule, which is negative and highly significant, indicates that annualized M2 growth contracts 1.6% ($0.40\% \times 4$) in response to a 1% increase of annual inflation.

We test the endogenous-switching policy rule, represented by equation (10), against other alternatives. One alternative is the same rule without any of the time-varying features (i.e., $\gamma_{x,t} = \gamma_x$ and $\sigma_{x,t} = \sigma_x$). The log maximum likelihood value for the constant-parameter rule is 192.42. We then allow $\gamma_{x,t}$ to depend on the two different states of the economy (the normal and shortfall states). The log maximum likelihood value for this rule is 198.49. The log maximum likelihood value for our endogenous-switching rule (i.e., allowing $\sigma_{m,t}$ to be time varying in addition to $\gamma_{x,t}$) is 203.78. The likelihood ratio test for a comparison between the rule with time-varying $\gamma_{x,t}$ only and the constant-parameter rule rejects the constant-parameter rule at a 0.05% level of statistical significance, implying that the data strongly favor the time-varying parameter $\gamma_{x,t}$. The likelihood ratio test for a comparison between the rule with both time-varying $\gamma_{x,t}$ and $\sigma_{m,t}$ and the rule with only time-varying $\gamma_{x,t}$ rejects the latter rule at a 0.11% level of statistical significance, implying that the data

[24]See Kahneman and Tversky (1979) and Chen, Xu, and Zha (2017) for theoretical justifications.

strongly favor additional time-variation in volatility.[25] These econometric tests rationalize the statistical results of high significance reported in Table 4.

V.2. **Exogenous M2 growth rates.** Figure 3 reports the decomposition of M2 growth into the endogenous component and the exogenous component according to the estimated monetary policy rule. All the series in the figure are expressed in annual changes. Endogenous monetary policy tracks the series of actual M2 growth rates very closely (see top chart of Figure 3). This suggests that a large fraction of the variation in M2 growth can be attributed to the systematic reaction of policy authorities to the state of the economy, which is what one would expect of endogenous monetary policy.

The series of exogenous M2 growth is the gap between actual and endogenous M2 growth rates as displayed in the bottom chart of Figure 3. Other policy changes such as those in the reserve requirement often aim at stabilizing inflation and aggregate output and should be encompassed by endogenous monetary policy. To test this hypothesis, we regress the series of endogenous M2 growth rates on changes in the reserve requirement ratio (contemporaneous and lagged changes) and find the statistical significance of the regression coefficients exceedingly high. On the other hand, when we regress the estimated exogenous M2 growth series on the same variables, we find the regression coefficients statistically insignificant (See Table 5 for details). These results indicate that the estimated series of exogenous M2 growth is orthogonal to changes in the reserve requirement and thus reflects only the outcome of open market operations. After controlling for endogeneity of monetary policy, the exogenous series allows us to analyze how contractionary monetary policy contributed to the rise of shadow banking products as well as the rise of risky assets in the form of ARIX on banks' balance sheet in 2009-2015.

VI. Impacts of monetary policy on activities off and on the balance sheet: an empirical analysis

In this section we first discuss the construction of the two datasets at a level of individual banks and then use these data to test the four hypotheses laid out in Section IV.4.

VI.1. **Data construction.** While the aggregate time series on shadow banking reported in Figure 1 are informative, the rapid growth of shadow banking per se would not have been an issue to the banking system had the banking sector not been actively involved in the

[25] The two tests are supported by both the Bayesian information criterion (BIC) and the Akaike information criterion (AIC).

first place. The real issue therefore is to ascertain whether the role nonstate banks played in intermediating shadow banking loans was significantly different from the role of state banks or nonbank trustees, which is critical for identifying the risk-taking behavior of nonstate banks. To address this issue, it is imperative that one go beyond the aggregate time series and gather micro information on shadow banking activities facilitated by individual banks as well as on the corresponding banks' balance-sheet activities.

VI.1.1. *Off balance sheet: a quarterly panel entrusted loan dataset.* The entrusted loan dataset constructed for this paper maps each loan transaction between two nonfinancial firms to a particular trustee. During the long construction process, we manually collect all the pdf files of raw entrusted-loan announcements made by listed firms in China. Listed firms are those that issue A-share stocks to the public and thus are listed in China's stock exchanges. Chinese law requires listed lending firms to make public announcements about each entrusted-loan transaction. Listed borrowing firms could choose to make announcements but are not required by law. China Securities Law Article 67, published in 2005, also requires all listed firms to announce major events which may have influenced their stock prices.[26] According to Article 2 of the CSRC's "Rules for Information Disclosure by Companies Offering Securities to the Public" published in 2011, listed firms have responsibility to disclose all entrusted-loan transactions. Moreover, according to two disclosure memoranda provided by the Shenzhen Stock Exchange in 2011, a listed company must disclose information of entrusted loans as long as its subsidiary firm is a lender of entrusted loans, even if the company itself is not a direct lender.

A raw announcement made for each transaction concerns either a newly originated loan or a repaid loan. Information in each raw announcement contains the names of both lender and borrower, the amount transacted, and the trustee name.[27] For each year between 2010 and 2013, we verify the number of collected *raw* announcements against the number published by the PBC's 2011-2014 Financial Stability Reports (the number is always published in the next-year report). Figure 4 plots the number of announcements. One can see from the figure that the discrepancy between our data and the numbers published by the Financial Stability

[26]The Chinese Securities Regulatory Commission (CSRC) publishes such documents at `http://www.sac.net.cn/flgz/flfg/201501/t20150107_115050.html`.

[27]Allen, Qian, Tu, and Yu (2015) use the annual reports of listed nonfinancial companies to gather information about entrusted lending. Most of the trustee information, however, is missing in the annual reports.

Reports is of little importance. Although both our data source and the PBC's data source are from WIND, at the time when the PBC reported the number of announcements, some companies had not yet made announcements until a later year. Some of these delayed announcements are included in our data collection, which explains part of this inconsequential discrepancy.

We clean up raw announcements by removing announcements of repayment of entrusted loans and duplicated announcements and by correcting inaccurate reports of loan amounts (see Appendix A for details). We call cleaned-up announcements "announcements" to be distinguished from "raw announcements." For the period from 2009 to 2015, the total number of announcements is 1379. Prior to the year 2009, there are only a handful of data observations (announcements). From the announcements of entrused loans, we construct a quarterly panel dataset that contains the total loan volume, the average loan amount, and the number of loans facilitated by each financial trustee. We have 80 individual banks and 45 nonbank trustees, a total of 125 trustees. These 80 individual banks include the five state banks; the rest are all nonstate banks.

VI.1.2. *On balance sheet: a quarterly panel bank asset dataset.* The second dataset we manually construct is a quarterly panel dataset of bank loans and ARIX holdings on the balance sheets of 16 publicly listed banks. There are a total of 19 banks listed in the Hongkong, Shenzhen, or Shanghai Exchange, but only 16 of them have information about ARIX. These 16 publicly listed banks include the five state banks; the rest are all nonstate banks. We read through annual reports of these 16 publicly listed banks, collected the data on bank loans and ARI, and constructed the data on ARIX by excluding central bank bills.

The annual reports are downloaded from WIND. Our quarterly panel of entrusted loan data are bridged to the balance-sheet information from WIND. When a particular entrusted loan transaction is announced, we first identify the name of the bank and then link the transaction to the WIND information of this bank. This allows us to compute the correlation of entrusted lending off balance sheet and ARIX on the balance sheet as discussed in Section III.2.2. Bankscope provides another data source for obtaining financial information such as LDR, size, capital, liquidity, and profitability of a particular bank, but Bankscope does not have information on ARIX or bank excess reserves, which we collected from banks' annual reports.

Equipped with these two panel datasets, we are ready to estimate panel regressions on the role of monetary policy in both shadow banking loans and risky assets on the balance sheet.

For the entrusted loan dataset, we could also run regressions on the data at the transaction level instead of the bank level as in Jiménez, Ongena, Peydró, and Saurina (2014). Since the bank asset dataset is not transaction-based, however, we choose the panel regression approach to both datasets at the bank level so that we can establish the link between the findings based on entrusted lending and on risky investments on the balance sheet and at the same time provide some perspective on the degree of how representative is the estimated impact of monetary policy based on our entrusted loan dataset (Section VI.4).

VI.2. **Testing Hypotheses I and II: off-balance-sheet activities.** To test Hypotheses I and II postulated at the end of Section IV, we run the following panel regression[28]

$$\log \mathscr{L}_{bt} = \alpha + \alpha_g g_{t-1} + \beta_{ns} g_{t-1} \mathscr{I}\left(\mathrm{NSB}_b\right) + \beta_{sb} g_{t-1} \mathscr{I}\left(\mathrm{SB}_b\right) + \mathrm{Control}_{bt} + u_{bt}, \tag{11}$$

where NSB stands for nonstate banks, SB stands for state banks, $\mathscr{I}\left(\mathrm{NSB}_b\right)$ returns 1 if the trustee is a nonstate bank and 0 otherwise, and $\mathscr{I}\left(\mathrm{SB}_b\right)$ returns 1 if the trustee is a state bank and 0 otherwise. The subscript "bt" stands for a particular trustee (b) that facilitates entrusted lending at time t and $\mathscr{L}_{bt}$ represents the total loan amount facilitated by trustee b at time t. The variable g_{t-1} is an annual change in exogenous M2 supply in the previous year. The regression residual is u_{bt}. The control variables, denoted by $\mathrm{Control}_{bt}$, include GDP_{t-1} (an annual change in GDP in the previous year), Inf_{t-1} (an annual change in the GDP deflator in the previous year), and the types of trustees $\mathscr{I}\left(\mathrm{NSB}_b\right)$ and $\mathscr{I}\left(\mathrm{SB}_b\right)$. GDP and inflation variables control for macroeconomic effects other than those of exogenous monetary policy. Controlling for the trustee type is necessary for obtaining the accurate estimate of double interactions between monetary policy and the type of trustee. The sample size for this panel regression is 583.

Table 6 reports the estimated results of panel regression (11) for the relevant coefficients (bar those of control variables). The coefficient α_g reflects the impact of monetary policy on entrusted loans facilitated by *nonbank trustees*. The positive coefficient value indicates that the amount of entrusted lending facilitated nonbank trustees decreases, not increases, in response to a fall in M2 growth (and the coefficient is statistically significant at a 10% level). This result indicates that nonbank trustees did not actively participate in entrusted loans during the period of monetary policy tightening.

[28]The panel regression is unbalanced because it is not uncommon that a trustee may have facilitated one entrusted loan in the whole sample or a few loans but in distant intervals separated by years.

The coefficient β_{sb} of the double-interaction term $g_{t-1}\mathscr{I}(\mathrm{SB}_b)$ captures how much of entrusted lending is intermediated by state banks in addition to the lending channeled by nonbank trustees when M2 growth changes. From Table 6 one can see that this marginal effect is statistically insignificant, confirming Hypothesis I.

The coefficient β_{ns} of the double-interaction term $g_{t-1}\mathscr{I}(\mathrm{NSB}_b)$ captures how much of entrusted lending is intermediated by nonstate banks in addition to the lending channeled by nonbank trustees when M2 growth changes. This marginal effect is estimated to be negative and the estimate is highly significant. The negative sign means that a fall in M2 growth leads to an increase, not a decrease, of entrusted lending. The overall impact of M2 growth on entrusted lending intermediated nonstate banks, $\alpha_g + \beta_{ns}$, is large and highly significant. Indeed, the total volume of entrusted lending intermediated by nonstate banks increases by 10.65% (at a less than 1% level of statistical significance) in response to a one-percentage-point fall in M2 growth, an empirical result confirming Hypothesis II.

VI.3. **Robustness analysis.** In this section we perform a robustness analysis of the previous regression results. The analysis centers on two questions. Is an increase of entrusted lending driven by an increase of the number of transactions (extensive margin) or an increase of the average loan amount (intensive margin)? And do the empirical results for nonstate banks simply reflect the effects of bank-specific attributes such as LDR, size, capital, and liquidity?

VI.3.1. *Intensive versus extensive margins.* The active role played by nonstate banks in funneling entrusted loans may reflect the number of loans (extensive margin), not the average loan amount (intensive margin). The large number of loans may reflect the diversification strategy of nonstate banks, not necessarily a risk-taking behavior. To see whether nonstate banks' promotion of entrusted lending stems from the increasing number of loans or the increasing average loan amount, we run two additional panel regressions as

$$S_{bt} = \alpha + \alpha_g g_{t-1} + \beta_{ns} g_{t-1}\mathscr{I}(\mathrm{NSB}_b) + \beta_{sb} g_{t-1}\mathscr{I}(\mathrm{SB}_b) + \mathrm{Control}_{bt} + u_{bt}, \tag{12}$$

where S_{bt} represents either the log value of the average loan amount facilitated by trustee b at time t or the number of loans facilitated by trustee b at time t.

Tables 7 and 8 report the regression results. The estimated values in Table 7 are comparable to those in Table 6. For the number of loans intermediated by nonstate banks, state banks, or nonbank financial trustees, the estimates reported in Table 8 are all statistically insignificant. Thus, the increase of the total loan amount channeled by nonstate banks is driven by the intensive margin. There is no evidence that state banks or nonbank financial companies intermediated more entrusted lending when monetary policy tightened in terms of either the number of loans or the average loan amount.

VI.3.2. *Individual bank attributes.* One critical question is whether the bank variable $\mathscr{I}(\mathrm{NSB}_b)$ is an outcome of other bank characteristics such as LDR, size, liquidity, and capital position. A significant portion of our data sample contains entrusted loans facilitated by nonbank financial trustees. Because the data on characteristics of these trustees such as size and liquidity do not exist, we need to reduce our sample by selecting the data intermediated by commercial banks only. With this reduced sample (342 observations), we extend regression (11) by adding control of various bank attributes as in Kashyap and Stein (2000) and Jiménez, Ongena, Peydró, and Saurina (2014). These attributes are the LDR (China-specific), log value of total assets (size), the ratio of bank equity to total assets (capital), the ratio of liquid assets to total assets (liquidity), the ratio of total net income to total assets (ROA), and the nonperforming loan ratio (NPL). Table 9 reports the descriptive statistics of these bank characteristics. As one can see, there are considerable variations across banks for each of these characteristics.

We add all these bank attributes to the existing control variables and run the following panel regression:

$$\log \mathscr{L}_{bt} = \alpha + \alpha_g g_{t-1} + \beta_{ns} g_{t-1} \mathscr{I}(\mathrm{NSB}_b) + \mathrm{Control}_{bt} + u_{bt}, \tag{13}$$

where the control variables, represented by $\mathrm{Control}_{bt}$, are GDP_{t-1}, Inf_{t-1}, $\mathscr{I}(\mathrm{SB}_b)$, $\mathscr{I}(\mathrm{NSB}_b)$, and all the bank-specific attributes listed in Table 10. After controlling for these bank-specific attributes, the bank variable $\mathscr{I}(\mathrm{NSB}_b)$ does not reflect whether the bank is small or large, whether the bank's LDR is different from the LDRs of other banks, how strong the bank's capital position is, or whether the bank's other characteristics differ from those of other banks. Moreover, the demand of entrusted loans has no bearing on whether a trustee is a state bank or a nonstate bank, ceteris paribus. As long as the borrower's loan demand is met, the borrower does not care whether the loan is facilitated by a nonbank trustee, a state bank, or a nonstate bank. The finding of risk-taking behaviors of nonstate banks by funneling more entrusted loans when monetary policy tightens is consistent with their actions to bring off-balance-sheet activities into their balance sheet in the form of ARIX as argued in Section III.2.2 and further discussed in Sections VI.4 and VII.2.

After control of the above bank attributes, therefore, the bank variable $\mathscr{I}(\mathrm{NSB}_b)$ captures only the *institutional* difference between state and nonstate banks in that state banks do not circumvent the government's own regulations against bringing risky shadow loans onto the balance sheet while nonstate banks do take advantage of regulation arbitrage.

The impact of M2 growth changes on entrusted lending funneled by nonstate banks for regression (13) is the sum of α, β_{ns}, and the coefficients of double-interaction terms related to all bank characteristics or attributes (listed in Table 10) at the mean bank level.[29] The regression is run on a smaller sample because there is no data on the balance-sheet information of nonbank trustees. With the smaller sample, the estimated impact is expected to differ from the estimate for regression (11) (-10.65% vs. -14.00% in Table 6). To see whether bank attributes severely affect the estimated impact of monetary policy, we need to compare the results based on the same sample. For that purpose, we run regression (13) on the same reduced sample with bank attributes included in the control variables as well as without. The estimated impact without any bank attribute is -14.00% (Table 11). Given the standard error 5.73%, this estimate is not statistically different from -17.97%, the estimated impact of monetary policy with inclusion of all bank attributes in the control variables. Similar results hold when the average entrusted loan amount is considered (compare the results for the smaller sample with and without bank attributes in Table 7).

These results suggest that the bank variable $\mathscr{I}(\mathrm{NSB}_b)$ in the regressions without any bank-specific attribute included in control variables captures the institutional asymmetry between state and nontate banks, not the difference in specific attributes such as size, the LDR, capital position, and liquidity. In other words, the institutional asymmetry discussed in Section III.3.2 is, to a large extent, orthogonal to bank-specific characteristics.

VI.4. **Testing Hypotheses III and IV: the asset side of the balance sheet.** As previously argued, state banks do not avail themselves of regulatory arbitrage against the government's own policies. As a result, the share of ARIX in total credit on their balance sheet was extremely small and had remained flat during the boom period of shadow banking since 2008. The opposite is true for nonstate banks, which have rapidly brought shadow loans into their balance sheet in the form of ARIX during the same period (Figure 2). Using the quarterly panel data on bank assets from 16 publicly listed banks, this section performs an econometric test of Hypotheses III and IV postulated at the end of Section IV.

[29] We use "mean bank" to indicate that the average value of each characteristic across banks is used as an input for computing the overall impact of money growth when bank characteristics are controlled for.

This testing also helps address a potential limitation of our empirical analysis that is related to selection of the types of nonfinancial firms in our entrusted loan dataset. The data are gathered from publicly listed firms. Many publicly listed firms are state owned and have better access to traditional bank loans than private firms. It can be argued that banks are more likely to use shadow banking products to extend credit to private firms than to publicly listed firms. In such a case, our results on the risk-taking behavior of nonstate banks may have been underestimated. Although there is no data on entrusted loans originated from private firms, our quarterly panel data of ARIX on the balance sheet include entrusted rights as well as assets related to other shadow products. Since entrusted rights in ARIX contain entrusted loans between private firms, an empirical analysis based on the bank asset panel dataset will provide some perspective on the degree of underestimation.

The 16 publicly listed banks include all the state banks as well as the largest nonstate banks. Their assets take up, on average for the period 2009-2015, 81% of total bank assets and 83.4% of total bank loans in the entire banking system. Thus, these banks are representative of the Chinese banking system as a whole. ARIX encompasses all shadow products brought onto the balance sheet; for nonstate banks, entrusted rights form the largest subcategory of ARIX (Section III.3.2). The importance of entrusted rights within ARIX helps explain the high correlation between on-balance-sheet ARIX and off-balance-sheet entrusted lending for nonstate banks (Table 2).

Using the bank asset dataset, we run the following quarterly panel regression[30]

$$\log \mathscr{A}_{bt} = \alpha + \alpha_g g_{t-1} + \beta_{ns} g_{t-1} \mathscr{I}\left(\mathrm{NSB}_b\right) + \mathrm{Control}_{bt} + \varepsilon_{bt}, \tag{14}$$

where $\mathscr{A}_{bt}$ represents ARIX for bank b at time t and the control variables, which include GDP_{t-1}, Inf_{t-1}, and $\mathscr{I}\left(\mathrm{NSB}_b\right)$, are similar to those used in previous regressions. Table 11 reports the estimated results. The impact of a change in M2 growth on nonstate banks' ARIX is estimated to be a 37.69% increase in response to a one-percentage-point decrease in M2 growth and the estimate is highly significant statistically. The estimation of regression (14) is carried out without controlling for various bank attributes.

As shown in Section VI.3.2, the bank variable $\mathscr{I}\left(\mathrm{NSB}_b\right)$ is uncorrelated with these attributes so that their omission does not materially affect the estimate for the entrusted loan data. To see whether this result continues to hold for the bank asset dataset, we run the same regression as (14) but add all the bank attributes listed in Table 9 to the existing

[30]The panel regression is unbalanced because some ARIX observations are missing in the original annual reports. These missing data are only a handful, however.

control variables. This exercise results in a loss of about 50 observations because the data on several bank attributes in certain years are missing for some banks. When we run the same regression on this reduced sample without including any bank attribute as a control variable, the estimated impact on nonstate banks' ARIX is a 45.73% increase in response to a one-percentage-point fall in M2 growth. As expected, this value is different from the estimated 37.69% based on the original and larger sample (Table 11).

Taking into account all bank attributes, the impact of a one-percentage-point drop in M2 growth on nonstate banks' ARIX is estimated to be a 42.33% increase in response to a one-percentage-point fall in M2 growth (Table 11). With the estimated standard error (8.89%) taken into consideration, this estimate is not significantly different from the estimated 45.73% without inclusion of any bank attribute as a control variable. Such a finding is very similar to the result discussed in Section VI.3.2 where the entrusted loan dataset is used.

To determine a degree to which we underestimate the risk-taking behavior of nonstate banks based on the entrusted loan data, we compare the regression results with control of all the bank attributes (a similar result holds if we compare the regression results without any bank attribute). That is, we compare the estimated 17.97% based on the entrusted loan data (Table 6) to the estimated 42.33% based on the bank asset data (Table 11). Because the entrusted loan data pertain to new loans (flow) and the bank asset data are about outstanding loans (stock), we convert the flow estimate 17.97% to its stock value as $(1 + 17.97\%) * 30.10\% = 35.51\%$, where 30.10% is an average quarterly growth rate of ARIX between 2009 and 2015. Comparing the stock coefficient 35.51% based on the entrusted loan data to the stock estimate 42.33% based on the bank asset data, we conclude that although the regression result based on the entrusted loan data may underestimate the risk-taking behavior of nonstate banks, the degree of underestimation may not be large, especially when one takes into account the standard error of the estimate.

The impact of monetary policy on state banks' ARIX is estimated to be a 26.56% decrease, *not an increase*, in response to a one-percentage-point fall in M2 growth and the estimate is at a 5% level of statistical significance (Table 11). This finding confirms Hypothesis III. By contrast, the impact of monetary policy on nonstate banks' ARIX is estimated to be a 37.69% *increase* in response to a one-percentage-point fall in M2 growth, with an extremely high statistical significance. This sharp result, confirming Hypothesis IV, is consistent with the result estimated from the entrusted loan dataset.

The finding of a highly significant impact of monetary policy on nonstate banks' ARIX holdings provides an additional support for the argument that the active participation of nonstate banks in intermediating entrusted loans when monetary policy tightens is explained by their own risk-taking behavior, not by borrowers' demand for entrusted loans. The reason is that the demand itself would not be able to explain why only nonstate banks, not state banks, would actively bring shadow banking products into their balance sheet via ARIX. The results from our panel regressions on both entrusted lending and ARIX are mutually consistent; together they show that nonstate banks were willing to use the ARIX category to take the credit risk of shadow banking products for higher profits.

Because controlling for bank attributes reduces the size of the sample and because we have shown that the bank variable $\mathscr{I}\,(\mathrm{NSB}_b)$ does not reflect any of these attributes in a significant way, we continue to use the original and larger sample in which bank-specific attributes are omitted in our panel regressions. Since only a handful of ARIX observations are missing, we interpolate these missing ones and run the panel regression (14) with the balanced dataset. The results are reported in Table 12. A comparison of Tables 11 and 12 shows that the regression results, with and without interpolated ARIX data, are almost identical. The balanced dataset is thus used for our panel vector autoregression (VAR) analysis of monetary policy in the next section.

VII. The effectiveness of monetary policy on the banking system

M2-based monetary policy in China is transmitted through the banking system. When monetary policy tightens, bank loans fall (Figure 1). As nonstate banks tend to increase risky investments in the form of ARIX on their balance sheet, however, the effect of monetary policy tightening on the total credit in the banking system (the sum of bank loans and ARIX holdings) may be blunted. The potential influence of shadow banking products on the effectiveness of quantity-based monetary policy has been a serious concern of the central government of China. In this section we analyze the extent to which the use of shadow banking products in the form of ARIX reduces the effectiveness of monetary policy in China. We first provide calibrated theoretical predictions and then build a panel VAR model for obtaining credible empirical evidence.

VII.1. **The dynamic equilibrium model and its implications.** We develop a dynamic equilibrium model and simulate the model to explore the dynamic impact of monetary policy on the asset side of banks' balance sheet.

VII.1.1. *The model.* We extend the simple one-period model to a dynamic model in two dimensions. First, all banks in the dynamic model are infinitely lived and choose to issue dividends and accumulate equity every period. Second, bank loans have a longer maturity than risky investment assets brought onto the balance sheet from shadow banking products. While the basic structure of the dynamic model is the same as in Section IV, additional features are incorporated in the model to make it more realistic for calibration.

In the lending state, the law of motion for bank loans evolves as

$$B_t = \delta B_{t-1} + S_t,$$

where $(1-\delta)B_{t-1}$ represents a fraction of loans that is retired and S_t represents new *safe* loans made by the bank to comply with the safe-loan regulation. Denote cash at the beginning of t by $\tilde{C}_t$ such that

$$C_t = \tilde{C}_t + \varphi_t,$$

where φ_t represents additional cash holdings chosen by the bank. The leverage ratio constraint is

$$D_t/R_t^D \leq \kappa \left[\mathscr{E}_t - \mathrm{DIV}_t\right],$$

where κ is the leverage ratio, the term in brackets after κ represents the equity net of the dividend payout, and the equity is determined by the following balance-sheet equation

$$\underbrace{D_t/R_t^D}_{\text{deposits}} + \underbrace{\mathscr{E}_t - \mathrm{DIV}_t + (1-q_t^r)I_t^r + (1-q_t)B_t}_{\text{equity}} = \underbrace{C_t}_{\text{cash}} + \underbrace{I_t^r + B_t}_{\text{assets}}.$$

The liquidity constraint, as a proxy for a regulation on the sufficiency of the bank's liquid assets, is a lower bound for cash holdings in the model:

$$C_t \geq \psi \left[\mathscr{E}_t - \mathrm{DIV}_t\right].$$

In the balancing stage, the only difference between the dynamic model and the one-period model is that a default shock is generalized as

$$\varepsilon_t = \begin{cases} 1 & \text{with probability } 1-p^r \text{ (the no-default state)} \\ \phi & \text{with probability } p^r \text{ (the default state)} \end{cases},$$

where $0 \leq \phi < 1$ represents the recovering rate of risky assets in the default state. The balance-sheet constraint for each bank is

$$\underbrace{D_t/R_t^D - \varepsilon_t I_t^r}_{\text{liabilities}} + \underbrace{\mathscr{E}_t - \mathrm{DIV}_t - (1-\varepsilon_t)\, I_t^r + (1-q_t^r)I_t^r + (1-q_t)B_t}_{\text{equity}} = \underbrace{C_t + B_t}_{\text{assets}}.$$

As in Section IV, the bank takes $\mu(\varepsilon_{m,t})$, as well as r^b, q_t, q_t^r, R_t^D, as given when solving its problem.

It follows from Bianchi and Bigio (2014) that a combination of the two stages leads to the single-state dynamic-programming problem as

$$V(\mathscr{E};\varepsilon_m) = \max U(\text{DIV}) + \beta E_{m,\omega,\varepsilon}\left[V(\mathscr{E}';\varepsilon'_m)\,|\,\varepsilon_m\right] \tag{15}$$

subject to

$$\mathscr{E} - \text{DIV} = \underbrace{C}_{\text{cash}} + \underbrace{q^r I^r + qB}_{\text{assets}} - \underbrace{D/R^D}_{\text{liabilities}}, \tag{16}$$

$$D/R^D \leq \kappa\left[\mathscr{E} - \text{DIV}\right], \tag{17}$$

$$x = qB - \theta\frac{(1-\omega)\,D}{R^D}, \tag{18}$$

$$\mathscr{E}' = \underbrace{C - \omega D}_{\text{cash}} + \underbrace{q'\delta B + (1-\delta)B}_{\text{assets}} - \underbrace{\left[(1-\omega)D + \chi(x) - \varepsilon R^D I^r\right]}_{\text{liabilities}}, \tag{19}$$

$$C \geq \psi\left[\mathscr{E} - \text{DIV}\right]. \tag{20}$$

where β is a subjective discount factor, $\mathscr{E}$ is the single state for this optimization problem, E_m represents the mathematical expectation with respect to unexpected monetary policy changes, and $E_{\omega,\varepsilon}$ is the mathematical expectation with respect to the (ω,ε) measure. Comparing equations (16)-(20) to equations (1)-(5), one can see that the repeated one-period model is a simplified version of the dynamic model such that the bank uses all of its equity for dividend at the end of the period. A numerical solution method for the dynamic model (15) is provided in Appendix E.

VII.1.2. *Calibration.* To obtain quantitative implications of the dynamic model, we calibrate the key model parameters carefully. These parameters are $\left\{\beta, \kappa, R^D, \delta, q^r, q, \psi, p^r, \gamma, \mu, r^b, \phi, \theta\right\}$. The time period of the model is calibrated to be quarterly.

Following Bianchi and Bigio (2014), we set $\beta = 0.98$. We set $\theta = 0.75$, which is the PBC's official LDR limit. We set $\kappa = 7.2$ so that the capital adequacy ratio $\mathscr{E}/(C + qB + q^r I^r)$ is 12% in steady state.[31] The deposit rate $R^D = 1.0068$ corresponds to an annual interest rate of 2.7%, which is the mean deposit interest rate between 2009 and 2015. We set $\delta = 0.33$ such that the average maturity of bank loans is 1.5 times that of risky assets to be consistent with

[31]On May 3, 2011, the CBRC issued "Notice on the New Regulatory Standard for China's Banking Industry," which requires the capital adequacy ratio for most banks in the banking system to be no less than 11.5%.

the data. We set $q^r = 0.9882$ such that an annualized return of a risky investment is 7.5% $\left(\frac{R^D}{q^r} \times 4\right)$, consistent with the mean return on entrusted lending during the 2009-2015 period (Table 1). We set $q = 0.9762$ such that an annualized loan rate is 6.5% $\left(\left(\delta + \frac{1-\delta}{q}\right) \times 4\right)$, consistent with the average loan rate for the 2009-2015 period (Table 1). The parameter for the lower bound of liquid assets is set to be $\psi = 2.354$ such that the liquidity ratio, $\frac{C}{C+qB+q^r I^r}$, is targeted to be 27%, which equals the average liquidity ratio for the 2009-2015 period (Table 9).

According to Sheng, Edelmann, Sheng, and Hu (2015), the non-performing loan (NPL) rate for China's shadow banking is 4% under their optimistic scenario and 10% under their benchmark scenario. Therefore, we take the median and set the probability of default for risky investments at $p^r = 0.07$, which is much higher than the average NPL rate for bank loans reported in Table 9. Such a low NPL rate for bank loans is consistent with the assumption that bank loans are safe.

Without loss of generality, we set the risk aversion parameter at $\gamma = 2$. The steady state value of μ is set to be -1 for $\varepsilon_m = 0$ (no monetary policy shock in the steady state). The cost of meeting deposit shortfalls is set at $r^b = 1.75\%$ according to the recent WIND data. The recovery rate of risky assets is set at $\phi = 0.85$. This high rate reflects the reality in China that banks benefit from the government's implicit guarantees on their deposits as well as on risky investments.[32]

VII.1.3. *Impulse responses.* We use the calibrated model to simulate the dynamics of bank loans and risky assets in response to a contractionary shock to monetary policy. The initial state at $t = 0$ is in the steady state. A negative shock to monetary policy, $\varepsilon_{m,t} < 0$, occurs at $t = 1$. In response to a one-standard-deviation shock,[33] we simulate the dynamic paths of new bank loans S_t and risky investments I_t^r for $t \geq 1$ with the initial response of I_t^r set at 0.45%, the same value as the estimated one for the empirical panel VAR model studied in Section VII.2.

Figure 5 displays the cumulative impulse responses of I_t^r and S_t. Risky assets increase and reach 1.7% at the tenth quarter (see top panel of Figure 5). By contrast, bank loans decline and reach -1.1% at the tenth quarter (see middle panel of Figure 5). The economic intuition behind these results comes directly from the asset pricing equation governing the tradeoff

[32]See Dang, Wang, and Yao (2015) for a formal model of implicit guarantees of China's shadow banking.

[33]An annualized rate of the one-standard-deviation monetary policy shock is estimated to be 2.8% (see bottom panel of Figure 3).

between safe bank loans and risky investment assets (equation (9)). When $\varepsilon_{m,t}$ falls, the probability of deposit withdrawal increases. This leads to a rise of the probability of deposit shortfall and a rise of the expected regulation cost. As a result, the return on risky assets relative to the return on bank loans increases, making it optimal for the bank to rebalance its portfolio by increasing risky assets in total assets.

Under our calibrated parameterization, the increase in risky assets dominates the decline in bank loans in absolute magnitude so that the total credit increases in response to monetary policy tightening. The bottom panel of Figure 5 shows that the total credit increases throughout the entire period and reaches 0.6% at the tenth quarter.

VII.2. **Panel VAR evidence.** To provide an empirical analysis of the effectiveness of monetary policy on the banking system during the period of booming shadow banking, we extend the Romer and Romer (2004) methodology and develop a dynamic panel model that is estimated against our bank asset data. The dynamic quarterly panel model is of simultaneous-equation form as

$$A_0^b \begin{bmatrix} \Delta B_{bt} \\ \Delta \mathscr{A}_{bt} \end{bmatrix} = c^b + \sum_{k=1}^{\ell} A_k^b \begin{bmatrix} \Delta B_{bt-k} \\ \Delta \mathscr{A}_{bt-k} \end{bmatrix} + \begin{bmatrix} \sum_{k=0}^{\ell} c_k^b \varepsilon_{m,t-k} \\ 0 \end{bmatrix} + \eta_{bt}, \tag{21}$$

where the subscript b represents an individual bank, B_{bt} represents bank loans made by bank b at time t, $\mathscr{A}_{bt}$ represents ARIX accumulated by bank b at time t, η_{bt} is a vector of i.i.d. disturbances that capture other shocks that are orthogonal to monetary policy shocks, ℓ is the lag length set to 4 (one year), and for $k = 0, \ldots, \ell$

$$c^b, c_k^b, A_k^b = \begin{cases} c^{ns}, c_k^{ns}, A_k^{ns}, & \text{if bank } b \text{ is a nonstate bank} \\ c^{sb}, c_k^{sb}, A_k^{sb}, & \text{if bank } b \text{ is a state bank} \end{cases}.$$

Both ΔB_{bt} and $\Delta \mathscr{A}_{bt}$ are scaled by nominal GDP to keep the panel VAR stationary. The lagged variables ΔB_{bt-k} and $\Delta \mathscr{A}_{bt-k}$ on the right hand side of the panel equations are used to capture changes of B_{bt} and $\mathscr{A}_{bt}$ influenced by different maturities at which some of bank assets are retired. After controlling for these lagged variables, the dynamic impact of $\varepsilon_{m,t}$ reflects the effect only on new loans and new investment. The inclusion of all exogenous M2 growth rates for the last four quarters captures both the current quarterly change and an annual change of M2 supply.

The only identifying restriction imposed on system (21) is that exogenous changes in M2 growth, represented by $\varepsilon_{m,t}$, affect bank loans B_{bt} but not risky assets $\mathscr{A}_{bt}$. In theory, $\varepsilon_{m,t}$ affects deposits directly, which in turn affects bank loans due to the LDR regulation. This effect does not exist for risky assets brought onto the balance sheet from shadow banking products. Thus, the restriction is consistent with our theoretical framework.

The asset pricing equilibrium condition in our theory, represented by (9), indicates that B_{bt} and $\mathscr{A}_{bt}$ must be simultaneously determined. The simultaneity suggests that no restrictions be imposed on the contemporaneous matrix A_0^b for $b = ns$ or $b = sb$. All the coefficients in system (21) have two different values, depending on whether the bank is state controlled or not. Allowing for different values captures the institutional asymmetry between state and nonstate banks as well as other potential differences between these two groups of banks. In short, our panel VAR model imposes restrictions that are consistent with our theoretical framework on the one hand, and remain minimal to avoid "incredible restrictions" as advocated by Sims (1980) on the other hand.

Because of the simultaneity in the dynamic panel system, a key question is whether the dynamic responses of B_{bt} and $\mathscr{A}_{bt}$ in response to $\varepsilon_{m,t}$ are uniquely determined. Since $\varepsilon_{m,t-k}$ for $k = 0, \ldots, \ell$ enters the first equation but not the second equation and because $\varepsilon_{m,t-k}$ is exogenously given, the dynamic system represented by (21) is globally identified according to Theorem 1 of Rubio-Ramírez, Waggoner, and Zha (2010). With the bank asset data on B_{bt} and $\mathscr{A}_{bt}$, therefore, all the coefficients c^b and A_k^b for $b = ns, sb$ are uniquely determined by maximum likelihood estimation.

Given the estimated coefficients, the next step is to calculate the dynamic responses of B_{bt} and $\mathscr{A}_{bt}$ in response to $\varepsilon_{m,t}$. As an illustration, we consider the following simple one-variable process

$$\Delta x_t = a_0 + \sum_{k=1}^{\ell} b_k \Delta x_{t-k} + \sum_{k=0}^{\ell} c_k \varepsilon_{m,t-k} + \eta_t.$$

For this simple example, the dynamic responses of x_{t+h} for $h = 0, 1, 2, \ldots$ to a one-standard-deviation unit of $\varepsilon_{m,t}$ can be calculated as

- x_t $(h = 0)$: c_0;
- x_{t+1} $(h = 1)$: $c_1 + b_1 c_0 + c_0$;
- x_{t+2} $(h = 2)$: $c_2 + b_2 c_0 + b_1(c_1 + b_1 c_0) + c_1 + b_1 c_0 + c_0$.

Although the complete formula for the dynamic responses to $\varepsilon_{m,t}$ in the dynamic panel system is much more involved, it has a calculation method similar to the above example.

Denote the dynamic responses of bank loans and ARIX holdings by DRB_t^{ns} and DRA_t^{ns} for nonstate banks. Denote the state-bank counterparts by DRB_t^{sb} and DRA_t^{sb}. Then the dynamic responses for all banks are

$$\mathrm{DRB}_t^{all} = \lambda\,\mathrm{DRB}_t^{ns} + (1-\lambda)\,\mathrm{DRB}_t^{sb},$$
$$\mathrm{DRA}_t^{all} = \lambda\,\mathrm{DRA}_t^{ns} + (1-\lambda)\,\mathrm{DRA}_t^{sb},$$

where the superscript *all* stands for all 16 banks (nonstate and state banks combined) and λ is the share of nonstate banks in total assets, which is 0.47. As discussed in Section VI.4, these 16 banks are representative of the banking system in China.

The sample period for estimation of the dynamic panel model is from 2009Q1 to 2015Q4. The estimated dynamic responses DRB_t^{all} and DRA_t^{all} to a one-standard-deviation fall in M2 growth are plotted in Figure 6. Bank loans decline and reach the trough at -1.5% in the fourth quarter; at the same time, ARIX holdings respond in an opposite direction by increasing and reaching the peak at 2.06% in the sixth quarter. The ARIX response is almost entirely contributed by nonstate banks; state banks' response is insignificant. Overall, the estimates of the average dynamic responses are statistically significant judged by the error bands displayed in Figure 6.[34] As a result, the total credit in the banking system as a whole (bank loans and ARIX holdings combined) declines slightly (-0.5%) on impact but increases steadily over time; the estimated increase is marginally significant judged by the error bands. From the view point of monetary policy, the effect of contractionary monetary policy on the banking system is ineffective because the responses of ARIX more than offset those of bank loans.[35] These empirical findings are consistent with our theoretical predictions discussed in Section VII.1.3.

VII.3. **Policy recommendation.** Within the system of quantity-based monetary policy in China, what regulatory remedy would make the bank lending channel of monetary policy more effective? The difficulty in dealing with ARIX is that the degree of its risk is largely unknown partly because the detailed assets contained in the ARIX category are murky and partly because the extent to which ARIX is implicitly guaranteed by the government is unknown. The lack of precise knowledge about risk factors within ARIX and the unknown degree of implicit guarantee make it difficult, if not impossible, to make necessary risk adjustments to capital adequacy related to ARIX. The CBRC recognizes this difficulty and

[34]The estimates and error bands have somewhat zigzag paths due to possible seasonal effects. Such effects are not uncommon as shown in Romer and Romer (2004).

[35]A more ambitious project, although it is beyond the scope of this paper, is to study whether the transmission of monetary policy into the real economy through ARIX is different from transmission through traditional banking.

has begun to impose a direct restriction on growth of the total credit by requiring it to be in line with M2 growth targeted by the PBC.

To evaluate and quantify the effect of such a restriction on the bank lending channel is infeasible at this point due to the lack of empirical observations. We can, however, employ both panel VAR and theoretical dynamic model to conduct counterfactual exercises. Under the scenario that investment in risky shadow assets is no longer allowed for all banks, we impose zero restrictions on the ARIX coefficients so that the estimated coefficient matrices become diagonal:

$$A_k^b = \begin{bmatrix} A_{k,11}^b & 0 \\ 0 & A_{k,22}^b \end{bmatrix}$$

for $k = 0, 1, \ldots, \ell$. The counterfactual exercise is to impose the off-diagonal zeros on the originally estimated A_k^b and then compute impulse responses. The dynamic responses of bank loans to a one-standard-deviation fall of $\varepsilon_{m,t}$, as displayed in the left panel of Figure 7, decline over time and the magnitude stays within the error bands of the originally estimated panel VAR. As ARIX does not respond to monetary policy tightening by construction in this counterfactual exercise, the total credit contracts.[36]

This empirical finding is supported by the same counterfactual exercise based on our theoretical model. The counterfactual model we consider is to restrict the response of I_t^r to contractionary monetary policy (a one-standard-deviation fall of $\varepsilon_{m,t}$) to be zero. With this restriction, we simulate this counterfactual model while keeping the parameter values the same as in Section VII.1.2. The impulse responses of bank loans to contractionary monetary policy, as displayed in the right panel of Figure 7, are negative and do not differ much from those generated by the original dynamic model when there is no regulatory restriction on risky investments. This result is remarkably similar to what we find from the panel VAR (comparing the two panels in Figure 7). Because the responses of risky assets are zero, the total credit falls in this counterfactual model.

The economic intuition behind our counterfactual finding is clear in the context of our theoretical framework. In the absence of the response of investment in risky assets, the bank' optimal portfolio choice implies that the return on bank loans falls until it equals the deposit rate to restore the equilibrium. A combination of monetary policy tightening and the regulatory restriction on the LDR causes a simultaneous increase in the expected regulation

[36]The total credit would contract even more if we consider an alternative scenario in which ARIX must decrease, by regulation, to align with a fall of M2 growth.

cost and a reduction of the return on bank loans. Consequently, bank deposits fall and so do total bank assets.

In light of our counterfactual results, recent regulatory changes to restrict growth of the total credit to be in line with M2 growth is moving in the right direction to improve the effectiveness of monetary policy on the banking system. In China, the quantity-based monetary policy system works through the bank lending channel to influence the total credit on the asset side of banks' balance sheet. This system was set up long before shadow banking became popular. But the rise of ARIX allowed banks to bypass the LDR and safe-loan regulations by promoting shadow banking activity. Consequently, it marginalized the effectiveness of monetary policy tightening on total bank credit.

Alternative and comprehensive reforms would require simultaneous changes in monetary and regulatory policies: moving the monetary policy system toward using the policy interest rate as the main instrument, removing the LDR regulation in its entirety, and strengthening the criterion of capital adequacy requirements by appropriately adjusting the risk associated with the detailed assets within the ARIX category. The central government is moving gradually toward these reforms, but their speed and success depend on how the government will address much broader issues such as liberalizing financial markets and restructuring overcapacity and government-protected industries, a topic that merits thorough and separate research in the future.

VIII. Conclusion

Based on China's institutional arrangements, we estimate quantity-based monetary policy and develop a theoretical framework for analyzing how banks reallocate from bank loans to risky investments in response to monetary policy tightening when the safe-loan and LDR regulations are put in place. We construct two micro datasets at the individual bank level: entrusted loans off balance sheet and bank assets on the balance sheet. These unique datasets enable us to establish empirical evidence that nonstate banks, in response to contractionary monetary policy during the period 2009-2015, significantly increased their activity in promoting entrusted lending off balance sheet and at the same time bringing shadow banking products onto the balance sheet. We estimate a dynamic panel VAR model and find that nonstate banks' active participation in bringing shadow banking products onto the balance sheet in the form of ARIX hampered the effectiveness of monetary policy on the total bank credit. This finding is consistent with our theoretical result.

Our research focuses on the bank lending channel: how monetary policy affects the asset side of banks' balance sheet. It abstracts from a host of other important issues. One issue is how the bank lending channel is transmitted into the real economy. It is possible that the transmission mechanism for bank loans differs materially from transmission for ARIX holdings. The importance of this topic merits future research.

Another issue relates to policy reforms. Recent debates center on how China should gradually move away from quantity-based monetary policy to interest rate monetary policy. The transition, if taking place, inevitably requires appropriate regulatory and financial reforms. The CBRC has begun to reform the LDR regulation and restrict nonstate banks from actively promoting shadow banking products. The PBC has begun to liberalize various interest rates in financial markets. Understanding the current quantity-based monetary policy system and its interactions with regulatory policies is necessary for understanding the transitional impact of monetary and regulatory reforms on the banking system as well as on the real economy. We hope that the steps taken in this paper will help foster further research on quantifying the effects of monetary and regulatory policies.

Table 1. Bank loans versus entrusted loans (averages for 2009-2015)

Loan type	Loan maturity	Loan rate
Bank loans	30.91	6.51
Entrusted loans	20.99	7.59

Note. Loan maturity is expressed in months and loan rate in percent. Both measures are averages weighted by loan amount. Data sources: CEIC and our constructed entrusted loan dataset.

Table 2. Correlation between new entrusted loans ($\mathscr{L}$) channeled by banks and changes in ARIX or the share of ARIX in 2009-2015

Description	State banks	p-value	Nonstate banks	p-value
$\mathrm{Corr}\left(\Delta\mathrm{ARIX}, \mathscr{L}\right)$	0.224	0.197	0.621^{***}	0.000
$\mathrm{Corr}\left(\frac{\mathrm{ARIX}}{\mathrm{ARIX}+B}, \mathscr{L}\right)$	-0.179	0.304	0.458^{***}	0.001

Note. The symbol "B" stands for bank loans.

Table 3. Capital adequacy ratios, excess reserve ratios, and LDRs across types of banks in 2009-2015 (%)

Description	Capital adequacy ratio	Excess reserve ratio	Loan-to-deposit ratio
State banks	13.07	1.45	68.06
Nonstate banks	12.16	3.32	71.12
Overall	12.71	1.90	68.85
Std. Err.	4.49	0.46	7.05
P-value	0.85	0.00	0.959

Note. Each reported ratio is weighted by bank assets. The calculation is based on the balance-sheet information of all commercial banks reported by Bankscope and WIND. Capital adequacy ratios and LDRs are downloaded directly from Bankscope and excess reserve ratios are manually collected from banks' annual reports, which are downloaded from WIND. The standard error (Str. Err.) for the difference between the ratio for state banks and the ratio for nonstate banks, along with the corresponding p-value (P-value), is reported in the last two rows of the table.

Table 4. Estimated monetary policy

Coefficient	Estimate	SE	p-value
γ_m	0.391^{***}	0.101	0.000
γ_π	-0.397^{***}	0.121	0.001
$\gamma_{x,a}$	0.183^{***}	0.060	0.002
$\gamma_{x,b}$	-1.299^{***}	0.499	0.009
$\sigma_{m,a}$	0.005^{***}	0.001	0.000
$\sigma_{m,b}$	0.010^{***}	0.002	0.000

Note. "SE" stands for standard error. The three-star superscript indicates a 1% significance level.

Table 5. P-values for hypothesis testing on changes in the reserve requirement ratio

Monetary Policy	Contemporaneous	Including one lag
Endogenous	0.004^{***}	0.006^{***}
Exogenous	0.150	0.282

Note. The testing hypothesis is that the sum of coefficients of changes in the reserve requirement ratio is zero. "Contemporaneous" indicates that the right-hand-side variable is contemporaneous with the dependent variable. "Including one lag" indicates that the right-hand-side variables include both contemporaneous and lagged variables. The dependent variable is either endogenous or exogenous M2 growth. The three-star superscript indicates a 1% significance level.

Table 6. Estimated results for the panel regression on total entrusted lending

Explanatory variable	Coefficient	(Std. Err.)
$g_{t-1} : \alpha_g$	13.12^{*}	(7.51)
$g_{t-1}\mathscr{I}(\mathrm{SB}_b) : \beta_{sb}$	4.31	(10.72)
$g_{t-1}\mathscr{I}(\mathrm{NSB}_b) : \beta_{nsb}$	-23.77^{***}	(7.70)
Impact of money growth via nonstate banks: $\alpha_g + \beta_{nsb}$	-10.65^{***}	(4.39)
- Including bank characteristics with a smaller sample	$-17.97^{\dagger}$	
- Excluding bank characteristics with a smaller sample	-14.00^{***}	(5.73)

Note. The superscript * represents a 10% significance level and *** a 1% significance level. The superscript † means that the overall impact has no standard error but the double-interaction term is statistically significant at a 1% level.

Table 7. Estimated results for the panel regression on the average entrusted loan amount

Explanatory variable	Coefficient	(Std. Err.)
$g_{t-1} : \alpha_g$	13.24^{**}	(6.38)
$g_{t-1}\mathscr{I}(\mathrm{SB}_b) : \beta_{sb}$	3.36	(9.26)
$g_{t-1}\mathscr{I}(\mathrm{NSB}_b) : \beta_{nsb}$	-21.80^{***}	(6.61)
Impact of money growth via nonstate banks: $\alpha_g + \beta_{nsb}$	-8.56^{**}	(4.18)
- Including bank characteristics with a smaller sample	$-17.09^{\dagger}$	
- Excluding bank characteristics with a smaller sample	-14.68^{***}	(4.09)

Note. The superscript ** represents a 5% significance level and *** a 1% significance level. The superscript † means that the overall impact has no standard error but the double-interaction term is statistically significant at a 1% level.

Table 8. Estimated results for the panel regression on the number of entrusted lending transactions

Explanatory variable	Coefficient	(Std. Err.)
$g_{t-1} : \alpha_g$	-4.69	(13.58)
$g_{t-1}\mathscr{I}(\mathrm{SB}_b) : \beta_{sb}$	9.28	(14.78)
$g_{t-1}\mathscr{I}(\mathrm{NSB}_b) : \beta_{nsb}$	-6.80	(19.87)

Table 9. Descriptive statistics of individual bank characteristics from 2009 to 2015

Attribute/variable	Obs	Mean	Std. Dev.	Min	Median	Max
LDR	396	69.49	7.11	47.43	71.70	85.16
Size	396	14.86	1.20	11.42	14.84	16.84
Capital	396	6.05	1.25	3.18	5.99	12.34
Liquidity	396	27.01	7.13	12.21	25.44	48.10
ROA	396	1.06	0.19	0.42	1.06	1.58
NPL	396	1.08	0.56	0.38	0.96	4.32

Note. All variables except Size (log value of total assets) are expressed in percent.

Table 10. Control variables for individual bank characteristics

ST	LDR_{t-1}	Size_{t-1}	Capital_{t-1}	Liquidity_{t-1}	ROA_{t-1}	NPL_{t-1}
DIT	$g_{t-1}\text{LDR}_{t-1}$	$g_{t-1}\text{Size}_{t-1}$	$g_{t-1}\text{Capital}_{t-1}$	$g_{t-1}\text{Liquidity}_{t-1}$	$g_{t-1}\text{ROA}_{t-1}$	$g_{t-1}\text{NPL}_{t-1}$

Note. "ST" stands for single term and "DIT" double-interaction term.

Table 11. Estimated results for the unbalanced panel regression on ARIX

Explanatory variable	Coefficient	(Std. Err.)
$g_{t-1} : \alpha_g$	26.56^{**}	(12.55)
$g_{t-1}\mathscr{I}(\text{NSB}_b) : \beta_{nsb}$	-64.26^{***}	(15.45)
Impact of money growth via state banks: α_g	26.56^{**}	(12.55)
Impact of money growth via nonstate banks: $\alpha_g + \beta_{nsb}$	-37.69^{***}	(9.85)
- Including bank characteristics with a smaller sample	$-42.33^{\dagger}$	
- Excluding bank characteristics with a smaller sample	-45.73^{***}	(8.89)

Note. The superscript ** represents a 5% significance level and *** a 1% significance level. The superscript † means that the overall impact has no standard error but the double-interaction term is statistically significant at a 1% level.

Table 12. Estimated results for the balanced panel regression on ARIX

Explanatory variable	Coefficient	(Std. Err.)
$g_{t-1} : \alpha_g$	26.35^{**}	(12.63)
$g_{t-1}\mathscr{I}(\mathrm{NSB}_b) : \beta_{nsb}$	-63.65^{***}	(16.68)

Note. The superscript ** represents a 5% significance level and *** a 1% significance level.

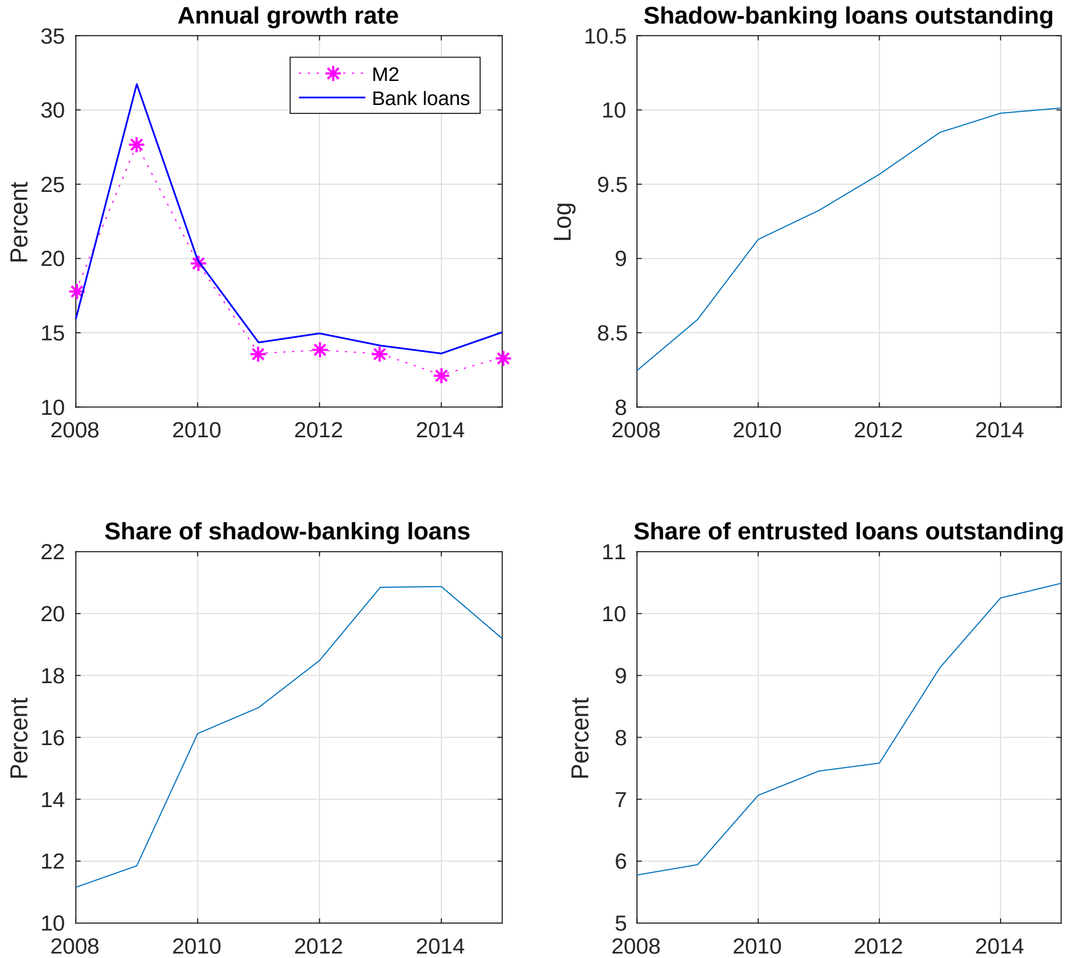

FIGURE 1. Aggregate data. The share of shadow banking loans is the ratio of shadow banking loans to the sum of shadow banking loans and bank loans. The share of entrusted loans is the ratio of entrusted loans to the sum of entrusted loans and bank loans. Entrusted loans are the most important component of shadow banking loans. Data sources: PBC and CEIC (the database provided by China Economic Information Center, now belonging to the Euromoney Institutional Investor Company).

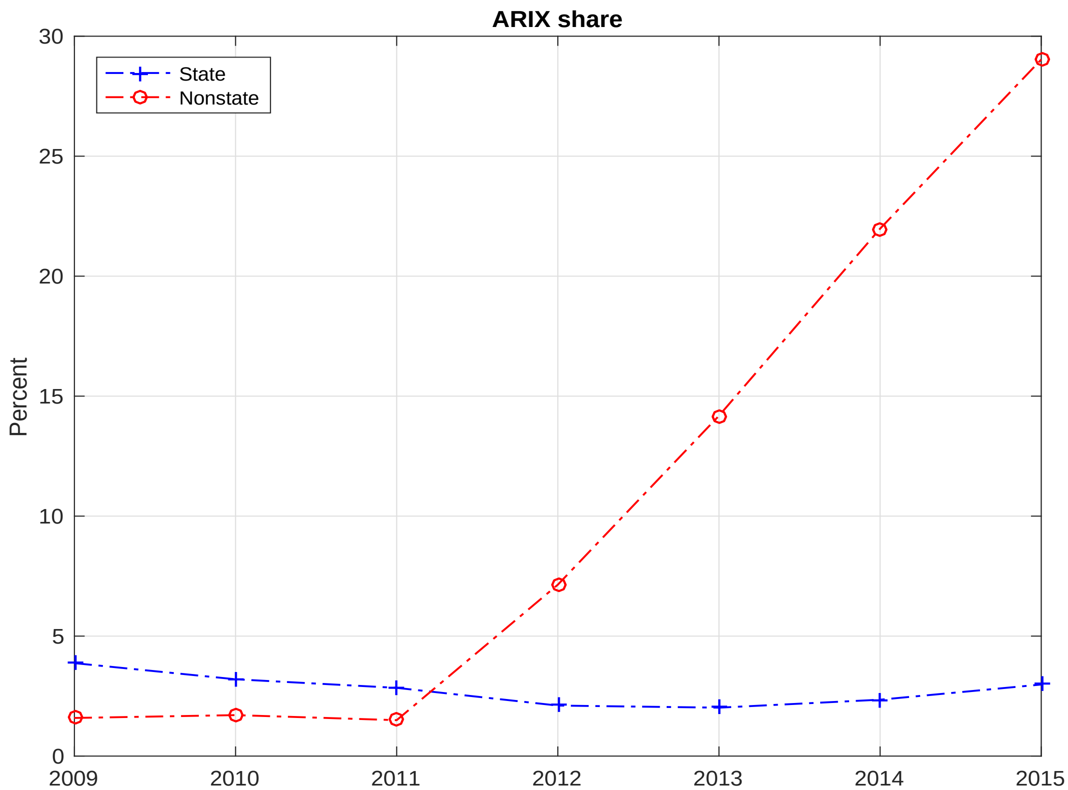

FIGURE 2. Micro data. "ARIX share" is the ratio of ARIX holdings to the sum of ARIX holdings and bank loans on the balance sheets of the 16 publicly listed commercial banks. Based on the bank asset data from these individual banks, the data are further grouped into those from state banks and from nonstate banks. Data sources: PBC and WIND.

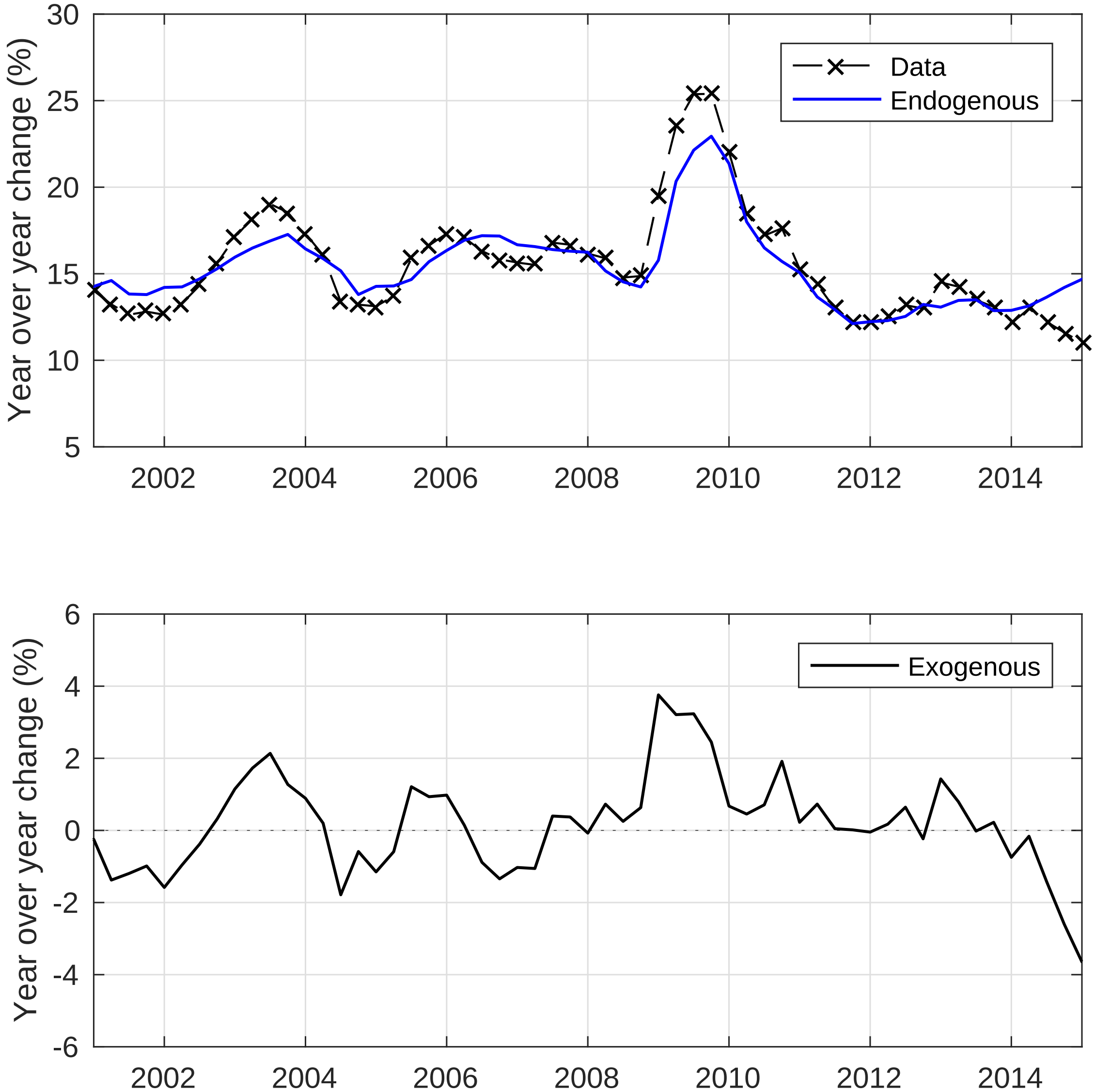

FIGURE 3. Monetary policy. Top panel: annual M2 growth rates and estimated endogenous monetary policy. The gap between the actual M2 growth path and the endogenous policy path represents exogenous M2 growth. Bottom panel: exogenous M2 growth.

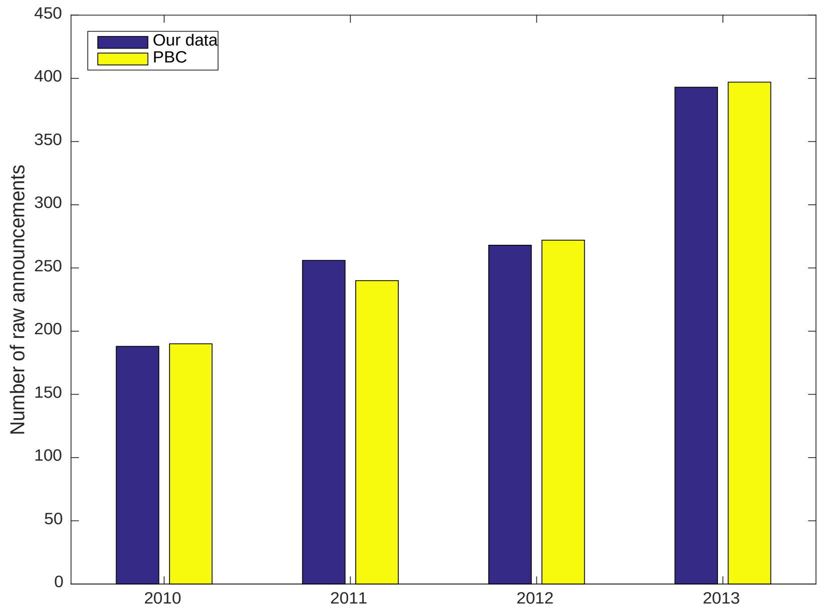

FIGURE 4. Cross-check. The number of raw announcements we collect is reported against the number published by the PBC's Financial Stability Reports. There were no numbers published by the PBC in other years than 2010-2013. Data source: PBC and WIND.

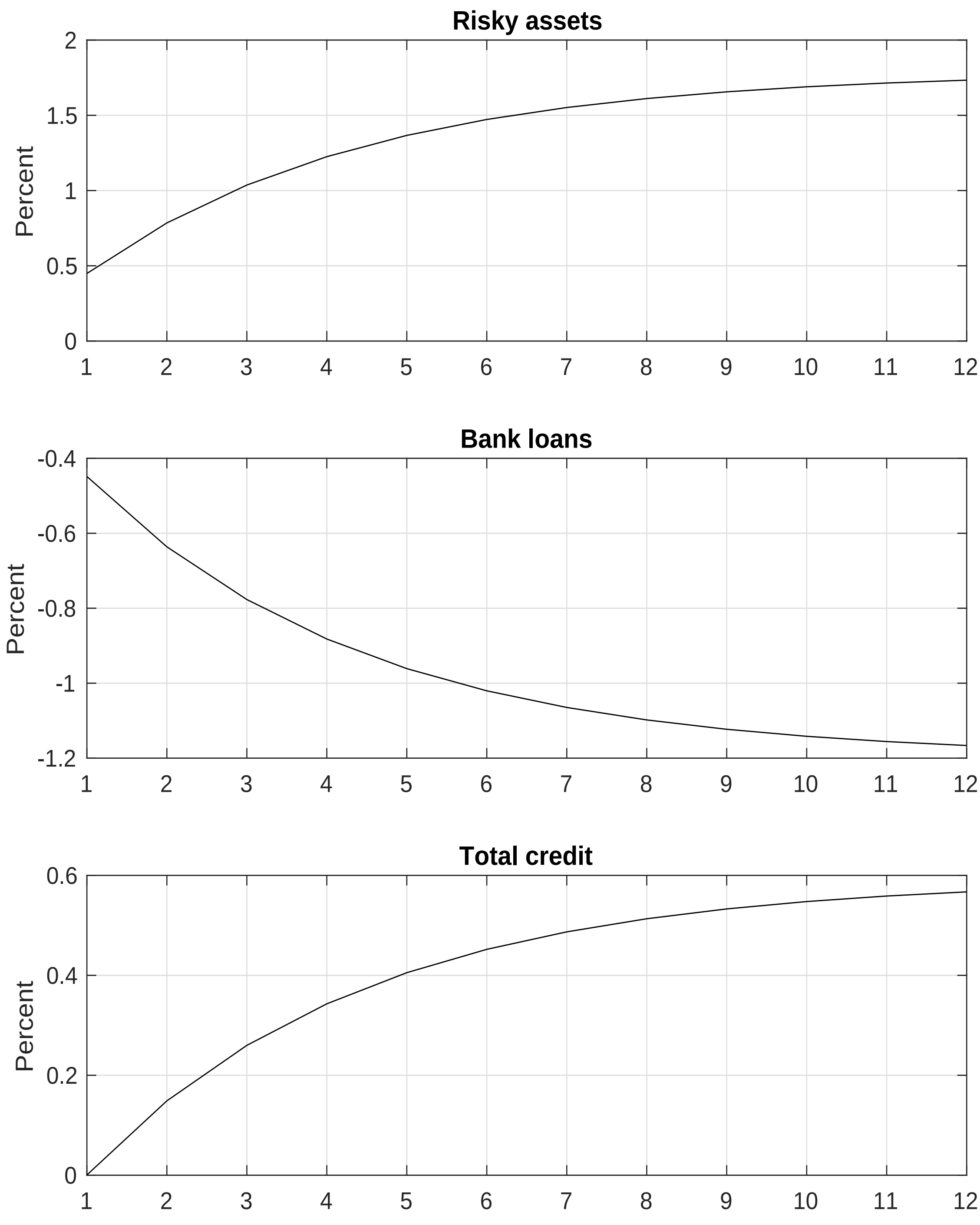

FIGURE 5. Dynamic responses to a one-standard-deviation fall of exogenous money growth in the theoretical model.

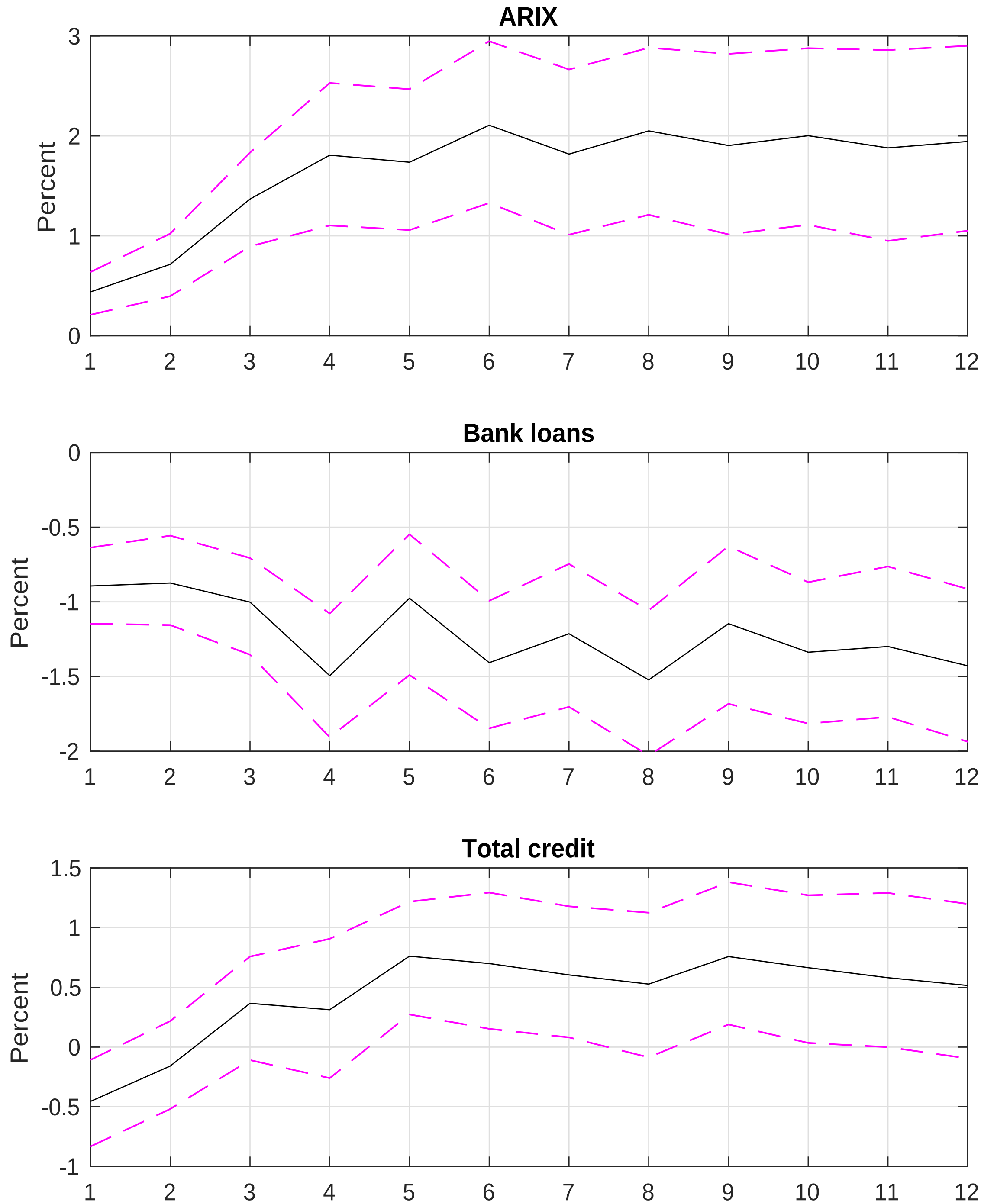

FIGURE 6. Estimated quarterly dynamic responses to a one-standard-deviation fall of exogenous M2 growth. The estimation is based on the constructed banking data. Solid lines are the maximum likelihood estimates and dashed lines represent the .68 probability bands.

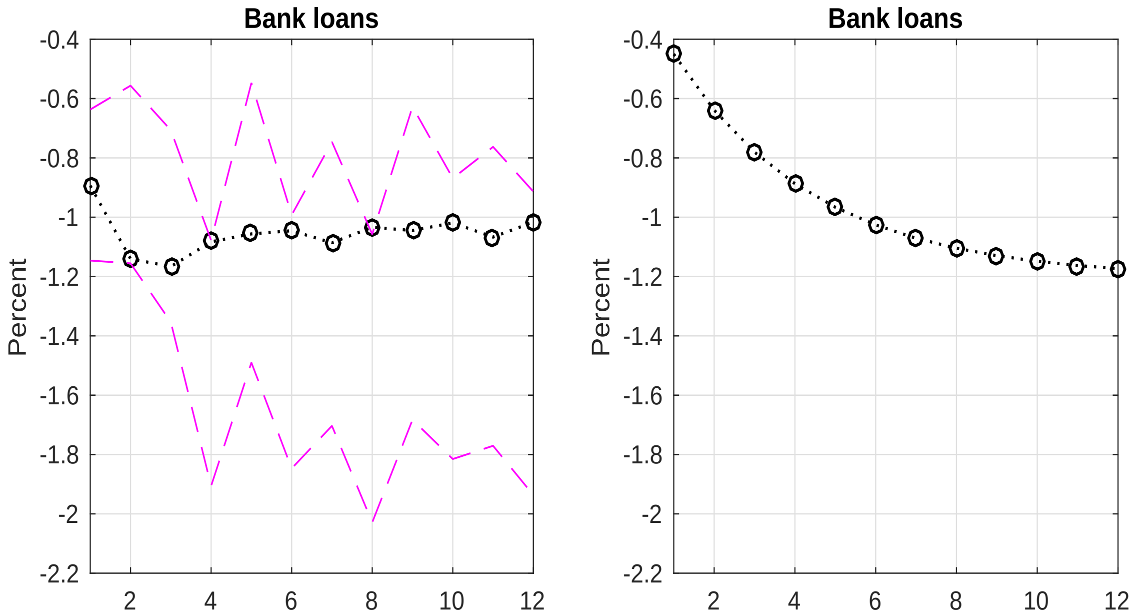

Figure 7. Dynamic responses to a one-standard-deviation fall of exogenous money growth in a counterfactual economy in which risky assets on banks' balance sheet are prohibited by law. The left panel reports the counterfactual path from the restricted panel VAR (dotted circle line) along with the .68 probability bands from the original panel VAR (dashed lines). The right panel displays the counterfactual path simulated from the theoretical model.

References

Allen, F., Y. Qian, G. Tu, and F. Yu (2015): "Entrusted Loans, A Close Look at China's Shadow Banking System," Manuscript, University of Pennsylvania.

Bianchi, J., and S. Bigio (2014): "Banks, Liquidity Management and Monetary Policy," Federal Reserve Bank of Minneapolis Research Department Staff Report 503.

Brunnermeier, M. K., M. Sockin, and W. Xiong (Forthcoming): "China's Gradualistic Economic Approach: Does It Work for Financial Development?," *American Economic Review Papers & Proceedings.*

Chang, C., K. Chen, D. F. Waggoner, and T. Zha (2016): "Trends and Cycles in China's Macroeconomy," *NBER Macroeconomics Annual 2015*, 30, 1–84, University of Chicago Press.

Chen, K., T. Xu, and T. Zha (2017): "Optimal Monetary Policy Applicable to China," Unpublished Manuscript.

Christiano, L. J., M. S. Eichenbaum, and C. L. Evans (1996): "The Effects of Monetary Policy Shocks: Some Evidence from the Flow of Funds," *Review of Economics and Statistics*, 78(1), 16–34.

——— (1999): "Monetary Policy Shocks: What Have We Learned and To What End?," in *Handbook of Macroeconomics*, ed. by J. B. Taylor, and M. Woodford, vol. 1A, pp. 65–148. North-Holland, Amsterdam, Holland.

——— (2005): "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy*, 113, 1–45.

Christiano, L. J., and D. Ikeda (2013): "Leverage Restrictions in a Business Cycle Model," Manuscript, Northwestern University.

Dang, T. V., H. Wang, and A. Yao (2015): "Shadow Banking Modes: The Chinese versus US System," Columbia University Working Paper.

Gertler, M., and N. Kiyotaki (2010): "Financial Intermediation and Credit Policy in Business Cycle Analysis," in *Handbook of Monetary Economics*, ed. by B. M. Friedman, and M. Woodford, vol. 3, chap. 11, pp. 547–599. Elsevier B. V.

Hachem, K., and Z. M. Song (2016): "Liquidity Regulation and Unintended Financial Transformation in China," NBER Working Paper No. 21880.

Hamilton, J. D. (1994): *Times Series Analysis*. Princeton University Press, Princeton, NJ.

He, Q., L. Lu, and S. Ongena (2015): "Who Gains from Credit Granted Between Firms? Evidence from Inter-corporate Loan Announcements Made in China," Bank of Finland Discussion Paper 1.

Jiménez, G., S. Ongena, J.-L. Peydró, and J. Saurina (2014): "Hazardous Times for Monetary Policy: What do Twenty-three Million Loans Say About the Impact of Monetary Policy on Credit Risk-Taking?," *Econometrica*, 82(2), 463–505.

Kahneman, D., and A. Tversky (1979): "Prospect Theory: an Analysis of Decision Under Risk," *Econometrica*, 47(2), 263–291.

Kashyap, A. K., and J. C. Stein (2000): "What Do a Million Observations on Banks Say About the Transmission of Monetary Policy?," *American Economic Review*, 90, 407–428.

Leeper, E. M., C. A. Sims, and T. Zha (1996): "What Does Monetary Policy Do?," *Brookings Papers on Economic Activity*, 2, 1–78.

Qian, X., and X. Li (2013): "Operating Mechanism and Guarding Financial Risks of Entrusted Loans: Stemming from the Public Data of Listed Companies in China from 2004-2013," *Enterprise Development (in Chinese)*, 10, 125–134.

Romer, C. D., and D. H. Romer (2004): "A New Measure of Monetary Shocks: Derivation and Implications," *American Economic Review*, 94(4), 1055–1084.

Rotemberg, J. J., and M. Woodford (1997): "An Optimization-Based Econometric Framework for the Evaluation of Monetary Policy," in *NBER Macroeconomics Annual*, ed. by B. S. Bernanke, and J. J. Rotemberg, pp. 297–346. The MIT Press, Cambridge (MA).

Rubio-Ramírez, J. F., D. F. Waggoner, and T. Zha (2010): "Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference," *Review of Economic Studies*, 77, 665–696.

Sheng, A., C. Edelmann, C. Sheng, and J. Hu (2015): "Bringing Light upon The Shadow—A Analysis of China's Shadow Banking," Discussion paper, Oliver Wyman Management Consulting Company and Fund Global Institute, Research Report (in Chinese).

Sims, C. A. (1980): "Macroeconomics and Reality," *Econometrica*, 48(1), 1–48.

Sims, C. A., and T. Zha (2006): "Were There Regime Switches in U.S. Monetary Policy?," *American Economic Review*, 96, 54–81.

Taylor, J. B. (1993): "Discretion versus Policy Rules in Practice," in *Carnegie-Rochester Conference Series on Public Policy*, ed. by A. H. Meltzer, and C. I. Plosser, vol. 39, pp. 195–214. Amsterdam.

——— (2000): "Using Monetary Policy Rules in Emerging Market Economies," Unpublished Manuscript, Standford University.

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The materials after this page are supplemental appendices.

In the appendices below, all labels for equations, tables, definitions, and propositions begin with S, standing for *supplement* to the main text.

Appendix A. Details of the data construction

We read all the raw announcements of entrusted lending between nonfinancial firms from 2009 to 2015. One main reason we must read raw announcements line by line is that there were often multiple announcements made by an individual lender for the same transaction. In such cases, we manually combine these raw announcements into one announcement. Some announcements were for repayment of entrusted loans. To avoid double counting, we drop those announcements because the same transaction was recorded in previous announcements. Another reason for reading through raw announcements relates to the nuances of the Chinese language in expressing how the transaction of an entrusted loan was conducted. For some announcements, the amount of a particular entrusted loan was planned but never executed or executed with a different amount in a later announcement. During the loan planning stage, the name of the trustee was often omitted from an announcement. If we had not been careful about these announcements, we would have exaggerated the number and the amount of entrused loans collected. A fourth reason is that we must remove announcements about loans that had already been paid to avoid duplication. The announcements organized this way are the ones we use for the paper and we call them "announcements" rather than "raw announcements" with the understanding that those announcements have been already cleaned up from raw announcements.

Our data construction involves extracting the transaction data, manually, from our cleaned-up announcements of new loans. For each announcement, we record the lender and the borrower. Because the same transaction may be announced by both lender and borrower, two announcements may correspond to only one transaction. In such cases we manually compare both announcements to ascertain the accuracy of our processed data set.[37] After the comparison, we merge the two announcements for the same transaction into one unique observation. It turns out that the number of such announcements is only one for the period 2009-2015. Subtracting this double-counted announcement gives us 1379 unique observations. The timing of the observation corresponds to the exact timing of the transaction and thus does not necessarily correspond to the time when an announcement was made.

[37]We find that the lender's announcement typically contains more information than the borrower's.

The transaction data constructed from these unique observations are used for our empirical analysis.

The announcement data we construct is the most important source for off-balance-sheet activities. These data are are also used by the PBC in their financial stability reports and we cross-check our data with these reports. We read through more than a thousand relevant announcements line by line and cross-check the data from different sources to decipher the reporting nuances in the Chinese language, eliminate redundant and duplicated observations, and obtain accurate and comprehensive data for entrusted lending facilitated by banks and nonbank trustees. During this construction process that has taken us several years to complete and is still continuing to refine the dataset, we identify lending firms, borrowing firms, and, most important of all, trustees that facilitated entrusted lending between nonfinancial firms. Our subsequent empirical and theoretical work shows how and why, among different types of trustees, banks behaved differently from nonbank trustees and how and why, among banks, nonstate banks behaved differently from state banks. Our data sample begins in 2009 and ends in 2015. There are relatively few observations before 2009. China's shadow banking accelerated during the period of monetary tightening after the government's 2008-2009 unprecedented economic stimulus and was heavily regulated from the beginning of 2016 forward.

Table S1 shows how we arrive at the number of unique observations without duplicated announcements. Thus, the number of unique observations must equal the sum of "NLA" and "NBA" minus "NLABA" (the number of duplications). Clearly, the number of announcements made by lenders was considerably greater than the number of announcements made by borrowers, a fact that is consistent with the legal requirement that listed lending firms must reveal entrusted-loan transactions.

Table S2 shows a breakdown of transactions by different types of trustees and different types of loans. Affiliated loans involve both lending and borrowing firms within the same conglomerate. While most entrusted loans facilitated by nonbank trustees were affiliated ones, a majority of affiliated loans were channeled by banks, a fact that is not well known. As one can see from the table, no matter whether entrusted loans were affiliated or not, small banks facilitated more transactions than large banks, and large banks faciliated more transactions than nonbank trustees. Thus, banks played a critical role in facilitating both affiliated and non-affiliated entrusted loans.

Nonstate banks accounted for the largest fraction of both loan transactions and loan volume (amount). Table S3 shows that the number of entrusted-loan transactions facilitated by nonstate banks took 50% of the total number and the amount of entrusted loans 47% of the total amount. Thus, nonstate banks played a special role in funneling entrusted loans.

Table S1. Number of announcements made by lenders and borrowers

Description	NLA	NBA	NLABA	Total
Number of observations	1152	228	1	1379

Note. NLA: number of lenders' announcements; NBA: number of borrowers' announcements; NLABA: number of the same transactions announced by both lenders and borrowers.

Table S2. A breakdown of the total number of transactions by types of trustees and types of loans

Description	NBTs	State banks	Nonstate banks	Total
Non-affiliated loans	5	11	255	376
Affiliated loans	304	256	443	1003
Total	309	372	698	1379

Note. NBTs: nonbank trustees.

Table S3. Proportions (%) of loan transactions and loan volume according to different types of trustees

Description	NBTs	State banks	Nonstate banks	Total
Number of transactions	22.41	26.98	50.62	100
Loan volume	28.73	24.03	47.24	100

Note. NBTs: nonbank trustees.

For on-balance-sheet data, we construct the bank asset dataset using banks' annual reports downloaded from the WIND database (the data information system created by the Shanghai-based company called WIND Co. Ltd., the Chinese version of Bloomberg). Each annual report contains more than a hundred pages for us to read through and collect the relavent quarterly information. The Bankscope database (a comprehensive, global database of banks financial statements, ratings, and intelligence, provided by Bureau Van Dijk) is also used for obtaining other balance-sheet information such as capital adequacy ratio. We organize all these data into a quarterly panel dataset from 2009Q1 to 2015Q4.

Appendix B. Solving the one-period model

In the asset pricing equation represented by (9), the left hand side is the expected return on risky investments, adjusted for the risk premium due to the default risk. The right hand side is the expected return on safe bank loans, adjusted for the expected regulation cost and regulation risk premium. The risk premium is always positive. The expected regulation cost, also positive, is the expected marginal cost associated with the lending amount B subject to the LDR regulation. This term captures the cost of recovering deposit shortfalls.

The necessary and sufficient condition for (9) to hold is

$$E_\varepsilon(R^I) > R^B - E_\omega\left[R_b^x(w_b, w_d; \omega)\right] - \frac{\mathrm{Cov}_\omega\left(R_b^x, E_\varepsilon(R^E)^{-\gamma}\right)}{E_\varepsilon\left[E_\omega(R^E)^{-\gamma}\right]}. \tag{S1}$$

Equation (S1) states that the expected return on risky investments is greater than the effective return on bank loans such that the bank has an incentive to invest in risky assets, even if the bank is risk-averse. Thus, it is optimal for the bank to increase the share of risky assets in its total investment on the asset side of the balance sheet.

To obtain an intuition of the mechanism through which monetary tightening affects banks' holdings of shadow banking products, we consider the case where the bank is risk neutral ($\gamma = 0$) so that a closed form solution can be derived. In this case, both default and regulation risk premia drop off equation (9).

Proposition S1. Under the assumption ($\gamma = 0$), we have (i) $\partial \frac{I^r}{I^r+B} / \partial \varepsilon_m < 0$ and (ii) $\frac{\partial I^r}{\partial \varepsilon_m} < 0$.

Proof. We first establish that the share of risky assets in total assets, $\frac{I^r}{I^r+B}$, increases as ε_m decreases. Substituting

$$0 = w_c + w_i + w_b - w_d,$$

into

$$E_{\omega,\varepsilon} \frac{\left[w_c + R^I w_i + R^B w_b - R^D w_d - R^x\right]^{1-\gamma}}{1-\gamma} \tag{S2}$$

transforms the optimization problem to

$$\max_{\{w_c, w_i, w_b, w_d\}} \left\{E_{\omega,\varepsilon}\left[\left(-(R^B-1)w_c + (R^I - R^B)w_i - (R^B - R^D)w_d - R^x(w_b, w_d; \omega)\right)\right]\right\} \tag{S3}$$

subject to $w_d \leq \kappa$ (with the Lagrangian multiplier ϕ_d) and $w_c \geq 0$ (with the Lagrangian multiplier ϕ_c). The first order condition with respect to w_c gives

$$\phi_c - (R^B - 1) = 0.$$

It follows from $R^B > 1$ that $\phi_c > 0$, which implies that $w_c = 0$.

Substituting $w_c = 0$ and $w_i = -w_b + w_d$ into (S2) reduces the optimization problem to

$$\max_{\{w_b, w_d\}} E_{\omega,\varepsilon}\left[(R^B - R^I)w_b + (R^I - R^D)w_d - R^x(w_b, w_d; \omega)\right] \tag{S4}$$

subject to $w_d \le \kappa$ and $\phi_d(\kappa - w_d) = 0$. The first order condition with respect to w_b gives

$$E_\varepsilon\left[R^B - R^I\right] - E_\omega\left[R^x_b(w_b, w_d; \omega)\right] = 0,$$

where

$$R^x_b(w_b, w_d; \omega) = \frac{\partial R^x(w_b, w_d; \omega)}{\partial w_b},$$

which leads to the asset pricing condition between safe loans and risky investment:

$$R^B - \underbrace{E_\omega\left[R^x_b(w_b, w_d; \omega)\right]}_{\text{expected regulation cost}} = E_\varepsilon(R^I).$$

The left hand side of the above equation represents the *effective* return on safe loans, expressed as the bank lending rate minus the expected regulation cost. The right hand side is the expected return on risky investments. The expected regulation cost is the expected marginal cost of meeting the LDR ceiling. It is straightforward to show that this regulation cost is

$$\begin{aligned} E_\omega\left[R^x_b(w_b, w_d; \omega)\right] &= r^b \times \underbrace{\text{Prob}\left(\omega \ge 1 - w_b/\left(w_d\theta\right)\right)}_{\text{regulation risk}} \\ &= r^b \frac{w_b/\left(w_d\theta\right)}{1-\mu}. \end{aligned}$$

Hence, the no-arbitrage condition becomes

$$R^B - \frac{w_b/\left(w_d\theta\right)}{1-\mu} r^b = E_\varepsilon(R^I). \tag{S5}$$

By definition,

$$\frac{q^r I^r}{q^r I^r + qB} = \frac{w_i}{w_i + w_b} = 1 - \frac{w_b}{w_d}.$$

To prove that the share of risky assets increases when ε_m falls is equivalent to prove that $\frac{\partial(w_b/w_d)}{\partial\mu} < 0$. Taking the total derivative of $(S5)$ gives $\frac{dw_b/w_d}{d\mu} = -\frac{w_b/w_d}{1-\mu} < 0$. Intuitively, when μ rises as a result of a fall of ε_m, the regulation cost $E_\omega\left[R^x_L\left(L, 1; \omega\right)\right]$ will increase. It follows from $(S5)$ that the effective return on safe loans will decline *relative to* the effective return on risky investments. Hence, w_b/w_d falls, implying that $\frac{q^r I^r}{q^r I^r + qB}$ and $\frac{I^r}{I^r + B}$ increase.

Defining $L = \frac{w_b}{w_d}$ as the LDR, we rewrite the bank's portfolio choice problem (S4) as

$$\max_{L, w_d} E_{\omega,\varepsilon}\left[w_d\left[\left(R^I - R^D\right) - \left(R^I - R^B\right)L - R^x\left(L, 1; \omega\right)\right]\right]$$

subject to $w_d \leq \kappa$. The first order condition with respect to L is

$$R^B - \underbrace{E_\omega\left[R_L^x\left(L,1;\omega\right)\right]}_{\text{expected liquidity cost}} = E_\varepsilon\left(R^I\right), \tag{S6}$$

where

$$\begin{aligned} R_L^x\left(L,1;\omega\right) &= \frac{\partial R^x\left(L,1;\omega\right)}{\partial L}, \\ E_\omega\left[R_L^x\left(L,1;\omega\right)\right] &= r^b \times \underbrace{\text{Prob}\left(\omega \geq 1 - L/\theta\right)}_{\text{regulation risk}}. \end{aligned}$$

This asset pricing equation with respect to L is an alternative expression of the previous asset pricing equation with respect to w_b (i.e.,equation (9) in the main text). As one will see, this alternative expression makes our proof more transparent. We establish the following lemma.

Lemma S1. With the low deposit rate such that

$$R^D < R^B - r^b, \tag{S7}$$

the credit constraint $w_d \leq \kappa$ is always binding.

Proof. We begin with

$$E_\omega\left[R^x\left(L,1;\omega\right)\right] = r^b \times L \times \text{Prob}\left(\omega \geq 1 - L/\theta\right) \tag{S8}$$

and

$$E_\omega\left[R_L^x\left(L,1;\omega\right)\right] = r^b \times \text{Prob}\left(\omega \geq 1 - L/\theta\right). \tag{S9}$$

Define the leverage return as

$$R^L = \left(R^I - R^D\right) - \left(R^I - R^B\right)L - R^x\left(L,1;\omega\right).$$

We have

$$E_{\omega,\varepsilon}\left[R^L\left(L;\omega,\varepsilon\right)\right] = E_\varepsilon\left[\left(1-L\right)\left(R^I - R^D\right) + L\left(R^B - R^D\right)\right] - E_\omega\left[R^x\left(L,1;\omega\right)\right] \tag{S10}$$

The first order condition with respect to w_d is

$$E_{\omega,\varepsilon}\left[R^L\left(L;\omega,\varepsilon\right)\right] = \phi^d \tag{S11}$$

The left hand side is the effective expected return on leverage, adjusted for the expected regulation cost.

Proving that the credit constraint is binding is equivalent to proving that the effective expected return on leverage is positive. That is, we need to show

$$E_{\omega,\varepsilon}\left[R^L(L;\omega,\varepsilon)\right]>0,$$

which implies that $\phi^d>0$.

Combining equation $(S8)$ with equation $(S9)$ leads to

$$E_\omega\left[R^x(L,1;\omega)\right]=LE_\omega\left[R_L^x(L,1;\omega)\right]. \tag{S12}$$

Substituting $(S12)$ into the left side of $(S11)$ and reordering, we have

$$\begin{aligned}E_{\omega,\varepsilon}\left[R^L(L;\omega,\varepsilon)\right]&=(1-L)\,E_\varepsilon\left(R^I\right)+L\left\{R^B-E_\omega\left[R_L^x(L,1;\omega)\right]\right\}-R^D\\&=R^B-E_\omega\left[R_b^x(L,1;\omega)\right]-R^D,\end{aligned}$$

where the second equality comes from the asset pricing condition $(S6)$. It follows from

$$E_\omega\left[R_b^x(L,1;\omega)\right]=r^b\,\mathrm{Prob}\left(\omega\geq1-L/\theta\right)<r^b$$

and $(S9)$ that

$$R^B-r^bE_\omega\left[R_b^x(L,1;\omega)\right]>R^B-r^b.$$

Given (S7), we have

$$E_{\omega,\varepsilon}\left[R^L(L;\omega,\varepsilon)\right]>0.$$

Hence, $\widetilde{\phi}^d>0$ or $\phi^d>0$. □

We now prove that $\frac{\partial I^r}{\partial\varepsilon_m}<0$. Because $q^rI^r=w_i$, it is sufficient to prove that $\partial w_i/\partial\mu>0$. Since $w_i+w_b=w_d$, we have $\frac{w_i}{w_i+w_b}=\frac{w_i}{w_d}=\frac{w_i}{\kappa}$. Therefore, $\partial\frac{q^rI^r}{q^rI^r+q\widetilde{B}}/\partial\mu>0$ gives $\partial w_i/\partial\mu>0$. With $\partial w_i/\partial\mu>0$, we have $\partial\left(q^rI^r\right)/\partial\mu>0$ or $\partial\left(I^r\right)/\partial\mu>0$, implying that $\frac{\partial I^r}{\partial\varepsilon_m}<0$.

□

Appendix C. GDP target as a lower bound for quantity-based monetary policy

The monetary policy goal is to support GDP growth beyond its annual target while keeping CPI inflation stable. According to the Chinese law, the PBC must formulate and implement monetary policy under the leadership of the State Council. Since 1988, GDP growth target has been specified in the State Council's Report on the Work of Government (RWG). The Central Economic Work Conference organized jointly by the State Council and the Central Committee of Communist Party of China (CPC), typically held in December of each year, decides on a particular target value of GDP growth for the coming year. Once the target is decided, it will be formally announced by the Premier of the State Council as part of the RWG to be presented to the NPC's annual session during the next spring.[38]

The central government's GDP growth target for a particular year is a lower bound of GDP growth for that year. Because of its strongest desire of maintaining social stability, the government views such a lower bound as a crucial factor in keeping unemployment low by means of economic growth. For example, when explaining why the 6.5% target was a targeted lower bound for GDP growth during a press conference for the NPC's 2016 annual assembly, Xu Shaoshi (Head of the National Development and Reform Commission (NDRC) under the State Council) remarked that "The floor is employment, the floor has another implication, which is economic growth. Therefore, we set this lower bound [of GDP growth]." The central government's GDP growth target as a lower bound is an overarching national priority for every government unit, especially for the PBC.

Important decisions on changing monetary policy are made by the Politburo consisting of General Secretary of CPC, Premier of the State Council, and other top central government officials including the PBC governor. Unlike the Federal Reserve System, therefore, the PBC is not independent of other central government units and its decision on quarterly changes of monetary policy is severely constrained by its obligation of meeting the ultimate goal of surpassing targeted GDP growth and by the central government's view about how monetary policy should be conducted. For example, the 2009Q1 MPR states: "In line with the overall arrangements of the CPC Central Committee and the State Council, and in order to serve the overall objective of supporting economic growth, expanding domestic demand, and restructuring the economy, the PBC implemented a moderately loose monetary policy, adopted flexible and effective measures to step up financial support for economic growth, and ensured that aggregate money and credit supply satisfy the needs of economic development."

Appendix D. Conventional monetary policy rule specifications

As discussed in the text, there is no applicable concept of potential GDP for emerging-market economies like China. Nonetheless, if one wishes to estimate conventional monetary policy rules mechanically with the Chinese data, one could obtain $\bar{x}_t$ using either the HP filtered series with the smoothing parameter set at 1600 for the quarterly series or the fitted log-linear trend. We estimate the following conventional monetary policy rule using "output

[38]See the link http://www.gov.cn/test/2006-02/16/content_200875.htm for the State Council's RWG since 1954.

Table S4. Estimation of conventional monetary policy rules for M2 growth

	HP filtered			Log-linear detrended			$\bar{g}_{x,t} = g^*_{x,t}$		
Coefficient	Estimate	SE	p-value	Estimate	SE	p-value	Estimate	SE	p-value
γ_m	0.607***	0.095	0.000	0.514***	0.096	0.000	0.568***	0.093	0.000
γ_π	−0.551***	0.191	0.005	−0.628***	0.155	0.000	−0.554***	0.159	0.000
γ_x	0.131	0.142	0.358	0.085***	0.032	0.009	0.094	0.063	0.138

Note. "SE" stands for standard error. The three-star superscript indicates a 1% significance level.

gap" constructed from one of the these trended series:

$$g_{m,t} = \gamma_0 + \gamma_m g_{m,t-1} + \gamma_\pi(\pi_{t-1} - \pi^*) + \gamma_x(g_{x,t-1} - \bar{g}_{x,t-1}) + \sigma_m \varepsilon_{m,t}. \tag{S13}$$

For comparison, the inflation and output growth variables on the right-hand side are lagged one period to be consistent with the timing specification of practical monetary policy represented by equation (10).

Table S4 reports the regression results. As one can see, the estimated coefficient of "output gap" is statistically insignificant for the HP filtered approach or carries a wrong sign for the log-linear detrending method. The positive sign of output coefficient implies destabilizing monetary policy. These results confirm our argument that the standard concept of output gap is inappropriate for understanding China monetary policy.

We also estimate the conventional monetary policy rule (S13) using $\bar{g}_{x,t} = g^*_{x,t}$, which is consistent with optimal monetary policy under the output loss function represented by (**??**). The estimates are also reported in Table S4. As seen in the table, their magnitude is remarkably similar to that when potential GDP is approximated by either HP filter or log-linear trend. What is common across the three cases (HP filter, log-linear trend, and $\bar{g}_{x,t} = g^*_{x,t}$) is that monetary policy is strongly anti-inflation. But the output coefficient for the $\bar{g}_{x,t} = g^*_{x,t}$ case has a wrong sign and is statistically insignificant.

Another conventional specification for monetary policy is the widely-used empirical Taylor rule for many developed economies as described in Rotemberg and Woodford (1997):

$$R_t = \alpha_0 + \alpha_R R_{t-1} + \alpha_\pi(\pi_t - \pi^*) + \alpha_x(x_t - \bar{x}_t) + \varepsilon_{R,t}, \tag{S14}$$

where R_t is the (net) nominal interest rate. Table S5 reports the estimated results with various short-term market interest rates. As one can see, although the persistence parameter

α_R is statistically significant, α_π is statistically insignificant at a 10% level for all four cases while α_x is statistically significant only at a 10% level for three out of four interest rates. These results imply that monetary policy does not care at all about inflation pressures, contradictory to the MPRs (the central bank's own reports). Worse than this implication, these results are unstable as they are sensitive to how potential output is computed. When log-linear trend is applied to output as potential GDP and the 7-day Repo rate is used, for example, the output coefficient becomes statistically insignificant at a 49% significance level but the inflation coefficient is now significant at a 1.6% significance level. When lagged output gap and inflation are used as regressors instead of the contemporaneous counterparts, α_π is often statistically significant at a 1% significance level but α_x is statistically insignificant at a 10% significance level, a result similar to the conventional monetary policy rules for M2 growth. Clearly, the results for the interest rate rules are all over the map, depending on which interest rate, which potential output, or which variable (lagged or contemporaneous) is used.

Such unstable and contradictory results are not surprising; they only confirm our argument that Chinese financial markets are yet to be fully developed and that the standard interest rate rule may be incompatible with the central government's ultimate target of *real GDP growth*. This target is achieved by carefully planning M2 growth to support the central government's strategy of allocating medium and long term bank credits to investment in heavy industries. The standard interest rate rule (S14) does not take into account these key institutional factors.

Appendix E. Solving the dynamic equilibrium model

We begin with the detailed description of the model. Some essential parts of the model are based on Bianchi and Bigio (2014). We then define the competitive equilibrium and proposes a numerical algorithm for solving the model.

E.1. **Model details.**

E.1.1. *Lending stage.* The law of motion for bank loans evolves as

$$B_t = \delta \tilde{B}_t + S_t, \tag{S15}$$

where $\tilde{B}_t = B_{t-1}$ represents outstanding bank loans at the beginning of t or at the end of $t-1$ and $(1-\delta)\tilde{B}_t$ represents a fraction of loans that is retired and S_t represents new *safe*

Table S5. Estimation of the widely-used Taylor rule

	1-day Repo			7-day Repo		
Coefficient	Estimate	SE	p-value	Estimate	SE	p-value
α_R	0.706***	0.078	0.000	0.770***	0.063	0.000
α_π	0.007	0.103	0.948	0.144	0.098	0.144
α_x	0.139*	0.078	0.079	0.147*	0.076	0.057
	1-day Chibor			7-day Chibor		
Coefficient	Estimate	SE	p-value	Estimate	SE	p-value
α_R	0.707***	0.078	0.000	0.779***	0.063	0.000
α_π	−0.010	0.101	0.919	0.149	0.096	0.123
α_x	0.132*	0.076	0.085	0.117	0.074	0.119

Note. "SE" stands for standard error. The one-star superscript indicates a 10% significance level and the three-star superscript a 1% significance level.

loans made by the bank to comply with the safe-loan regulation. Denoting cash by C. We have

$$C_t = \tilde{C}_t + \varphi_t, \tag{S16}$$

where $\tilde{C}_t$ represents cash holdings at the beginning of t and φ_t represents additional cash holdings chosen by the bank at time t.

At the beginning of period t, the bank's balance-sheet constraint is

$$\tilde{D}_t + \mathscr{E}_t = \underbrace{\tilde{C}_t + (1-\delta)\tilde{B}_t}_{\text{new cash}} + q_t \delta \tilde{B}_t, \tag{S17}$$

where $\tilde{D}_t$ denotes deposits and $\mathscr{E}_t$ the bank's equity or capital. Table S6 or Table S7, below, represents the balance sheet in which the left-hand-side column indicates the asset side and the right-hand-side column the liability side.

Table S6. Balance sheet at the beginning of the period

Asset	Liability
Cash $\left(\tilde{C}_t + (1-\delta)\tilde{B}_t\right)$ Loans $\left(q_t \delta \tilde{B}_t\right)$	Deposits $\left(\tilde{D}_t\right)$ Equity $(\mathscr{E}_t)$

Table S7. Balance sheet at the beginning of the period

Asset	Liability
Cash $\left(\tilde{C}_t\right)$	Deposits $\left(\tilde{D}_t - (1-\delta)\tilde{B}_t\right)$
Loans $\left(q_t \delta \tilde{B}_t\right)$	Equity $(\mathscr{E}_t)$

The bank's balance-sheet constraint, after choosing C_t (or φ_t), I_t^r, B_t (or S_t), D_t, and dividend DIV_t, is

$$D_t/R_t^D + \mathscr{E}_t - \mathrm{DIV}_t = C_t + q_t^r I_t^r + qB_t, \tag{S18}$$

which leads to

$$\underbrace{D_t/R_t^D}_{\text{deposits}} + \underbrace{\mathscr{E}_t - \mathrm{DIV}_t + (1-q_t^r)I_t^r + (1-q_t)B_t}_{\text{equity}} = \underbrace{\tilde{C}_t}_{\text{cash}} + \underbrace{I_t^r + B_t}_{\text{assets}}, \tag{S19}$$

where R_t^D is the deposit rate. The balance sheet now becomes Table S8.

Table S8. Balance sheet after the bank's optimization

Asset	Liability
Cash (C_t)	Deposits D_t/R_t^D
Risky assets I_t^r	Equity $\mathscr{E}_t - \mathrm{DIV}_t +$ $(1-q_t^r)I_t^r + (1-q_t)B_t$
Safe loans B_t	

Substituting (S15), (S16), and (S17) into (S19) gives us the flow-of-funds constraint as

$$\underbrace{D/R_t^D - \tilde{D}_t}_{\Delta\text{deposits}} + \underbrace{(1-q_t^r)I_t^r + (1-q_t)S_t - \mathrm{DIV}_t}_{\Delta\text{equity}} = \underbrace{\varphi_t + I_t^r + \left(B_t - \tilde{B}_t\right)}_{\Delta\text{assets}}. \tag{S20}$$

E.1.2. *Balancing stage.* At the balancing stage, the amount of bank loans is subject to the LDR regulation as

$$q_t B_t \leq \theta \frac{(1-\omega_t)\, B_t}{R_t^D},$$

where θ is the LDR ceiling set by the PBC. Denote

$$x_t = q_t B_t - \theta \frac{(1-\omega_t)\, D_t}{R_t^D} \tag{S21}$$

and

$$\chi(x_t) = \begin{cases} r^b x_t & \text{if } x_t \geq 0 \\ 0 & \text{if } x_t < 0 \end{cases},$$

where $r^b > 0$ is the extra cost of obtaining additional deposits x_t.

If default on I_t^r (risky assets) does not occur (in the no-default state), one can derive from equation (S19) the balance-sheet constraint for the bank as

$$\underbrace{D_t/R_t^D - I_t^r}_{\text{debt reduction}} + \underbrace{\mathscr{E}_t - \text{DIV}_t + (1-q_t^r)I_t^r + (1-q_t)B_t}_{E_t\text{: equity}} = \underbrace{C_t + B_t}_{\text{assets}}. \tag{S22}$$

If I_t^r is defaulted (in the default state), the bank's balance-sheet constraint becomes

$$\underbrace{D_t/R_t^D - \phi I_t^r}_{\text{liabilities}} + \underbrace{\mathscr{E}_t - \text{DIV}_t - (1-\phi)\, I_t^r + (1-q_t^r)I_t^r + (1-q_t)B_t}_{\tilde{E}_t\text{:equity}} = \underbrace{C_t + B_t}_{\text{assets}}. \tag{S23}$$

where $0 \leq \phi < 1$, representing the recovering rate of risky assets in the default state. Since $\tilde{E}_t = E_t - (1-\phi)\, I_t^r$, the bank's equity is reduced in the default state. At the end of period t (the beginning of period $t+1$), the stock variables are balanced as

$$\tilde{D}_{t+1} = D_t(1-\omega_t) + \chi(x_t) - \varepsilon_t R_{t+1}^D I_t^r, \tag{S24}$$

$$\tilde{C}_{t+1} = C_t - \omega_t D_t, \tag{S25}$$

$$\tilde{B}_{t+1} = B_t, \tag{S26}$$

where

$$\varepsilon_t = \begin{cases} 1 & \text{with probability } 1 - p^r \text{ (the no-default state)} \\ \phi & \text{with probability } p^r \text{ (the default state)} \end{cases}.$$

E.1.3. *The bank's optimization problem.* The bank's optimization problem is complex. To maintain tractability, we simplify the liability side behavior as it is not a focus of our model. The asset side story, motivated by China's institutional arrangements and our empirical evidence, is a central piece of our theory. To avoid notational glut and make our theory transparent, we omit the time subscript whenever no confusion arises. The optimizing behavior at the lending stage can thus be described as

$$V^l\left(\tilde{C}, \tilde{B}, \tilde{D}; \varepsilon_m\right) = \max U(\text{DIV}) + E_{\omega,\varepsilon}\left[V^b(C, B, D; \varepsilon_m)\right],$$

where V^l is the value function at the lending stage, V^b is the value function at the balancing stage, and $E_{\omega,\varepsilon}$ is the mathematical expectation with respect to the (ω, ε) measure. The bank takes $\varepsilon_m, \mu, r^b, q, q^r$, and $R^D\}$ as given when solving its problem. By choosing $(\mathrm{DIV}, \varphi, S, I^r)$, the bank solves the above problem subject to

$$D/R_t^D = \tilde{D} - (1-\delta)\tilde{B} + \mathrm{DIV} + \varphi + q^r I^r + qS, \tag{S27}$$

$$C = \tilde{C} + \varphi, \tag{S28}$$

$$B = \delta\tilde{B} + S, \tag{S29}$$

$$D/R^D \leq \kappa\left[C + q^r I^r + qB - D/R^D\right], \tag{S30}$$

$$C_t \geq \psi\left[C + q^r I^r + qB - D/R^D\right], \tag{S31}$$

where constraint (S27) corresponds to (S20); and constraint (S30), derived from (S19) and (17), represents the credit constraint on the bank's optimization problem.

The balancing stage behavior can be described as

$$V^b(C, B, D; \varepsilon_m) = \beta E_m\left[V^l(\tilde{C}', \tilde{B}', \tilde{D}'; \varepsilon_m') \mid \varepsilon_m\right]$$

subject to

$$\tilde{D}' = (1-\omega)D + \chi(x) - \varepsilon R^D I^r, \tag{S32}$$

$$\tilde{C}' = C - \omega D, \tag{S33}$$

$$\tilde{B}' = B, \tag{S34}$$

$$x = qB - \theta(1-\omega)D/R^D, \tag{S35}$$

where β is a subjective discount factor and E_m represents the mathematical expectation with respect to monetary policy shocks. Constraints (S32), (S33), and (S34) correspond to (S24), (S25), and (S26), respectively; and constraint (S35) corresponds to (S21).

Combining the two stages, we describe the overall optimization problem as

$$\begin{aligned} V^l(\tilde{C}, \tilde{B}, \tilde{D}; \varepsilon_m) = {} & \max U(\mathrm{DIV}) \\ & + \beta E_{m,\omega,\varepsilon}\left[V^l\left(C - \omega D, B, (1-\omega)D + \chi(x) - \varepsilon R^D I^r; \varepsilon_m'\right) \big| \, \varepsilon_m\right] \end{aligned} \tag{S36}$$

subject to (S27), (S28), (S29), (S30) and (S31). The choice variables for this optimization are $(\mathrm{DIV}, \varphi, S, I^r)$. Given $\mathscr{E} = \tilde{C} + q\delta\tilde{B} - (\tilde{D} - (1-\delta)\tilde{B})$, we have the following proposition:

Proposition S2. The optimization problem (S36) can be simplified and collapsed into the single-state representation

$$V(\mathscr{E}; \varepsilon_m) = \max U(\mathrm{DIV}) + \beta E_{m,\omega,\varepsilon}\left[V(\mathscr{E}'; \varepsilon_m') \mid \varepsilon_m\right] \tag{S37}$$

subject to (S30), (S35), and

$$\mathscr{E} - \mathrm{DIV} = \underbrace{C}_{\text{cash}} + \underbrace{q^r I^r + qB}_{\text{assets}} - \underbrace{D/R^D}_{\text{liabilities}}, \tag{S38}$$

$$\mathscr{E}' = \underbrace{C - \omega D}_{\text{cash}} + \underbrace{q'\delta B + (1-\delta)B}_{\text{assets}} - \underbrace{\left[(1-\omega)D + \chi(x) - \varepsilon R^D I^r\right]}_{\text{liabilities}}, \tag{S39}$$

where the single state is $\mathscr{E}$, (S38) corresponds to (S18), (S39) is derived from (S17), (S24), (S25), and (S26) (by moving time t in (S17) forward to time $t+1$), and the choice variables are $(\mathrm{DIV}, C, B, D, I^r)$.

Proof. The proof for Proposition S2 follows from the fact that $\mathscr{E}$ is a sufficient statistics for the bank's problem. In other words, once $\mathscr{E}$ is determined, the bank's optimal decision does not depend on the sources from which the equity $\mathscr{E}$ is accumulated. □

Since constraints (S30), (S38), and (S39) are linear in $\mathscr{E}$ and the objective function is homothetic in $\mathscr{E}$, the solution to the bank's problem not only exists but also is unique and the policy function is linear in equity $\mathscr{E}$. Moreover, thanks to the Principle of Optimality, the bank's dynamic problem can be separated into two subproblems, one concerning an intertemporal choice of dividend payoffs and the other relating to an intratemporal portfolio allocation. The following proposition formalizes these two results.[39]

Proposition S3. Let

$$U(\mathrm{DIV}) = \frac{\mathrm{DIV}^{1-\gamma}}{1-\gamma},$$

where $\gamma \geq 1$. Optimization problem (S37) satisfies the two properties: homogeneity in $\mathscr{E}$ and separability of portfolio choice from dividend choice.

- **Homogeneity**. The value function $V(\mathscr{E}; z)$ is

$$V(\mathscr{E}; z) = v(z)\mathscr{E}^{1-\gamma},$$

and $v(z)$ satisfies the Bellman equation over the choice variables $\{\mathrm{div}, \tilde{c}, i^r, \tilde{b}, \tilde{d}\}$

$$v(z) = \max U(\mathrm{div}) + \beta E_{m,\omega,\varepsilon}\left[v(z')\ \left(e'(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m)\right)^{1-\gamma} \mid z\right] \tag{S40}$$

[39]The homogeneity and separability properties in Proposition S3 are similar to Bianchi and Bigio (2014).

subject to

$$d/R^D \leq \kappa \left[c + q^r i^r + qb - d/R^D\right], \tag{S41}$$

$$1 = c + \text{div} + q^r i^r + qb - d/R^D, \tag{S42}$$

$$e' = c + (q'\delta + 1 - \delta)b - d - \chi\left(qb - \theta(1-\omega)d/R^D\right) + \varepsilon R^D i^r, \tag{S43}$$

$$c \geq \psi \left[c + q^r i^r + qb - d/R^D\right], \tag{S44}$$

where

$$[\text{div}, c, b, d, i^r, e'] = \frac{[\text{DIV}, C, B, D, I^r, \mathscr{E}']}{\mathscr{E}}. \tag{S45}$$

- **Separability**. Problem (S40) can be broken into two separate problems. The first problem is for banks to make an optimal portfolio choice by choosing $\{w_c, w_i, w_b, w_d\}$ to maximize the certainty-equivalent portfolio value as

$$\Omega(\varepsilon_m', \varepsilon_m) = \max\{E_{\omega,\varepsilon}\left[w_c + R^I w_i + R^B w_b - R^D w_d - R^x\right]^{1-\gamma}\}^{\frac{1}{1-\gamma}} \tag{S46}$$

subject to

$$1 = w_c + w_i + w_b - w_d, \tag{S47}$$

$$w_d \leq \kappa(w_c + w_i + w_b - w_d), \tag{S48}$$

$$w_c \geq \psi(w_c + w_i + w_b - w_d) \tag{S49}$$

and taking the following prices as given

$$R^I = \frac{\varepsilon R^D}{q^r},\ R^B = \frac{q'\delta + 1 - \delta}{q},\ R^x = \chi\left(w_b - \theta(1-\omega)w_d\right), \tag{S50}$$

where

$$w_c = \frac{c}{1 - \text{ div}},\ w_i = \frac{q^r i^r}{1 - \text{ div}},\ w_b = \frac{qb}{1 - \text{ div}}, w_d = \frac{d/R^D}{1 - \text{ div}}.$$

The second problem is to choose div in response to aggregate shocks:

$$v(\varepsilon_m) = \max_{\text{div}} U(\text{div}) + \beta(1-\text{div})^{1-\gamma} E_m\left[\Omega(\varepsilon_m', \varepsilon_m)^{1-\gamma}\, v(\varepsilon_m') \,\middle|\, z\right]. \tag{S51}$$

Proof. We begin with the proof of *homogeneity.* We use the conjecture-verify approach to this complicated problem. We conjecture that the form of the value function is

$$V(\mathscr{E}; \varepsilon_m) = v(\varepsilon_m)\mathscr{E}^{1-\gamma}.$$

Because

$$\mathscr{E}' = e'(\omega, \varepsilon; \varepsilon_m', \varepsilon_m)\mathscr{E},$$

the optimization problem (S37) can be rewritten as

$$\begin{aligned} V(\mathscr{E};\varepsilon_m) &= \max U(\operatorname{div}\mathscr{E}) + \beta E_{m,\omega,\varepsilon}\left[v(z')\ \left(e'(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m)\mathscr{E}\right)^{1-\gamma} \,\middle|\, \varepsilon_m \right] \\ &= \mathscr{E}^{1-\gamma}\left\{ \max U(\operatorname{div}) + \beta E_{M,\omega,\varepsilon}\left[v(\varepsilon'_m)\ \left(e'(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m)\right)^{1-\gamma} \,\middle|\, \varepsilon_m \right] \right\} \end{aligned}$$

subject to (S41), (S42), and (S43). Let $\tilde{v}(\varepsilon_m)$ be the solution of

$$\tilde{v}(\varepsilon_m) = \max U(\operatorname{div}) + \beta E_{m,\omega,\varepsilon}\left[\tilde{v}(\varepsilon'_m)\ \left(e'(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m)\right)^{1-\gamma} \,\middle|\, \varepsilon_m \right] \tag{S52}$$

subject to (S41), (S42), and (S43). Hence, $v(\varepsilon_m) = \tilde{v}(\varepsilon_m)$, which verifies the conjecture of our Bellman equation

$$V(\mathscr{E};z) = v(z)\mathscr{E}^{1-\gamma}.$$

We turn to the proof of *separability*. From (S55) we have

$$\left(e'(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m)\right)^{1-\gamma} = (1-\operatorname{div})^{1-\gamma}\left(R^E\left(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m\right)\right)^{1-\gamma}$$

so that

$$E_{\omega,\varepsilon}\left[\left(e'(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m)\right)^{1-\gamma} \right] = (1-\operatorname{div})^{1-\gamma} E_{\omega,\varepsilon}\left[\left(R^E\left(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m\right)\right)^{1-\gamma} \right]. \tag{S53}$$

Since the utility is a power function, the certainty equivalence of $E_{\omega,\varepsilon}\left[\left(R^E\left(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m\right)\right)^{1-\gamma} \right]$, denoted as $\Omega(\varepsilon'_m,\varepsilon_m)$, follows as

$$\begin{aligned} \Omega(\varepsilon'_m,\varepsilon_m) &= \max_{\{w_c,w_i,w_b,w_d\}} \left\{ E_{\omega,\varepsilon}\left[\left(R^E\left(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m\right)\right)^{1-\gamma} \right] \right\}^{\frac{1}{1-\gamma}} \\ &= \max_{\{w_c,w_i,w_b,w_d\}} \left\{ E_{\omega,\varepsilon}\left[\left(w_c + R^I w_i + R^B w_b - R^D w_d - R^x\right)^{1-\gamma} \right] \right\}^{\frac{1}{1-\gamma}} \end{aligned} \tag{S54}$$

subject to (S47) and (S48). Substituting (S53) into (S52) and using the definition of $\Omega(\varepsilon'_m,\varepsilon_m)$ in (S54), we obtain (S51). □

Note that equations (S41), (S42), and (S43) are derived from equations (S30), (S38), and (S39) and that equation $(S43)$ implies e' is a function of $\omega,\varepsilon,\varepsilon'_m$, and ε_m such that

$$e'(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m) = (1-\operatorname{div})R^E\left(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m\right), \tag{S55}$$

where R^E is the return on the bank's equity after dividend payout

$$R^E\left(\omega,\varepsilon;\varepsilon'_m,\varepsilon_m\right) = w_c + R^I w_i + R^B w_b - R^D w_d - \chi\left(w_b - \theta(1-\omega)w_d\right). \tag{S56}$$

Proposition S3 breaks the potentially unmanageable problem into two tractable problems by separating dividend decision about DIV in response to monetary policy shocks from portfolio choice of φ, S, I^r, and D in response to idiosyncratic risks.

Thanks to the homogeneity feature, banks during the lending stage are replicas of one another scaled by equity, making aggregation a straightforward exercise. In other words, the equilibrium sequence of the aggregate variables $\{\mathrm{DIV}_t, C_t, B_t, D_t, I_t^r, \mathscr{E}_t\}_{t=0}^{\infty}$ is the same as its counterpart in an otherwise identical representative bank environment in which each period the representative bank faces a deposit withdraw shock $\mu(\varepsilon_m)$. This allows us to simplify the problem by solving the competitive equilibrium of the representative bank's problem numerically.

E.2. **Equilibrium.** Define $\overline{E} = \int_0^1 E(j)\, dj$ as the aggregate of equity in the banking sector. The equity of an individual bank evolves according to $E'(j) = e'(\omega, \varepsilon; \varepsilon_m', \varepsilon_m) E(j)$. The measure of equity holdings of each bank is denoted by $\Gamma(E)$. Since the model is invariant to scale, we only need to keep track of the evolution of the average equity, which grows at the rate $E_{\omega,\varepsilon}[e'(\omega, \varepsilon; \varepsilon_m', \varepsilon_m)]$ because

$$\overline{E}' = \int_0^1 E'(j)\, dj = \int_0^1 E(j)\, dj \int_{\varepsilon,\omega} e'(\omega, \varepsilon; \varepsilon_m', \varepsilon_m) f(\omega, \varepsilon)\, d(\omega, \varepsilon) = \overline{E} \times E_{\omega,\varepsilon}[e'(\omega, \varepsilon; \varepsilon_m', \varepsilon_m)].$$

We define the (partial) equilibrium for the banking sector as follows.

Definition S1. Given M_0, D_0, B_0, a competitive equilibrium is a sequence of bank policy rules $\{c_t, d_t, b_t, i_t^r, \mathrm{div}_t\}_{t=0}^{\infty}$, bank value $\{v_t\}_{t=0}^{\infty}$, government policies $\{\mu(\varepsilon_{m,t})\}_{t=0}^{\infty}$, and the measure of equity distribution $\{\Gamma_t\}_{t=0}^{\infty}$ such that

(1) Given policy sequences $\{\mu(\varepsilon_{m,t})\}_{t=0}^{\infty}$, the policy functions $\{c_t, d_t, b_t, i_t^r, \mathrm{div}_t\}_{t=0}^{\infty}$ are a solution to problem (S46). Moreover, v_t is the value for problem (S51).
(2) Γ_t evolves consistently with $e'(\omega, \varepsilon; \varepsilon_m', \varepsilon_m)$.
(3) All policy functions satisfy $[\mathrm{div}, c, b, d, i^r, e'] = \frac{[\mathrm{DIV},\, C, B, D, I^r, \mathscr{E}']}{\mathscr{E}}$.

E.3. **Derivation of first-order conditions.** The portfolio choice of the representative bank is

$$\max_{L, w_d} \left\{ E_{\omega,\varepsilon}\left[R^I + w_d\left[\left(R^I - R^D\right) - \left(R^I - R^B\right)L - R^x(L, 1; \omega)\right]\right]^{1-\gamma}\right\}^{\frac{1}{1-\gamma}}$$

subject to $w_d \leq \kappa$. The first order condition with respect to L is

$$R^B - \underbrace{E_\omega\left[R_L^x(L, 1; \omega)\right]}_{\text{expected liquidity cost}} - \underbrace{\frac{\mathrm{Cov}_\omega\left(R_L^x, E_\varepsilon(R^E)^{-\gamma}\right)}{E_\omega\left[E_\varepsilon(R^E)^{-\gamma}\right]}}_{\text{regulation risk premium}} = E_\varepsilon\left(R^I\right) - \underbrace{\left[-\frac{Cov_\varepsilon\left(R^I, E_\omega\left(R^E\right)^{-\gamma}\right)}{E_\varepsilon\left[E_\omega\left(R^E\right)^{-\gamma}\right]}\right]}_{\text{default risk premium}}. \quad \text{(S57)}$$

The first order condition with respect to w_d is

$$E_{\omega,\varepsilon}\left[\left(R^E\right)^{-\gamma}R^L\right]=\frac{\mu}{E_{\omega,\varepsilon}\left[(R^E)^{-\gamma}\right]^{\frac{\gamma}{1-\gamma}}}\equiv\widetilde{\mu}, \tag{S58}$$

where μ is the Larangian multiplier associated with the inequality constraint $w_d\le\kappa$. Plugging the definition of R^L into $(S58)$ and reordering the terms, we have

$$E_\varepsilon\left\{\left[\left(R^B-R^I\right)L+\left(R^I-R^D\right)\right]E_\omega\left[\left(R^E\right)^{-\gamma}\right]\right\}-E_\omega\left[E_\varepsilon\left(R^E\right)^{-\gamma}R^x\left(L,1;\omega\right)\right]=\widetilde{\mu},$$

which gives

$$\begin{aligned}\frac{\widetilde{\mu}}{E_{\omega,\varepsilon}\left[(R^E)^{-\gamma}\right]} &= LR^B-R^D+(1-L)\left[E_\varepsilon\left(R^I\right)+\frac{Cov_\varepsilon\left(R^I,E_\omega\left(R^E\right)^{-\gamma}\right)}{E_\varepsilon\left[E_\omega\left(R^E\right)^{-\gamma}\right]}\right]\\ &\quad-\frac{E_\omega\left[E_\varepsilon\left(R^E\right)^{-\gamma}R^x\left(L,1;\omega\right)\right]}{E_{\omega,\varepsilon}\left[(R^E)^{-\gamma}\right]}\\ &= LR^B-R^D+(1-L)\left[R^B-E_\omega\left[R^x_b(w_b,w_d;\omega)\right]-\frac{\mathrm{Cov}_\omega\left(R^x_L,E_\varepsilon(R^E)^{-\gamma}\right)}{E_\omega\left[E_\varepsilon(R^E)^{-\gamma}\right]}\right]\\ &\quad-\frac{LE_\omega\left[E_\varepsilon\left(R^E\right)^{-\gamma}R^x_b\right]+E_\omega\left[E_\varepsilon\left(R^E\right)^{-\gamma}R^x_d\right]}{E_{\omega,\varepsilon}\left[(R^E)^{-\gamma}\right]},\end{aligned} \tag{S59}$$

where the second equality is derived by utilizing equation (S57) and

$$R^x\left(L,1;\omega\right)=LR^x_b+R^x_d,$$

$$R^x_b=\begin{cases} r^b \text{ if } \omega\ge 1-\frac{L}{\theta}\\ 0 \ \ \text{otherwise}\end{cases},$$

and

$$R^x_d=\begin{cases} -r^b\theta\left(1-\omega\right) \ \text{ if } \omega\ge 1-\frac{L}{\theta}\\ 0 \qquad\qquad\quad \text{otherwise}\end{cases}.$$

Note that

$$\begin{aligned}\frac{E_\omega\left[E_\varepsilon\left(R^E\right)^{-\gamma}R^x_b\right]}{E_{\omega,\varepsilon}\left[(R^E)^{-\gamma}\right]} &= \frac{E_{\omega,\varepsilon}\left[\left(R^E\right)^{-\gamma}\right]E_\omega\left[R^x_b\right]+cov_\omega\left[E_\varepsilon\left(R^E\right)^{-\gamma},R^x_b\right]}{E_{\omega,\varepsilon}\left[(R^E)^{-\gamma}\right]}\\ &= E_\omega\left[R^x_b\left(w_b,w_d;\omega\right)\right]+\frac{cov_\omega\left[E_\varepsilon\left(R^E\right)^{-\gamma},R^x_b\right]}{E_{\omega,\varepsilon}\left[(R^E)^{-\gamma}\right]}\end{aligned} \tag{S60}$$

Substituting ($S60$) into ($S59$), we have

$$R^B - E_\omega\left[R_b^x\left(w_b, w_d; \omega\right)\right] - \frac{\mathrm{Cov}_\omega\left(R_L^x, E_\varepsilon(R^E)^{-\gamma}\right)}{E_\omega\left[E_\varepsilon(R^E)^{-\gamma}\right]} - R^D - \frac{E_\omega\left[E_\varepsilon\left(R^E\right)^{-\gamma} R_d^x\right]}{E_{\omega,\varepsilon}\left[\left(R^E\right)^{-\gamma}\right]} = \frac{\widetilde{\mu}}{E_{\omega,\varepsilon}\left[\left(R^E\right)^{-\gamma}\right]}. \quad \text{(S61)}$$

E.4. **Transitional dynamics and steady state.** Because of the homogeneity and separability features, the policy function for the portfolio choice of the bank, scaled by ex-dividend equity, is the same every period. We now solve the value function and dividend payout for transitional dynamics as well as the steady state. It follows from the first-order condition for problem (S51) that

$$\mathrm{div}^{-\gamma} = \beta\left(1-\gamma\right)\left(1-\mathrm{div}\right)^{-\gamma} E_M\left[v\left(\varepsilon_m'\right) \mid \varepsilon_m\right]\Omega(\varepsilon_m', \varepsilon_m)^{1-\gamma} \quad \text{(S62)}$$

which gives

$$\mathrm{div} = \frac{1}{1 + \left\{\left(1-\gamma\right)\beta E_M\left[v\left(\varepsilon_m'\right) \mid z\right]\Omega(\varepsilon_m', \varepsilon_m)^{1-\gamma}\right\}^{\frac{1}{\gamma}}}. \quad \text{(S63)}$$

Substituting ($S63$) into (S40) and reorganizing the terms, we obtain the value function

$$v\left(z\right) = \frac{1}{1-\gamma}\left\{1 + \left[\left(1-\gamma\right)\beta E_M\left[v\left(\varepsilon_m'\right) \mid z\right]\Omega(\varepsilon_m', \varepsilon_m)^{1-\gamma}\right]^{\frac{1}{\gamma}}\right\}^{\gamma}. \quad \text{(S64)}$$

At steady state, $\varepsilon_m = \varepsilon_m'$ and $v\left(\varepsilon_m\right) = E_m\left[v\left(\varepsilon_m'\right) \mid \varepsilon_m\right]$. Hence, ($S64$) implies the steady state value function as

$$v^{ss}\left(\varepsilon_m\right) = \frac{1}{1-\gamma}\left[\frac{1}{1-\beta^{\frac{1}{\gamma}}\Omega(\varepsilon_m)^{\frac{1-\gamma}{\gamma}}}\right]^{\gamma} \quad \text{(S65)}$$

Substituting ($S65$) into ($S63$), we obtain

$$\mathrm{div}^{ss} = 1 - \beta^{\frac{1}{\gamma}}\Omega(z)^{\frac{1-\gamma}{\gamma}}. \quad \text{(S66)}$$

E.5. **Algorithms for a numerical solution.**

E.5.1. *Steady state.* Given $\mu(\varepsilon_m), r^b, q, q^r$, and R^D, we need to solve for

$$\left\{L^*, w_d^*, w_b^*, w_i^*, R^{B*}, \Omega^*, \mathrm{div}^*, v^*, w_\varsigma^*\right\},$$

where $\varsigma = \{c, i, b, d\}$ and the superscript $*$ indicates that the values are at steady state. The algorithm for compute the steady state is as follows.

(1) Guess q, the price for B.
(2) Calculate $w_d^* = \kappa, R^B = \delta + \frac{1-\delta}{q}$.

(3) Solve L^* according to the no-arbitrage equation

$$R^B - r^b \times \text{prob}\left(\omega > 1 - \frac{L}{\theta}\right) - \frac{\text{Cov}_\omega\left(R_b^x, E_\varepsilon(R^E)^{-\gamma}\right)}{E_\omega\left[E_\varepsilon(R^E)^{-\gamma}\right]} = E_\varepsilon\left(R^I\right) - \left[-\frac{Cov_\varepsilon\left(R^I, E_\omega\left(R^E\right)^{-\gamma}\right)}{E_\varepsilon\left[E_\omega\left(R^E\right)^{-\gamma}\right]}\right],$$

where

$$\text{Prob}\left(\omega > 1 - \frac{L}{\theta}\right) = \frac{L/\theta}{1-\mu}.$$

(4) Calculate $w_b^* = Lw_d^*, w_i^* = 1 - w_b^* + w_d^*$.

(5) Solve Ω^* according to

$$\Omega(\varepsilon_m', \varepsilon_m) = \{E_{\omega,\varepsilon}\left[R^I w_i^* + R^B w_b^* - R^D w_d^* - R^x\right]^{1-\gamma}\}^{\frac{1}{1-\gamma}},$$

where $R^I = \frac{\varepsilon R^D}{q^r}$, $R^x = \chi\left(w_b^* - \theta(1-\omega)w_d^*\right)$.

(6) Solve the value function and dividend payout according to $(S65)$ and $(S66)$.

(7) Calculate

$$w_c^* = \frac{c}{1-\text{ div}},\ w_i^* = \frac{q^r i^r}{1-\text{ div}},\ w_b^* = \frac{qb}{1-\text{ div}}, w_d^* = \frac{d/R^D}{1-\text{ div}}.$$

(8) Calculate $e' = c + \left[q\delta + (1-\delta)\right]b - r^b\left[qb\frac{L/\theta}{1-\mu(\varepsilon_m)} + \frac{\theta d/R^D(L/\theta)^2}{2(1-\mu(\varepsilon_m))}\right] + R^D\left(1-p^r\right)i^r$.

(9) If equity growth equals to zero (i.e., e' does not change within the numerical tolerance), stop. Otherwise, adjust the value of q and continue the iteration.

E.5.2. *Transitional dynamics.* Given the sequence of $\{\mu(\varepsilon_{m,t})\}_{t=0}^{\infty}$, the algorithm for computing the dynamic responses is as follows.

(1) Calculate $w_{d,t} = \kappa, R_t^B = \frac{q\delta+1-\delta}{q}$.

(2) Solve L_t according to the no-arbitrage equation

$$R_t^B - r^b \times \text{prob}_t\left(\omega_t > 1 - \frac{L_t}{\theta}\right) - \frac{\text{Cov}_\omega\left(R_b^x, E_\varepsilon(R^E)^{-\gamma}\right)}{E_\omega\left[E_\varepsilon(R^E)^{-\gamma}\right]} = E_\varepsilon\left(R^I\right) - \left[-\frac{Cov_\varepsilon\left(R^I, E_\omega\left(R^E\right)^{-\gamma}\right)}{E_\varepsilon\left[E_\omega\left(R^E\right)^{-\gamma}\right]}\right],$$

where

$$R_t^E = R_t^I + w_{d,t}\left[\left(R_t^I - R_t^D\right) - \left(R_t^I - R_t^B\right)L_t - R^x\left(L_t, 1; \omega_t\right)\right],$$

$$R_t^I = \frac{\varepsilon_t R_t^D}{q^r},$$

$$R^x\left(L_t, 1; \omega_t\right) = \chi\left(L_t - \theta\left(1-\omega_t\right)\right).$$

(3) Calculate $w_{b,t} = L_t\kappa; w_{i,t} = 1 - w_{b,t} + w_{d,t}$.

(4) Solve Ω_t according to $\Omega_t = \{E_{\omega,\varepsilon}\left[R_t^E\right]^{1-\gamma}\}^{\frac{1}{1-\gamma}}$.

(5) Solve the value function and dividend payout according to $(S64)$ and $(S63)$.

(6) Calculate

$$w_{c,t} = \frac{c_t}{1 - \text{ div}_t},\ w^*_{i,t} = \frac{q^r i^r_t}{1 - \text{ div}_t},\ w^*_{b,t} = \frac{q b_t}{1 - \text{ div}_t}, w^*_{d,t} = \frac{d_t / R^D}{1 - \text{ div}_t}.$$

(7) Calculate $e_{t+1} = c_t + [q\delta + (1-\delta)]\, b_t - r^b \left[q b_t \frac{L_t/\theta}{1-\mu(\varepsilon_{m,t})} + \frac{\theta d_t / R^D (L_t/\theta)^2}{2(1-\mu(\varepsilon_{m,t}))} \right] + R^D \left(1 - p^r\right) i^r_t.$

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