The Impact of Discriminatory Credit Constraints on Macroeconomy: An Estimated Banking DSGE Model with Endogenous Loan-to-Value Ratios

Yuchao PENG\textsuperscript{a,b,*}, Lili Yan\textsuperscript{a,1}

\textsuperscript{a}School of Finance, Central University of Finance and Economics, Beijing, 100081, China
\textsuperscript{b}Durham University Business School, Durham, DH1 3LH, UK

Abstract
This paper builds a banking DSGE model with endogenous loan-to-value ratios which capture complex relationships between banks and firms. Reflecting the relationship between banks and enterprises, the loan-to-value ratio for state-owned enterprises is endogenously greater than that for private enterprises in China. This is referred to the discriminatory credit constraints in this paper. Compared to the case without, existence of discriminatory credit constraints can amplify the impacts of negative technology shocks on output, and reduce the effectiveness of expansionary monetary policy. Empirical evidence from Chinese industrial firms supports our conclusion.

Keywords: Credit Constraints, Endogenous loan-to-value ratios, Political connections, DSGE models, Ownership, Chinese firms

JEL Classification: E32, E4, E52

1. Introduction

Financial sector plays a crucial role in the working of modern economies. Exploring the sector’s functions and the constraints thereof proves essential for a better understanding of the business cycle of the economy in question. Moreover, some banking activities such as discriminatory lending based on the borrower’s ownership or political connections, may affect the effectiveness of fiscal and monetary policies. Recently in 2008 when the Chinese government launched a massive stimulus programme as a response to the adverse effect of the global financial crisis, most newly injected liquidity went to state-owned enterprises,
causing private enterprises suffering more binding credit constraints (see Figure 1), leading to the misallocation of financial resources. Therefore, our main objective is to understand whether discriminatory credit constraints can affect economic fluctuation or not, and to find the reason why countercyclical monetary policy has failed to save the China’s economy.

This paper contributes to the existing literature on financial frictions and business cycle by exploring the Chinese case. Following the seminal work of Moore and Kiyotaki (1997) (henceforth, KM) and Bernanke et al. (1999) (henceforth, BGG), scholars have shown great research interests in the impacts of financial frictions on business cycle (Brunnermeier et al., 2012). On the demand side, the literature offers two major approaches (Brzoza-Brzezina et al., 2013). One approach is à la external finance premium (financial accelerator), e.g., Carlstrom and Fuerst (1997), Goodfriend and McCallum (2007), Christensen and Dib (2008), Le et al. (2014) and so on. The other approach focuses on credit constraints e.g., Iacoviello (2005), Gertler et al. (2013) and so on. Research in these approaches finds that 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), Iacoviello (2015). They propose that bank capital regulation and the deterioration of banks’ balance sheet are the essential factors driving the business cycle. Such research has considerably promoted theoretical developments of studies on financial frictions.

However, existing research on credit constraints generally regards the loan-to-value ratio as a constant or an exogenous shock, merely caring for the banking discrimination on borrowers’ asset scale or prices, ignoring the fact that different types of firms may face different loan-to-value ratios. The heterogeneity of the financial frictions in turn may further amplify economic fluctuations in some way. Recent research about financial crisis and financial regulation has highlighted the role of loan-to-value ratio as an important instrument for macro prudent policy (Mendicino and Punzi, 2014; Rubio and Carrasco-Gallego, 2014), since the ratio can counter-cyclically respond to total loan or output. However, in reality, it is the firms and banks that decide this ratio when coping with information asymmetry and resisting loan default risks.

Our research is also related to the literature on political connections, banking discrimination due to ownership types and misallocation of financial resources. While market-oriented reforms have reshaped many aspects of the Chinese economy, state-owned enterprises and private enterprises are still subject to different treatments (Dedola and Neri, 2007). Especially, state-owned enterprises have more access to finance (Brandt and Li, 2003; Ge and Qiu, 2007; Li et al., 2008; Cull et al., 2009; Song et al., 2012). Because of their craving for
promotions, local officials desire to see the banks to lend more to state-owned than to private firms, as this may bring about more fiscal revenue (Gordon and Li, 2011). A recent paper by Cull et al. (2014) empirically explores the relationships among investment of state-owned enterprises, political connections and financial constraints. The research shows that political connections are a significant factor driving financial misallocation in China. Researchers have also examined discriminatory practice of bank lendings and the influences thereof on financial misallocation and TFP losses (Midrigan and Xu, 2010; Song et al., 2012; Gilchrist et al., 2013; Carvalho, 2014; Moll, 2014). However, they rarely take the influence of such biases on economy’s fluctuations into account. Recent work of Le et al. (2014) contributes to the literature on this issue by constructing a DSGE model for the Chinese economy, which shows that, in the longer term, a lending policy favouring state firms could be harmful to China’s economic growth. But they do not explicitly model the banking preference over two ownership types of firms, nor examine the role of discriminatory credit constraints on the economy’s fluctuations.

Following GNSS’s work, we build a dynamic sophisticated general equilibrium model for the Chinese economy with a banking sector. In the model, the banks set different loan-to-value ratios for state-owned enterprises (SOEs) and private enterprises (PEs). In analyzing the consequences of discriminatory credit constraints including its impacts on business cycles, we allow an interaction process between the banks and state-owned enterprises for setting the loan-to-value ratios when solving the optimization problems. We distinguish performing and non-performing loans, which are not known until the loans become mature. Given that the loan-to-value ratios are dependent on banks’ management of risk, we following BGG to introduce a cost of “Costly State Verification” (CSV) to the model. This will enable to characterise the evolvement of the loan-to-value ratios as an endogenous process. To examine the role that political connections play in China’s bank lending, we introduce a subsidy factor into the banks’ profit function. Thus, we can derive the different credit constraints over different types of enterprises, while assuming, as the starting point, that the loan interest rate is the same for both state-owned and private enterprises under no-arbitrage conditions.

We parameterize the model based on the findings of the existing literature and the data of China’s economy. Estimation using Bayesian methods allows the model to dynamic, while calibration to keep the model to fit the data. According log marginal density, we find the ability of the model with discriminatory credit constraints to fit the data is better than the ability of the model without. Comparisons are then made between the transmission mechanisms of a negative technology shock from the two models, respectively. We find that the total output and total loans to enterprises are significantly lower in the presence of discriminatory credit constraints. Moreover, analysis of the impulse-responses functions
shows that, given an expansionary monetary shock, the total output and total loans increase less in the model with discriminatory credit constraints than without. The outcome suggests that discriminatory credit constraints could amplify the effects of technology shocks and reduce the effectiveness of monetary policy. For robustness, we further empirically examine the impact of discriminatory credit constraints on the relationship between the monetary policy, technology improvements and economic growth. Evidence from China’s industrial level data is supportive of our model findings.

This paper contributes to the literature by extending DSGE models to capture the impact of credit constraints on business cycle. We combine both demand and supply sides financial frictions to capture not only the effects of the real economy on business cycles, but also that of financial factors on economic fluctuations. Moreover, this model characterizes risk-resisting behaviour of banks with the loan-to-value ratios endogenously evolving. Findings of this paper provide a new explanation of the recent decline of China’s growth. Our conclusion calls for further reform of the Chinese economy, including reform of the financial system.

The remainder of the paper is organized as follows: Section 2 develops a DSGE model with a banking sector. Then Section 3 is devoted to the estimation of the model. Sections 4 and 5 present the impulse responses analysis and empirical analysis, respectively. Section 6 comprises concluding remarks.

2. The Model

In this section, we extend the GNSS model by distinguishing two types of enterprises based on their ownership structure: the state-owned and private enterprises. We attempt to describe the discriminatory credit constraints confronted by these two type firms, and calibrate its impacts on the economy when exogenous shocks occur. The economy comprises patient and impatient households, banks, SOEs and PEs, retailers, capital goods producers and a central bank. The LTV ratios are decided by the banks that also incur the default cost (CSV cost). We assume that the LTV ratio for impatient households is constant, while that for enterprises is time-varying. Given that in China the terms and conditions for the banks for extending loans to SOEs are less restrictive than that to other type of firms, because of SOE’s strong government background, we assume that the government will pay subsidies to the banks that directly extend loans to SOEs.
2.1. Households

2.1.1. Patient Households

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

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ (1 - a^p) \varepsilon^c_t \log \left( c_t^p - a^p \tilde{c}_t^p \right) + \log h_t^p - \frac{(n_t^{P,A})^{1+\phi^A}}{1 + \phi^A} - \frac{(n_t^{P,B})^{1+\phi^B}}{1 + \phi^B} \right]$$

(1)

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\(^2\), $\varepsilon^c_t$ is the consumption preference shock, $a^p$ is the parameter to measure the consumption habit, $h_t^p$ is housing service, $n_t^{P,A}$ and $n_t^{P,B}$ 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:

$$c_t^p + d_t^p + q_t^h \Delta h_t^p \leq w_t^{P,A} n_t^{P,A} + w_t^{P,B} n_t^{P,B} + \frac{d_{t-1}^p (1 + r_{t-1}^d)}{\pi_t} + t_t^p$$

(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, deducting the subsidy via government to banks.

2.1.2. Impatient Households

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

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ (1 - a^I) \varepsilon^c_t \log \left( c_t^I - a^I \tilde{c}_t^I \right) + \log h_t^I - \frac{(n_t^{I,A})^{1+\phi^A}}{1 + \phi^A} - \frac{(n_t^{I,B})^{1+\phi^B}}{1 + \phi^B} \right]$$

(3)

and subject to:

$$c_t^I + \frac{b_{t-1}^I (1 + r_{t-1}^H)}{\pi_t} + q_t^h \Delta h_t^I \leq w_t^{I,A} n_t^{I,A} + w_t^{I,B} n_t^{I,B} + b_t^I$$

(4)

\(^2\)This variable cannot be decided by individual household. In the aggregated first order conditions, it is equal to $c_t^p$. 

5
where \( b_t \) is the money borrowed from banks with a net loan interest \( r^{bh} \). The households should provide their housing as collateral, so they confront a borrowing constraint set by banks

\[
b_t (1 + r^{bh}_t) \leq m^H E_t [q^{h}_{t+1} h_t \pi_{t+1}]
\]

(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 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 \( c^s_t \).

\[
E_0 \sum_{t=0}^{\infty} \beta^s_t (1 - a^s) \log (c^s_t - a^I \tilde{c}^s_{t-1})
\]

(6)

where, \( \beta^s_t \) is the subjective discount factor of enterprise \( s \), \( \tilde{c}^s_t \) 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

\[
y^A_t = z^A_t z^A_t (u^A_t k^A_{t-1})^{\alpha^A} (n^A_t)^{1-\alpha^A}
\]

(7)

where, \( k^A_{t-1} \) is the capital, \( z_t \) is technology shocks, \( z^A_t \) is special technology shocks for SOE, and \( u_t \) is time-varying utilization rate of capital (Schmitt-Grohé and Uribe, 2006), which leads to a cost:

\[
\psi (u^A_t) k^A_{t-1} = k^A_{t-1} \left( \frac{\kappa^u_1}{2} (u^A_t - 1)^2 + \kappa^u_2 (u^A_t - 1) \right)
\]

where \( \kappa^u_1 \) and \( \kappa^u_2 \) 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 \( n^A_t \) is aggregated from patient labour and impatient labour by C-D technology with parameter \( \mu^A_t \):

\[
n^A_t = (n^I_t A)^{\mu^A_t} (n^P_t A)^{1-\mu^A_t}
\]

(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:

\[
y_t^A + b_t^A + q_t^k (1 - \delta) k_{t-1}^A = q_t^k k_t^A + \psi (u_t^A) k_{t-1}^A + w_t^{P,A} n_t^{P,A} + w_t^{I,A} n_t^{I,A} + c_t^A + \frac{b_{t-1}^A (1 + r_b^E t-1)}{\pi_t}
\]

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, \(r_b^E\) 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 (\(m_{t-1}^A/2\kappa_w\) multiplied by total debt). For enterprises, the loan payable is diminished, so they only return \(1 - m_{t-1}^A/2\kappa_w\) 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 \(\kappa_f m_{t-1}^A q_t^k k_{t-1}^A\), 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:

\[
y_t^A + b_t^A + q_t^k (1 - \delta) k_{t-1}^A = q_t^k k_t^A + \psi (u_t^A) k_{t-1}^A + w_t^{P,A} n_t^{P,A} + w_t^{I,A} n_t^{I,A} + c_t^A + \frac{b_{t-1}^A (1 + r_b^E t-1)}{\pi_t} + \eta (1 - \eta m_{t-1}^A/2\kappa_w) + \eta \kappa_f m_{t-1}^A q_t^k k_{t-1}^A
\]
The firm also confronts borrowing constraint set by banks

\[ b_t^A \left( 1 + r_t^{bE} \right) \leq m_t^A E_t \left[ q_t^k k_t^A \pi_{t+1} (1 - \delta) \right] \]  

(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 \( w_t^m \) to improve their labor efficiency by \( \chi \). Then the production function of private firm is:

\[ y_t^B = z_t^B (1 - \zeta) \left( w_t^B k_t^B \right)^{\alpha_B} \left( \chi n_t^B \right)^{1 - \alpha_B} \]  

(12)

Meanwhile, to prevent the manager diverting funds from the company to their own benefit, the remuneration satisfies an incentive constraint \( w_t^m > \zeta y_t^B \), where \( \psi \) is the parameter satisfying an assumption \( \chi > (1 - \zeta)^{\frac{\psi}{1 - \alpha_B}} \) 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

\[
\frac{y_t^B}{x_t^B} + b_t^B + q_t^k (1 - \delta) k_{t-1}^B = q_t^k k_t^B + \psi \left( u_t^B k_{t-1}^B \right) + w_t^B n_t^B + w_t^B n_t^B + c_t^B + b_{t-1}^B \left( 1 + r_t^{bE} \right) \left( 1 - \frac{m_{t-1}^B}{2 \kappa_w} \right) + \eta \kappa_f m_{t-1}^B q_t^B \]

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 \( k_t^w \) with deposit \( d_t \) transferred from deposit retail branches on the liabilities side. On the assets side, they will issue loans \( b_t^A \) to impatient households, and loans \( b_t^A \) and \( b_t^B \) to state-owned and private enterprises respectively. The law of evolution for bank capital is \( \pi_t k_t^w = (1 - \delta^b) k_{t-1}^w + j_{t-1}^{bank} \), where \( \delta^b \) measures resources used to manage the bank capital, \( j_{t-1}^{bank} \) 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:

$$\max_{m_t^*, b_t^*, b_t^I} r_t^{WE} (b_t^A + b_t^B) + r_t^{WH} b_t^I - r_t d_t - \frac{\kappa_{kb}}{2} \left( \frac{k_w^t}{b_t} - \nu b \right)^2 - \frac{\eta}{2 \kappa_w} (m_t^A + m_t^P) \left( 1 + r_b^{TE} \right) + T (b_t^A)$$

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, $T (b_t^A)$ is the subsidy from government for loans to state-owned firms, $T (b_t^A) = \kappa_T^1 (b_t^A - \bar{b}^A)^2 / \bar{b}^A + \kappa_T^2 b_t^A$, where $\kappa_T^1$ and $\kappa_T^2$ 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 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 constraints 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 $b_t^A + b_t^B + b_t^I = b_t = k_w^t + d_t$. In addition, they choose the loan-to-value ratio under the condition $m_t^* q_{t+1}^{k_t^*} k_t^* \pi_{t+1} (1 - \delta) \geq (1 + r_b^{TE}) b_t^s$. After some algebra with regard to the first order conditions, we can derive the interest spread between wholesale loan rates and Taylor Rule rate:

$$r_t^{WH} = r_t - \kappa_{kb} \left( \frac{k_w^t}{b_t} - \nu b \right) \left( \frac{k_w^t}{b_t} \right)^2$$ (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

---

3When closing the model, the cost of this subsidy is finally borne by patient households.
and private enterprises:

\[ r_t^{wE} = r_t^{wH} + \eta m_t^B \frac{1 + r_t^{bE}}{\kappa_w} \]  

(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:

\[ m_t^A - m_t^B = \frac{T' (b_t^A) \kappa_w}{\eta (1 + r_t^{bE})} \]  

(15)

It is obvious that the extent of discriminatory credit constraints 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 \( r_d^i t \) 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

\[ d_t = \left[ \int_0^1 d_t (i)^{1/\varepsilon_d} \, dt \right]^{\varepsilon_d} \],

where \( \varepsilon_d \) is the elasticity of substitution of deposit. After cost minimization, we can derive the deposit demand of each retailer as

\[ d_t^d (i) = \left( \frac{r_d^i t}{r_t} - \varepsilon_d \right) \frac{\kappa_d}{2} \left( \frac{r_d^i t}{r_t - 1 (i)} - 1 \right)^2 r_d^d t \]  

(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 \( r_d^d (i) \) yield, after imposing symmetric equilibrium, is:

\[ -1 + \varepsilon_d - \varepsilon_d \frac{r_t}{r_d} - \kappa_d \left( \frac{r_d^i t}{r_t - 1} - 1 \right) \frac{r_d^d t}{r_t - 1} + \beta_d E_t \left[ \frac{\lambda_{t+1}^P}{\lambda_t^P} \kappa_d \left( \frac{r_d^i t}{r_t} - 1 \right) \frac{r_d^d t}{r_d^i t} \right] = 0 \]  

(17)

In the steady state the deposit interest is \( r_d^d t = \frac{\varepsilon_d}{\varepsilon_d - 1} r_t \). Because \( \varepsilon_d < 0 \), 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 $b^j_t (i) = \left( r^j_t (i) / r^j_{t-1} \right)^{-\varepsilon_{bj}} b^j_t$, where $\varepsilon_{bj}$ is the elasticity of substitution of loan demand. Loan retailer branches select loan interest rate to maximize their profit as follows:

$$
\max_{r^j_t (i)} E_0 \sum_{t=0}^{\infty} \Lambda^p_{0,t} \left[ r^{bE}_t (i) b^{E}_t (i) - r^{wE}_t b^{E}_t (i) - \frac{\kappa_{bE}}{2} \left( \frac{r^{bE}_t (i)}{r^{bE}_{t-1} (i)} - 1 \right)^2 r^{bE}_t b^{E}_t 
+ r^{bH}_t (i) b^{H}_t (i) - r^{wH}_t b^{E}_t (i) - \frac{\kappa_{bH}}{2} \left( \frac{r^{bH}_t (i)}{r^{bH}_{t-1} (i)} - 1 \right)^2 r^{bH}_t b^{H}_t \right]
$$

(18)

where, $\Lambda^p_{0,t}$ is random discount factor of patient households, $\kappa_{bE}$ and $\kappa_{bH}$ are parameter of sticky extent. The first order conditions for $r^{bE}_t (i)$ and $r^{bH}_t (i)$ yield, after imposing symmetric equilibrium,

$$
1 - \varepsilon_{bj} + \varepsilon_{bj} \frac{r^{wj}_t}{r_{bj}^j} - \kappa_d \left( \frac{r^j_t}{r^j_{t-1}} - 1 \right) \frac{r^j_t}{r^j_{t-1}} + \beta_P E_t \left[ \frac{\lambda_{t+1}}{\lambda^p_t} \kappa_{bj} \left( \frac{r^j_{t+1}}{r^j_t} - 1 \right) \frac{r^j_{t+1}}{r^j_t} + \frac{\varepsilon_{bj}}{\varepsilon_{bj} - 1} \right] = 0
$$

(19)

In the steady state the loan interest is $r^j_t = \frac{\varepsilon_{bj}}{\varepsilon_{bj} - 1} r^{wj}_t$. 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

$$
\pi^t_{bank} = r^{bE}_t \left( b_A + b_B \right) + r^{bH}_t b^I_t - r^d_t d_t - \frac{\kappa_{wb}}{2} \left( \frac{b^w_t}{b_t} - \nu^b \right)^2

- \frac{\eta}{2 \kappa_w} \left( m^A_t + m^B_t \right) \left( 1 + r^{bE}_t \right) + T \left( b^A_t \right)
$$

(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:

$$
\max_{i^k_t} E_0 \sum_{t=0}^{\infty} \Lambda^p_{0,t} \left[ g^k_t \left[ 1 - \frac{\kappa_t}{2} \left( \frac{i^k_t}{i^k_{t-1}} - 1 \right) \right]^2 i_t - i_t \right]
$$

(21)

where, $i_t$ is investment, $\Lambda^p_{0,t}$ is random discount factor of patient households, $\kappa_t$ is the adjustment cost parameter, and $\varepsilon_{k}$ is shocks to the efficiency of investment. 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:

$$\frac{1}{q^k_t} = 1 - \kappa_I \left( \frac{i^k_{t-1}}{i^k_t} - 1 \right) - \frac{\kappa_I}{2} \left( \frac{i^k_{t-1}}{i^k_t} - 1 \right)^2 + \beta_p \kappa_I E_t \left[ \frac{\lambda^P_{t+1}}{\lambda^P_t} \left( \frac{i^k_{t+1}}{i^k_t} - 1 \right) \right]$$

And the aggregated capital is $k^A_t + k^B_t - (1 - \delta) (k^A_{t-1} + k^B_{t-1}) = \left[ 1 - \frac{\kappa_I}{2} \left( \frac{i^k_{t}}{i^k_{t-1}} - 1 \right)^2 \right] i^k_t$.

### 2.4.2. Retailer

In our model, the retailers combine the different products of two types of enterprises, by C-D technology $y_t = (y^A_t)^{\mu^y} (y^B_t)^{1-\mu^y}$ 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

$$\frac{\mu^y}{1 - \mu^y} = \frac{y^A_t x^B_t}{y^B_t x^A_t}$$

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,

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

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

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

As to housing market, we assume the housing held by all households is equal to an exogenous constant $\bar{h}$, that is, $h^l_t + h^P_t = \bar{h}$. The central bank follows the standard Taylor rule:\footnote{Although scholars have not reached a consensus about whether China’s monetary policy is quantity-based or price-based, we select Taylor rule for simplification as China’s current economic reform is towards a financial system with a price-based monetary policy.}

12
\[
\log \frac{1 + r_t}{1 + \bar{r}} = \rho \log \frac{1 + r_{t-1}}{1 + \bar{r}} + (1 - \rho) \left[ \phi_y \log \frac{y_t}{\bar{y}} + \phi_\pi \log \frac{\pi_t}{\bar{\pi}} \right] + \varepsilon_t^r
\]  

(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. \(\varepsilon_t^r\) is monetary policy shocks.

2.5. Log-Linearization and Model Solution

Following Iacoviello (2005) and GNSS, we solve the model by log-linearizing it around the steady state. This means that we cannot capture non-linear characters of the economy, such as precautionary saving, buffer-stock behaviors and so on. Using perturbation methods, we can analysis the impact of a small shock on the economy in a neighbourhood of steady state, which may not alter the model structure. One of the advantage of this method is to allow the model to move a little but to ensure the credit constraints still binding. Full log-linearized model can be found in appendice B.

3. Estimation

We estimate the model using Bayesian methods. In this section, we first describe the data, calibrate the structural parameters according to related literature and China’s data, and then we report the prior and posterior distributions as well as results of the comparison between the models with discriminatory and without. We estimate the model parameters for purpose of driving it to dynamic, while we also calibrate the key parameters affecting steady state to keep the model fit Chinese economy’s data.

3.1. Data

We estimate the model based on China’s quarterly data covering the period from 2004Q1 to 2014Q3. The observables we adopted include real consumption, real industrial added value\(^5\), real investment, GDP deflation rate and interbank overnight interest (Shanghai Interbank Offered Rate, SHIBOR) as proxy of central bank policy rate. We eliminate the trend of season-adjusted data, using HP filter with smoothing parameter of 1600. Figure 2 plots the transformed data.

\[\text{[FIGURE 2 ABOUT HERE]}\]

\(^5\)We select industrial added value as proxy of output, as it is more reliable than gross domestic product in China.
3.2. Calibration Parameters

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 0.970, which means they are more impatient than state-owned enterprises.

We calibrate the steady state of LTV ratios according to Chinese industrial firm data from the 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 capital assets to calibrate LTV ratio. According to the calculation result, 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 then calculate 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 0.33 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 and Kyle, 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. With respect to the subsidy to banks for SOE loans, we will estimate the parameter $\kappa^T_1$, however, the parameter $\kappa^T_2$ is subject to the steady state of LTV ratios, so we calculate it as 0.0004.

3.3. Prior Distributions and Posterior Estimates

Tables 2 and 3 report the prior and posterior distribution of estimated parameters, while Figure 3 plots the prior and posterior marginal distribution. Using Metropolis algorithm, we get draws from posteriors distribution of the parameters. We ran 10 chains, each of 100,000 draws.

With regard to the parameters of consumption habit, we assume prior mean as 0.5 for both households and enterprises, following GNSS. The estimation of consumption habit for patient household is approximate with Ma (2014), Ma and Li (2015). But the estimation of consumption habit for PE is much lower than those of others (0.2842), which indicates that PE is more flexible than SOE and households. For the parameter of sticky price, we assume the prior mean is 0.75, which means the enterprise has one chance to change their price a year. The posterior distribution of Fischer elasticity for both patient households and impatient households is very close to the prior one, which might be a signal of weak identification.

Because we do not know the distribution of Chinese adjustment cost, so we assume prior mean of those parameters as 10 with a standard deviation of 5, in order to explore the characteristic of Chinese economy. The posterior mean of deposit rate adjustment cost is much higher than GNSS, which reflected deposit interest rate is more rigidity, and is mainly controlled by central bank. But the posterior mean of adjustment cost of loan interest rate to enterprises is much lower than GNSS, as Chinese loan interest has realized liberalization. About the parameter of leverage deviation cost of bank, estimated value is 13.3707, slightly greater than GNSS’s 11.49. It is because the bank will be strictly punished by regulatory department of China, once the capital acquirement rate is not satisfied. So this is in line with Chinese reality.
As to the coefficient of Taylor rule, we assume the prior mean and standard deviation as general, while the estimation is also in line with existing literature. The prior and posterior distribution of continuity of Taylor rule is similar to GNSS. Table 3 lists the prior and posterior distribution of estimated parameters in external process. Concerning technology improvement is the crucial factor to drive the China’s economy, we assume the prior mean of the continuity of technology shock as 0.8 (higher than 0.5 for other shocks). As a result, its estimation is 0.9474 and much greater than prior mean, which supports our assumption.

3.4. Robustness and Model Comparison

In order to prove that the model proposed is more suitable, we compared models with different assumptions. The ability of the model to fit the data is directly associated with the discrimination assumption and endogenous evolution of LTV ratios. Table 4 reports the comparison results of models with discriminatory credit constraints (benchmark model) and without, as well as models with exogenous loan-to-value ratios. By comparing the log marginal density for all models, we find that the benchmark model obtains a slightly greater log data density than non-discriminatory model, which significantly indicates that assumption of discriminatory credit constraint may improve the ability to fit the data.

With respect to the models with exogenous LTV ratios, overall, the log marginal density of them are much less than the model with LTV ratios endogenously evolving. This means it is important to allow LTV ratios to endogenously behaviour. For robustness, we assume the prior probability for each model is the same with 0.25, and we obtain the posterior model probability of benchmark model is 0.74526, which indicates that the benchmark model can better fit the Chinese economy’s data than any other three models. We have also explored the impulse response functions of the models with exogenous LTV ratios, and found that the discriminatory credit constraints cannot be sufficiently captured (see appendix C).

Finally, we have re-estimated the model by enlarging the prior standard errors of parameters by 50% following GNSS. And we found no major difference in the posterior distribution of the structural parameters. We also alter some doubted calibrated parameters to check the robustness of the model. The parameter of weight of SOE-produced goods has been changed from 0.4 to 0.2, and we have found no major difference in the trend of the model’s behaviour, but the amplification effect on technology shocks and the attenuation effect on monetary policy shocks are further enlarged. This means that the biased treatment is more important along with the growth of the private economy’s weight. We have also adjusted the parameter of capital share \( \alpha^s \) in production function, and found the impulse response functions are almost the same. The detail results can be found in appendix C.

[TABLE 4 ABOUT HERE]
4. Simulation and Discussion

In this section, we analyse the role of discriminatory credit constraints by comparing the impulse responses of technology shocks and monetary policy shocks generated by the above benchmark model, a modified model without discriminatory credit constraints and a modified model with a less severe discrimination. We find that the discrimination amplifies the technology shocks to the economy and hinders the effectiveness of monetary policy, but its impacts decrease when the discrimination becomes more severe.

4.1. Technology Shock

Figure 4 displays the impulse responses to an unexpected transitory negative technology shock for the benchmark model (discriminatory) and a model without discrimination (non-discriminatory), which is generated by calibrating the parameter $\kappa_1^T = 0$ and $\kappa_2^T = 0$ to eliminate the subsidy to banks for SOE loans\(^6\). Overall, in the benchmark model, the response of output is amplified compared to the model without discrimination, while the response of total loan to enterprises is almost unchanged at the first three periods and amplified subsequently. It reveals that the discriminatory credit constraints set by the bank seems to enhance the endogenous perturbation of the shock. To understand these results, it is useful to analyse how the assumption of the bank discrimination affects the transmission channels of the technology shock usually at work in financial friction models à la KM.

First of all, we review the transmission process of a technology shocks in non-discretionary models with both impatient households and enterprises credit-constrained. A negative technology shock triggers a drop in output and an increase in marginal cost, which cause an augmentation in product price and a decline in demands of consumption and housing investment. Since the shock is temporary, in order to keep the consumption smoothed, the patient households tend to cut their savings while the impatient households and the enterprises are willing to borrow more. In equilibrium, both the total loan and deposit supply decreases. Monetary policy aims at counteracting the induced inflationary pressures of consumption goods by raising the nominal interest rate. The decline in the demand for housing and capital would generate a significant fall in housing price and capital price, which determines a reduction in the net worth of collateral and makes the credit constraints for impatient households and the enterprises even tighter. As a result, they have to make yet deep cuts in their consumptions as well as housing and capital investment in subsequent periods. This is the collateral channel. Moreover, due to the banks’ monopolistic markups, all the real variables display a high persistence: the output bottoms after about four quarters and consumption bottoms after about six periods, which are in line with GNSS.

\(^6\)At the meanwhile, the steady state of LTV ratios for SOE and PE are equal.
As for collateral channel in discriminatory model, the responses of loan and capital for SOEs and PEs display significantly different situation. Because the banks would like to reduce the loan default risk and CSV cost, the augmentation in policy rate and a decline in deposit supply trigger both an increase in loan interest rate and a fall in LTV ratios. However, having received subsidies for SOE loans, the banks choose to further reduce the loan amount to PEs. As a result, the shock generates a small drop or even a subtle increase in the loans to SOEs but a significant drop in the loans to PEs. With the decline in the price of capital, SOEs can enlarge investment, but PEs’ capital stocks continuously decrease due to increasingly binding credit constraints. In the simulation, the response of SOEs’ LTV ratio decreases slightly for about three periods after the shock and then quickly increases above the steady state value, while the response of PEs’ LTV ratio decreases significantly and even becomes worse after ten periods. It reveals that the LTV ratio of SOEs is counter-cyclical, while that of PEs is pro-cyclical, which are consistent with Figure 1. These results confirm our hypothesis. In China, SOEs have a much stronger negotiation power than PEs in the credit market because of their close relationship with the government. It is because of political connections between SOEs and the government that the banks prefer to lend to SOEs rather than PEs under the same or even worse condition.

Why the credit constraints with different extent amplify the fluctuations? Why the financial accelerator effect (KM type) is enlarged when the credit constraints is discriminatory? Analysis above is not sufficient to answer this question. An important reason is that the discriminatory credit constraints results in a larger drop in the capital price due to financial resources misallocation. As mentioned above, better financial positions allow SOEs to enlarge the production and augment the supply of intermediate goods, while PEs are forced to further decrease investment and production resulting in a sharper decline in supply. But the demand structure of intermediate goods cannot change immediately, so the capital return of PEs becomes relatively higher than that of SOEs. Since the capital is homogeneous and traded in the same market, the resources are supposed to flow to firms with higher capital return. However, discriminatory credit constraints induces to an adversative result that the financial resources continuously flow to SOEs, which is a situation of financial resources misallocation. As we know, capital price is positively related to the average capital return, so the misallocation can induce to a sharper decline in the capital price, which in turn causes the borrowers’ net worth to drop more and the credit constraints to be more stringent. As a result, the discrimination leads to a lower amount of loans to enterprises and a lower total output.

Furthermore, the discriminatory credit constraints may lead to a deterioration of the economic structure and an excess capacity of SOEs. As Figure 4 predicts, a negative technology
shock causes a greater proportion of loans to SOEs, so they can purchase more production factors to offset the impact of the shock although their capital utilization quickly falls below the steady state level. PEs have to suffer a larger production drop because of the tighter credit constraints, but their capital utilization is much higher than that of SOEs. A number of papers finds that SOEs in China are less efficient than PEs, and many SOEs belong to industries with overcapacity. The Chinese government has been committed to optimizing the industrial structure and to making the market play a greater role in allocating resources. However, our model suggests that the influence of the discriminatory credit constraints may be contrary to the government’s wishes.

4.2. Monetary Policy Shock

Figure 5 plots the dynamic responses following an expansionary monetary policy shock. In face of an unexpected decline in the policy interest rate, banks reduce the deposit rate and loan rate, which then induce a rise in the demand for consumption and housing investment. Accordingly, enterprises increase their production, with an increase in price of capital, housing and consumption goods. The rise in consumption goods price (inflation) reduces the real value of all borrowers’ debt obligations, and the rise in price of capital and housing further increases the borrowing capacity of enterprises and impatient households respectively. As a consequence, the household’s loan increase significantly, but the situation is complicated for enterprises. In the non-discriminatory model, enterprises’ loans decrease owing to a decline in the LTV ratio, although the total amount of loans issued by banks increases. This implies that a large amount of increasing liquidity flows to household and helps to drive up housing price. While in our benchmark model with discriminatory credit constraints, SOEs’ loans increase slightly because the magnitude of the decline in the LTV ratio is relatively small, while PEs’ loan continues to decline as a result of the continuing decline of LTV ratio.

To be clear, although the presence of discriminatory credit constraints does not qualitatively alter the responses of the main macroeconomic variables, it has some influence from a quantitative perspective. Financial resources misallocation induced by discrimination causes a higher increase in impatient households’ loan, which in turn triggers a much higher housing price. The ”crowding-out” effect of the higher housing price dampens the argumentation in consumption and output. Take a look back on the global financial crisis of 2008, PEs suffer a huge economic loss because of the sharp decline of export demand, which forces them to confront greater difficulties to get financed. Subsequently, the Chinese government launched the ”four trillion” rescue plan in order to stimulate the economy; however, As the model predicts, most of the liquidity flew to real estate and SOEs, therefore leading to significant housing market boom and a more severe overcapacity in some industries.
Furthermore, in the model with discriminatory credit constraints 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 in China.

4.3. Further Analysis on Amplification Effect of Discriminatory credit constraints

According to the above analysis on impulse response, we find that discriminatory credit constraints has an amplification effect on the transmission of negative technology shocks. However, there is an important question that why a subsidy to banks may further worsen output. As we know, the subsidy is to encourage banks to increase the loan amount counter-cyclically, which is similar to macro prudential policy. In order to answer this question and make clear the source of amplification effect, we further examine the impulse response under different parameters of subsidy.

As shown in Figure 6, 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 constraints 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 constraints. 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.

[FIGURE 6 ABOUT HERE]

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)

\[ \text{As the first order marginal subsidy rate } \kappa_2^T \text{ is depends on the steady state of LTV ratios of SOEs and PEs, we can adjust only the second order marginal subsidy rate } \kappa_1^T \text{ to change the extent of discrimination.} \]
we can have the expression of gap of LTV ratios:

\[
m_t^A = m_t^B + \frac{\kappa_w \left( \kappa_1^T \left( b_t^A / \bar{b}^A - 1 \right) + \kappa_2^T \right)}{\eta \left( 1 + r_t^{bE} \right)}
\]

(26)

where \( b_t^A \) is SOE loan, \( \kappa_1^T \) and \( \kappa_2^T \) 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 \( \kappa_1^T \), 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 Figure 6, we know generally the gap of LTV ratios is positive related to the subsidy parameter \( \kappa_1^T \), but the marginal effect is negative related to the parameter.

In connection with financial crisis, a number of researches argue that macro prudential policy may be effective to relief the economic recession. One of the policy instrument is loan-to-value ratio. If the discriminatory credit constraints does exist, however, lowering loan-to-value ratios will lead to an unequal financial supporting to all types of firms, which may cause the macro prudential policy less effective. This is why China’s expansionary monetary policy fails to allow economy to realize a long-term recovery.

5. Empirical Evidence from China

Finally, for robustness, we empirically test the impact of discriminatory credit constraints on macroeconomy using data of Chinese industrial firms. We focus our testing efforts on two notions in the model. First, in the industries with more severe discriminatory credit constraints, the technology improvement more affects the output growth. Second, in the industries with more severe discriminatory credit constraints, expansionary monetary policy is less effective to stimulate the output growth.

5.1. Regression Specifications

First, we specify 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 year \( t \), measuring the technology improvement, \( Int_t \) is the average overnight interbank interest rate of year \( t \),
measuring the monetary policy, $DCC_{i,t}$ is the ratios of average SOE LTV ratio to average PE LTV ratio in industry $i$ in the year $t$, measuring the extent of discriminatory credit constraints, $N_{i,t}$ is logarithm of employee numbers of industry $i$ in the year $t$, measure the labor\footnote{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.}, $\mu_i$ and $\varepsilon_{i,t}$ are fixed 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:

$$IAV_{i,t} = \beta_0 + \alpha K_{i,t} + \varepsilon_{i,t}$$
$$TFP_{i,t} = IAV_{i,t} - \hat{\alpha} K_{i,t} - (1 - \hat{\alpha}) N_{i,t}$$

where $IAV_{i,t}$ is the ratio of logarithm of industrial added value to logarithm of employee numbers, $K_{i,t}$ 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.

Given possible effects of discriminatory credit constraints as drawn from analysis of impulse response functions, we follow Fisman and Love (2003) to specify the regression model as follows to examine the effects of discriminatory credit constraints:

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

where, $(DCC_{i,t} \times TFP_{i,t})$ is a productive items of TFP and the discrimination extent of credit constraints. Because 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 growth of industrial added value.

Similarly, in order to test the effect of discrimination extent on the effectiveness of monetary policy, we build another regression model with a product term as follows:

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

where, $(DCC_{i,t} \times Int_t)$ represents product items of $Int_t$ and the discrimination extent of credit constraints. 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 datasets we use come from the China Annual Survey of Industrial Firms from 1999 to 2008. First, we sort the firms according to their ownership types, i.e. 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 the LTV ratio, we eliminate the firms with long-term debt and negative capital assets, because we already use the ratio of long-term debt to capital assets as the proxy of the LTV ratio. Moreover, we exclude the firms whose LTV ratio is greater 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 constraints, we aggregate the firms’ data to industrial-level data. In the China Annual Survey of Industrial Firms, 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. Due to data availability, we cannot obtain the data covering the years from 2008 to 2014. However, since discriminatory credit constraints is long-standing in China, the data from 1999 to 2008 can be used to examine its impact.

Finally, we estimate the TFP of each industry in each year. As shown in the first column in Table 7, the capital share is significant at the 5% level, with a value of 0.790. It is marginally greater than other scholars’ estimated results, because for our model we select industrial firms that have a relatively higher capital share than that in the agriculture and service industry. Then we calculate the TFP through Eq.(29). The measurement and descriptive statistics of variables are reported in Tables 5 and 6, respectively. Owing to lack of space, the correlation analysis is not reported, but all the correlation coefficients are smaller than the co-linearity threshold of 0.7 (Mason et al., 1990).

5.3. Results and Analysis

5.3.1. Amplification Effect on TFP

Table 7 reports the regression results. As shown in Table 5, Reg.(5) estimates the model(30) using the Fix Effects method. The coefficient on the 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

---

9Due to data availability, we cannot obtain the data covering the years from 2008 to 2014. However, since discriminatory credit constraints is long-standing in China, the data from 1999 to 2008 can be used to examine its impact.

10The Hausman test has been made for all panel regressions. All the results indicate it is appropriate to use the fixed effect model.
of discrimination of credit constraints 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 findings from the DSGE model analysis. Discriminatory credit constraints can amplify the impact of technology shock on total output.

The coefficient on TFP is significantly positive, and the coefficient on the interest rate is significantly negative, also in line with existing theories. 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 the existing literature. The coefficient on \( DCC_{i,t} \) is significantly negative, which shows that discriminatory credit constraints is damaging to economic growth.

\[ \text{[TABLE 7 ABOUT HERE]} \]

5.3.2. Attenuation Effect on Monetary Policy

Table 7 also reports the regression results of Eq.(31). As shown in Reg.(5), the coefficient on the product item \( \text{DCC}_{i,t} \times \text{Int}_t \) is 5.238 and significant at the 5% level; the coefficient of real interest rate is -27.70, significant at the 1% level. According to the coefficients, if the extent of discrimination of credit constraints increases by 1 unit, when the real interest rate decreases by 0.1 percentage points, the increase of the growth rate of industrial value addition will decrease by 0.5238 percentage points. That is, in industries where the extent of discriminatory credit constraints between SOEs and PEs is greater, expansionary monetary policy will be less effective in promoting economic growth. Therefore, discriminatory credit constraints may hinder the effectiveness of expansionary monetary policy.

In Reg.(5), the estimates 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).

6. Conclusion Remarks

Discriminatory credit constraints have played a critical role in amplifying economic fluctuations and reducing the effectiveness of expansionary monetary policy in China. Such constraints in China are importantly driven by political connections. When the economy is hit by a negative shock, inequity in the credit market can induce financial misallocation, further leading to deterioration of total loans and output. These findings can find supportive evidence from China’s firm data. This research therefore calls for further reform of the Chinese economy including the reform of the financial system.

The marginal theoretical contribution of this paper is to find a new financial accelerator: discriminatory credit constraints that may amplify the economic fluctuation primarily driven in non-financial sector, and that have an attenuation effect on expansionary policy. With respect to the model setup, we combine the financial frictions in lending supply side and
demand side by endogenously modelling the loan-to-value ratios. The managerial impaction is that the amelioration of financial system on equality may promote economic development, by reducing economic volatility and keeping the effectiveness of macro prudential policy and expansionary monetary policy.

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: Observable Variables Used in Estimation

Note: All variables are expressed as log deviation from the HP-filter trend.
Figure 3: The Prior and Posterior Marginal Distribution

Note: Draws based on 10 chains, each with 100,000 draws based on Metropolis algorithm. Solid line denotes the posterior marginal distribution, while dashed lines prior marginal distribution.
Figure 4: The Amplification Effect of Discriminatory Credit Constraints on the Transmission of a Negative Technology Shock

Note: All interest rate is shown as absolute deviations from steady state. All other variables are shown as percentage deviation from steady state. The line marked with dots is from model with discriminatory credit constraints, while the line without marks is from model with non-discriminatory credit constraints (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 dash line are expressed as SOE and PE respectively.
Figure 5: The Weakening Effect of Discriminatory Credit Constraints on the Transmission of an Expansionary Monetary Policy Shock

Note: All interest rate is shown as absolute deviations from steady state. All other variables are shown as percentage deviation from steady state. The line marked with dots is from model with discriminatory credit constraints, while the line without marks is from model with non-discriminatory credit constraints (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 dash line are expressed as SOE and PE respectively.
Figure 6: The Amplification Effect and Different Extent of Discrimination

Note: All interest rate is shown as absolute deviations from steady state. All other variables are shown as percentage deviation from steady state. Solid line and dotted line are expressed as SOE and PE respectively. The line marked with “x” is from model with discriminatory credit constraints, while the line without marks is from model without discriminatory credit constraints (No subsidy for SOE loan and the same LTV steady state). The line marked with diamond is from model with discriminatory credit constraints and lower marginal subsidy rate (with $\kappa^T = 0.02$, while in benchmark model the estimation of $\kappa^T$ is 0.0418). The first three figures are about macro variables. In the last three figures, solid line and dash line are expressed as SOE and PE respectively.
Table 1: Calibrated Parameters Influencing Steady State

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<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>
<td>0.975</td>
</tr>
<tr>
<td>$\beta_A$</td>
<td>Discount factor of SOE</td>
<td>0.975</td>
</tr>
<tr>
<td>$\beta_B$</td>
<td>Discount factor of PE</td>
<td>0.97</td>
</tr>
<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>
</tbody>
</table>
Table 2: Prior and Posterior Distribution of Structure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior distribution</th>
<th>Posterior distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_a$ SOE Consu. Habit</td>
<td>Beta 0.500 0.1000</td>
<td>Mean 0.5155 0.3709 0.6601</td>
</tr>
<tr>
<td>$a_b$ PE Consu. Habit</td>
<td>Beta 0.500 0.1000</td>
<td>Mean 0.2842 0.1911 0.3756</td>
</tr>
<tr>
<td>$a_I$ Impa. HH. Consu. Habit</td>
<td>Beta 0.500 0.1000</td>
<td>Mean 0.5233 0.3902 0.6579</td>
</tr>
<tr>
<td>$a_P$ Patient HH. Consu. Habit</td>
<td>Beta 0.500 0.1000</td>
<td>Mean 0.6401 0.5288 0.7529</td>
</tr>
<tr>
<td>$\gamma$ Price Stickiness</td>
<td>Beta 0.750 0.0500</td>
<td>Mean 0.7398 0.6738 0.8081</td>
</tr>
<tr>
<td>$\kappa_{bE}$ Firm Rate Adjust. Cost</td>
<td>Gamma 10.000 5.0000</td>
<td>Mean 1.2015 0.1847 2.1873</td>
</tr>
<tr>
<td>$\kappa_{bH}$ HH Rate Adjust. Cost</td>
<td>Gamma 10.000 5.0000</td>
<td>Mean 7.4002 0.1551 17.6430</td>
</tr>
<tr>
<td>$\kappa_d$ Deposit Rate Adjust. Cost</td>
<td>Gamma 10.000 5.0000</td>
<td>Mean 17.0277 9.5802 23.9459</td>
</tr>
<tr>
<td>$\kappa_f$ Invest. Adjust. Cost</td>
<td>Gamma 10.000 5.0000</td>
<td>Mean 7.5306 2.1167 12.9512</td>
</tr>
<tr>
<td>$\kappa_{kb}$ Leverage Dev. Cost</td>
<td>Gamma 10.000 5.0000</td>
<td>Mean 13.3707 5.5518 20.8138</td>
</tr>
<tr>
<td>$\phi_a$ Patient HH. Fischer Elas.</td>
<td>Gamma 1.000 0.2000</td>
<td>Mean 1.0085 0.6772 1.3303</td>
</tr>
<tr>
<td>$\phi_b$ Impa. HH. Fischer Elas.</td>
<td>Gamma 1.200 0.2000</td>
<td>Mean 1.2054 0.8791 1.5225</td>
</tr>
<tr>
<td>$\phi_\pi$ T. R. coeff on $\pi$</td>
<td>Gamma 1.500 0.2000</td>
<td>Mean 1.6657 1.4265 1.8884</td>
</tr>
<tr>
<td>$\phi_y$ T. R. coeff on $y$</td>
<td>Gamma 0.150 0.1000</td>
<td>Mean 0.3141 0.1295 0.4933</td>
</tr>
<tr>
<td>$\rho$ T. R. Continuity</td>
<td>Beta 0.700 0.1000</td>
<td>Mean 0.6742 0.5714 0.7799</td>
</tr>
<tr>
<td>$\kappa_T$ 2nd order subsidy rate</td>
<td>Inv. Gamma 0.050 0.1000</td>
<td>Mean 0.0418 0.0151 0.0729</td>
</tr>
</tbody>
</table>

Note: Results based on 10 chains, each with 100,000 draws based on Metropolis algorithm.

Table 3: Prior and Posterior Distribution of Structure Parameters: External Processes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior distribution</th>
<th>Posterior distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho_c$ Consumption Preference</td>
<td>Beta 0.500 0.1000</td>
<td>Mean 0.5388 0.3970 0.6833</td>
</tr>
<tr>
<td>$\rho_k$ Invest. Efficiency</td>
<td>Beta 0.500 0.1000</td>
<td>Mean 0.3820 0.2448 0.5184</td>
</tr>
<tr>
<td>$\rho_z$ Total Technology</td>
<td>Beta 0.800 0.1000</td>
<td>Mean 0.9474 0.9140 0.9822</td>
</tr>
<tr>
<td>$\rho_{za}$ Technology Of SOE</td>
<td>Beta 0.500 0.1000</td>
<td>Mean 0.4865 0.3181 0.6670</td>
</tr>
<tr>
<td>$\rho_{zb}$ Technology Of SPE</td>
<td>Beta 0.500 0.1000</td>
<td>Mean 0.2032 0.1084 0.2866</td>
</tr>
<tr>
<td>Standard deviations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_c$ Consumption Preference</td>
<td>Inv. Gamma 0.100 0.2000</td>
<td>Mean 0.0630 0.0406 0.0848</td>
</tr>
<tr>
<td>$\sigma_k$ Invest. Efficiency</td>
<td>Inv. Gamma 0.100 0.2000</td>
<td>Mean 0.0289 0.0235 0.0341</td>
</tr>
<tr>
<td>$\sigma_r$ Monetary Policy</td>
<td>Inv. Gamma 0.100 0.2000</td>
<td>Mean 0.0153 0.0129 0.0174</td>
</tr>
<tr>
<td>$\sigma_z$ Total Technology</td>
<td>Inv. Gamma 0.100 0.2000</td>
<td>Mean 0.0809 0.0435 0.1164</td>
</tr>
<tr>
<td>$\sigma_{za}$ Technology Of SOE</td>
<td>Inv. Gamma 0.100 0.2000</td>
<td>Mean 0.0877 0.0252 0.1425</td>
</tr>
<tr>
<td>$\sigma_{zb}$ Technology Of PE</td>
<td>Inv. Gamma 0.100 0.2000</td>
<td>Mean 0.8056 0.3875 1.2768</td>
</tr>
</tbody>
</table>

Note: Results based on 10 chains, each with 100,000 draws based on Metropolis algorithm.
### Table 4: Model Comparison Based on Log Marginal Density

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Priors</td>
<td>0.2500</td>
<td>0.2500</td>
<td>0.2500</td>
<td>0.2500</td>
</tr>
<tr>
<td>Log Marginal Density</td>
<td>460.2433</td>
<td>459.1757</td>
<td>456.3142</td>
<td>457.3104</td>
</tr>
<tr>
<td>Bayes Ratio</td>
<td>1.0000</td>
<td>0.3438</td>
<td>0.0197</td>
<td>0.0532</td>
</tr>
<tr>
<td>Posterior Model Probability</td>
<td>0.7059</td>
<td>0.2427</td>
<td>0.0139</td>
<td>0.0376</td>
</tr>
</tbody>
</table>

Note: Results based on 10 chains, each with 100,000 draws based on Metropolis algorithm. For comparison, the prior distribution is selected as the same for all models. Discri. Endo-LTV denotes the benchmark model with discriminatory credit constraints and endogenous loan-to-value ratios. Non-Discri. Endo-LTV indicates the model without discrimination but with endogenous loan-to-value ratios. Non-Discri. Exogen-LTV and Discri. Exogen-LTV denote the model with discriminatory credit constraints and without respectively, in which the loan-to-value ratios for SOEs and PEs are exogenously given.

### Table 5: 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</td>
<td>Average overnight Shanghai Inter-Bank Offer Rate (%)</td>
<td>Winds Database</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 6: 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>0.520</td>
<td>-1.433</td>
<td>0.956</td>
<td>2.524</td>
</tr>
<tr>
<td>$Int_t$ (%)</td>
<td>335</td>
<td>2.445</td>
<td>0.734</td>
<td>1.860</td>
<td>2.320</td>
<td>4.450</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>
</tr>
</tbody>
</table>
Table 7: 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>OLS</td>
<td>IAV_{toN,t}</td>
<td>IAV_{t}</td>
<td>IAV_{t}</td>
<td>IAV_{t}</td>
<td>IAV_{t}</td>
<td>IAV_{t}</td>
</tr>
<tr>
<td>FE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K_{toN,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>TFP_{t}</td>
<td>0.420***</td>
<td>0.382***</td>
<td>0.485***</td>
<td>0.142</td>
<td>0.193**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0755)</td>
<td>(0.0745)</td>
<td>(0.0791)</td>
<td>(0.0991)</td>
<td>(0.0926)</td>
<td></td>
</tr>
<tr>
<td>Int_{t}</td>
<td>-0.599***</td>
<td>-0.569***</td>
<td>-0.789***</td>
<td>-0.524***</td>
<td>-0.832***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0410)</td>
<td>(0.0410)</td>
<td>(0.0794)</td>
<td>(0.0415)</td>
<td>(0.0736)</td>
<td></td>
</tr>
<tr>
<td>DCC_{i,t}</td>
<td></td>
<td></td>
<td>-0.130***</td>
<td>-0.596***</td>
<td>-0.492***</td>
<td>-1.343***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0425)</td>
<td>(0.152)</td>
<td>(0.111)</td>
<td>(0.202)</td>
</tr>
<tr>
<td>DCC_{i,t} × Int_{i,t}</td>
<td></td>
<td></td>
<td>0.216***</td>
<td></td>
<td>0.321***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(0.0675)</td>
<td></td>
<td>(0.0655)</td>
<td></td>
</tr>
<tr>
<td>DCC_{i,t} × TFP_{t}</td>
<td></td>
<td></td>
<td></td>
<td>0.367***</td>
<td>0.525***</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.105)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.102)</td>
</tr>
<tr>
<td>N_{i,t}</td>
<td>0.680***</td>
<td>0.738***</td>
<td>0.749***</td>
<td>0.750***</td>
<td>0.771***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0435)</td>
<td>(0.0464)</td>
<td>(0.0451)</td>
<td>(0.0448)</td>
<td>(0.0418)</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.295***</td>
<td>8.901***</td>
<td>8.400***</td>
<td>8.657***</td>
<td>8.424***</td>
<td>8.816***</td>
</tr>
<tr>
<td></td>
<td>(0.0463)</td>
<td>(0.556)</td>
<td>(0.564)</td>
<td>(0.553)</td>
<td>(0.544)</td>
<td>(0.511)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.766</td>
<td>0.944</td>
<td>0.947</td>
<td>0.950</td>
<td>0.951</td>
<td>0.958</td>
</tr>
<tr>
<td>Number of industry</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Hausman Test P Value</td>
<td>0.0000</td>
<td>0.0010</td>
<td>0.0001</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
Appendix A. Data Source

In this paper, we use China’s data to calibrate the model economy, and use the China industrial data to empirically test the conclusion from model analysis. In front of the research, we also use LTV ratio data of Chinese industrial enterprises to show the existence and characters of discriminatory credit constraints.

Appendix A.1. Calibration data

LTV ratios: Calculated based on data from National Bureau of Statistics of China. They are calculated as the difference of total debts and payables, divided by total assets. Due to the accurateness, we use this data as the calibrated reference for LTV ratio steady state of SOEs and PEs in the model economy.

Taylor Rule Interest Rate Steady State: Averaged by Shanghai inter-bank offered rate (SHIBOR) during period from 2004 to 2014 (Wind. Database).

Deposit Interest Rate Steady State: Averaged by Chinese average deposit benchmark interest rate during period from 2004 to 2014 (Wind. Database).

Loan Interest Rate Steady State: Averaged by Chinese average loan benchmark interest rate during period from 2004 to 2014 (Wind. Database).


Appendix A.2. Estimation data


Real Consumption: Calculated from National Bureau of Statistics of China, deflated by GDP deflator.

Real Investment: Calculated from National Bureau of Statistics of China, deflated by GDP deflator.

Policy Interest Rate: Averaged by 60-day Shanghai inter-bank offered rate (SHIBOR) during period from 2004 to 2014 (Wind. Database).

Appendix A.3. Regression data

In empirical work, we adopt Chinese industrial data from China Annual Survey of Industrial Firms during period of 1998-2008, including industry added value per firm per year, employee, capital assets and so on. The interest rate is from Wind. database. The detail on data manipulation is given in the subsection 5.1. The industries and average extent of discrimination is in Figure A.1.
Table A.1: Industries and Average Extent of Discriminatory Credit Constraint

<table>
<thead>
<tr>
<th>code</th>
<th>Industry</th>
<th>Average $DCC_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Coal mining and washing industry</td>
<td>1.185</td>
</tr>
<tr>
<td>7</td>
<td>Petroleum and natural gas exploitation</td>
<td>0.509</td>
</tr>
<tr>
<td>8</td>
<td>Ferrous metal mining industry</td>
<td>0.969</td>
</tr>
<tr>
<td>9</td>
<td>Non ferrous metal mining industry</td>
<td>1.189</td>
</tr>
<tr>
<td>10</td>
<td>Non metal mining industry</td>
<td>1.025</td>
</tr>
<tr>
<td>11</td>
<td>Other mining industry</td>
<td>0.333</td>
</tr>
<tr>
<td>13</td>
<td>Agricultural and sideline products processing industry</td>
<td>1.086</td>
</tr>
<tr>
<td>14</td>
<td>The food manufacturing industry</td>
<td>1.176</td>
</tr>
<tr>
<td>15</td>
<td>Beverage manufacturing industry</td>
<td>0.870</td>
</tr>
<tr>
<td>16</td>
<td>Tobacco industry</td>
<td>1.657</td>
</tr>
<tr>
<td>17</td>
<td>The textile industry</td>
<td>1.506</td>
</tr>
<tr>
<td>18</td>
<td>Textile and garment, shoes, hat manufacturing</td>
<td>1.387</td>
</tr>
<tr>
<td>19</td>
<td>Leather, fur, feathers and its products</td>
<td>1.533</td>
</tr>
<tr>
<td>20</td>
<td>Wood processing and wood, bamboo, rattan, palm, and straw products</td>
<td>1.739</td>
</tr>
<tr>
<td>21</td>
<td>Furniture manufacturing industry</td>
<td>2.308</td>
</tr>
<tr>
<td>22</td>
<td>Papermaking and paper products industry</td>
<td>1.292</td>
</tr>
<tr>
<td>23</td>
<td>Printing and record medium reproduction</td>
<td>0.897</td>
</tr>
<tr>
<td>24</td>
<td>Stationery and sports goods manufacturing industry</td>
<td>2.337</td>
</tr>
<tr>
<td>25</td>
<td>Petroleum processing, coking and nuclear fuel</td>
<td>0.869</td>
</tr>
<tr>
<td>26</td>
<td>Chemical raw materials and chemical products manufacturing</td>
<td>1.124</td>
</tr>
<tr>
<td>27</td>
<td>Pharmaceutical manufacturing industry</td>
<td>0.738</td>
</tr>
<tr>
<td>28</td>
<td>Chemical fiber manufacturing industry</td>
<td>1.448</td>
</tr>
<tr>
<td>29</td>
<td>Rubber products industry</td>
<td>1.163</td>
</tr>
<tr>
<td>30</td>
<td>Plastic products industry</td>
<td>1.364</td>
</tr>
<tr>
<td>31</td>
<td>Non metallic mineral products industry</td>
<td>1.337</td>
</tr>
<tr>
<td>32</td>
<td>Ferrous metal smelting and rolling processing industry</td>
<td>1.069</td>
</tr>
<tr>
<td>33</td>
<td>Non ferrous metal smelting and rolling processing industry</td>
<td>1.295</td>
</tr>
<tr>
<td>34</td>
<td>The metal products industry</td>
<td>1.089</td>
</tr>
<tr>
<td>35</td>
<td>General equipment manufacturing industry</td>
<td>1.277</td>
</tr>
<tr>
<td>36</td>
<td>Special equipment manufacturing industry</td>
<td>1.360</td>
</tr>
<tr>
<td>37</td>
<td>Transportation equipment manufacturing industry</td>
<td>0.970</td>
</tr>
<tr>
<td>39</td>
<td>Electrical machinery and equipment manufacturing industry</td>
<td>1.616</td>
</tr>
<tr>
<td>40</td>
<td>Communications equipment, computers and others</td>
<td>1.499</td>
</tr>
<tr>
<td>41</td>
<td>Instrumentation and culture, office machinery manufacturing</td>
<td>1.494</td>
</tr>
<tr>
<td>42</td>
<td>Handicraft and other production</td>
<td>1.835</td>
</tr>
<tr>
<td>43</td>
<td>The waste of resources and waste materials recycling industry</td>
<td>1.518</td>
</tr>
<tr>
<td>44</td>
<td>Electricity, heat production and supply industry</td>
<td>1.052</td>
</tr>
<tr>
<td>45</td>
<td>Gas production and supply industry</td>
<td>1.045</td>
</tr>
<tr>
<td>46</td>
<td>Water production and supply industry</td>
<td>0.772</td>
</tr>
</tbody>
</table>
Appendix B. Log-Linear Model

Using perturbation method, we transfer the whole economy system to log-linear system by unfolding the function around steady state. In steady state, we assume inflation rate is zero, and the capital acquirement rate is just equal to the one set by PBoC. The linear system is as follows:

Appendix B.1. Patient Household

\[-\frac{1}{1-a^d}c^P_t + \frac{a^P}{1-a^P}c^P_{t-1} = \hat{\lambda}^P_t - \hat{\varepsilon}^c_t \quad (B.1)\]

\[\phi^A \hat{n}^P,A_t = \hat{\lambda}^P_t + \hat{w}^P,A_t \quad (B.2)\]

\[\phi^B \hat{n}^P,B_t = \hat{\lambda}^P_t + \hat{w}^P,B_t \quad (B.3)\]

\[-\hat{h}^P_t = \frac{1}{1-\beta_P} \hat{\lambda}^P_t - \frac{\beta_P}{1-\beta_P} \hat{\lambda}^P_{t+1} + \frac{1}{1-\beta_P} \hat{q}^h_t - \frac{\beta_P}{1-\beta_P} \hat{q}^h_{t+1} \quad (B.4)\]

\[\hat{\lambda}^P_t + \hat{\pi}_{t+1} = \hat{\lambda}^P_{t+1} + (1-\beta_P) \hat{r}^d_t \quad (B.5)\]

Appendix B.2. Impatient Household

\[-\frac{1}{1-a^d}c^I_t + \frac{a^I}{1-a^I}c^I_{t-1} = \hat{\lambda}^I_t - \hat{\varepsilon}^c_t \quad (B.6)\]

\[\phi^A \hat{n}^I,A_t = \hat{\lambda}^I_t + \hat{w}^I,A_t \quad (B.7)\]

\[\phi^B \hat{n}^I,B_t = \hat{\lambda}^I_t + \hat{w}^I,B_t \quad (B.8)\]

\[\hat{b}^I_t + \frac{r^{bH}}{1+r^{bH}} \hat{b}^{bH}_t = \hat{q}^h_{t+1} + \hat{h}^I_t + \hat{\pi}_{t+1} \quad (B.9)\]

\[\frac{\hat{c}^I_t}{\hat{y}} + \frac{\hat{b}^I_t}{\hat{y}} \left[ \frac{r^{bH}}{1+r^{bH}} \hat{b}^{bH}_{t-1} + \hat{b}^I_{t-1} - \hat{\pi}_{t-1} - \hat{b}^I_t \right] + \frac{\hat{q}^h_t \hat{h}^I_t}{\hat{y}} \left( \hat{h}^I_{t-1} - \hat{h}^I_t \right) \]

\[\frac{\hat{c}^I_{t-1}}{\hat{y}} + \frac{\hat{b}^I_{t-1}}{\hat{y}} \left[ \frac{r^{bH}}{1+r^{bH}} \hat{b}^{bH}_{t-2} + \hat{b}^I_{t-2} - \hat{\pi}_{t-2} - \hat{b}^I_{t-1} \right] + \frac{\hat{q}^h_{t-1} \hat{h}^I_{t-1}}{\hat{y}} \left( \hat{h}^I_{t-2} - \hat{h}^I_{t-1} \right) \]

\[-\hat{h}^I_t \left( 1 - \beta_I - \xi^I m^H \right) = \hat{\lambda}^I_t + \hat{q}^h_t - \beta_I \left( \hat{\lambda}^I_{t+1} + \hat{q}^h_{t+1} \right) - \xi^I m^H \left( \hat{\lambda}^I_t + \hat{\xi}^I_{t+1} + \hat{q}^h_t + \hat{\pi}_{t+1} \right) \quad (B.10)\]

\[\hat{\lambda}^I_{t+1} + \frac{\beta_I + \xi^I}{\beta_I} \left( 1 - (\beta_I + \xi^I) \right) \hat{r}^{bH}_t + \frac{\xi^I}{\beta_I} \hat{c}^I_t = \hat{\lambda}^I_t + \hat{\pi}_{t+1} \quad (B.11)\]

Appendix B.3. Entrepreneurs

We combine the same equation of SOE and PE, indexed by \( s = A, B \).

\[\hat{y}^s_t = \hat{z}_t + \hat{z}^s_t + \alpha^s (\hat{n}^s_t + \hat{k}^s_{t-1}) + (1-\alpha^s) \hat{n}^s_t \quad (B.13)\]

\[\hat{n}^s_t = \mu^{n,s} \hat{n}^{l,s}_t + (1-\mu^{n,s}) \hat{n}^{P,s}_t \quad (B.14)\]
\[
\tilde{r}^{bE} + \frac{\tilde{b}^{t}}{1 + \tilde{r}^{bE}} \tilde{b}^{t} = \hat{\bar{m}}^{s} + \hat{c}^{k}_{t+1} + \hat{\pi}_{t+1}^{s} + \hat{\lambda}^{s}_{t} \\
- \frac{1}{1 - \beta_{s}} \hat{\bar{m}}^{s} = \hat{\lambda}^{s}_{t} \\
- \hat{x}^{s}_{t} - \hat{\bar{n}}^{P,s}_{t} + \hat{\bar{y}}^{s}_{t} = \hat{\bar{w}}^{P,s}_{t} \\
- \hat{x}^{s}_{t} - \hat{\bar{n}}^{I,s}_{t} + \hat{\bar{y}}^{s}_{t} = \hat{\bar{w}}^{I,s}_{t} \\
- \hat{x}^{s}_{t} + \hat{\bar{y}}^{s}_{t} - \hat{\bar{u}}^{s}_{t} = \psi''_{s}(\bar{u}^{s}) \hat{\bar{u}}^{s}_{t} + \hat{\lambda}^{s}_{t+1} \\
\frac{\alpha^{s}}{\bar{y}^{s}} (\hat{\bar{g}}^{s}_{t} - \hat{x}^{s}_{t}) + \frac{\bar{b}^{s}_{t}}{\bar{y}^{s}} \hat{b}^{t}_{t} = \delta \bar{k}^{s}_{t} \hat{q}^{k,s}_{t} + \frac{\bar{k}^{s}_{t}}{\bar{y}^{s}} \left[ \hat{\bar{m}}^{s} - (1 - \delta) \hat{\lambda}_{t}^{s} \right] + \psi'_{s}(\bar{u}^{s}) \frac{\bar{k}^{s}_{t}}{\bar{y}^{s}} \hat{\bar{u}}^{s}_{t} + \frac{c^{s}}{\bar{y}^{s}} \hat{\bar{c}}^{s}_{t} \\
+ \left[ \frac{\bar{b}^{s}_{t}}{\bar{y}^{s}} (1 + \tilde{r}^{bE}) \left( 1 - \frac{\bar{m}^{s}}{2\kappa_{w}} \right) \right] \hat{b}^{s}_{t} + \frac{\tilde{r}^{bE}}{1 + \tilde{r}^{bE}} \hat{b}^{s}_{t} - \hat{\bar{\pi}}_{t} \\
- \eta \frac{\bar{m}^{s}}{2\kappa_{w}} (1 + \tilde{r}^{bE}) \hat{\bar{m}}^{s}_{t-1} + \eta \kappa_{f} \bar{m}^{s} \frac{\bar{k}^{s}_{t}}{\bar{y}^{s}} \left( \hat{\bar{m}}^{s}_{t-1} + \bar{q}^{k}_{t-1} + \hat{\bar{\lambda}}^{s}_{t-1} \right) \\
\left( \hat{\bar{\lambda}}^{s}_{t+1} - \hat{\bar{\lambda}}^{s}_{t} - \hat{\bar{x}}^{s}_{t+1} + \hat{\bar{y}}^{s}_{t+1} - \hat{\bar{\lambda}}^{s}_{t} \right) \left[ 1 - \beta_{s} (1 - \delta) - \eta \kappa_{f} \bar{m}^{s} \right] - \frac{\tilde{\xi}^{s}}{\lambda^{s}} \bar{m}^{s} (1 - \delta) = \\
\hat{\bar{q}}^{k}_{t} - \beta_{s} (1 - \delta) - \eta \kappa_{f} \bar{m}^{s} \left( \hat{\bar{\lambda}}^{s}_{t+1} - \hat{\bar{\lambda}}^{s}_{t} \right) = \beta_{s} \left[ \psi'_{s}(\bar{u}^{s}) \hat{\bar{u}}^{s}_{t} + \eta \kappa_{f} \bar{m}^{s} \left( \hat{\bar{m}}^{s}_{t} + \bar{q}^{k}_{t} \right) \right] \\
- \frac{\tilde{\xi}^{s}}{\lambda^{s}} \bar{m}^{s} (1 - \delta) \left( \hat{\bar{\xi}}^{s}_{t} - \hat{\bar{\lambda}}^{s}_{t} + \hat{\bar{\bar{\lambda}}}_{t+1} \right) \\
\tilde{r}^{bE} \tilde{r}^{bE} + \frac{\tilde{\xi}^{s}}{\lambda^{s}} \left( \hat{\bar{\xi}}^{s}_{t} - \hat{\bar{\lambda}}^{s}_{t} \right) + \hat{\bar{\lambda}}^{s}_{t+1} = \left( \frac{1}{1 + \tilde{r}^{bE}} - \frac{\tilde{\xi}^{s}}{\lambda^{s}} \right) \left[ \hat{\bar{\lambda}}^{s}_{t} + \hat{\bar{\pi}}_{t+1} + \frac{\eta \bar{m}^{s}}{2\kappa_{w} - \eta \bar{m}^{s}} \hat{\bar{\lambda}}^{s}_{t} \right] \\
\frac{\bar{m}^{A}}{(1 - \delta) \bar{m}^{A} (1 - \delta) - 2\kappa_{w} \kappa_{f}} \hat{\bar{m}}^{A}_{t} = \hat{\bar{\xi}}^{A}_{t} - \hat{\bar{\lambda}}^{A}_{t+1} + \hat{\bar{\pi}}_{t+1} \\
\hat{\bar{k}}^{w}_{t} + \hat{\bar{\pi}}_{t} = (1 - \delta^{b}) \hat{\bar{k}}^{w}_{t-1} + \delta^{b} \hat{\bar{\pi}}_{t-1}^{bank} \\
\bar{b}^{A} \hat{\bar{b}}^{A}_{t} + \bar{b}^{B} \hat{\bar{b}}^{B}_{t} + \bar{b}^{t} \hat{\bar{b}}^{t}_{t} = \bar{b} \bar{b} \\
\bar{b} \bar{b} = \hat{\bar{k}}^{w} \hat{\bar{k}}^{w} + (\bar{b} - \bar{k}^{w}) \hat{\bar{\hat{d}}} \\
\hat{\bar{\hat{r}}}^{wH} = \hat{\bar{\hat{r}}} + \frac{\kappa_{hh}}{\bar{r}} (\nu^{b})^{3} (\hat{\bar{\hat{b}}} - \hat{\bar{k}}^{w}) \\
\text{Appendix B.4. Banking Sector}
\[
\tilde{r}^w H \tilde{r}^w E = \tilde{r}^w H \tilde{r}^w_t + \eta \tilde{m}^B \left( \frac{1}{\nu^w \nu^E} \left( \tilde{m}_t^A + \tilde{m}_t^B \right) \right)
\]
\[
\tilde{m}_t^A - \tilde{m}_t^B = \frac{\nu^w \nu^E}{\eta} \left( \kappa_1 \hat{b}^A \left( 1 + \nu^b E \right) \hat{b}_t^A - \kappa_2 \hat{r}_t^b \right)
\]
\[
-e^d \frac{\tilde{r}^d}{\tilde{r}} \left( \tilde{r}_t^d - \tilde{r}^d \right) - \nu^d \left( \tilde{r}_t^d - \tilde{r}^d \right) + \beta^d \nu^d \left( \tilde{r}_t^d - \tilde{r}^d \right) = 0
\]
\[
\hat{r}_t^b H = \hat{r}_t^b H + \beta^d \nu^d \left( \tilde{r}_t^d - \tilde{r}^d \right) + \beta^d \nu^d \left( \tilde{r}_t^d - \tilde{r}^d \right) = 0
\]
\[
\tilde{r}_t^d = \tilde{r}_t^d + \frac{\eta (1 + \tilde{r}^b E)}{2 \nu^w} \sum_{s=A,B} \tilde{m}_t^s \tilde{b}^s \left( \tilde{m}_t^s + \frac{\tilde{r}^b E}{1 + \tilde{r}^b E} \tilde{r}^b E + \hat{b}_t^s \right) + \kappa_2 \tilde{b}^B \tilde{b}_t^A
\]

**Appendix B.5. CGP & Retailer**

\[
\hat{q}_t^k = \kappa_1 \left( \hat{q}_t^k + \hat{q}_t \right) - \beta \kappa_1 \left( \hat{q}_t^k + \hat{q}_t \right)
\]
\[
\sum_{s=A,B} \left[ \hat{k}_t^s \left( \hat{k}_t^s - (1 - \delta) \hat{k}_t^s - \hat{k}_t \right) \right] = \hat{g}_t
\]
\[
\hat{y}_t = \mu^y \hat{y}_t^A + (1 - \mu^y) \hat{y}_t^B
\]
\[
\hat{y}_t^A - \hat{y}_t^B = \hat{y}_t^A - \hat{y}_t^B
\]
\[
\hat{r}_t = \beta \hat{r}_{t+1} - \frac{(1 - \gamma)(1 - \beta \gamma)}{\gamma} \left[ \mu^y \hat{r}_t^A + (1 - \mu^y) \hat{r}_t^B \right]
\]

**Appendix B.6. Market Clear, Monetary Policy and Technology shock**

\[
\bar{y} \bar{y}_t = \bar{y} \left( \hat{q}_t + \hat{q}_t^k \right) + \sum_{s=1,2,3} (\hat{c}_t^s + \hat{c}_t) \left( \hat{k}_t^w - \hat{r}_t \right)
\]
\[
\frac{1 + \bar{r}}{1 + \bar{r}} \hat{r}_t = \rho \frac{1 + \bar{r}}{1 + \bar{r}} \hat{r}_{t-1} + (1 - \rho) \left[ \phi_y \left( \hat{y}_t - \hat{y}_{t-1} \right) + \phi_{\pi} \hat{\pi}_t \right] + \sigma \hat{e}_t
\]

where \( \hat{e}_t \) is a normal distribution shock, \( \sigma \) is the standard error of the monetary policy shock. For all other shocks, \( \hat{\Theta}_t = \left[ \hat{z}_t^A, \hat{z}_t^B, \hat{z}_t, \hat{z}_t, \hat{z}_t^k \right] \), they follow an AR(1) process:

\[
\hat{\Theta}_t = \rho \hat{\Theta}_{t-1} + \sigma \hat{e}_t
\]
Appendix C. Robustness

Figure C.1: Transmission of a Negative Technology Shock from model with Exogenous-LTV

Note: All interest rate is shown as absolute deviations from steady state. All other variables are shown as percentage deviation from steady state. The line marked with “x” is from model with discriminatory credit constraints, while the line without marks is from model with non-discriminatory credit constraints (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 C.2: Transmission of a Expansionary Monetary Shock from model with Exogenous-LTV

Note: All interest rate is shown as absolute deviations from steady state. All other variables are shown as percentage deviation from steady state. The line marked with “x” is from model with discriminatory credit constraints, while the line without marks is from model with non-discriminatory credit constraints (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 C.3: The Amplification Effect of Discriminatory Credit Constraints on the Transmission of a Negative Technology Shock with Smaller SOE Weight

Note: Results based on 10 chains, each with 100,000 draws based on Metropolis algorithm.
Figure C.4: The Attenuation Effect of Discriminatory Credit Constraints on the Transmission of a Expansionary Monetary Shock with Smaller SOE Weight

Note: Results based on 10 chains, each with 100,000 draws based on Metropolis algorithm.
Table C.2: Prior and Posterior Distribution of Structure Parameters in Robustness

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior distribution</th>
<th>Posterior distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Distribution</td>
<td>Mean</td>
</tr>
<tr>
<td>$a_a$ SOE Consu. Habit</td>
<td>Beta</td>
<td>0.500</td>
</tr>
<tr>
<td>$a_b$ PE Consu. Habit</td>
<td>Beta</td>
<td>0.500</td>
</tr>
<tr>
<td>$a_I$ Impa. HH. Consu. Habit</td>
<td>Beta</td>
<td>0.500</td>
</tr>
<tr>
<td>$a_P$ Patient HH. Consu. Habit</td>
<td>Beta</td>
<td>0.500</td>
</tr>
<tr>
<td>$\gamma$ Price Stickiness</td>
<td>Beta</td>
<td>0.750</td>
</tr>
<tr>
<td>$\kappa_{bE}$ Firm Rate Adjust. Cost</td>
<td>Gamma</td>
<td>10.000</td>
</tr>
<tr>
<td>$\kappa_{bH}$ HH Rate Adjust. Cost</td>
<td>Gamma</td>
<td>10.000</td>
</tr>
<tr>
<td>$\kappa_d$ Deposit Rate Adjust. Cost</td>
<td>Gamma</td>
<td>10.000</td>
</tr>
<tr>
<td>$\kappa_f$ Invest. Adjust. Cost</td>
<td>Gamma</td>
<td>10.000</td>
</tr>
<tr>
<td>$\kappa_{kb}$ Leverage Dev. Cost</td>
<td>Gamma</td>
<td>10.000</td>
</tr>
<tr>
<td>$\phi_a$ Patient HH. Fischer Elas.</td>
<td>Gamma</td>
<td>1.000</td>
</tr>
<tr>
<td>$\phi_b$ Impa. HH. Fischer Elas.</td>
<td>Gamma</td>
<td>1.200</td>
</tr>
<tr>
<td>$\phi_y$ T. R. coeff on $\pi$</td>
<td>Gamma</td>
<td>1.500</td>
</tr>
<tr>
<td>$\phi_y$ T. R. coeff on $y$</td>
<td>Gamma</td>
<td>0.150</td>
</tr>
<tr>
<td>$\rho$ T. R. Continuity</td>
<td>Beta</td>
<td>0.700</td>
</tr>
<tr>
<td>$\kappa_{1T}$ 2nd order subsidy rate</td>
<td>Inv. Gamma</td>
<td>0.050</td>
</tr>
<tr>
<td>$\rho_c$ Consumption Preference</td>
<td>Beta</td>
<td>0.500</td>
</tr>
<tr>
<td>$\rho_k$ Invest. Efficiency</td>
<td>Beta</td>
<td>0.500</td>
</tr>
<tr>
<td>$\rho_z$ Total Technology</td>
<td>Beta</td>
<td>0.800</td>
</tr>
<tr>
<td>$\rho_{za}$ Technology Of SOE</td>
<td>Beta</td>
<td>0.500</td>
</tr>
<tr>
<td>$\rho_{zb}$ Technology Of SPE</td>
<td>Beta</td>
<td>0.500</td>
</tr>
<tr>
<td>$\sigma_c$ Consumption Preference.</td>
<td>Inv. Gamma</td>
<td>0.100</td>
</tr>
<tr>
<td>$\sigma_k$ Invest. Efficiency</td>
<td>Inv. Gamma</td>
<td>0.100</td>
</tr>
<tr>
<td>$\sigma_r$ Monetary Policy</td>
<td>Inv. Gamma</td>
<td>0.100</td>
</tr>
<tr>
<td>$\sigma_z$ Total Technology</td>
<td>Inv. Gamma</td>
<td>0.100</td>
</tr>
<tr>
<td>$\sigma_{za}$ Technology Of SOE</td>
<td>Inv. Gamma</td>
<td>0.100</td>
</tr>
<tr>
<td>$\sigma_{zb}$ Technology Of PE</td>
<td>Inv. Gamma</td>
<td>0.100</td>
</tr>
</tbody>
</table>

Note: Results based on 10 chains, each with 100,000 draws based on Metropolis algorithm.