Monetary Supply Transmission in a DSGE Model with a Shadow Banking System in China

Su-sheng Wang, Fang Zhao

Abstract—**This paper develops a dynamic stochastic general equilibrium (DSGE) model with two types of banks, in which banks can finance risky loan and affect their quality. In particular, we analyze how such financial system affects the effectiveness of monetary policy transmission. We find that an expansionary monetary policy shock has a negative impact on the net worth of commercial banks, but increases the net worth of shadow banks. Moreover, the quality of commercial bank loans decreases whereas that of shadow banks increases. The model predicts that long periods of loose monetary policy can accelerate bank financing.**

Index Terms—**Dynamic stochastic general equilibrium, financial intermediaries, shadow banking, monetary policy**

I. Introduction

THE years leading to the 2007-2009 financial crisis in the United States have been characterized by the development of a new set of financial institutions that formed the shadow banking system. The term "shadow banking system" is attributed to McCulley (2007) [1], referring to financial institutions outside regulation system, rivaling traditional banking system regulated by central banks. According to the Financial Stability Board (2012) [2], shadow banking is "credit intermediation or lending activity that involves entities and transactions outside the regular banking system". In fact, the shadow banks engage in liquidity transformation and convert illiquid loans in instruments in demand. Different explanations have been given for this rapid growth of shadow banking, such as regulatory arbitrage or an increasing demand for riskless assets, but an important element for the fast growth of shadow banking can be clearly identified in financial innovation [3]. However, the definition and the development of shadow banking are country-specific. In China, the definition of shadow banking differs from that in the developed economics, both in terms of the actors providing the services and the products involved. Specifically, shadow banking in China normally refers to traditional quasi-banking products without strict supervision [4].

Manuscript received Sep, 7, 2015; revised Dec, 6, 2015. This work was supported in part by the Shenzhen Municipal Science and Technology Innovation Council under Grant JCYJ20140417173156l0.

Susheng Wang is with Department of Urban Planning and Management, Shenzhen Graduate School Harbin Institute of Technology, Shenzhen, China. (e-mail: wangsusheng@gmail.com)

Fang Zhao is with Department of Urban Planning and Management, Shenzhen Graduate School Harbin Institute of Technology, Shenzhen, China. (e-mail: zhao.fang20052140@163.com)

Shadow banking has become increasingly important in China in recent years. There are many reasons for the surging shadow banking activities in China, and the demand mainly comes from the credit fund. Since the commercial banks in China have a better reputation and less credit failure to provide services and products to the financial market, they have taken the dominate place in the social financing system. When the credit amount and structure are strictly controlled by regulators and government, commercial banks have the preference to provide loans to established large Chinese firms, while not extending enough credit to institutions and enterprises, such as local financing platforms or small and medium-sized enterprises [5]. This has led to the emergence of a shadow banking system as an important channel for alternative funding to bridge these financing gaps. The huge demand for credit is an important reason to stimulate the rapid growth of shadow banking in China. Especially since the global financial crisis in 2008, when the Chinese government substantially increased the money supply and credit to the financial market, which prompted even more rapid growth in shadow banking.

Shadow banking has caused concerns and raises questions about the lack of proper financing channels in China's credit market and the inherent risks that would aggravate the challenges for the conduct of monetary policy [6]. Since the second half of 2008, due to the USA financial turmoil, the global financial environment was gradually deteriorating; therefore, the Chinese government began to implement the loose monetary policy. China's monetary policy basically employs a wide variety of non-market policy instruments, including the deposit rate ceiling, as well as quantitative measures such as reserve requirements, lending quotas and "window guidance" [7]. However, these policy tools ignore new financing channels outside the well-regulated banking system, such as shadow banks. On the one side, the shadow banking system creates the credit fund and also increases the total amount of money supply. On the other side, funding through the shadow banks is independent of the central bank's supervision; in fact, since the shadow banks finance the amount of external funds outside the banking system, it eventually changes the equilibrium of money supply. This leads to the less the efficiency in monitoring total credit growth and managing macro-level liquidity.

Under this background, this study aims to analyze whether the shadow banking system can affect the effectiveness of monetary policy transmission and weaken the economy. We do it by building a DSGE model with two types of financial intermediaries—commercial banks and shadow banks. In this

(Advance online publication: 26 August 2016)

model, we explicitly analyze the behavior of financial system within parallel shadow banking system, aims at providing further insights into the transmission of monetary policy.

The paper is organized as follows. Section 2 provides a brief review of related literature. Section 3 presents the construction of a tractable DSGE model with a shadow banking sector. Section 4 details the calibration of the model. Section 5 presents the impulse responses in both an expansionary monetary policy shock and a "persistently increasing money supply" scenario. Finally, Section 6 summarizes the paper and offers suggestions for further research.

II. Related literature

This paper draws from different strands of literature related to financial system in DSGE models, as well as their implications for the monetary policy. The DSGE models are currently the benchmark macroeconomics models, which originate from the fusion of the RBC models of 1980s and the New Keynesian sticky-price models of the early 1990s [8]. The following studies focus on the assumption of frictionless financial markets and financial intermediaries, which play a passive role. However, many studies argue that financial intermediaries have important roles in influencing the performance of the economy, including through the transmission of monetary policy [9], [10], [11], [12]. Recently more DSGE models with a financial sector are being developed [13], [14], [15], [16], but there have been only a few attempts to include the shadow banks as well as to analyze the monetary policy implications of the shadow banking sector in a DSGE framework. Verona et al. (2011) [17] address whether a "too low for too long" interest rate policy may generate a boom-bust cycle or not, and they suggest a DSGE model in which a micro-founded shadow banking sector is included. They conclude that long periods of accommodative monetary policy create the preconditions for a boom-bust cycle. In fact, fluctuations in both real and financial variables are remarkably amplified only when being faced with perverse incentives. Andrew Sheng (2011) [18] proposed a bold innovation that M5 should be used as a monetary supply variable in the shadow banking system. Empirical studies have supported the idea that the existence of shadow banking does increase the difficulty in implementing monetary policy. Sunderam (2013) [19] presents a model that estimates the demand function for household money. The study shows that these short-term financing claims created by shadow banking system, namely ABCP, indeed have properties of quasi money, whose circulation is significantly increased with the growth of a household's money demand. Ricks (2012) [20] shows that, although the creation of the shadow banks does not internalize the crisis cost, they lead to an excessive number of private money circulation. Meeks et al. (2013) [21] introduce a shadow banking sector that funds itself from commercial banks, and assume that traditional banks have a weaker friction when investing in shadow banks liabilities. However, there is no role for loan quality in the shadow banking system. Faia (2012) [22] studies the effect of a secondary market for loans in a DSGE model with a moral hazard problem, where loan quality is determined exogenously and only the commercial banking system is present. Mazelis (2014) [23] has investigated the impact of monetary policy shocks on aggregate loan supply in a DSGE framework with commercial banks and shadow banks.

Chinese scholars have taken the relationships between shadow banking and monetary policy into consideration. Zhou (2011) [24] believes that, to some extent, shadow banking could obtain derived deposits from commercial banks, which would weaken traditional monetary policy tools. Meanwhile, the shadow banking system reduces the effectiveness of money supply through macro control and produces external effects on money market. The concept of "securities lender of last resort" is proposed. Wang (2010) [25] utilizes trust wealth investment as an example, and concludes that the shadow banking system not only blurs the transmission mechanism of window guidance, but substantially increases new money supply, which interferes with the target of the central bank when making monetary policy decisions. Lee (2013) [26] finds that money supply would be significantly affected by the shadow banks in the long term. In the first few years, shocks are greater, but later the money supply is relatively stable. This analysis suggests that the credit-oriented monetary policy should be adopted in order to reduce the impact of the shadow banking. Chen and Zhang (2012) [27] adopt short-term constraints of a SVAR model, in which shadow banks have an impact on economic growth, inflation and money supply. The empirical results indicate that shadow banking can promote economic growth and money supply. However, the influence on inflation is insignificant. In summary, these studies on the shadow banking and monetary policy transmission in China mostly adopt measurement methods, such as Co-integration, Granger causality, or VAR model. Their research objectives only focus on the relationship between the shadow banking scale and money supply.

To sum up, the literature has not yet presented an all-encompassing DSGE model appropriate for modelling China's shadow banking sector and monetary supply transmission. In this paper, we will shed light on the interplay between the commercial banking sector and the shadow banking sector in China by means of a conceptual DSGE framework, identifying relevant features which help to explain the dynamics of the shadow banking sector. We do so by augmenting a framework with a shadow banking sector, along the lines of Ferrante (2013) [3].

III. The Baseline Model

The model assumes five types of agents: households, non-financial firms, monetary authority and two types of banks: commercial banks and shadow banks. Two types of banks are able to invest in productive capitals by financing risky loans and they also own a unique technology, allowing them to screen the quality of these assets. Households, however, can only invest by lending funds to banks. Because banks have technological advantage in evaluating loans, we assume households are limited in market participation. Two types of banks have the same screening technology, but they differ in their "diversification skills" [3]. In the following section, this assumption of asymmetric information on loan characteristics will imply different dynamics for the leverage and the quality of loans, which are originated by commercial banks or shadow banks.

A. Households

There is a continuum of living risk-averse households, indexed by $j \in (0,1)$. At time t, each household consumes, supplies labor, and allocates savings. The only way in which they can save is to lend funds to the two types of financial intermediaries. The instantaneous utility function of a household j is given by

$$E_t^j \sum_{i=0}^{\infty} \beta^i [\log(C_{t+i}) + \frac{\gamma}{\gamma-1} (\frac{M_{t+i}}{P_{t+i}})^{\frac{\gamma-1}{\gamma}} - \frac{\chi L_{t+i}^{1+\eta}}{1+\eta}]. \quad (1)$$

In this formula, C_t denotes household consumption, cash M_t and L_t labor supply. The financial intermediaries offer two types of securities to outside investors. We assume that commercial banks issue liabilities D_t and pay a return R_{t+1}^d whereas the shadow banks offer securities S_t that pay a risk-free return R_{t+1}. Commercial banks will always be able to repay the promised return on D_t. The budget constraint for households is given by

$$P_t C_t + D_t + S_t + M_t \le M_{t-1} + R_t^d D_{t-1} + R_t S_{t-1} + \Pi_t + W_t L_t. \quad (2)$$

Where W_t represents real wage, and Π_t are profits deriving from the ownership of capital producing firms.

In addition, households are assumed to own the capital stock $K_t(i)$, and given their investment decision, the aggregate capital stock accumulates as follows:

$$K_{t+1} = (1-\delta)K_t + [1 - S(I_t / I_{t-1})]I_t \quad (3)$$

Where I_t is aggregate investment, $S(\cdot)$ denotes investment adjustment cost and the rate of capital depreciation δ. Similar to CEE (2003), in steady state, $S(1) = S'(1) = 0, S''(\cdot) > 0$.

In equilibrium, the household's utility function (1), subject to the budget constraint and capital's law of motion (2) and (3), yields the following set of first-order conditions with respect to C_t, L_t, D_t, S_t, M_t and I_t:

$$C_t^{-1} = \lambda_t P_t. \quad (4)$$

$$W_t = \chi L_t^{\eta} / \lambda_t. \quad (5)$$

$$E_t \beta \Lambda_{t,t+1} R_{t+1}^d = 1. \quad (6)$$

$$E_t \beta \Lambda_{t,t+1} R_{t+1} = 1. \quad (7)$$

$$(M_t / P_t)^{-1/\gamma} + \beta P_t E_t \{\lambda_{t+1}\} - \lambda_t P_t = 0. \quad (8)$$

$$Q_t = 1 + S'(\frac{I_t}{I_{t-1}})\frac{I_t}{I_{t-1}} - E_t \beta \Lambda_{t,t+1} S'(\frac{I_{t+1}}{I_t})(\frac{I_{t+1}}{I_t}). \quad (9)$$

Where, $\Lambda_{t,t+1} = C_t / C_{t+1}$, λ_t is the Lagrange multiplier associated with the budget constraint. Q_t is the value of a unit of capital that the bank is financing. Capital producers create new capital by using the final good as input. They sell new raw capital to firms in different projects at the price Q_t. In the steady state, profits are redistributed lump sum to households.

Households are heterogeneous with respect to labor supply, which leads to monopolistic competition in the labor market. According to SW (2003), we adopt "Calvo" as a way to introduce sticky nominal wages. Suppose the probability for wage adjustment signal, which each household in every period receives, is $(1-\xi_w)$. Households, who receive the adjustment signal, will formulate optimal nominal wages W_t^*.

Under labor demand constraints, the demand function for the j^{th} household is:

$$L_t(j) = (\frac{W_t(j)}{W_t})^{-\theta_t^*} L_t. \quad (10)$$

Where $L_t(j)$ is labor demand, W_t is the aggregate wage level and θ_t^* denotes wage elasticity of labor demand. The percentage of re-optimizing households $(1-\xi_w)$ set their wages by maximizing the function:

$$\max E_t \sum_{i=0}^{\infty} (\beta \xi_w)^i U(C, \frac{M}{P}, L). \quad (11)$$

From the first order condition:

$$\sum_{i=0}^{\infty} (\beta \xi_w)^k E_t \left\{ L_{t+i} \lambda_{t+i} (\frac{W_t^*}{P_{t+i}} + u_{t+i}^w \frac{U_{n,t+i}}{\lambda_{t+i}}) \right\} = 0. \quad (12)$$

Where $U_{n,t+i} = -L_{t+i}^{\eta}$, $\lambda_{(t+i)} = C_t^{-1}$, u_{t+i}^w represents the wage markup.

B. Non-Financial Firms

In this section, we present the technological framework analyzing the representative non-financial firms. Suppose there are two "sectors", each with a continuum of firms located on a continuum of regions. Under perfect competition, the non-financial firms operate under a Cobb-Douglas technology with productive capital and labor. Since labor is perfectly mobile, we can write aggregate output Y_t as a function of aggregate productive capital K_t and aggregate labor L_t, where A_t is aggregate productivity. The production function is given by

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}, \alpha \in (0,1). \quad (13)$$

Given the effective capital available for productions, non-financial firms choose labor in order to satisfy:

$$W_t = (1-\alpha) Y_t / L_t. \quad (14)$$

So that we can define gross profits per unit of effective capital as:

$$Z_t = (Y_t - W_t L_t) / K_t = \alpha (Y_t / K_t). \quad (15)$$

During each period, firms finance the purchase of capital by obtaining funds from financial intermediates. According to the definition, the factor prices divided by the marginal productivity of price equals the marginal cost; therefore, we obtain $MC_t = A_t^{-1} (Z_t)^{\alpha} (W_t / P_t)^{\alpha} \alpha^{-\alpha} (1-\alpha)^{\alpha-1}$. Combining with $MPL_t = (1-\alpha) A_t K_t^{\alpha} L_t^{-\alpha}$, we also get the labor demand curve $L_t = (1-\alpha)\alpha^{-1} z_t w_t^{-1} K_t$. We assume firms adopt the "Calvo" pricing mechanism, in which production sectors adjust the normal price to optimal price P_t^* with a constant probability $(1-\xi_p)$. At time t, firms set optimal price by maximizing:

$$\max E_t \sum_{i=0}^{\infty} \xi_p^i \beta^k Y_{t+i} (P_t^* - P_{t+i} MC_{t+i})(\lambda_{t+i} / \lambda_t) \tag{16}$$

We obtain the first order condition:

$$\sum_{i=0}^{\infty} \xi_p^i E_t \left\{ (\beta^k \frac{\lambda_{t+i}}{\lambda_t}) Y_{t+i} (P_t^* - u_{t+i}^p P_{t+i} MC_{t+i}) \right\} = 0 \tag{17}$$

C. Financial Intermediaries —Commercial banks and Shadow banks

In order to quantify effects of financial intermediaries, we incorporate a financial system in a DSGE framework, which is based on the partial-equilibrium modelling work of Ferrante (2013) and Chen et al. (2011) of a Chinese banking sector [29]. More precisely, we embed those ingredients from the two papers that are needed to analyze China's monetary policy into the banking sector introduced in Ferrante (2013). The banking sector determines loans quality and net worth. In the following section, we will derive the optimal contract for a commercial bank and for a shadow bank.

(1) Aggregate loan quality

We assume that there are two types of financial intermediaries, commercial banks and shadow banks. Both financial intermediations can provide funds to the non-financial firms in order to finance risky capital. Let Z_t be the flow of income from one unit of productive capital. Then we can define the rate of return on the loan through the function:

$$R_{t+1}^k = (Z_{t+1} + (1-\delta) Q_{t+1}) / Q_t. \tag{18}$$

We suppose capital producers can obtain raw capital K_t on every region, which turns into $\theta_H K_t$ units of productive capital in the next period if the project succeeds. Otherwise, it becomes $\theta_L K_t$ if the project fails, with $\theta_H > \theta_L$, in which θ_H represents high idiosyncratic realization and θ_L low idiosyncratic realization. Projects on a specific region will be perfectly correlated, so that either all will fail or all will succeed. The paper assumes that the probability of success p differs between the two sectors. In particular, the two sectors will be perfectly negatively correlated, in every period one sector will be good and the other one will be bad. When a sector turns out to be good, the probability of success of loans is p^G. For the sector that is bad, p^B is the probability of success of loans. Defining the average realization of a project, conditional on the type of sector as $\bar{\theta}^j$ for $j = G, B$.

$$\bar{\theta}^G = p^G \theta_H + (1-p^G)\theta_L,\ \bar{\theta}^B = p^B \theta_H + (1-p^B)\theta_L. \tag{19}$$

Although the financial intermediaries plan to finance projects in a specific region in a given sector at time t, we do not know whether that sector will be good or bad at time $t+1$. However, by facing a non-pecuniary convex cost $c(\pi_t)$, banks can increase the probability of selecting a loan in a sector that will be good in the next period. Therefore, we can define the expected quality of a project with screening intensity π_t as

$$E_t[\Theta_{t+1}(\pi_t^i)] = E_t[\pi_t^i \bar{\theta}^G + (1-\pi_t^i)\bar{\theta}^B],\ i = cb, sb \tag{20}$$

As will be shown below, all the commercial banks will choose the same π_t^{cb} and all the shadow banks will choose the same π_t^{sb}. π_t^{cb} is the loan quality originated by the commercial bank and π_t^{sb} is the loan quality of shadow bank. After the idiosyncratic default realization projects become homogeneous raw capital again, and the evolution of aggregate capital $K_t = K_t^{cb} + K_t^{sb}$ is revealed. In addition, aggregate loan quality π_t can be defined as

$$\pi_t = (\pi_t^{cb} K_t^{cb} + \pi_t^{sb} K_t^{sb}) / K_t \tag{21}$$

(2) The loan quality for commercial bank

There is a continuum of risk in neutral commercial banks that provides funds to non-financial firms located in one region. By using its own net worth N_t^{cb} and issuing liabilities D_t, each commercial bank finances the investment in its project $Q_t K_t^{cb}$ .The return on commercial banks liabilities R_t^d will be independent of idiosyncratic risk, but it will carry aggregate risk. In this sense, liabilities D_t include both deposits and other types of non risk-free securities. The balance sheet of a commercial bank will be

$$Q_t K_t^{cb} = N_t^{cb} + D_t. \tag{22}$$

The commercial banks can credibly commit to repay to their creditors b_{t+1}, which will have to satisfy the following solvency constraint $b_{t+1} \le \theta_L R_{t+1}^k$, where R_{t+1}^k denotes the aggregate return on capital. This constraint comes from the fact that households cannot observe whether the loans held by the commercial bank have defaulted or not. Importantly, it also guarantees that the commercial bank will always be able to repay its creditors.

As before, we assume the financial intermediaries are able to increase the probability of selecting a good project and face non-pecuniary cost. Therefore, commercial banks select the loan quality π_t^{cb}, by facing a non-pecuniary cost $c(\pi_t^{cb}) = \tau_t(\pi_t^2 - \kappa)/2$, which is proportional to the value of the loans financed. The implied objective for the commercial banks is

$$E_t Q_t K_t^{cb} \left\{ \Theta_{t+1}(\pi_t^{cb}) R_{t+1}^k - c(\pi_t^{cb}) - b_{t+1} \right\}. \tag{23}$$

Finally, after solving the optimal contract, we also have to consider the participation constraint (PC) that guarantees that creditors receive an appropriate return on their lending

$$D_t \le E_t \beta \Lambda_{t,t+1} b_{t+1} Q_t K_t^{cb}, \text{ and } \Lambda_{t,t+1} = C_t / C_{t+1} \tag{24}$$

Given these assumptions, the one period contract between the commercial banks and the households will have to solve

$$\begin{aligned} \max_{K_t^{cb}, \pi_t^{cb}, D_t, b_{t+1}} \quad & E_t Q_t K_t^{cb} \left\{ \Theta_{t+1}(\pi_t^{cb}) R_{t+1}^k - c(\pi_t^{cb}) - b_{t+1} \right\} \\ s.t \quad & Q_t K_t^{cb} = N_t^{cb} + D_t. \\ & b_{t+1} \le \theta_L R_{t+1}^k. (SC) \\ & D_t \le E_t \beta \Lambda_{t,t+1} b_{t+1} Q_t K_t^{cb}. (PC) \end{aligned} \tag{25}$$

After substituting for D_t from the balance sheet equation, the first order conditions with respect to $K_t^{cb}, b_{t+1}, \pi_t^{cb}$ are

$$E_t[\Theta_{t+1}(\pi_t^{cb})R_{t+1}^k - c(\pi_t^{cb}) - b_{t+1}] = \lambda_t^{cb}[1 - E_t\beta\Lambda_{t+1}b_{t+1}]. \quad (26)$$

$$Q_t K_t^{cb}[\lambda_t^{cb}\beta\Lambda_{t+1} - 1] = \omega_{t+1}. \quad (27)$$

$$c'[\pi_t^{cb}] = E_t\bar{\Delta}_{t+1}R_{t+1}^k. \quad (28)$$

where ω_{t+1} and λ_t^{cb} are the Lagrange multipliers on the solvency constraint and the participation constraint.

From (28), we obtain the first order condition on the screening level

$$c'(\pi_t^{cb}) = E_t\bar{\Delta}_{t+1}R_{t+1}^k,\ \bar{\Delta} = (\bar{\theta}^G - \bar{\theta}^B). \quad (29)$$

The equation (29) shows that since the payment to households does not depend on whether the loan is in a good or bad sector, the commercial bank will retain all the exposure to the idiosyncratic risk and hence it will equalize the marginal cost of monitoring to the expected marginal benefit, given by the expected return that a good project delivers $E_t\bar{\Delta}_{t+1}R_{t+1}^k$. If we use the specific functional form for the cost function, from (29) we can directly obtain the loan quality of π_t^{cb} set by the commercial bank as

$$\pi_t^{cb} = [E_t(\bar{\theta}^G - \bar{\theta}^B)R_{t+1}^k] / \tau_t. \quad (30)$$

Then, substituting $(b_{t+1} \le \theta_L R_{t+1}^k)$ into (23) results into

$$\lambda_t = \frac{E_t[\Theta_{t+1}(\pi_t)R_{t+1}^k - c(\pi_t) - \theta_L R_{t+1}^k]}{1 - \theta_L E_t\beta\Lambda_{t+1}R_{t+1}^k}. \quad (31)$$

Finally, we will assume that if both constraints are in a steady state in our calibration, the amount of assets that commercial banks can intermediate will be limited by a constraint on their leverage ratio ϕ_t^{cb}, defined as $Q_t K_t^{cb} = \phi_t^{cb} N_t^{cb}$. We can combine the (SC) and (PC) in order to obtain the leverage ratio ϕ_t^{cb} of commercial banks, satisfying

$$Q_t K_t^{cb} = \frac{1}{[1 - \theta_L E_t\beta\Lambda_{t.t+1}R_{t+1}^k]} N_t^{cb} = \phi_t^{cb} N_t^{cb}. \quad (32)$$

As can be seen from (32), the leverage capacity is increasing in the expected aggregate return to capital $E_t R_{t+1}^k$. The leverage is going to be higher; therefore, the recovery rate on defaulted projects will also be higher. The debt capacity of commercial banks is not directly linked to the riskiness of their loans. The return obtained by households after lending to commercial banks is defined as

$$R_{t+1}^d = \theta_L R_{t+1}^k[\phi_t^{cb} / (\phi_t^{cb} - 1)]. \quad (33)$$

(3) The loan quality for shadow bank

We assume that the aggregate return on capital R_{t+1}^k and the default rate on bad loans p_{t+1}^B are known. The shadow bank will fund its capital K_t^{sb} by using its net worth N_t^{sb} and by issuing securities S_t. The shadow bank's balance sheet will then be

$$Q_t K_t^{sb} \le N_t^{sb} + S_t. \quad (34)$$

Different from commercial banks, the shadow bank's contract will specify payments to the households, which are contingent on the realized type of the loan pool. This is defined as b_{t+1}^j for $j = G, B$. The implied payments to investors will be

$$b_{t+1}^j = \bar{\theta}^j R_{t+1}^k - r_{t+1}^j. \quad (35)$$

Where, r_{t+1}^j for $j = G, B$ as the bank return per unit of loan. Because of limited liability, we need to have

$$r_{t+1}^j \ge 0 \Rightarrow b_{t+1}^j \le \bar{\theta}^j R_{t+1}^k. \quad (36)$$

The expected return of the shadow bank, including the non-pecuniary, will be given by

$$Q_t K_t^{sb}\left\{\pi_t^{sb} r_{t+1}^G + (1 - \pi_t^{sb}) r_{t+1}^B - c(\pi_t^{sb})\right\}. \quad (37)$$

Because the investors' payment depends on the quality of the loans originated by the shadow bank π_t^{sb}, which is unobservable by outsiders, a moral hazard with hidden action exists. Therefore, an incentive constraint will be required, which guarantees that the shadow banks select the loans quality.

$$\pi_t^{sb} = \arg\max_{\pi_t^{sb}} Q_t K_t^{sb}\left\{\pi_t^{sb} r_{t+1}^G + (1 - \pi_t^{sb}) r_{t+1}^B - c(\pi_t^{sb})\right\}. \quad (38)$$

In addition, the way in which banks can affect the loan's return distribution satisfies the "convexity-of-distribution" function condition. By using the first order condition of (38), we can write the incentive constraint (IC)

$$c'(\pi_t^{sb}) = (r_{t+1}^G - r_{t+1}^B). \quad (39)$$

Finally, we have to consider the participation constraint for lenders, which guarantees that the household obtains an expected return equal to the opportunity cost of its funds. If the household is able to utilize diversification to eliminate the idiosyncratic project risk by lending to different shadow banks, the relevant opportunity cost will be the risk free rate R_{t+1}. The participation constraint (PC) will be

$$Q_t K_t^{sb}\left\{\pi_t^{sb} b_{t+1}^G + (1 - \pi_t^{sb}) b_{t+1}^B\right\} \ge S_t R_{t+1}. \quad (40)$$

The contract for the shadow bank will express that, if the pool of loans reveals to be bad, the whole return will be given to creditors and the shadow bank will default, resembling a risky debt contract.

We assume that the risk-neutral banker is willing to bear all the aggregate risk, which guarantees that the lender payment is equal to the expected risk-free rate. This means that the participation constraint in (40) will imply b_{t+1}^G. We focus on a parametrization that allows a value of b_{t+1}^G satisfying (37) to exist for any aggregate state. In this case, the household can diversify the residual idiosyncratic risk by investing in a "mutual fund" of shadow banks. Therefore, the household can earn the risk-free rate on S_t. In addition, this implies that, when there is a low realization of R_{t+1}^k, b_{t+1}^G will have to rise. The shadow banks with a good pool of loans will pay a higher amount to a household, diminishing the shadow banks' net worth. As a consequence of aggregate risk, we consider the simplified contract and given the fact that $r_{t+1}^B = 0$, it is implied that $b_{t+1}^{B} = \bar{\theta}^{B} R_{t+1}^{k}$. We can write the optimal contracting problem with aggregate risk as

$$\max_{K_t^{sb},\pi_t^{sb},b_{t+1}^{G}} Q_t K_t^{sb}\left[\pi_t^{sb} r_{t+1}^{G} + (1-\pi_t^{sb}) r_{t+1}^{B} - c(\pi_t^{sb})\right].$$

$$s.t.\quad c^{'}(\pi_t^{sb}) = E_t r_{t+1}^{G} \quad (IC)$$

$$Q_t K_t^{sb}\left\{\pi_t^{sb} R_{t+1}^{k} - \pi_t^{sb} r_{t+1}^{G}\right\} \geq S_t R_{t+1} \ (PC) \qquad (41)$$

In particular, by substituting the (PC) in the (IC) we can write

$$\max_{K_t^{sb},\pi_t^{sb},b_{t+1}^{G}} \phi_t^{sb} N_t^{sb}\{E_t \Theta_{t+1}(\pi_t^{sb}) R_{t+1}^{k} - R_{t+1} - c(\pi_t^{sb})\} + N_t^{sb} R_{t+1}.$$

$$s.t.\quad \phi_t^{sb}\{R_{t+1} - E_t[\Theta_{t+1}(\pi_t^{sb}) R_{t+1}^{k}] + \pi_t^{sb} c^{'}(\pi_t^{sb})\} = R_{t+1}. \qquad (42)$$

where ϕ_t^{sb} is the leverage equation of shadow banks. By solving the maximization problem (42), we derive the first order conditions for ϕ_t^{sb} and π_t^{sb} as

$$\begin{aligned}&\{E_t \Theta_{t+1}(\pi_t^{sb}) R_{t+1}^{k} - R_{t+1} - c(\pi_t^{sb})\}\\ &= \lambda_t\{R_{t+1} - E_t[\Theta_{t+1}(\pi_t^{sb}) R_{t+1}^{k}\} + \pi_t^{sb} c^{'}(\pi_t^{sb})\}.\end{aligned} \qquad (43)$$

$$\begin{aligned}&E_t \bar{\Delta}_{t+1} R_{t+1}^{k} - c^{'}(\pi_t^{sb})\\ &= \lambda_t\{\pi_t^{sb} c^{''}(\pi_t^{sb}) - [E_t \bar{\Delta}_{t+1} R_{t+1}^{k} - c^{'}(\pi_t^{sb})]\}.\end{aligned} \qquad (44)$$

where λ_t is the multiplier on the reduced form constraint. By combining the two equations (43) and (44) for λ_t above, we obtain

$$\begin{aligned}&\{E_t \Theta_{t+1}(\pi_t^{sb}) R_{t+1}^{k} - R_{t+1} - c(\pi_t^{sb})\}\pi_t^{sb} c^{'}(\pi_t^{sb})\\ &= [E_t \bar{\Delta}_{t+1} R_{t+1}^{k} - c^{'}(\pi_t^{sb})]\{\pi_t^{sb} c^{'}(\pi_t^{sb}) - c^{'}(\pi_t^{sb})\}.\end{aligned} \qquad (45)$$

Equation (45) is going to define the level of the loan quality for shadow banks π_t^{sb} . In particular, given the cost function $c(\pi_t) = \tau_t(\pi_t^2 - \kappa)/2$, we will have that $c^{'}(\pi_t) = \tau_t \pi$ and $c^{''}(\pi_t) = \tau_t$. By substituting the cost function in (45) we obtain that the screening level of the loan quality for shadow banks (π_t^{sb}) is

$$\begin{aligned}\pi_t^{sb} &= \frac{R_{t+1} - E_t \bar{\theta}^{B} R_{t+1}^{k} - \tau_t \kappa}{E_t(\bar{\theta}^{G} - \bar{\theta}^{B}) R_{t+1}^{k}} +\\ &\frac{[(R_{t+1} - E_t \bar{\theta}^{B} R_{t+1}^{k} - \tau_t \kappa)^2 + \kappa(E_t(\bar{\theta}^{G} - \bar{\theta}^{B}) R_{t+1}^{k})^2]^{1/2}}{E_t(\bar{\theta}^{G} - \bar{\theta}^{B}) R_{t+1}^{k}}.\end{aligned} \qquad (46)$$

From (46), we notice that shadow banks π_t^{sb} will be decreasing in the parameter affecting the marginal cost of screening τ_t .

Finally, by substituting (39) into (40), we obtains the leverage equation of the shadow banks ϕ_t^{sb} .

$$\phi_t^{sb} = R_{t+1} / [R_{t+1} - E_t[\Theta_{t+1}(\pi_t^{sb}) R_{t+1}^{k}] + \pi_t^{sb} c'(\pi_t^{sb})]. \qquad (47)$$

At this point we can characterize the demand for capital and the optimal loan quality for the shadow bank.

First of all, if the (IC) binds, it can be shown that the following must hold: $c'(\pi_t^{sb}) < c'(\pi_t^{cb}) \Rightarrow \pi_t^{sb} < \pi_t^{cb}$ .This result comes from the fact that, unlike the commercial banks, the shadow banks do not retain all the idiosyncratic risk coming from the choice of π_t^{sb} . The shadow banks, which would be able to pledge a larger portion of return on its loans, do not internalize all the expected benefits from monitoring. As a result, they will have less incentive to screen their projects.

Secondly, from (47), we obtain the leverage ratio of shadow bank ϕ_t^{sb} . In this case, the leverage of the shadow bank increases in the total expected return on the pool of loans $E_t \Theta_{t+1}(\pi_t^{sb}) R_{t+1}^{k}$, whereas it decreases in the expected payment due to the bank $\pi_t^{sb} c^{'}(\pi_t^{sb}) = \pi_t^{sb} E_t r_{t+1}^{G}$.

Finally, following the results above, it can be shown that the loan quality of shadow banks π_t^{sb} will be determined as

$$\pi_t^{sb} = \varphi(E_t R_{t+1}^{k}, R_{t+1}) \text{, and } \frac{\partial \varphi}{\partial E_t R_{t+1}^{k}} < 0, \frac{\partial \varphi}{\partial R_{t+1}} > 0 \qquad (48)$$

In the end, we can summarize the key differences between commercial banks and shadow banks. First, shadow banks will have a higher leverage than commercial banks, which fulfills the pledge of a larger share of the expected return on their loans. Since $\pi_t^{sb} < \pi_t^{cb}$, shadow banks can finance a larger amount of funds per unit of net worth. However, this leads to lower quality projects being used. Secondly, the endogenous quality of loans that depends on π_t^{i} , for $i = cb, sb$, will move counter-cyclically for commercial banks and pro-cyclically for shadow banks.

(4) The Net Worth of financial intermediaries

We assume that financial intermediaries are risk-neutral with exogenous exit probability (1-σ). We suppose that finance frictions exist in the standard model, which guarantees bankers do not need to save enough to overcome financial constraints. In addition, suppose that new bankers substitute existing bankers in financial sectors, which carry endowment in first period ω^{i} , for $i = cb, sb$.

If we consider a parametrization, such as the agency problem for the commercial and shadow banks, the maximum leverage constraints are independent of individual-specific factors that aggregate across the two financial sectors. The demand for capital in the commercial banking sector and the demand in the shadow banking sector will be determined by

$$Q_t K_t^{cb} = \phi_t^{cb} N_t^{cb}. \qquad (49)$$

$$Q_t K_t^{sb} = \phi_t^{sb} N_t^{sb}. \qquad (50)$$

Therefore, the total capital intermediated by the financial sector is given by

$$Q_t K_t = \phi_t^{cb} N_t^{cb} + \phi_t^{sb} N_t^{sb}. \qquad (51)$$

From (51), we find that the overall bank asset demand is affected by variations in both N_t^{cb} and N_t^{sb} . In particular, given the higher leverage of shadow banks, aggregate capital will be affected directly by fluctuations in the net worth of non-traditional intermediaries. If we aggregate across surviving and entering bankers, we obtain the following evolution of the aggregate net worth for the commercial banking sector and the shadow banking sector. Both sectors include the retained earnings of surviving bankers and the endowment of new entrants.

$$N_t^{cb} = \sigma\left\{\Theta_t(\pi_{t-1}^{cb}) - \theta_L\right\}\left[Z_t + (1-\delta)Q_t\right]K_{t-1}^{cb} + W^{cb}. \quad (52)$$

$$N_t^{sb} = \sigma\left\{\Theta_t(\pi_{t-1}^{sb})\right\}\left[Z_t + (1-\delta)Q_t\right]K_{t-1}^{sb} + W^{sb}. \quad (53)$$

where $W^{cb} = (1-\sigma)\omega^{cb}$ and $W^{sb} = (1-\sigma)\omega^{sb}$. We assume that new bankers are able to start a new banking business only by taking over the franchise of existing banks. From (52) and (53), we see how net worth depends on the average quality of the loan that originates in a specific financial sector.

$$\Theta_t(\pi_{t-1}^i) = \pi_{t-1}^i\bar{\theta}^G + (1\text{-}\pi_{t-1}^i)\bar{\theta}^B,\ i = cb, sb. \quad (54)$$

First of all, the lower π_{t-1}^i is, the more exposed to shocks $\bar{\theta}^B$ and the more net worth N_t^i will be. In addition, at time t any drop in the screening level will negatively affect the earnings in the next period. Furthermore, because of the higher leverage and the risk-free return on liabilities, the net worth of shadow banks will drop significantly in response to negative shock.

(5) Monetary policy

To tie macroeconomic performance to policy variables and reflect the particularities of Chinese central banking mentioned above, we enhance the description of the conventional monetary policy tool and incorporate monetary policy transmission channels outlined above into our DSGE framework. We suppose the central bank takes the growth rule for the money supply to formulate and implement monetary policy. To define the money supply, we observe

$$M_t = M_{t-1}(1 + x_t)/\pi_t. \quad (55)$$

where x_t is monetary growth, $\hat{x}_t = \rho_x\hat{x}_{t-1} + \eta_t^x$ is the monetary policy rule, ρ_x is the monetary policy smoothing parameter and finally η_t^x stands for the monetary policy shock, following an $i.d.d$ normal distribution process. (55) indicates that current money growth is a function of the previous period's monetary growth.

(6) Market Equilibrium

The equations describing the behavior of households, firms, and the central bank combine to form a nonlinear system describing the model's equilibrium. Output is divided between consumption C_t and investment I_t. The aggregate resource constraint in the economy requires that the quantity of final goods satisfies:

$$Y_t = C_t + [1 + S(\frac{I_t}{I_{t-1}})I_t].$$

IV. Numerical Exercises

A. Calibrated Parameters

In calibrating the DSGE model presented above, we draw from a wide range of available information. Parameters are selected in order to capture specific ratios in the Chinese economy assuming the quarter as the time unit. In this subsection, for most parameters we use a standard calibration in line with the established New Keynesian literature [28]. We set the discount factor β to 0.99, which matches the equilibrium annual net interest rates of 3%. To ensure a high equilibrium investment share, we set the capital share α to 0.33, a utility weight on labor χ to 0.25. Moreover, the inverse of Frisch elasticity is set to $\varphi = 1/3$ and the depreciation rate of capital δ at 0.025, and the elasticity of the price of capital to investments, given by S'' is set at 2.

The values of the remaining parameters, which are related to the banking system, are calibrated within the range considered in the Ferrante (2013). We use $\sigma = 0.95$ implying that the average life of banks is about three and half years. The remaining six parameters specific to the banking sector, p^G、p^B、θ_H、θ_L、κ、τ, are calibrated in Table I. Next, we turn to the calibration of the monetary policy. We start with the smoothing parameter of the monetary policy, which is set to $\rho_x = 0.7995$. This ensures that the guidelines of the central bank slowly follow the policy rule. For the impulse response functions, we calibrate the standard deviation of monetary shock $\sigma_x = 0.02$. Table I reports the values of the calibrated parameters .

TABLE I
CALIBRATED PARAMETER VALUES

Agents	Value	Source	Description
Households			
β	0.99	Funke et al (2012)[31]	Discount factor
Firms			
α	0.33	Levin et al.(2005)[32]	Capital share
δ	0.025	CMR [30]	Depreciation rate
S''	2.00	Ferrante. (2013) [3]	Elasticity of price to investments
φ	0.33	CMR	Frisch elasticity
χ	0.25	Erceg et al.(2000)[33]	Labor Utility weight
Banks			
σ	0.95	Our Calibration	Bankers survival probability
p^G	1.00	Ferrante (2013)	Success rate on good loans
p^B	0.66	Ferrante(2013)	Success rate on bad loans
θ_H	1.03	Ferrante(2013)	High Idiosyncratic realization
θ_L	0.66	Ferrante(2013)	Low Idiosyncratic realization
τ	0.15	Our calibration	Monitoring cost parameter
κ	0.70	Our calibration	Monitoring cost parameter
W^{cb}	0.02	CMR[30]	Commercial bank endowment
W^{sb}	0.02	CMR[30]	Shadow bank endowment
Policy and shock process			
ρ_x	0.7995	Our calibration	Persistence parameters
σ_x	0.02	Our calibration	Structural shock

B. Identify the Steady State Values

To estimate the model we use quarterly date for the period 1996Q1-2013Q4. The data comes from China statistical yearbook database. The macroeconomic time series underlying the data for observables are real GDP, real investment, real consumption and the GDP price deflator. π_t —Headline Consumer price Index inflation at quarterly non-annualised rates; y_t —Real Gross Domestic Product at market prices; r_t —the seven-day interbank interest rate; i_t —total investment in fixed assets; c_t —total retail sales of consumer goods; m_t —the money supply (M2). Since the model is expressed in log-deviations from steady state for estimation purposes, I take the log difference from the HP filter trend (smoothing parameter is set to 1600).

Given these parameters above, Table II reports the implied steady state values for the baseline model and the traditional banking model. We define that the baseline model as the economy with the shadow banking system and the commercial banking system, whereas the traditional banking model with only commercial banks. For the steady state of macroeconomics variables, we use the computational procedure and then compute the first-order Taylor series approximation to the equilibrium conditions in the neighborhood of the steady state [30]. In the baseline model, we choose a level of $\pi^{sb} = 0.75$ and $\pi^{cb} = 0.84$. In the steady-state equilibrium, we set the return of capital over the risk free rate $R = 1.0101$, which match the average of deposits for the period 1996-2013. We set the aggregate capital financed by commercial banks K^{cb}=1.5 and the shadow banks' capital K^{sb}=1.5. We set the aggregate level of capital K to 3. While in the traditional banking model, we set a level of $\pi^{cb} = 0.83$ and $K^{cb} = 1.5$, the aggregate level of capital K is equal to 2.55. For the remaining three variables, such as the price of capital Q , output Y , consumption C , the steady values are shown in Table II.

C. Bayesian Parameters Estimation Results

All parameters describing the shock process and structural parameters describing banks are estimated using Bayesian methods. First, we estimate the model of the posterior distribution by maximizing the log posterior function, which combines the prior information on the parameters with the likelihood of the data. In a second step, the Metropolis-Hastings algorithm is used to get a complete picture of the posterior distribution and to evaluate the marginal likelihood of the model. We finish the simulation analysis under the Matlab environment. The results estimated by Bayesian parameters are shown in Table III. The persistence parameters are relatively high for all shock processes.

TABLE II
STEADY-STATE VALUES

Var	Description	Baseline Model	Traditional Banking Model
Q	Capital price	1.00	1.00
Y	Output	0.40	0.35
C	Consumption	0.30	0.25
K	Aggregate capital	3.00	2.5
K^{cb}	commercial bank capital	1.5	1.5
K^{sb}	shadow bank capital	1.50	
π^{sb}	Shadow bank loan quality	0.75	
π^{sb}	Commercial bank loan quality	0.84	0.83
A	Technology	1.0	1.00
R	Risk-free return	1.0101	1.0101

Note: when not specified, the source for data is our calibration and the sample period is 1996Q1-2013Q4. Some parameters come from Ferrante.

TABLE III
BAYESIAN ESTIMAITON RESULTS

Symbol	Persistence Parameters	Mean	Std. Dev
ρ_A	Technology	0.8345	0.0352
ρ_{μ^p}	Price markup	0.8042	0.0544
ρ_{μ^w}	Wage markup	0.8517	0.0657
ξ_w	Calvo wages	0.7429	0.0140
ξ_p	Calvo prices	0.8305	0.0144
σ_A	Technology	0.0277	0.0200
σ_{μ^p}	Price markup	0.0516	0.0230
σ_{μ^w}	Wage markup	0.1015	0.0355
γ	Interest elasticity	0.6115	0.1209

V. IMPULSE RESPONSES ANALYSIS

In this section we perform the quantitative analysis. Due to the higher levels of leverage and the lower quality of the loans, we illustrate how the existence of the shadow banking system makes the economy more fragile in comparison to the traditional banking economy. We conduct two policy experiments. In the first experiment, we compare the baseline model with the traditional banking model (the baseline model: black solid line; the traditional banking model: blue solid line). We study the transmission of an expansionary monetary policy by analyzing the impulse response functions of the key variables in Fig.1. It allows us to assess whether the transmission mechanism of monetary policy is affected by the presence of a shadow banking system, compared to a model with only commercial bank system.

In the second experiment, we test the impulse responses of economic variables in a "persistently increasing money supply" scenario for the baseline model. This experiment analyzes how an extended period of loose monetary policy amplifies fluctuations in real and financial activity. The results are shown in Fig. 2.

A. The Economy's Response to an Expansionary Monetary Policy Shock

In this section, we consider a monetary policy shock where the central bank increases its money supply by one percentage point. The snowed line represents the baseline model and the solid line gives the traditional banking model, respectively. The responses of selected aggregate variables to a percentage point increase of the money supply are shown in Fig.1.

As shown in Fig.1, the responses of aggregate variables in the two economics are qualitatively standard. The increase in the money supply drives investment up, leading to a greater deviation from the steady-state values in both investments and asset prices. The investment displays a hump-shaped response and peaks after three to eight quarters. The price of capital shows maximum upward reactions at impact before returning to its steady state. The expansionary monetary policy leads to a boom in economy with rising output, consumption and inflaiton, after the initial rapid rise, they gradually return to its steady state value.

Next, we turn to the variables specific to the banking sector in the baseline model in Fig. 1. We conclude that during the

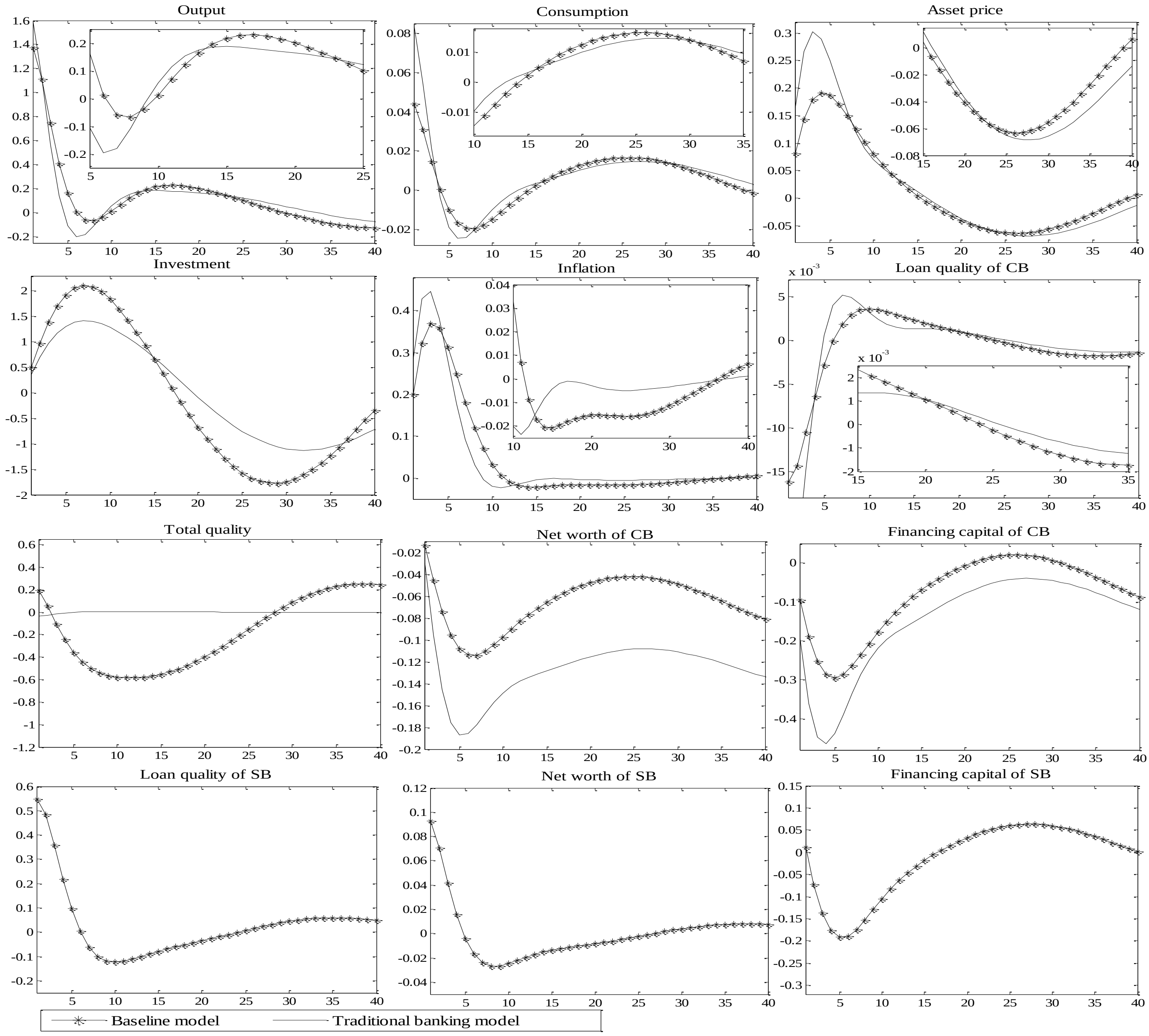

Fig.1. Impulse responses of selected aggregate variables to a 1% increase in the money supply. The inset shows the local amplification and distinguishes the items that are not differentiated easily.

previous twenty quarters, the capital financed by commercial banks K_t^{cb} is basically the same as that of the shadow banks K_t^{sb} .With increasing quarters, the capital financed by shadow banks reaches its highest level of 0.5% in response to the monetary policy shock. However, after the capital funded by commericial banks reaches the steady state values, it declines slowly. This indicates that an expansionary monetary policy helps to push the increase in financing by shadow banking sector. In additon, we note that the monetary policy shock leads to a decrease in net worth of commercial banks, while shadow bank's net worth rises and gradually returns to the steady-state values. Although the net worth of commerical banks reaches the highest level, it deviates 0.5% from the steady state value. In the case of an expansionary monetary policy shock, the volatility on net worth of commerical banks is larger than that of shadow banks. Meanwhile, an additional variable that will determine the recovery of the economy is the loans quality. The loans quality of commercial banks decreases rapidly in response to the shock in the previous ten quarters, whereas shadow banks' loans quality increases by more than 5%. These opposite movements are a consequence of their different contract structures. Since the rise in shadow banks' loan quality is larger than the drop in commercial banks' loans quality. Therefore, the aggregate loans quality increases by about 1%.

Furthermore, when only considering the response to the commercial banking sector in the traditional banking economy, we see that in most cases the responses to aggregate variables are pretty similar to those in the baseline model. The monetary policy shock produces only a modest increase in output. If we compare the responses in the baseline economy with those in the traditional banking economy, we see that the monetary policy shock has smaller consequences when shadow banks are persent. It is obvious that the impact of the monetary policy shocks is somewhat dampened in the baseline model. One reason is that when only commercial banks are in the economy, there is lower aggregate leverage. In addition, the introduction of shadow banking changes the traditional money demand and supply mechanism, which

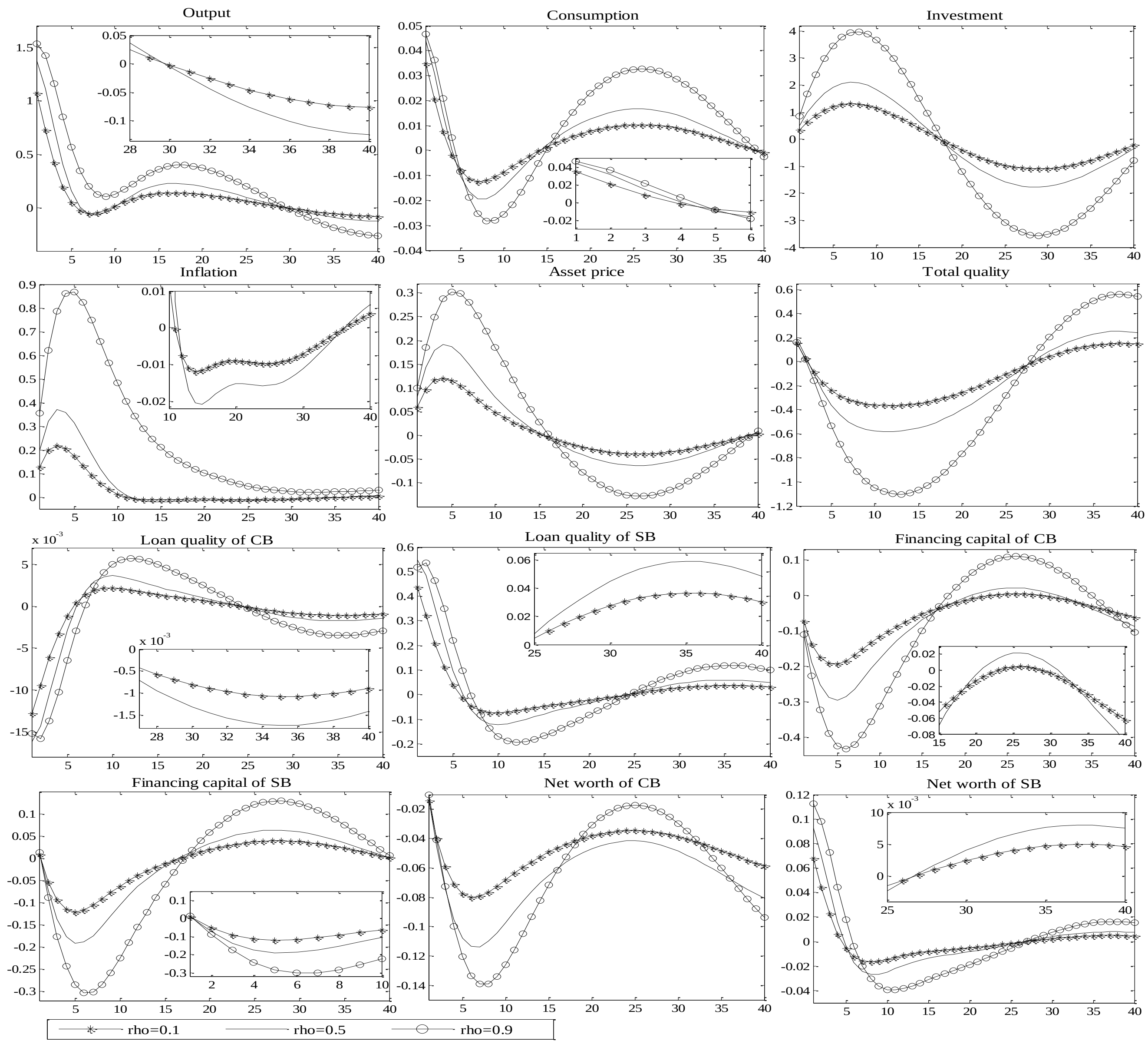

Fig. 2. Impulse responses of selected variables to a persistent increase in the money supply. The inset shows the local amplification and distinguishes the items that are not differentiated easily.

weakens money supply indicators' testability and the effectiveness of monetary policy.

B. The Economy's Response in a "Persistently Increasing Money Supply" Scenario

At the macroeconomic level, it has been recognized that loose monetary policies have historically been a key factor in driving boom-bust cycles of all types. Since the 2007-2009 financial crises in the USA, Chinese government has already supported the economic recovery by maintaining an extraordinarily accommodative monetary policy, using multiple tools. Even though the interaction between microeconomics distortions in the financial sector and a persistently loose monetary policy environment seems to have been relevant in generating the boom-bust cycle, the relative importance of each of these factors is still open to debate.

Our model is well-suited to analyze the interaction between long periods of accommodative monetary policy and financial market distortions, as well as to disentangle their relative importance. To do so, in this section we create a "persistently increasing money supply" scenario and analyze the model's dynamics. We reproduce such a scenario by setting three different variants (variant 1 (rho=0.1), variant 2 (rho=0.5), variant 3 (rho=0.9)). Because the baseline model is the economy in the presence of the shadow banking system, which is a better representation of China's emerging financial market, we compare the responses to monetary policy impulses under three different variants in the baseline model. The results are shown in Fig.2.

Fig.2 displays the impulse responses of selected variables in the baseline model. The increasing money supply leads to a rise in investment. As a result, outputs rises which drive inflation up. In addition, higher money supply increases consumption and asset prices until period 5. In period 10, output is well above its steady state value. The subsequent loose monetrary policy leads to an expansion of output, consumption and investment and a rapid rise in the price of capital. Nevertheless, variant 3 exhibits the effects of monetary policy shocks on the real economy are considerably amplified. Such the response in investment is about twice as large as that in the other variants. The percentage increase in the price of capital, at its peak, is roughly the double of the increase that occurs in the other variants. These show the overheated economy phenomenon, and the results of moneary policy shocks depend on the expected economic agents.

Next, we look at the remaining variables related to the banking sector. As Fig. 2 illustrates, before period 10, the net worth respectively held by commercial banks decreases while shadow banks increases rapidly under the three variants. Then, shadow banks' net worth rises slowly and gradually returns to its steady state value. In fact, because of the higher leverage the drop in shadow banks' net worth makes the financial constraints more binding, which provides assets to other financial sectors. Moreover, after the initial jump, the net worth held by commercial banks steadily returns to its steady state value.The most striking difference is that the endogenous quality of loans will be moving countercyclically for commercial banks but procyclically for shadow banks during the period of persistently high money supply. This phenomenon could be explained. During an economic boom, there is a sharp appreciation in collateral and better quality assets. The commercial banks dominate in China's modern economic system and generally provide high quality loans to enterprises, such as low-risk firms or state-owned enterprises , whereas the shadow bank loans are primarily provided to risk-based SMEs. In an expansionary monetary policy environment, loan qualities are increasing. The endogenous quality of loans, which is procyclical for shadow banks, increases the risk in economies to some extent. Although central bank's expansionary monetary policy improves the loan quality of the commercial banking system, the procyclical behavior of shadow banking reduces the overall quality screening. Fig. 2 also shows that in variant 3, the monetary policy shock leads to a higher financing capital for both types of banks—commercial banks and shadow banks. This shows that an expansionary monetary policy increases the financing scale of financial intermediaries. Similar to a persistently low interest rate environment, enterpreneurs with much greater enthusiasm increase the demand for fund. Hence, the loans frequency of financial intermediaries also increase.

VI. Conclusions and Discussions

This paper analyzes whether the financial intermediary plays an important role in amplifying fluctuations in real financial activity during periods of accommodative monetary policy. We have built a present-generation nonlinear DSGE model with binding constraints. The DSGE model provides a conceptual framework to discuss the macroeconomic effects of financial market reforms in China. Starting from a DSGE monetary model, we have introduced a micro-founded market comprised with a shadow banking sector. We have first analyzed the responses to an expansionary monetary policy shock under two models. The results show that the effects of monetary policy on economic activity are narrowed when shadow banks are taken into account. In the baseline model, the drop in asset prices and investment aggravates the shadow banking system. We have then simulated a "persistently increasing money supply" scenario by setting three different variants in the baseline model. Our main result is that the shadow banking system will affect the effectiveness of monetary policy transmission. Specifically, in the persistent monetary policy shocks, the loans quality and net worth in the shadow banking sector gradually decrease, whereas commercial banks move reversely. In addition, the shadow banking system increases the aggregate leverage of the financial sector through amplifying exogenous shocks and reducing banks' incentives to invest in high loans quality. Overall, this increases their exposure to monetary policy shocks.

Besides, our results have important implications for further research. Since there is a significant difference between China's shadow banking and foreign shadow banking. In the domestic shadow banking system, the SMEs have a higher demand for funds, which increases systemic risk. In comparison, commercial banks are subject to both the supervision and risk constraint. It is difficult to provide adequate credit to these high risk firms. The shadow banking system bridges these funding gaps. From the view of balance sheets of banks, the development of shadow banking can reduce the loans quality and also increase the risk, which makes the financial system unstable. In an evolving economic environment, the idiosyncratic risk may be partially diversified by shadow banks, however, along with the slow economic development, the loans quality of shadow banks will clearly decrease, which will amplify bank's operational risk. Although the shadow banking in China is different from the investment banks in advanced economics, we need to pay attention on it. In the future, we will need to reduce credit risk and tighten the standards of loans quality originated by shadow banking, as well as strengthen the supervision.

References

[1] P. McCulley, Teton reflection. PIMCO, Global Central Bank Focus, September 2007.

[2] Financial Stability Board, "Shadow Banking: Strengthening Oversight and Regulation; Recommendations of the Financial Stability Board", 2012.

[3] F. Ferrante, "A Model of Endogenous Loan Quality and the Collapse of the Shadow Banking System", Federal Reserve Board, 2015.

[4] X. Zhang and P. Hess, "Demand and Supply of Shadow Banking in China", Central Banking and Financial Stability in East Asia. Springer International Publishing, pp. 141-156, 2015.

[5] M. Funke, P. Mihaylovsk and H, Zhu, "Monetary policy transmission in China: A DSGE model with parallel shadow banking and interest rate control", 2015.

[6] Y. L. Lu, H. F, Guo, E. H.Kao and H.G. Fung, "Shadow banking and firm financing in China", *International Review and Economics and Finance*, vol. 36, pp. 40-53, 2015.

[7] Q. Chen, M. Funke and M. Paeta, "Market and non-market monetary policy tools in a calibrated DSGE model for mainland China", Hamburg University, Department of Economics, 2012.

[8] F. Verona, MM.F.Martins and I. Drumond, "(Un) anticipated monetary policy in a DSGE model with a shadow banking system", Bank of Finland Research Discussion Paper, 2013 (4).

[9] C.J. Erceg, L. Guerrieri and C. J. Gust, "SIGMA: A New Open Economy Model for Policy Analysis", *International Journal of Central Banking*, pp.1-50, 2006.

[10] R. Harrison, K. Nikolov, M.Quinn, G. Ramsay, A. Scott and R. Thomas, "The Bank of England quarterly model", Technical report, Bank of England, 2005.

[11] F. Smets and R. Wouters, "An Estimated Stochastic Dynamic General Equilibrium Model of the Euro Area", *The Journal of the European Economic Association*, vol.5, pp.1123-1175, 2003.

[12] H. Wang, X. Deng and W. Yang, "Pricing Model for Owner's Payment Bond in China", *International Journal of Applied Mathematics*, vol. 45, no. 4, 2015.
[13] M. Gertler and P. Karadi, "A model of unconventional monetary policy", *Journal of monetary Economics*, vol. 58, no.1, pp.17-34, 2011.
[14] M.K. Brunnermeier and Y. Sannikov, "A macroeconomic model with a financial sector". National Bank of Belgium, Working Paper, 2012.
[15] Z. He and A. Krishnamurthy, "Intermediary asset pricing", National Bureau of Economic Research, 2008.
[16] K. Du, G. Liu and G. Gu, "Accelerating Monte Carlo Method for Pricing Multi-asset Options under Stochastic Volatility Models", *IAENG International Journal of Applied Mathematics*, vol.44, no.2, pp. 62-70, 2014.
[17] F. Verona, M.M.F. Martins and I. Drumond, "Monetary policy shocks in a DSGE model with a shadow banking system", Universidade do Porto, Faculdade de Economia do Porto, 2011.
[18] A. Sheng, "Central banking in an era of quantitative easing", Levy Economics Institute, Working paper, 2011.
[19] A. Sunderam, "Money creation and the shadow banking system", *Review of Financial Studies*, 2014.
[20] M. Ricks, Reforming the Short-Term Funding Markets, Harvard University John M. Olin Center for Law, Economics and Business Discussion Paper, pp.713, 2012.
[21] R. Meeks, B. Nelson and P. Alessandri, "Shadow banks and macroeconomic instability", Bank of Italy Temi di Discussione (Working Paper), pp. 939, 2013.
[22] E. Faia, "Credit risk transfers and the macroeconomy", Working paper Series 1256, European Central Bank, 2010.
[23] F. Mazelis, "Monetary policy effects on financial intermediation via the regulated and the shadow banking systems". SFB 649 Discussion Paper, 2014.
[24] F. Mazelis, "Monetary policy effects on financial intermediation via the regulated and the shadow banking systems". SFB 649 Discussion Paper, 2014.
[25] L.P. Zhou, "Shadow banking system credit creation: Mechanism, effect and response ideas", *Financial Review*, no. 4, pp. 37-53, 2011.
[26] Z.W. Wang, "The effect of Shadow banking system on China's Money Supply—Based on the financial products market", *China Finance*, no. 23, pp.30-31, 2010.
[27] X.K. Li, "Empirical analysis of the Dynamic Relationship between the Shadow Banking and Money Supply", *Accounting*, no.10, pp. 82-84, 2013.
[28] J. Chen and X. L. Zhang, "An empirical analysis of the effect of shadow banking on China's economic development", Research on Financial and Economic Issues, no. 8, pp. 66-72, 2012.
[29] J. Zheng, S. Gan, X. Feng and D. Xie, "Optimal Mortgage Refinancing Based on Monte Carlo Simulation", *IAENG International Journal of Applied Mathematics*, vol.42,no.2, pp.111-121, 2011.
[30] H. Chen, Q. Chen and S. Gerlach, "The implementation of monetary policy in China: the interbank market and bank lending", Hong Kong Institute of Monetary Research, Working Papers, no.26, 2011.
[31] L.J. Crhistiano, R. Motto and M. Rostagno, "Financial factors in economics fluctuations", European Central Bank, Working paper Series, 2010.
[32] M. Funke and M. Paetz, "A DSGE-based assessment of nonlinear loan-to-value policies: Evidence from Hong Kong", Working paper, 2012.
[33] A. T. Levin, A. Onatski and J. Williams, "Monetary policy under uncertainty in micro-founded macroeconometric models", vol. 20, pp.229-312, 2006.
[34] C. J. Erceg, D. W, Henderson and A. T. Levin, "When the Underwriter Is the Market Maker: An Examination of Trading in the IPO Aftermarket", *Journal of Finance*, vol. 55, no. 3, pp. 1039-1074, 2000.