The Impact of Discriminatory Credit Constraint on Business Cycle: A DSGE Model with Endogenous Loan-to-Value

Yuchao Peng† Lili Yan‡
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Abstract

This paper builds a banking DSGE model with endogenous loan-to-value ratios, taking the different relationship between different types of firms and banks into account. Due to the political connections between the bank and enterprises, loan to value ratio for state-owned enterprises is endogenously higher than that for private enterprises, which is referred to discriminatory credit constraint in this paper. Compared to non-discriminatory credit constraint, we find that discriminatory credit constraint can further amplify the impact of negative technology shocks on output, and reduce the effectiveness of expansionary monetary policy. Empirical evidence from China industrial firms’ data supports our conclusion.

JEL Classification: E32, E34

Key Words: Discriminatory Credit Constraint, Endogenous Loan-to-Value, Business Cycle, Political Connections, DSGE model.

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†Department of Finance, Business School, Durham University, Durham, UK. School of Finance, Central University of Finance and Economics, Beijing, China. Email: yuchaopeng@hotmail.com.

‡School of Finance, Central University of Finance and Economics, Beijing, Email: llyanll@163.com
“The longer term implications of focussing lending on state firms and starving the high growth private sector could return to haunt the banks with bad debts in the future.”

—Le et al. (2014)

1 Introduction

The US subprime mortgage crisis and the following world financial crisis suggest that financial sector plays an increasingly important role in modern economy’s running, and it is also the key to understand how economy fluctuates. Over the last several decades, there has been an increasing literature in this area (Kiyotaki & Moore, 1997; Bernanke et al., 1999). However, most of researches pay little attention to an existing phenomenon in financial activities: discriminatory credit constraint, which may influence the economic fluctuation and the effectiveness of fiscal and monetary policies. For instance, China suffered a sharp drop in total imports and exports, and a fall in GDP growth rate in the fourth quarter of 2008 because of the sluggish global economy. In order to stimulate the economy, the Chinese government decisively launched the “four trillion” rescue plan, and simultaneous countercyclical expansionary monetary policy. However, most of the liquidity extracted by People Bank of China flew to state-owned enterprises, causing private enterprises suffering more binding credit constraint (see Figure 1). Even though the firms provided the collateral with the same value, the banks were willing to lend more money to state-owned firms, which are backed up by Chinese government. Banking discrimination of ownership leads to the misallocation of financial resources, thus hindering the economy’s recovery: China’s economic growth experienced a short recovery in 2009 and 2010, then following by a continuous decline. This paper presents a dynamic stochastic general equilibrium model where the loan-to-value ratios are endogenously by firms and banks. Our main objective is to understand weather discriminatory credit constraint can affect economic fluctuation or not, and to find the reason why countercyclical monetary policy has failed to save the China’s economy.

[FIGURE 1 ABOUT HERE]

This paper fits existing researches on financial frictions and business cycle. Since Kiyotaki and Moore (1997) and Bernanke et al. (1999)(henceforth, BGG), numerous scholars have researched on the impact of financial frictions on business cycle\(^1\). On the demand side, the literature is mostly based on two alternative approaches\(^2\): one

\(^1\)See the survey of Brunnermeier et al. (2012) to know the literature on financial frictions in macro economies.

\(^2\)See Brzoza-Brzezina et al. (2013) about the comparison of two approaches.
is about external finance premium (financial accelerator), e.g., Carlstrom and Fuerst (1997), Christensen and Dib (2008), Le et al. (2014) and so on; the other is about credit constraint e.g., Iacoviello (2005, 2015). They find financial frictions can sharpen economic fluctuation by amplifying primary shocks. On the supply side, many DSGE models are constructed revolving around the banking sector, e.g. Gerali et al. (2010) (henceforth, GNSS), Gertler and Karadi (2011), Angeloni and Faia (2013) and so on. They propose that bank capital regulation and the deterioration of banks’ balance sheet are the essential factors driving the business cycle. These researches have dramatically contributed to the theoretical development of financial frictions. However, when researching on credit constraint, the majority of scholars regard the loan-to-value ratio as constant or exogenous shock, merely caring for the banking discrimination on borrowers’ asset scale and asset price, nay, ignore that different types of firms may confront different loan-to-value ratios, which may further influence the economic fluctuation in another way. Despite recent researches about financial crisis and financial regulation propose that the loan-to-value ratio is an important instrument of macro prudential policies (Mendicino & Punzi, 2014; Rubio & Carrasco-Gallego, 2014), by assuming that the loan-to-value ratios counter-cyclically respond to total loan or output, however, this assumption does not fit the reality, because it is the firms and the banks who decide the ratios in order to cope with the information asymmetry and to resist loan default risks. As a consequence, these models with non-discriminatory credit constraint and exogenous loan-to-value ratios cannot help to solve the problem of China’s economy.

Our research is also related to the literature about political connections, banking discrimination on the ownership and financial misallocations. Despite the marketization reforms that have had a major impact on all aspects of the Chinese economy, state-owned enterprises and private enterprises are still subject to different treatment (Dollar and Wei, 2007)). Especially, state-owned enterprises have more access to finance (Brandt & Li, 2003; Ge & Qiu, 2007; Li et al., 2008; Cull et al., 2009; Song et al., 2012). Because of incentives for promotion, local government officials may force the banks to provide more loans to state-owned enterprises, which may bring fiscal revenue (Gordon & Li, 2012). Recent paper of Cull et al. (2013) contribute to this topic by empirically testing the relationships among investment behaviour of state-owned enterprises, political connections and financial constraint, proving that financial misallocation in China indeed results from political connections. Numerous researchers implement plentiful research on banking discrimination and its influence on financial misallocation and TFP losses (Midrigan & Xu, 2010; Song et al., 2012; Gilchrist et al., 2013; Carvalho, 2014; Moll, 2014), however, they rarely take the influence on business cycles into account. Recent work of Le et al. (2014) contributes to the issue by constructing a DSGE model of China, and proposing that the longer term implications of focussing lending on state firms could be harmful to China’s economic growth. But
they do not characterize the two types of firms into the model, and do not explain the implications of discriminatory credit constraint on economy’s fluctuation.

In this paper, based on GNSS’s work, we build a dynamic sophisticated general equilibrium model, where the banks can decide the loan-to-value ratio, taking both state-owned enterprises (henceforth, SOEs) and private enterprises (henceforth, PEs) into account, to analyze the impact of discriminatory credit constraint on business cycles\(^3\). The most specific part of our model is to allow the banks and state-owned enterprises to decide loan-to-value ratios when solving the optimization problems. We distinguish performing loans and non-performing loans, which are not known until the loan becomes mature. Because loan-to-value ratios are depended on banks’ behavior of resisting risk, we introduce a “Costly State Verification” (henceforth, CSV) cost, following BGG, to evolve the mechanism of the loan to value ratio endogenously. This model describes the political connections among the government, state-owned enterprises and the banks by introducing a subsidy into the banks’ profit function. Thus, we can derive the different credit constraints that different types of enterprises confront, under the assumption that loan interest ratio is the same for both state-owned enterprises and private enterprises according to non-arbitrage conditions.

We parameterize the model according to existing literature and the data of China’s economy. Subsequently, through several experiments designed to illustrate how the model behaves, we compare the transmission mechanism of a negative technology shock under discriminatory credit constraint and non-discriminatory credit constraint respectively. We find the total output and total loan to enterprises have experienced a more significant decline due to discriminatory credit constraint. Moreover, according to the impulse-responses of an expansionary monetary shock, we find that the output and total loan increase less in the model of discriminatory credit constraint than those in the model of non-discriminatory credit constraint. These results reveal that discriminatory credit constraint could amplify the technology shock and reduce the effectiveness of monetary policy. For robustness, we further empirically examine the impact of discriminatory credit constraint on the relationship between monetary policies, technology improvement and economic growth. The empirical evidence from China’s industrial level data has supported our conclusion from the model.

This paper contributes to the literature by extending DSGE models on credit constraint and business cycle. We combine the financial friction of both demand side and supply side, with credit constraint depending on both the firms’ financial position and the banks’ situation. The model can capture not only the effect of real economy on business cycles, but also the impact of financial factors on economy’s fluctuation. Moreover, this model can characterize risk-resisting behavior of banks with the loan-to-value ratios (henceforth, LTV ratios) endogenously evolving. As to the reality, this paper

\(^3\)To be clear, the model proposed by this paper may also be used to analysis the political connections and bank discrimination in other countries.
proposes a new explanation of the recent decline of China’s economic growth. Our conclusion supports the further deep reforms of marketization in China, the amelioration of financial system and the market-orientation transformation of financial architecture. Finally, this paper indirectly introduces political factors into DSGE model, filling the gap of existing literature to some extent.

The remainder of this paper is organized as follows: Section 2 introduces the full DSGE model, while Section 3 describes the calibration of the model. Sections 4 and 5 present the impulse response analysis and empirical analysis respectively. Section 6 comprises concluding remarks.

2 Model Setup

In this section, we extend the GNSS model by distinguishing two types of enterprise: state-owned enterprises and private enterprises. We attempt to describe the discriminatory credit constraint confronted by state-owned firms and private firms, and simulate its impacts on the economy when exogenous shocks occur. The whole economy incorporates patient and impatient households, wholesale banks, bank lending and bank deposit branches, SOEs and PEs, retailers, capital goods producers and a central bank. All the LTV ratios are decidable for wholesale banks, who also undertake the default cost (CSV cost). Due to strong relationship with government, SOEs may partly decide LTV too. As to LTV ratio for impatient households, we assume it constant for simplification, while that for enterprises is time-varied. Considering that the banks in China will provide less strict loan conditions to SOEs because of their strong government background, we assume that the government will pay subsidies to wholesale banks, which are directly connected to the loan amount supporting SOEs.

2.1 Households

2.1.1 Patient Households

Following GNSS, the representative of patient households maximizes its whole-life expected utilities:

\[
E_0 \sum_{t=0}^{\infty} \beta_t \left[ (1 - a^P) \log (c_t^P - a^P c_{t-1}^P) + \log h_t^P - \frac{(n_{t,A}^{P,A})^{1+\phi_A}}{1 + \phi_A} - \frac{(n_{t,B}^{P,B})^{1+\phi_B}}{1 + \phi_B} \right]
\]

where, \( c_t^P \) is the consumption of each patient household, \( \tilde{c}_t^P \) is the observable aggregate consumption of patient household in last period, \( a^P \) is the parameter to measure the consumption habit, \( h_t^P \) is housing service, \( n_{t,A}^{P,A} \) and \( n_{t,B}^{P,B} \) are the hours worked in the state-owned firms (Firm A) and private firms (Firm B) respectively, which have inverse
Fischer elasticity $\phi^A$ and $\phi^B$. The representative patient household earns a wage with a real wage rate $w_{t}^{P,A}$ of state-owned firms and $w_{t}^{P,B}$ of private firms to support their consumption and accumulation of housing $\Delta h_{t}^{P}$ with housing price $q_{t}^{h}$. The budget constraint is:

$$c_{t}^{P} + d_{t}^{P} + q_{t}^{h} \Delta h_{t}^{P} \leq w_{t}^{P,A} n_{t}^{P,A} + w_{t}^{P,B} n_{t}^{P,B} + \frac{d_{t-1}^{P} (1 + r_{t-1}^{d})}{\pi_{t}} + t_{t}^{P} \tag{2}$$

where $d_{t}^{P}$ is the deposit, $r_{t-1}^{d}$ is the net deposit interest rate of $t-1$ period, and $t_{t}^{P}$ is lump-sum taxes and dividends.

### 2.1.2 Impatient Households

Similarly, the impatient households also choose the labour supply, consumption and housing investment to maximize their expected utilities as:

$$E_{0} \sum_{t=0}^{\infty} \beta_{t} \left[(1 - a^{I}) \log(c_{t}^{I} - a^{I}\bar{c}_{t-1}^{I}) + \log h_{t}^{I} - \frac{(n_{t}^{I,A})^{1+\phi^{A}}}{1 + \phi^{A}} - \frac{(n_{t}^{I,B})^{1+\phi^{B}}}{1 + \phi^{B}}\right] \tag{3}$$

and subject to:

$$c_{t}^{I} + b_{t-1}^{I} (1 + r_{t-1}^{bH}) + q_{t}^{h} \Delta h_{t}^{I} \leq w_{t}^{I,A} n_{t}^{I,A} + w_{t}^{I,B} n_{t}^{I,B} + b_{t}^{I} \tag{4}$$

where $b_{t}^{I}$ is the money borrowed from banks with a net loan interest $r_{t}^{bH}$. The households should provide their housing as collateral, so they confront a borrowing constraint set by banks

$$b_{t}^{I} (1 + r_{t}^{bH}) \leq m^{H} E_{t} \left[q_{t+1}^{h} h_{t}^{I} \pi_{t+1}\right] \tag{5}$$

That means the total amount of loan and interest should be less than the expected value of housing multiplied by loan to value ratio $m^{H}$.

### 2.2 Enterprises

In this model, we incorporate two types of enterprise, state-owned enterprises and private enterprises, indexed as $s = A, B$ respectively. We intend to describe the different efficiency of state-owned and private enterprises, and to analyse the different financial friction they confront. In common with most standard set-ups, the representative enterprise selects the labour, capital, consumption and loans to maximize its whole-life
utility of consumption $c_t^s$.

$$E_0 \sum_{t=0}^{\infty} \beta_s^t (1 - a^s) \log (c_t^s - a^s \tilde{c}_{t-1}^s) \quad (6)$$

where, $\beta_s$ is the subjective discount factor of enterprise $s$, $\tilde{c}_{t-1}^s$ is the observable aggregate consumption in last period, and $a^s$ is the consumption habit parameter.

### 2.2.1 State-owned Enterprises

The production function of state-owned enterprises is like Cobb-Douglas technology

$$y_t^A = z_t \left( u_t^A k_{t-1}^A \right)^{\alpha_A} \left( n_t^A \right)^{1-\alpha_A} \quad (7)$$

where, $k_{t-1}^A$ is the capital, $z_t$ is technology shocks, and $u_t$ is time-varying utilization rate of capital (See Schmitt-Grohé & Uribe, 2006), which leads to a cost:

$$\psi (u_t^A) k_{t-1}^A = k_{t-1}^A \left( \frac{\kappa_1^u}{2} \left( u_t^A - \bar{u}_t^A \right)^2 + \kappa_2^u \left( u_t^A - \bar{u}_t^A \right) \right)$$

where $\kappa_1^u$ and $\kappa_2^u$ are positive parameters. Utilization rate of capital reflects the capacity. If the utilization rate decreases, the firm can be regarded as having excess capacity. The labour $n_t^A$ is aggregated from patient labour and impatient labour by C-D technology with parameter $\mu^n$:

$$n_t^A = \left( n_t^{I,A} \right)^{\mu^n} \left( n_t^{P,A} \right)^{1-\mu^n} \quad (8)$$

The state-owned enterprises earn revenue by selling their products. Their main expenditure consists of purchasing capital goods to invest, paying wages and their own consumption. They can borrow money from banks to help them start the business and smooth the consumption. Then we can write the budget constraint as follows:

$$\frac{y_t^A}{x_t^A} + b_t^A + q_t^k \left( 1 - \delta \right) k_{t-1}^A = q_t^k k_t^A + \psi (u_t^A) k_{t-1}^A + w_t^{P,A} n_t^{P,A} + w_t^{I,A} n_t^{I,A}$$

$$+c_t^A + \frac{b_{t-1}^A \left( 1 + r_t^{b,E} \right)}{\pi_t} \quad (9)$$

where, $\delta$ is the depreciation rate of capital, $q_t^k$ and $1/x_t^A$ are the relative price of state-owned enterprise-made products and capital goods compared to consumption goods price, $b_t^A$ is the amount of borrowed money, $r_t^{b,E}$ is the net loan interest for enterprises, $w_t^{P,A}$ and $w_t^{I,A}$ are real wage rates for patient households and impatient households respectively.

In order to introduce the endogenous law of evolution for loan to value ratio, we construct a scenario to show the loan default and information asymmetry. We assume
the project has probability to succeed of $1 - \eta$, and then the enterprise will return the total loan payable to banks including the interest. However, there is $\eta$ probability that the project may fail. If the project fails, both the enterprise and the banks will incur a cost. The enterprises are not willing to return the total debt, so loan default occurs. The bank will pay a cost for "Costly State Verification" (CSV, mentioned in BGG, 1999), which is assumed to be positively related to loan to value ratio and the total loan and interest payable ($m^A_{t-1}/2\kappa_w$ multiplied by total debt). For enterprises, the loan payable is diminished, so they only return $1 - m^A_{t-1}/2\kappa_w$ to the bank. This is a threshold value: if the return rate is less than the threshold, the bank will pay CSV cost to hire a person to recoup the loan payable. However, the enterprise should also incur the total cost of project failure. We assume the project failure cost is $\kappa_f m^A_{t-1} q^k q^k_{t-1}$, which is positively related to the loan to value ratio and capital. This is because when the LTV ratio is relatively higher, the enterprise will have higher leverage and will be motivated to invest in more risky projects, which will lead to more loss when the project fails.

Then we can aggregate the budget constraint of enterprises under two different conditions by weight of their probabilities, $1 - \eta$ and $\eta$ respectively:

$$\frac{y^A_t}{x^A_t} + b^A_t + q^k (1 - \delta) k^A_{t-1} = q^k k^A_{t-1} + \psi (u^A_t) k^A_{t-1} + w^{P,A}_t n^{P,A}_t + w^{I,A}_t n^{I,A}_t + c^A_t$$

$$+ \frac{b^A_{t-1} (1 + r^{bE}_{t-1})}{\pi_t} \left(1 - \eta \frac{m^A_{t-1}}{2\kappa_w}\right) + \kappa_f m^A_{t-1} q^k k^A_{t-1}$$

(10)

The firm also confronts borrowing constraint set by banks

$$b^A_t \left(1 + r^{bE}_t\right) \leq m^A_tE_t \left[q^k k^A_{t+1} \pi_{t+1} (1 - \delta)\right]$$

(11)

In our model, we assume the loan to value ratio is endogenous, which means the loan to value ratio depends on the negotiation of banks and enterprises. However, state-owned enterprises have more power in the loan market, so we assume that only state-owned enterprises and banks can make a decision about loan to value ratio.

2.2.2 Private Enterprises

Following Song et al. (2011) we assume the private enterprises can hire managers with remuneration $w^m_t$ to improve their labor efficiency by $\chi$. Then the production function of private firm is:

$$y^B_t = z_t (1 - \psi) \left(u^B_t k^B_{t-1}\right)^{\alpha_B} \left(\chi n^B_t\right)^{1-\alpha_B}$$

(12)

Meanwhile, to prevent the manager diverting funds from the company to their own benefit, the remuneration satisfies an incentive constraint $w^m_t > \psi y^B_t$, where $\psi$ is the
parameter satisfying an assumption \( \chi > (1 - \psi)^{-1/a_B} \) proved by Song et al. (2011) to keep the firm willing to hire a manager. Similarly to state-owned enterprises, we can write the budget constraint of private enterprises as

\[
\frac{y^B_t}{x^B_t} + b^A_t + q_t^k (1 - \delta) k^B_{t-1} = q_t^k k^B_t + \psi (u^A_t) k^B_{t-1} + w^P_t n^P_t + w^I_t n^I_t + c^B_t
\]

\[
+ \frac{b^B_{t-1} (1 + r^b_{t-1})}{\pi_t} \left( 1 - \eta \frac{m^B_{t-1}}{2 \kappa_w} \right) + \kappa_j m^B_{t-1} q_t^k k^B_{t-1}
\]

### 2.3 Banking Sector

Following Gerali et al. (2010), the bank sector in our model is also split into three parts: a wholesale bank and two retailer branches. Unlike Gerali et al. (2010), however, we assume the banks know the collateral provided by enterprises, and will choose LTV ratio to ensure that the borrowing constraint of enterprises is always binding.

#### 2.3.1 Wholesale Branch

Following GNSS, each wholesale branch operates under perfect competition. On the liabilities side they will combine their own bank capital \( k^w_t \) with deposit \( d_t \) transferred from deposit retail branches on the liabilities side. On the assets side, they will issue loans \( b^I_t \) to impatient households, and loans \( b^A_t \) and \( b^B_t \) to state-own and private enterprises respectively. The law of evolution for bank capital is

\[
\pi_t k^w_t = (1 - \delta^b) k^w_{t-1} + j^b_{t-1},
\]

where \( \delta^b \) measures resources used to manage the bank capital, \( j^b_{t-1} \) is profit of total banks.

According to the analysis on the scenario of loan default and information asymmetry, banks will incur a CSV cost. We assume that all of this cost is undertaken by wholesale branches, and then they will choose deposit and loans to maximize their expected profit as follows:

\[
\max_{m^A_t, b^A_t, b^I_t} r_t^{wE} (b^A_t + b^B_t) + r_t^{wH} b^I_t - r_t d_t - \frac{\kappa_{kb}}{2} \left( \frac{k^w_t}{b_t} - \nu^b \right)^2
\]

\[-\frac{\eta}{2 \kappa_w} (m^A_t + m^B_t) \left( 1 + r_t^{bE} \right) + T (b^A_t) \]

where, \( r_t^{wE}, r_t^{wH} \) are wholesale loan rate for enterprises and impatient households respectively, \( k^w_t \) and \( b_t \) are bank capital and total loan, \( \nu^b \) is the capital acquirement ratio set by the regulator, \( \kappa_{kb} \) and \( \kappa_w \) are parameters, \( T (b^A_t) \) is the subsidy from government \(^4\) for loans to state-owned firms, \( T (b^A_t) = \frac{\kappa^T T_1}{2} (b^A_t - \bar{b}^A)^2 / \bar{b}^A + \kappa^T T_2 b^A_t \), where \( \kappa^T T_1 \) and \( \kappa^T T_2 \) are positive parameters. This subsidy is to reflect the tight relations between banks and state-owned enterprises. As we know, the majority of banks in China are

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\(^4\)When closing the model, the cost of this subsidy is finally borne by patient households.
really controlled by government, which includes both central government and local government. Then the leaders and shareholders of state-owned firms may influence the banks to reduce the loan conditions and requirements. Moreover, motivated by the pursuit of promotion, officials of local government continuously improve their political performance by exerting pressure on banks and state-owned firms for GDP growth. Furthermore, when the loans of state-owned firms became non-performing, the government helps the banks to strip away bad assets. These phenomena reflect the strong relations between banks and state-owned enterprises, so we use the subsidy to reveal this relationship, which is also the main driver of discriminatory credit constraint between state-owned and private firms.

Following GNSS, we assume the deposit rate faced by the wholesale banks is equal to Taylor Rule rate \( r_t \), which is paid to the deposit retailer. The balance sheet constraint of wholesale branches is \( b_t^A + b_t^B + b_t^l = b_t = k_t^w + d_t \). In addition, they choose the loan to value ratio under the condition \( m_t^A q_t^{\pi_t+1} k_t^w (1 + \delta) = (1 + r_t^{bE}) b_t^l \). After some algebra with regard to the first order conditions, we can derive the interest spread between wholesale loan rates and Taylor Rule rate:

\[
\begin{align*}
    r_t^{wH} &= r_t - \kappa b_t \left( \frac{k_t^w}{b_t} - \nu b_t \right) \left( \frac{k_t^w}{b_t} \right)^2 \\
\end{align*}
\]  

(13)

Similar to GNSS, the interest spread comes from the cost of capital acquirement. Furthermore, we can get the interest spread between wholesale loan rates for impatient households and private enterprises:

\[
\begin{align*}
    r_t^{wE} &= r_t^{wH} + \eta m_t^B \frac{1 + r_t^{bE}}{\kappa_w} \\
\end{align*}
\]  

(14)

This spread reflects the cost of probability of loan default or CSV cost. Meanwhile, we also can derive a similar equation from the first order condition for loan of state-owned enterprises. Combining them, we can derive the relationship of loan to value ratios for two types of firms:

\[
\begin{align*}
    m_t^A - m_t^B &= \frac{T' \left( b_t^A \right) \kappa_w}{\eta \left( 1 + r_t^{bE} \right)} \\
\end{align*}
\]  

(15)

It is obvious that the extent of discriminatory credit constraint is positively related to the marginal subsidy rate to banks for SOE loans, and negatively related to the loan interest rate of enterprises.

### 2.3.2 Deposit Retailer Branch

The deposit retailer branches operate under monopoly competition. They collect deposits from patient households with deposit rates \( r_t^d(i) \) and transfer the deposits to
the wholesale branch with interest rate \( r_t \), equal to the Taylor Rule rate. According to Beneš and Lees (2007), the total deposit market each retailer confronts is 
\[
    d_t = \int_0^1 d_t(i)^{1/\varepsilon_d} \varepsilon_d \quad \text{where} \quad \varepsilon_d \text{ is the elasticity of substitution of deposit.}
\]
After cost minimization, we can derive the deposit demand of each retailer as 
\[
    d_t(i) = r_t d_t(i)^{-\varepsilon_d} \frac{r_t d_t(i)}{r_t d_t(i)}.
\]
We assume the deposit retailers have a quadratic adjustment cost when adjusting the deposit rate; then we can write the profit function of deposit retailer branch as:
\[
    \max_{r_t^d(i)} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[ r_t d_t(i) - r_t^d(i) d_t(i) - \frac{\kappa_d}{2} \left( \frac{r_t^d(i)}{r_{t-1}^d(i)} - 1 \right)^2 r_t^d d_t \right] \tag{16}
\]
where, \( \Lambda_{0,t}^P \) is random discount factor of patient households, and \( \kappa_d \) is parameter of sticky extent. The first order condition for \( r_t^d(i) \) yield, after imposing symmetric equilibrium, is:
\[
    -1 + \varepsilon_d - \varepsilon_d \frac{r_t}{r_d} - \kappa_d \left( \frac{r_t^d}{r_{t-1}^d} - 1 \right) \frac{r_t^d}{r_{t-1}^d} + \beta P E_t \left[ \frac{\Lambda_{t+1}^P}{\Lambda_t^P} \kappa_d \left( \frac{r_{t+1}^d}{r_t^d} - 1 \right) \frac{r_{t+1}^d d_{t+1}}{r_t^d} \right] = 0 \tag{17}
\]
In the steady state the deposit interest is 
\[
    r_t^d = \frac{\varepsilon_d}{\varepsilon_d - 1} r_t. \quad \text{Because } \varepsilon_d < 0, \text{ the deposit rate is marked down to Taylor rule rate.}
\]

### 2.3.3 Loan Retailer Branch

Similar to deposit retailer branches, we assume the loan retailer branches operate under monopoly competition. The loan demands of each loan retailer branch for enterprises and impatient households (indexed by \( j = E, H \)) are 
\[
    b_t^j(i) = \frac{r_t^d(i)}{r_t^d(i)} \quad \text{where } \varepsilon_b^j \text{ is the elasticity of substitution of loan demand.}
\]
Loan retailer branches select loan interest rate to maximize their profit as follows:
\[
    \max_{r_t^b(i)} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[ r_t b_t^E(i) b_t^E(i) - r_t w_t b_t^E(i) - \frac{\kappa_b^E}{2} \left( \frac{r_t b_t^E(i)}{r_{t-1}^b(i)} - 1 \right)^2 r_t b_t^E \right] \tag{18}
\]
where, \( \Lambda_{0,t}^P \) is random discount factor of patient households, \( \kappa_b^E \) and \( \kappa_b^H \) are parameter of sticky extent. The first order conditions for \( r_t^b(i) \) and \( r_t^b(i) \) yield, after imposing
symmetric equilibrium,
\[
1 - \varepsilon_{bj} + \varepsilon_{bj} \frac{r_{wj}}{r_{bj}} - \kappa_d \left( \frac{r_{bj}}{r_{bj} - 1} \right) \frac{r_{bj}}{r_{bj} - 1} + \beta P E_t \left[ \frac{\lambda_{P t}^{P P}}{\lambda_{t}^{P P}} \kappa_{bj} \left( \frac{r_{bj}^{t+1}}{r_{bj}^t - 1} \right) \frac{r_{bj}^{t+1}}{r_{bj}^t} \right] = 0
\]
(19)

In the steady state the loan interest is \( r_{bj}^t = \frac{\varepsilon_{bj}}{\varepsilon_{bj} - 1} r_{wj}^t \). Because \( \varepsilon_{bj} > 0 \), the loan interest rate is marked up to wholesale loan interest rate. Then, we can write the total profit of banking sector as
\[
j_{bank}^t = r_{bE}^t (b_A + b_B) + r_{bH}^t b_t^J - r_{d}^t d_t - \kappa_{kb} \left( \frac{k_{w}^t}{b_t} - \nu^b \right)^2 - \frac{\eta}{2\kappa_w} (m_A^t + m_B^t) \left( 1 + i_{bE}^t \right) + T (b_t^A)
\]
(20)

2.4 The Rest of the Economy

2.4.1 Capital Goods Producer

Following Iacoviello (2005) and GNSS, we assume the capital goods producer produces capital goods with a quadric adjustment cost, and then maximizes profit as follows:
\[
\max_{i_t} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[ q_{k}^t \left( 1 - \frac{\kappa_{I}}{2} \left( \frac{i_t}{i_{t-1}} - 1 \right)^2 \right) i_t - i_t \right]
\]
(21)

where, \( i_t \) is investment, \( \Lambda_{0,t}^P \) is random discount factor of patient households, \( \kappa_{I} \) is the adjustment cost parameter. In our model, both state-owned and private enterprises use homogenous capital, so the capital can be freely traded, which means all capital goods have a unique capital goods price \( q_{k}^t \). The first order condition is:
\[
\frac{1}{q_{k}^t} = 1 - \kappa_{I} \left( \frac{i_t}{i_{t-1}} - 1 \right) \frac{i_t}{i_{t-1}} - \frac{\kappa_{I}}{2} \left( \frac{i_t}{i_{t-1}} - 1 \right)^2 + \beta P \kappa_{I} E_t \left[ \frac{\lambda_{P t}^{P P}}{\lambda_{t}^{P P}} \left( \frac{i_{t+1}}{i_t} - 1 \right) \frac{i_{t+1}}{i_t} q_{k}^{t+1} - q_{k}^t \right]
\]

And the aggregated capital is \( k_t^A + k_t^B - (1 - \delta) (k_{t-1}^A + k_{t-1}^B) \) = \( \left( 1 - \frac{\kappa_{I}}{2} \left( \frac{i_t}{i_{t-1}} - 1 \right)^2 \right) i_t \).

2.4.2 Retailer

In our model, the retailers combine the different products of two types of enterprises, by C-D technology \( y_t = (y_t^A)^{\mu^y} (y_t^B)^{1-\mu^y} \) where, \( \mu^y \) is the weight of state-owned enterprises made products in total final goods. By maximization of profit under cost constraint, we can derive
\[
\frac{\mu^y}{1 - \mu^y} = \frac{y_t^A}{y_t^B} \frac{x_t^B}{x_t^A}
\]
(22)
We introduce the sticky price as (Calvo, 1983). Only $\gamma$ of retailer may change the price in each period, and then we can derive the New Keynes Philips Curve,

$$\log \frac{\pi_t}{\bar{\pi}} = \beta P \log \frac{\pi_{t+1}}{\bar{\pi}} - \frac{(1 - \gamma)(1 - \beta \gamma)}{\gamma} \left[ \mu^p \log \frac{x^A_t}{x^A} + (1 - \mu^p) \log \frac{x^B_t}{x^B} \right]$$

(23)

where, $\bar{x}$ is steady state of the relative price of the final goods to intermediate goods that is equal to the mark-up rate.

### 2.4.3 Market clear condition and Central bank

To close the model, we give the market clear condition for final goods as

$$y_t = q^k_t \left[ 1 - 1 \left( \frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t + \left[ c^A_t + c^B_t + c^H_t + c^P_t \right] + \frac{\delta^h k^w_t}{\pi} + Adj_t$$

(24)

As to housing market, we assume the housing held by all households is equal to an exogenous constant $\bar{h}$, that is, $h^I_t + h^P_t = \bar{h}$. The central bank follows the standard Taylor rule,

$$\log 1 + \frac{r_t}{\bar{r}} = \rho \log 1 + \frac{r_{t-1}}{\bar{r}} + (1 - \rho) \left[ \phi_y \log \frac{y_t}{y_{t-1}} + \phi_\pi \log \frac{\pi_t}{\bar{\pi}} \right] + \varepsilon_t^{MP}$$

(25)

where, $\rho$ measures the continuity of monetary policy, $\phi_y$ and $\phi_\pi$ are the weights assigned to inflation and output stabilization respectively, and $\bar{r}$ is steady state value of interest rate.

### 3 Calibration

In the previous section, we built the full DSGE model with discriminatory credit constraint. In this section, we calibrate the structural parameters according to related literature and China’s data, in order to analyze the impulse-response figures of the main economic variables under technical shock and monetary policy shock.

#### 3.1 Structure Parameters Affecting Steady State

We parameterize the model by season, according to China’s quarterly data covering the period from 2004Q1 to 2014Q1. Table 1 shows the calibrated parameters which influence the steady state of the model. We select average Chinese average deposit benchmark interest rate as steady state value of deposit interest rate. According to the steady state deposit interest rate, we calibrate the objective discount factor of patient households as 0.9926, which is close to the value calibrated by Chen et al. (2012).
For the discount factors of impatient households and of state-owned enterprises, we follow GNSS to calibrate them as 0.975. Considering that private enterprises are more motivated to enlarge production and borrow money, we calibrate their discount factor as 0.0970, which means they are more impatient than state-owned enterprises.

We calibrate the steady state of LTV according to Chinese industrial firm data from National Bureau of Statistics of China. We use the total debt minus amount payable to calculate the long-term debt, and then use the long-term debt divided by total fixed assets to calibrate LTV ratio. According to the data, we calibrate the LTV ratio of state-owned enterprises as 0.50, while the LTV ratio of private enterprises is only 0.46. As the data of household loan is not available, we calibrate the LTV ratio of impatient households as 0.7, the same as GNSS, which is in line with Chinese policy that buyers should pay at least 30% of housing price as a haircut. According to the Commercial Bank Report of the People’s Bank of China, the non-performing loan rate is around 1%, so we calibrate the steady state loan default rate as equal to 0.01. Then we can calculate the parameter of default cost for firm $\kappa_f$ as 1.4279. We use Chinese average loan benchmark interest rate as steady state value of loan interest rate to firms, and choose 7-day Shanghai inter-bank offered rate (SHIBOR) as the proxy of steady state value of Taylor Rule rate. There is an important assumption that the steady state value of banks’ leverage ratio is equal to the requirement of 0.08 set by the central bank (similar to GNSS). According to these interest rates, we can calibrate the parameter of CSV cost $\kappa_w$ as 1, and we calibrate the substitution elasticity of deposit market and loan market for enterprises in order to match the steady state LTV ratio. With regard to the substitution elasticity of the loan market for households, we follow GNSS to calibrate it as 2.79.

The depreciation rate of capital is calibrated as normal, 0.025 (Guo et al., 2015), which means 10% per year. Values for the capital share in production function vary in the literature, with Chinese scholars calibrating it in a range between 0.4 and 0.5 (Guo et al., 2015; Chen et al., 2012). To describe the characteristic of investment-led growth of SOEs, we calibrate the capital share of SOEs and PEs as 0.5 and 0.33 respectively. Following Gertler and Karadi (2011) and GNSS, we calibrate the steady state of utilization of capital as 1, and calibrate the parameter of adjustment cost for capital utilization as $\kappa_1^u = 0.00478$ and $\kappa_2^u = 0.0478$. Following the majority of studies, we calibrate the steady state mark-up rate in the goods market as 1.2, which matches the substitution elasticity of 6. Considering that the private economy is growing rapidly and already occupies more than 60% of the GDP (Szamosszegi et al., 2011), we calibrate the weight of SOE-produced goods as 0.4. Following GNSS, the share of impatient households is calibrated as 0.2.
We calculate the management cost of bank capital as 0.0865. The subsidy to banks for SOE loans is hard to calibrate. The steady state of marginal subsidy rate $\kappa^T_2$ can be calculated as 0.0004. As to the second order marginal subsidy rate $\kappa^T_1$, we calibrate it as 0.02, and will test its range in the further analysis.

### 3.2 Other Structure Parameters

Table 2 reports the calibration values of other parameters, which do not affect steady state. We calibrate the parameter of sticky price $\gamma$ as 0.75, which means the enterprise has one chance to change their price a year. The parameters of adjustment cost are calibrated according to GNSS posterior mean values. This is for two reasons. First, Chinese financial architecture is bank-oriented, as is the euro area, so their banking systems are similar to some extent. Secondly, our model is based on the GNSS model, so the parameters may be more suitable to show the mechanism of financial frictions. With regard to the coefficient of Taylor rule, we calibrate the coefficient on inflation rate $\phi_\pi$ as 1.5, while the coefficient on output is 0.125 (Chen et al., 2012; Rannenberg, 2013). Following GNSS, we calibrate the continuity parameter of monetary policy as 0.75. About consumption habit, we calibrate it as 0.5, according to the estimation result by Ma (2014); Ma and Li (2015).

![Table 2 Here](image)

### 4 Simulation and Discussion

In this section, we analyse the role of discriminatory credit constraint based on the impulse responses of technology shocks and monetary policy shocks. By comparing results from the model with discriminatory credit constraint with those from a model where the two types of enterprise have the same LTV ratio, we find the impact of discriminatory credit constraint on the economy. We also explain the mechanism whereby it amplifies the technology shocks and hinders the effectiveness of monetary policy. Finally, we focus on the source of discriminatory credit constraint. When enlarging the parameter value of marginal subsidy rate for SOE loans, we find that the impact of discriminatory credit constraint decreases.

#### 4.1 Technology Shock

Figure 2 describes the response fluctuations of the main macro-economic variables after one unit of negative technology shock. As a result of technology decrease, both the production cost and the product price increase, leading to a decline in consumption. While being aware that the technology shock is temporary, representative patient
households may increase their current consumption and diminish their deposit, causing the deposit supply to decrease. For impatient households and enterprises, their loan demand increases. Impatient households would like to borrow more money to maintain their consumption, while enterprises would like to borrow money to smooth the influence of negative technology shock. However, limited by equilibrium, the total loan decreases as deposit supply decreases, therefore causing the interest rate to increase. These results are in line with existing literature.

In our model, endogenous LTV ratios and different treatment of SOEs and PEs are described clearly. From Figure 2 we can see that under the situation of discriminatory credit constraint, loan to SOE grows slightly, while loan to PE falls significantly. This may be interpreted according to the different LTV ratios. Both the LTV of SOEs and that of PEs is decreasing, which reveals that the LTV of SOEs is counter-cyclical, while that of PEs is pro-cyclical. SOEs have more power to influence the bank because of their strong background, so the credit constraint they confront is less binding. However, PEs can only accept the loan condition proposed by banks. As a consequence, more loan resources flow to SOEs. Due to China’s special characteristics the financial market is not perfect, leading to banks’ unfair treatment towards different types of enterprise. In China, central and local government force banks to support SOEs with low requirements for collateral, and may even vouch directly for the SOEs so that they receive loans. These factors ensure that the loan direction is biased toward SOEs.

Under the conditions of negative technology shock, discriminatory credit constraint can enlarge the fluctuation of output. By changing the parameters to make the credit constraint of both types of enterprise the same, eliminating the subsidy to banks for SOE loans, we can get another series of impulse responses with no discrimination. From Figure 2, we can see that the growth of output with no discriminatory credit constraint is slightly higher. This means that the financial accelerator effect (KM type) is enlarged when the credit constraint is discriminatory. When the economy deteriorates, banks tend to lower LTV ratio to control the CSV cost. Due to the subsidy for SOE loans, banks only lower the LTV ratio of PEs, but maintain or increase the LTV ratio of SOEs. The relatively lower LTV ratio will induce a sharp decrease in capital demand. Because SOEs and PEs use the same capital for investment, the capital prices are influenced by capital demand of both types of enterprise.

As the figure shows, compared to the model with no discrimination, the decrease of LTV for PEs has a greater influence on the capital price, making it decrease further. This is due to resource misallocation. At the beginning, despite of the different LTV ratios, PEs and SOEs have almost the same productivity and there is no misallocation. However, the borrowing constraints with different binding extent lead to different operation situation of two types of firms. With more binding borrowing constraint, PEs
may only decrease loan and investment, or even fire sale the capital, which induce to supply’s further decline. Correspondingly, the supply of SOEs is less decreasing. Due to substitution elasticity of demand between two types of firms, the demand structure cannot change intermediately. Thus, SOEs’ profitability and capital return become lower than PE’s. Contiguous enlargement of the loan gap between SOE and PE leads to more severe misallocation, therefore causing aggregate capital price’s further decline. Further decline of capital price makes both the borrowing constraints of PEs and SOEs more binding, and causing aggregate output’s decline amplified. As a consequence, discriminatory credit constraint set by banks sharpens the decrease of capital price, and then the total collateral is less valuable, while the total loan of enterprises declines further, thus leading to more decline of total output.

Furthermore, discriminatory credit constraint may worsen the economic structure and sharpen the excess capacity of SOEs. From Figure 2, we can see that the capital of SOEs increases, while that of PEs decreases, and the capital utilization of SOEs decreases faster than that of PEs. This reflects the change of economic structure and greater excess capacity of SOEs. As we know, SOEs in China are less efficient, so their output growth relies on investment. Continuous investment improves SOEs? capacity of production, but the demand cannot satisfy the supply. At the beginning of the 21st century, benefitting from the trend of globalization, China’s exports increased rapidly, which supported the excess capacity of manufacturing. However, after the global crisis of 2008, external demand decreased sharply, and the problem of excess capacity became more important. Although our model cannot describe the results of economic structure imbalance and excess capacity, we know that they are disincentives to economic development.

4.2 Monetary Policy Shock

Figure 3 reports the impulse responses of the main macro-economic variables under a standard deviation of expansionary monetary policy shock. As a result of expansionary monetary policy, the deposit interest rate decreases, and then households decrease deposits to increase current consumption. The growth of aggregate demand stimulated by expansionary monetary policy causes output to grow. For banks, decreasing policy interest rate makes them lower loan interest rates, which leads to growth of total loan. These results are similar to those in the related literature.

We pay further attention to the loans to different types of enterprise. Compared with the model without discrimination, LTV ratio of SOEs decreases slightly, but that of PE decreases more significantly. More loans flow to SOEs rather than PEs. Due to the subsidy for SOEs, banks set relatively higher LTV for SOEs, but lower LTV.
ratio for PEs, in order to lend more money to SOEs and improve their profit. With a similar mechanism to the situation under negative technology shocks, decreasing PEs’ LTV has a dramatic influence on the capital price, as the figure shows. Total loan to enterprises decreases more sharply, therefore leading to lower effectiveness of expansionary monetary policy when stimulating output growth. Since expansionary monetary policy cannot promote economic growth effectively, growing liquidity cannot flow to the real economy, and then it flows to the housing market. Compared to the LTV ratios for enterprises, LTV ratio for impatient households is higher and more fixed, as household loan is less risky. When the real economy cannot absorb the liquidity released by central banks, it is reasonable that the liquidity flows to households. As a consequence, housing and real estate become more valuable due to their collateral value, leading to growing housing demand and a prosperous housing market. This is in line with China’s housing market boom since 2009.

Furthermore, in the model with discriminatory credit constraint SOEs confront the more serious problem of excess production capacity. This has the same mechanism as that under negative technology shocks. Banks’ unfair treatment to different types of enterprise leads to different capital investment decisions of SOEs and PEs. Having obtained financial support, SOEs implement more capital assets investment. However, unsustainable growth of aggregate demand cannot support fast growing supply, thus causing excess production capacity in SOEs. This is also in line with the actual situation since 2009.

4.3 Further Analysis on Amplification Effect of Discriminatory Credit Constraint

According to the above analysis on impulse response figures, we find that discriminatory credit constraint has an amplification effect on the transmission of negative technology shocks. In order to make clear the source of amplification effect and how it changes according to the extent of discrimination, we further examine the impulse response figures under different parameters of subsidy.

As the first order marginal subsidy rate $\kappa_{T}^2$ is depends on the steady state of LTV ratios of SOEs and PEs, we can adjust only the second order marginal subsidy rate $\kappa_{T}^1$ to change the extent of discrimination. As we can see from Figure 8, higher subsidy rate leads to relatively smaller amplification effect. This is due to the double effect of subsidy. In fact, the subsidy for SOE loan has both income effect and substitution effect on credit constraint and total loans to enterprises. On one hand, when the government improves the marginal subsidy rate, the banks may earn more income, and then they will properly lower the interest rate (under negative technology shocks) and increase loan supply to maximize their profit. This is income effect. On the other hand, when the government improves the marginal subsidy rate, the banks are willing to lend more
to SOEs rather than PEs, and then they will set higher LTV for SOEs and lower LTV for PEs. Resource misallocation makes the capital price decrease more sharply, leading to decline of total loan to enterprises. This is substitution effect. With regard to the total loan to enterprises, these two effects play opposite roles. Generally, the substitution effect is more significant than the income effect, so we find the amplification effect of discriminatory credit constraint. However, when we further improve the marginal subsidy rate, the substitution effect changes less, but income effect increases to some extent; therefore, the amplification effect is slightly weakened.

We can also find this mechanism through the equation of the gap between LTV ratios. Under the assumption of the same loan default rate for all types of enterprises, from Eq.(15) we can have the expression of gap of LTV ratios:

$$m_t^A = m_t^B + \frac{\kappa_w \left( \kappa_T^1 \left( b_t^A / b^A - 1 \right) + \kappa_T^2 \right)}{\eta \left( 1 + r_t^{bE} \right)}$$

(26)

Where $b_t^A$ is SOE loan, $\kappa_T^1$ and $\kappa_T^2$ are parameters of subsidy for SOE loan, $r_t^{bE}$ is the loan rate to enterprises. It is obvious that the gap of LTV ratio is positively related with the two parameters of subsidy for SOE loan, and negatively related with loan interest. When we increase the $\kappa_T^1$, under the condition of increasing $b_t^A$, the numerator of the fraction at the right hand side of Eq.(26) also increases. However, the income effect of increasing subsidy lowers the loan interest $r_t^{bE}$, decreasing denominator of the fraction, so we cannot judge the value of fraction increases or decreases. Through the figure, we know generally the gap of LTV ratios is positive related to the subsidy parameter $\kappa_T^1$, but the marginal effect is negative related to the parameter.

[FIGURE 4 ABOUT HERE]

5 Empirical Evidence from China

Finally, we analyse in detail the impact of discriminatory credit constraint on transmission of technology shocks and monetary shocks. In this section, we empirically test the robustness of the model result using data of Chinese industrial firms. We focus our testing on two conclusions from the model analysis: first, that the gap between LTV ratios of SOEs and PEs will be enlarged by expansionary monetary policy; secondly, that loans flow more to SOEs than to PEs under expansionary monetary policy shocks, due to discriminatory credit constraint.
5.1 Regression model

First, we build a benchmark regression model to analyse the factors influencing the economic growth:

\[ IAV_{i,t} = \beta_0 + \beta_1 TFP_{i,t} + \beta_2 Int_t + \beta_3 DCC_{i,t} + \beta_4 N_{i,t} + \mu_i + \varepsilon_{i,t} \]  

(27)

where, \( IAV_{i,t} \) is logarithm of industrial added value of industry \( i \) in the year \( t \), as the proxy of economic growth, \( TFP_{i,t} \) is logarithms of TFP of industry \( i \) in the year \( t \), measuring the technology level improvement, \( Int_t \) is real interest rate of year \( t \), measuring the monetary policy, is the ratios of average SOE LTV ratio to average PE LTV ratio in industry \( i \) in the year \( t \), measuring the discrimination extent of credit constraint, \( N_{i,t} \) is logarithm of employee numbers of industry \( i \) in the year \( t \), measuring the labor\(^5\), \( \mu_i \) and \( \varepsilon_{i,t} \) are fix effect and residual error respectively.

We estimate TFP using Solow Residual Method (Barro, 1999; Felipe, 1999). We first estimate the capital share of production function, under the assumption of constant returns to scales by (28), and then calculate TFP by equation (29). The two equations are as follows:

\[ IAVtoN_{i,t} = \beta_0 + \alpha KtoN_{i,t} + \varepsilon_{i,t} \]  

(28)

\[ TFP_{i,t} = IAV_{i,t} - \hat{\alpha} K_{i,t} - (1 - \hat{\alpha}) N_{i,t} \]  

(29)

where \( IAVtoN_{i,t} \) is the ratio of logarithm of industrial added value to logarithm of employee numbers, \( KtoN_{i,t} \) is the ratio of logarithm of capital assets to logarithm of employee numbers, \( \alpha \) is the capital share coefficient, \( \hat{\alpha} \) is its estimated value.

According to the conclusion above on discriminatory credit constraint drawn by impulse response figures, following Fisman and Love (2003) we can build the regression model as follows to examine the moderate effect of discriminatory credit constraint:

\[ IAV_{i,t} = \beta_0 + \beta_1 TFP_{i,t} + \beta_2 Int_t + \beta_3 DCC_{i,t} + \beta_4 (DCC_{i,t} \times TFP_{i,t}) + \beta_5 N_{i,t} + \mu_i + \varepsilon_{i,t} \]  

(30)

where, \( (DCC_{i,t} \times TFP_{i,t}) \) represents product items of TFP and the discrimination extent of credit constraint. Because the improvement of TFP may promote economic growth, so \( \beta_3 \) should be significantly positive. If coefficient \( \beta_4 \) is also significantly positive, it means the higher discrimination extent may amplify the influence of TFP on industrial added value growth.

Similarly, in order to test moderate effect of discrimination extent on the effective-

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\(^5\)We use capital and labour to estimated TFP by Solow Residual Method. Due to the co-linearity problem, we select only two of the three variables included in the regression model.
ness of monetary policy, we build another regression model with a product term as follows:

\[ IAV_{i,t} = \beta_0 + \beta_1 TFP_{i,t} + \beta_2 Int_t + \beta_3 DCC_{i,t} + \beta_4 (DCC_{i,t} \times Int_t) \beta_5 N_{i,t} + \mu_i + \epsilon_{i,t} \]  

(31)

where, \((DCC_{i,t} \times Int_t)\) represents product items of \(Int_t\) and the discrimination extent of credit constraint. Because the industrial added value is negatively related to interest rate, if coefficient \(\beta_4\) is significantly positive, it means the higher discrimination extent may hinder the influence of monetary policy on industrial added value growth.

5.2 Data Source and Description

The data set we use come from the China Annual Survey of Industrial Firms from 1999 to 2008. First, we sort the firms according to whether they belong to SOE or PE, and eliminate those firms with fewer than 8 employees in order to ensure the firms’ existence and scale. Secondly, to maintain the effectiveness of LTV ratio, we eliminate the firms with long-term debt and negative capital assets, because we use the ratio of long-term debt to capital assets as the proxy of LTV ratio. Moreover, we exclude the firms whose LTV ratio is bigger than 3, to ensure a reasonable and suitable scale of firms. Following this procedure, we have a sample with 397,069 observations. Thirdly, for the purpose of calculating the discrimination extent of credit constraint, we aggregate the firms’ data to industrial-level data. In the China Annual Survey of Industrial Firms, all firms are classified into 39 industries, such as Coal Mining, Oil and Gas, and Textiles. Taking all the factors into account, we obtain an industrial-level sample of 335 observations of 39 industries from 1999 to 2008. Finally, we estimate the TFP of each industry in each year. As shown in the first column in Table 5, the capital share is significant at 5% level, with a value of 0.790. It is marginally bigger than other scholars’ estimated results, because for our model we select industrial firms, which have a relatively higher capital share than the agriculture and public services industries. Then we calculate the TFP through Eq.(29). The measurement and descriptive statistic of variables are reported in Table 3 and Table 4 respectively. The correlation analysis is not reported, and all the correlation coefficients are smaller than the co-linearity threshold of 0.7 (Mason et al., 1990).

Due to the data availability, we cannot obtain the data covering the years from 2008 to 2014. However, since discriminatory credit constraint is long-standing in China, the data from 1999 to 2008 can be used to examine its impact.
5.3 Results and Analysis

5.3.1 Discriminatory Credit Constraint, TFP and Economic Growth

Table 5 reports the regression results. As shown in Table 5, Reg.(5) estimates the model(30) using the Fix Effects method. The coefficient of product item $DCC_{i,t} \times TFP_{i,t}$ is 0.257 and significant at 5% level. This reveals that, in industries where the extent of discrimination of credit constraint between SOE and PE is higher, when TFP decreases, the growth rate of industrial added value will decrease more dramatically. This is in line with our conclusion from the model analysis. Discriminatory credit constraint can amplify the impact of technology shock on total output.

The coefficient of TFP is significantly positive, and the coefficient of interest rate is significantly negative, also in line with existing theory. Reg.(3) is the benchmark estimation, which is the reference to regression models with product items. All estimated coefficients are significant, and in line with existing literature. The coefficient of $DCC_{i,t}$ is significantly negative, which shows that discriminatory credit constraint is damaging to economic growth.

5.3.2 Monetary Policy and Loan Flow Direction

Table 5 also reports the regression results of Eq.(31). As shown in Reg.(5), the coefficient of product item $DCC_{i,t} \times Int_{t}$ is 5.238 and significant at 5% level; the coefficient of real interest rate is -27.70, significant at 1% level. According to our calculation of coefficients, we find that if the extent of discrimination of credit constraint increases by 1 unit, when real interest rate decreases by 0.1 percentage points, the increase of industrial added value growth rate will decrease by 0.5238 percentage points. That is, in industries where discriminatory credit constraint between SOEs and PEs is greater, expansionary monetary policy will be less effective in promoting economic growth. Therefore, discriminatory credit constraint may hinder the effectiveness of expansionary monetary policy.

In Reg.(5), the estimated values of other coefficients are also significant, in line with the benchmark model. For robustness, we also add the two product items in regression at the same time. All the results are significant and consistent with Reg.(4) and Reg.(5).

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7 The Hausman test has been made for all panel regressions. All the results support the fixed effect model.
6 Conclusion Remarks

This paper proposes a new explanation for the recent decline of China’s economic growth. We formulate a DSGE model that incorporates endogenous LTV ratios. In our model, political connections result in the long-standing discriminatory credit constraint which plays an important role on amplifying economic fluctuation and reducing the effectiveness of expansionary monetary policy. When the economy suffers a negative shock, the inequity in credit market can induce to the financial misallocation, further leading to deterioration of total loan and output. The empirical evidence from China’s industrial data finds that the discrimination of credit constraint between SOE and PE will amplify the impact of technology shock on total output and hinder the effectiveness of expansionary monetary policy. These finding are consistent with the model’s predictions. Therefore, we support to the market-orientation transformation of financial architecture, the amelioration of financial system, and the improvement of equal rights on the access to finance, which is in line with Le et al. (2014) and the current policy of China.

In fact, political connections widely exist in many countries, especially in emerging countries. From the micro sight, political connections may help the firms to obtain more resources and better performance. From the macro sight, however, political connections may induce to the inequity in resource allocation, even resource misallocation, leading to TFP loss and sharp fluctuation of capital price that are harmful to both economic growth and fluctuation. Existing literature on business cycle pays more attention to real economy and financial factors, but neglects the political and institutional factors. This paper indirectly introduces political factors into DSGE model, filling the gap to some extent.

References


Figure 1: 2001.11-2013.09 Loan to Value Ratio of Industrial Enterprises and Industry Growth

Data Source: Calculated based on data from National Bureau of Statistics of China. Note: Due to lack of payables’ data, we use receivables as its proxy, so the loan to value ratio is calculated as the differences of total debs and receivables, divided by total assets. The black solid line is trend line of SOEs, while the red dash line is trend line of PEs.
Figure 2: The Amplification Effect of Discriminatory Credit Constraint on the Transmission of a Negative Technology Shock

Note: All variables are shown as percentage deviation from steady state. The red line is from model with discriminatory credit constraint, while the blue line is from model without non-discriminatory credit constraint (No subsidy for SOE loan and the same LTV steady state). The first eight figures are about macro variables. In the last four figures, solid line and dotted line are expressed as SOE and PE respectively.
Figure 3: The Weakening Effect of Discriminatory Credit Constraint on the Transmission of an Expansionary Monetary Policy Shock

Note: All variables are shown as percentage deviation from steady state. The red line is from model with discriminatory credit constraint, while the blue line is from model without non-discriminatory credit constraint (No subsidy for SOE loan and the same LTV steady state). The first eight figures are about macro variables. In the last four figures, solid line and dotted line are expressed as SOE and PE respectively.
Figure 4: The Amplification Effect and Different Extent of Discrimination

Note: It is similar to Figure 3 & 4. Triangle red line is model with discriminatory credit constrain and higher marginal subsidy rate (with $\kappa_1^T = 0.05$, while in benchmark model $\kappa_1^T = 0.02$).
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
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<td>$\beta_P$</td>
<td>Discount factor of Patient households</td>
<td>0.9926</td>
</tr>
<tr>
<td>$\beta_I$</td>
<td>Discount factor of Impatient households</td>
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<tr>
<td>$\bar{m}^A$</td>
<td>Steady state LTV ratio for SOE</td>
<td>0.5</td>
</tr>
<tr>
<td>$\bar{m}^B$</td>
<td>Steady state LTV ratio for PE</td>
<td>0.46</td>
</tr>
<tr>
<td>$m^H$</td>
<td>LTV ratio for Impatient households</td>
<td>0.7</td>
</tr>
<tr>
<td>$\eta$</td>
<td>Steady State Loan Default rate</td>
<td>0.01</td>
</tr>
<tr>
<td>$\kappa_w$</td>
<td>Parameter of default cost with LTV</td>
<td>1</td>
</tr>
<tr>
<td>$\kappa_f$</td>
<td>Parameter of CSV cost with LTV ratios</td>
<td>1.4279</td>
</tr>
<tr>
<td>$\varepsilon^d$</td>
<td>Substitution elasticity of Deposit market</td>
<td>-3.3</td>
</tr>
<tr>
<td>$\varepsilon^{bH}$</td>
<td>Substitution elasticity of Household Loan demand</td>
<td>2.79</td>
</tr>
<tr>
<td>$\varepsilon^{bE}$</td>
<td>Substitution elasticity of Enterprises Loan demand</td>
<td>10.7128</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation rate of capital</td>
<td>0.025</td>
</tr>
<tr>
<td>$\bar{u}$</td>
<td>Steady state utilization rate of capital</td>
<td>1</td>
</tr>
<tr>
<td>$\alpha^A$</td>
<td>Capital share of SOE</td>
<td>0.5</td>
</tr>
<tr>
<td>$\alpha^B$</td>
<td>Capital share of PE</td>
<td>0.4</td>
</tr>
<tr>
<td>$\kappa_2^u$</td>
<td>Parameter of adjustment cost for capital utilization</td>
<td>0.0478</td>
</tr>
<tr>
<td>$\kappa_1^u$</td>
<td>Parameter of adjustment cost for capital utilization</td>
<td>0.00478</td>
</tr>
<tr>
<td>$\bar{x}$</td>
<td>Steady state markup rate of goods market</td>
<td>1.2</td>
</tr>
<tr>
<td>$\mu^y$</td>
<td>Share of SOE-produced goods</td>
<td>0.4</td>
</tr>
<tr>
<td>$\mu^n$</td>
<td>Share of impatient household labor</td>
<td>0.2</td>
</tr>
<tr>
<td>$\delta^b$</td>
<td>Management cost of bank capital</td>
<td>0.0865</td>
</tr>
<tr>
<td>$\nu^b$</td>
<td>Capital acquirement rate</td>
<td>0.08</td>
</tr>
<tr>
<td>$\kappa_2^T$</td>
<td>Parameter of Subsidy rate to SOE loan</td>
<td>0.0004</td>
</tr>
<tr>
<td>$\kappa_1^T$</td>
<td>Parameter of Subsidy rate to SOE loan</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Table 2: Calibrated Parameters Not Influencing Steady State

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$</td>
<td>Price Stickiness</td>
<td>0.75</td>
</tr>
<tr>
<td>$\kappa_{bE}$</td>
<td>Firm rate adjust. cost</td>
<td>10.22</td>
</tr>
<tr>
<td>$\kappa_{bH}$</td>
<td>HH rate adjust. cost</td>
<td>3.63</td>
</tr>
<tr>
<td>$\kappa_d$</td>
<td>Deposit rate adjust. cost</td>
<td>9.51</td>
</tr>
<tr>
<td>$\kappa_f$</td>
<td>Invest. adjust. cost</td>
<td>10.26</td>
</tr>
<tr>
<td>$\kappa_{bb}$</td>
<td>Leverage dev. cost</td>
<td>11.49</td>
</tr>
<tr>
<td>$\phi_{\pi}$</td>
<td>T. R. coeff on $\pi$</td>
<td>1.5</td>
</tr>
<tr>
<td>$\phi_y$</td>
<td>T. R. coeff on $y$</td>
<td>0.125</td>
</tr>
<tr>
<td>$\rho$</td>
<td>T. R. Continuity</td>
<td>0.75</td>
</tr>
<tr>
<td>$a$</td>
<td>Consumption Continuity</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 3: Variables & Measurements

<table>
<thead>
<tr>
<th>Variable</th>
<th>Name</th>
<th>Measurements</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$IAV_{i,t}$</td>
<td>Output</td>
<td>Logarithm of aggregated industrial added value</td>
<td>China Annual Survey of Industrial Firms</td>
</tr>
<tr>
<td>$N_{i,t}$</td>
<td>Labor</td>
<td>Logarithm of aggregated employees</td>
<td>China Annual Survey of Industrial Firms</td>
</tr>
<tr>
<td>$K_{i,t}$</td>
<td>Capital Assets</td>
<td>Logarithm of aggregated capital assets</td>
<td>China Annual Survey of Industrial Firms</td>
</tr>
<tr>
<td>$TFP_{i,t}$</td>
<td>TFP</td>
<td>Calculated by Eq.(29)</td>
<td>Estimated by this paper</td>
</tr>
<tr>
<td>$Int_t$</td>
<td>Monetary Policy Real interest rate</td>
<td></td>
<td>WDI from Word Bank</td>
</tr>
<tr>
<td>$DCC_{i,t}$</td>
<td>Discrimination Extent</td>
<td>SOE average LTV / PE average LTV</td>
<td>China Annual Survey of Industrial Firms</td>
</tr>
</tbody>
</table>

Note: LTV is calculated as aggregated long-term loans divided by aggregated capital assets.

Table 4: Description of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs.</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Median</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>$IAV_{i,t}$</td>
<td>187</td>
<td>15.178</td>
<td>2.16</td>
<td>7.476</td>
<td>15.706</td>
<td>18.073</td>
</tr>
<tr>
<td>$N_{i,t}$</td>
<td>335</td>
<td>10.769</td>
<td>2.012</td>
<td>2.485</td>
<td>11.186</td>
<td>14.087</td>
</tr>
<tr>
<td>$K_{i,t}$</td>
<td>335</td>
<td>15.147</td>
<td>2.076</td>
<td>5.956</td>
<td>15.477</td>
<td>18.713</td>
</tr>
<tr>
<td>$TFP_{i,t}$</td>
<td>187</td>
<td>0.874</td>
<td>0.52</td>
<td>-1.433</td>
<td>0.956</td>
<td>2.524</td>
</tr>
<tr>
<td>$Int_t$</td>
<td>335</td>
<td>0.02</td>
<td>0.028</td>
<td>-0.023</td>
<td>0.025</td>
<td>0.072</td>
</tr>
<tr>
<td>$DCC_{i,t}$</td>
<td>335</td>
<td>1.258</td>
<td>0.726</td>
<td>0.056</td>
<td>1.12</td>
<td>6.628</td>
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</table>
Table 5: Regression Results

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>FE</td>
<td>FE</td>
<td>FE</td>
<td>FE</td>
<td>FE</td>
</tr>
<tr>
<td>IAVtoN_{i,t}</td>
<td>0.790***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0321)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KtoN_{i,t}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFP_{i,t}</td>
<td>0.352***</td>
<td>0.330***</td>
<td>0.397***</td>
<td>0.166*</td>
<td>0.198**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0711)</td>
<td>(0.071)</td>
<td>(0.0753)</td>
<td>(0.0961)</td>
<td>(0.0934)</td>
<td></td>
</tr>
<tr>
<td>Int_t</td>
<td>-22.81***</td>
<td>-21.91***</td>
<td>-27.70***</td>
<td>-20.51***</td>
<td>-28.10***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.397)</td>
<td>(1.444)</td>
<td>(2.811)</td>
<td>(1.528)</td>
<td>(2.715)</td>
<td></td>
</tr>
<tr>
<td>DCC_{i,t}</td>
<td>-0.0874**</td>
<td>-0.200***</td>
<td>-0.345***</td>
<td>-0.602***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.041)</td>
<td>(0.0621)</td>
<td>(0.112)</td>
<td>(0.133)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCC_{i,t} × Int_{i,t}</td>
<td>5.238**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2.193)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCC_{i,t} × TFP_{i,t}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.257**</td>
<td>0.355***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.104)</td>
<td>(0.105)</td>
</tr>
<tr>
<td>N_{i,t}</td>
<td>0.756***</td>
<td>0.795***</td>
<td>0.785***</td>
<td>0.804***</td>
<td>0.793***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0363)</td>
<td>(0.0402)</td>
<td>(0.0398)</td>
<td>(0.0397)</td>
<td>(0.0385)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.295***</td>
<td>7.270***</td>
<td>6.955***</td>
<td>7.125***</td>
<td>7.004***</td>
<td>7.261***</td>
</tr>
<tr>
<td></td>
<td>(0.0463)</td>
<td>(0.423)</td>
<td>(0.443)</td>
<td>(0.441)</td>
<td>(0.435)</td>
<td>(0.428)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.766</td>
<td>0.951</td>
<td>0.952</td>
<td>0.954</td>
<td>0.954</td>
<td>0.958</td>
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<tr>
<td>No. of Industry</td>
<td>39</td>
<td>39</td>
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<td>39</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Hausman Test (p Value)</td>
<td>0.0000</td>
<td>0.0005</td>
<td>0.0008</td>
<td>0.0023</td>
<td>0.0006</td>
<td></td>
</tr>
</tbody>
</table>

Note: Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1.