Li Ma, Miao Liu, Junxun Dai, Xian Huang, "Capital Requirements of Commercial Banks and Lending Discrimination against Small Businesses: Theory and Empirical Evidence from China", Annals of Economics and Finance, Vol 14, No 2 (SSCI 期刊), 391-417

Capital Requirements of Commercial Banks and Lending Discrimination against Small Businesses: Theory and Empirical Evidence from China *

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Abstract: The difficulty involved with acquiring a small business loan has become a serious problem that threatens to hamper the growth of world economy. This paper constructs a theoretical model framework of bank lending behavior under both interest rate control and interest rate liberation. The impacts surrounding the implementation of capital adequacy requirements on banks' lending behavior are analyzed with regards to this baseline model. Simulations and empirical tests are then conducted on the model to identify the correlation between the implementation of capital requirements and lending discrimination against small businesses. The findings suggest that commercial banks do discriminate against small businesses in lending operations, and capital requirements would intensify such discrimination, making small business loans more difficult to obtain. Financial supervisory authority should take more flexible measures for capital supervision and adequately amend the existing regulatory provisions to encourage and motivate commercial banks to grant small business loans and thus mitigate lending discrimination.

Key words: small businesses, lending discrimination, capital requirements
JEL Classification Numbers: E52, E 58, E41, E51

1. INTRODUCTION

Due to their large number, diversified performances, uncertain prospects and high lending costs, small businesses experience difficulty when applying for loans from banks. It is normal for a commercial bank to deny a loan to a business whose default risk outweighs the expected interest income. Unfortunately, some

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small businesses fail to get adequate credit from banks in the real world, even when the risk is low enough to make the loan profitable. The degree of this lending discrimination is usually positively correlated with the sizes of banks and each bank's sensitivity to risk. See Williamson (1988), Berger (1998), Strahan and Weston (1998) and Stein (2002) for examples.

Discrimination in lending to small businesses has existed for a long time and is very common. Most previous research attributes the root of this discrimination to the high risks arising from information asymmetry. However, small businesses' borrowing difficulties have not been completely resolved, even with the development of the social credit system as well as mitigation methods against the information asymmetry between banks and small businesses. The Macmillan Gap[1] has not narrowed but instead has actually broadened.

On the other hand, over the last twenty years one of the greatest changes in the commercial banking industry has been the implementation of capital adequacy requirements under the guidance of the Basel Accord. Regulatory authorities generally recognize the capital adequacy requirement as an effective mechanism for controlling the risks of commercial banks. Capital adequacy requirements significantly reduce the systematic risk in the banking system by establishing a correlation between the degree of riskiness in bank assets and the amount of bank capital, which motivates commercial banks to internalize the costs of excessive risk-taking behavior. However, with the advent of stricter bank capital requirements, the availability of credit to small businesses has become even scarcer around the world. Hence, some questions need to be answered: Does the implementation of capital adequacy requirements correlate to lending discrimination against small businesses? Do strict capital requirements lure commercial banks to direct capital towards large and medium-sized businesses, worsening the existing borrowing difficulties of small businesses? According to a recent study by Shan and Qi (2006), financial development comes as the second force in leading economic growth in China, only after the contribution from labor input. Considering the dominating role commercial banks play in China's credit market, and the dominating role that small businesses play in absorbing labor, answering these questions is particularly important to China's economy.

The majority of previous literature on the subject focuses either on small businesses' borrowing difficulties, or the effects of capital requirements on the lending behavior of commercial banks. There are few studies linking these two issues, utilizing theoretical models and empirical tests to formally analyze the impacts of capital requirements on small business loans. Our main contribution is to fill this void and address the above questions by building a theoretical framework on bank lending behavior and analyzing how capital adequacy requirements affect bank lending through the model. Our main theoretical finding is that, in general, banks discriminate against small businesses in lending matters; the implementation of capital adequacy requirements intensifies such discrimination. We show that this finding is consistent with empirical evidence based on Chinese data. The mathematical model applied in our paper has never been reported elsewhere. Moreover, to the extent that different types of banks may respond differently to policy shocks, as is shown in Chang and Jansen (2005), we first test the impact of capital requirements on banks' lending behavior using the classified data on Chinese commercial banks.

2. LITERATURE REVIEW

To explain small businesses' borrowing difficulties, previous researchers have tended to rely on

[1] "Macmillan Gap" means that a financing gap exists during the growth of Small Businesses. That is to say, capital providers are reluctant to grant loans as requested by Small Businesses.

information asymmetry. Leland and Pyle (1977) incorporated ideas put forth by Aklorf (1970) and Spence (1973) into the research of financial intermediaries and commercial bank management. They pointed out that commercial banks had an advantage when dealing with the problems of information asymmetry: they could present a reliable signal to reduce information asymmetry. On this basis, Baltensperger (1980) came up with the concept of credit rationing. Stigliz and Weiss (1981) used a classical model to prove that asymmetric information could cause credit rationing. Wette (1983) later argued that credit rationing preferences contributed to small businesses' borrowing difficulties. Cook (1999) held that it is difficult for small businesses to get loans unless they were able to improve their trade credit and thus alleviate information asymmetry. Li (2002) proved that the unique idiosyncrasies of small businesses caused borrowing difficulties and suggested information disclosure as a solution. Kon and Store (2003) analyzed the difference in application fees for a loan and the impact of inadequate qualification assessments on the borrowing market, proposing an incomplete screening model of small businesses' loans with information asymmetry. Craig, Jackson and Thomson (2007) pointed out that the small business credit guarantee scheme could reduce both information asymmetry and credit rationing in the market so more loans would become available to small businesses. They put forward empirical evidence showing the availability of small businesses loans with a credit guarantee and future per capita capital income had a significantly positive correlation. Tsuruta (2008) analyzed the data of Japanese small businesses and argued that those small businesses that possessed less pledgeable assets found it harder to get a loan; because of credit rationing, they were prone to using trade credit. The findings indicated trade credit indeed affected small business loans. David Vera and Kazuki Onji (2008) analyzed how small business financing was subject to changes in the loan scale and structure of commercial banks after a new round of bank mergers and demonstrated that such mergers did not reduce the scale of small business loans. Columba, Gambacorta and Mistrulli (2010) maintained that small businesses could reduce information asymmetry to get more loans at lower interest rates through mutual guarantee agencies.

With respect to the effects of capital requirements on the credit behavior of commercial banks, different authors hold different views. Some researchers suggest that capital requirements do not have a significant effect on risk preference. Dietrich and James (1983) held that credit behavior could not be affected by capital adequacy requirements because commercial banks were also subject to other regulatory requirements. Rochet (1992) argued capital requirements would not affect the risky asset portfolio selections of those banks in pursuit of value maximization, and that capital requirements could reduce the risk-taking behavior of those banks seeking utility maximization. According to Hovakimian and Kane (2000), capital requirements would neither adjust risks to be under guard line nor change a bank's credit scale and risk preference. Allen, Carletti and Marquez (2009) suggested that the amount of capital in most national banks was above the minimum capital requirements, and it was not subject to regulatory requirement changes.

There are also some papers suggesting that higher capital requirements give banks incentives to take on more risk. Kim and Santomero (1988) pointed out that capital adequacy requirements would encourage banks to choose riskier portfolios. Keely and Furlong (1990) suggested that strict capital supervision would increase a bank's asset risk and bankruptcy risk. Rime (2001) performed an empirical test on the data of the UBS and arrived at the conclusion that capital requirements would increase the proportions of risky assets against total bank assets. Altunbas, Carbo, Gardener and Molyneux (2007) analyzed European banks and concluded that a positive correlation did exist between the level of bank capital and the risk taken on by banks.

However, a third set of researchers suggests that higher capital requirements cause less risk-taking for

banks. Peek and Rosengren (1995) maintained that rigorous capital supervision would reduce credit supplies and productive investments. Chiuri, Ferri and Majnoin (2001) analyzed the situation in emerging economies and found that capital adequacy requirements both discouraged banks to offer credit and had significant negative effect on the economy. Konishi and Yasuda (2004) analyzed decisive factors of bank risks; their data showed that the implementation of capital adequacy requirements lowers the risks of banks. Meh and Moran (2010) found that the level of capital could affect a bank's ability to attract loanable funds and could then have implications on economic cycles. Furthermore, they argued that capital requirements would cause a decline in output and investment and thus indirectly affect the credit preference of commercial banks. Li Ma, et al (2011) analyzed the credit behavior of banks with capital adequacy requirements and argued that capital adequacy requirements change the credit behavior of banks and lower the risks to be taken, and that the sensitivity of banks to capital requirement adjustments varies with capital idiosyncrasies.

Previous research so far has focused on either the borrowing difficulties experienced by small businesses, or the effect of capital requirements on the risk preferences of commercial banks. However, few studies have linked these two related issues together to consider the effects of capital requirement adjustments on the borrowing difficulties of small businesses. To fill this void, we analyze the relationship between capital requirements and small businesses' borrowing difficulties. In section 3, we construct a baseline model on the lending behaviors of banks under both interest control and interest rate liberation, illustrating that banks discriminate against small businesses in both cases. In section 4, we study the effects of capital adequacy requirements through the baseline model and show how lending discrimination against small businesses is intensified. We then provide a concrete numerical example of our model based on Chinese data in section 5. In Section 6, we demonstrate empirical evidence of our model. Section 7 concludes.

3. MODELS

In this section, we construct a model of bank lending behavior under different interest rate conditions. Under this theoretical framework, we then analyze the existence of discrimination in small business lending.

3.1 Lending discrimination against small businesses under interest rate control

Interest rate control is a financial reality in most developing countries. As interest rate control makes it difficult for commercial banks to get an adequate risk premium, commercial banks are reluctant to provide loans for riskier small businesses. Therefore, discrimination exists in lending to small businesses.

3.1.1 Preference of large banks

Assume a large bank has two choices: lending to a large business or n small businesses. Both choices should be compared with the return r_f on a risk-free security. Suppose the credit scale M_b of a large business is equal to the total credit scale nM_s of n small businesses; and commercial banks offer the same lending rate r to the large business and small businesses under interest rate control. Denote that the large bank's return on investment is a random variable $\tilde{\xi}$, and the cost of lending to each business is C. Assume the default probabilities of a large business and a small business are p_b and p_s, respectively,

and $p_b < p_s$. The possible losses of commercial banks arising from the default of businesses in different scales are β_b and β_s, respectively, which are random variables following a uniform distribution from zero to the maximum return, i.e. $\beta_{b,s} \sim U(0,(1+r)M_{b,s})$.

The optimization of expected return for the case that a large bank lends to a large business requires,

$$\begin{aligned} E^*_{toBig}(\tilde{\xi}) &= \max\left([(1+r)M_b - C](1-p_b) + [(1+r)M_b - E\beta_b - C]p_b, (1+r_f)M_b\right) \\ &= \max\left((1+r)M_b - C - p_b E\beta_b, (1+r_f)M_b\right) \end{aligned} \tag{1}$$

The optimization of expected return for the case that a large bank lends to n small businesses requires,

$$\begin{aligned} E^*_{toSmall}(\tilde{\xi}) &= \max\left([(1+r)nM_s - nC](1-p_s) + [(1+r)nM_s - nE\beta_s - nC]p_s, (1+r_f)nM_s\right) \\ &= \max\left((1+r)nM_s - nC - p_s nE\beta_s, (1+r_f)nM_s\right) \end{aligned} \tag{2}$$

Since $nC > C$, and $p_s > p_b$, we have (1) > (2). Therefore, large banks prefer large businesses, and are reluctant to lend to small businesses.

3.1.2 Preference of small banks

Denote random variable $\tilde{\eta}$ as a small bank's return on investment. Suppose a single small bank is incapable of lending to a large business due to credit scale limits. The small bank then has two choices: lending to a small business and exclusively enjoy the profits, or lending to a large business in the form of a consortium made up of n small banks and then properly allocating the return. Similarly, both choices will be compared to the choice of a risk-free security.

To optimize the expected return for a small bank lending to a small business,

$$\begin{aligned} E^*_{toSmall}(\tilde{\eta}) &= \max\left([(1+r)M_s - C](1-p_s) + [(1+r)M_s - E\beta_s - C]p_s, (1+r_f)M_s\right) \\ &= \max\left((1+r)M_s - C - p_s E\beta_s, (1+r_f)M_s\right) \end{aligned} \tag{3}$$

The optimum value of expected return for the case that n small banks lend to a large business,

$$\begin{aligned} E^*_{toBig}(\tilde{\eta}) &= \max\left([(1+r)\frac{M_b}{n} - \frac{C}{n}](1-p_b) + [(1+r)\frac{M_b}{n} - \frac{E\beta_b}{n} - \frac{C}{n}]p_b, (1+r_f)\frac{M_b}{n}\right) \\ &= \max\left((1+r)M_s - \frac{C}{n} - p_b\frac{E\beta_b}{n}, (1+r_f)M_s\right) \end{aligned} \tag{4}$$

Since $C > \frac{C}{n}$, and $p_s > p_b$, we have (4)>(3). The result is almost the same as the instance of the large banks. It indicates that under such conditions, small banks prefer to form a consortium to compete for larger projects and show less interest in small businesses. We conclude that:

PROPOSITION 1. Lending discrimination against small businesses does exist under the premise of interest rate control.

3.2 Lending discrimination against small businesses under interest rate liberalization

Interest rate liberalization grants commercial banks more freedom to decide the lending rates offered to businesses with different levels of risk. Since interest rates are related to risk, and return varies with

interest rate, a bank's return shows strong relevance to the borrower's risk within the range of tolerable risk.

Risk has both positive and negative effects on a bank's return. On the one hand, banks are able to charge high risk premiums when approached by high-risk businesses; on the other hand, the businesses with a high default risk increase the probability of loan principal loss, which adversely affects the returns expected by the banks. Based on this logic, the dynamic relationship between bank's return and risk can be described by a differential equation as follows,

$$\frac{dR}{d\beta} = F(\beta)G(\beta) \tag{5}$$

Definition and hypothesis are given as,

R, net return of the bank,

β, default risk of borrowers,

$F(\beta)$, positive effect of risk, $\frac{dF}{d\beta} > 0$,

$G(\beta)$, negative effect of risk, $\frac{dG}{d\beta} < 0$.

Since the banks' return on lending must at least exceed the return r_f on the risk-free security, we have $F(\beta) = \max\left(f(\beta), r_f\right) = f(\beta)$ [2]. Assume $G(\beta) = M_p - g(\beta)$, where M_p stands for the money lent to businesses and $g(\beta)$ is the possible loss of loan principal arising from the default risks of businesses. Obviously, we have $\frac{df}{d\beta} > 0, \frac{dg}{d\beta} > 0$. We plug the above hypotheses into (5) and obtain equation (6) below, where $M_p(1+r_f)$ is the minimum return, i.e. the initial value condition of the differential equation.

$$\begin{cases} \frac{dR}{d\beta} = f(\beta)\left(M_p - g(\beta)\right) \\ R_0 = R\big|_{\beta=0} = M_p(1+r_f) \end{cases} \tag{6}$$

Solve the above equation and obtain Equation (7):

$$R(\beta) = M_p \int f(\beta)d\beta - \int f(\beta)g(\beta)d\beta + R_0 \tag{7}$$

The extreme point $\beta^* = g^{-1}(M_p)$ can be obtained when the first order derivative of (7) equals zero.

[2] For the sake of simplicity, we assume that banks would make an investment choice between loans and the risk-free security in this part. In the general case, if banks invest α % of capital into loan, the rest $1-\alpha$ % of capital would be invested into the risk-free security . So $F(\beta) = \alpha f(\beta) + (1-\alpha)r_f$. It makes Equation (6) more complicated but the characteristics of functions would never change accordingly.

Since $g(.)$ is a monotonically increasing function, β^* is unique. When $\beta > g^{-1}(M_p)$, we have $\frac{dR}{d\beta} < 0$, and R is decreasing with β; when $\beta < g^{-1}(M_p)$, we have $\frac{dR}{d\beta} > 0$, and R is increasing with β. When $\beta^* = g^{-1}(M_p)$, R reaches $R_{\max} = \left(M_p \int f(\beta)d\beta - \int f(\beta)g(\beta)d\beta + R_0\right)\Big|_{\beta^* = g^{-1}(M_p)}$. Moreover, because the value of $\frac{d^2R}{d\beta^2} = \frac{df}{d\beta}\left(M_p - g(\beta)\right) - f(\beta)\frac{dg}{d\beta}$ can be either positive or negative, the return function has an inflection point $\tilde{\beta}$. When $\beta < \tilde{\beta}$, we have $\frac{d^2R}{d\beta^2} > 0$, and the function is convex; when $\beta > \tilde{\beta}$, we have $\frac{d^2R}{d\beta^2} < 0$, and the function is concave. It will be seen later that the curvature of the return function has important implications.

Although mathematically we have $\beta \in (-\infty, +\infty)$, it is unrealistic in the real world. In the first place, β, the value at risk (VaR) of a business, must be greater than zero. In the second place, since a risk-free rate is the lower limit of a portfolio return, we must have $R_{\min} = M_p(1 + r_f)$, which is the value of the return function R at some point $\bar{\beta}$. Therefore, the return function R only changes in the interval $[0, \bar{\beta}]$. $[0, \bar{\beta}]$ is called the loanable interval of commercial banks, and thus the domain of β. The loans of commercial banks are only available to the businesses whose value at risk falls within the interval. If a business's VaR were greater than $\bar{\beta}$, commercial banks would rather invest all the money in the risk-free asset than lending it to those businesses because risk losses arising from adverse selection and moral hazards exceed the risk-free return.

Our model shows that large and medium-sized businesses have access to loans because $R(\beta) > R_{\min}$ for β within $[0, \bar{\beta}]$. And some small business cannot get loans if their risks fall to the right of this interval no matter how willing they are to compensate their risk through $f(\beta)$. The fact that only small businesses can be declined by banks demonstrates the lending discrimination against them in this scenario. And the shape of the return function $R(\beta)$ governs the degree of this lending discrimination on small businesses. In particular, the more concave $R(\beta)$ is to the right of β^*, the faster the marginal profit of lending to one more small business decreases. This results in a larger portion of small businesses falling out

of the loanable interval, and thus a higher degree of discrimination. We will illustrate this point more clearly with a concrete example using a simulation based on Chinese data in section 5. We conclude that:

Proposition 2. Lending discrimination against small businesses does exist under the premise of interest rate liberation.

4. INFLUENCE OF CAPITAL ADEQUACY REQUIREMENTS

4.1 Effect of capital requirements

According to Basel Capital Accord, the capital adequacy ratio is equal to capital divided by risky assets. When regulators strengthen the requirements on the capital adequacy ratio of commercial banks, commercial banks then have to cut down asset scales to maintain a high capital adequacy ratio because they are unable to promptly and flexibly realize capital infusions[3]. In previous research[4], we studied how a change in capital adequacy requirements affects credit scales of commercial banks. Both the model and the empirical test showed that stricter capital requirements indeed reduce the credit scale of commercial banks, giving rise to a credit crunch.

With a reduced credit scale, banks would squeeze small business loans, further worsening those small businesses' loan difficulties. In this section we use our model to explain how this occurs under interest rate liberation. In the model, reducing the credit scale of commercial banks means that the total amount of loans M_p declines. In the following we analyze what happens when M_p declines.

First, recall that the extreme point $\beta^* = g^{-1}(M_p)$. As $g(.)$ is a monotonically increasing function, we have $M_p \downarrow \Rightarrow g(\beta^*) \downarrow \Rightarrow \beta^* \downarrow$. It indicates that as stricter capital requirements cut down the credit scale, the extreme point of bank profits moves to the left.

Next, we derive the following relationship between the extreme value $R_{\max}$ and M_p:

$$\begin{aligned}\frac{dR_{\max}}{dM_p} &= \frac{d\left(M_p\int f(\beta)d\beta - \int f(\beta)g(\beta)d\beta + R_0\right)\Big|_{\beta^*=g^{-1}(M_p)}}{dM_p} \\ &= \int f(\beta)d\beta\Big|_{\beta^*=g^{-1}(M_p)} + f(\beta^*)\frac{dg^{-1}(M_p)}{dM_p}\left(M_p - g(\beta^*)\right)^5 \qquad (8) \\ &> 0\end{aligned}$$

(8) indicates that as the credit scale is cut down, the maximum profit of the commercial banks is squeezed.

Last, we can check how a bank's maximum willingness to lend $\bar{\beta}$ changes with M_p. $\bar{\beta}$ is the

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[3] Basel Capital Accord has strict requirements on the capital (core capital and supplementary capital) resources of commercial banks. Neither core capital nor supplementary capital can be infused in a short time.

[4] Huangxian, Ma Li and Daijunxun, An analysis on Credit Preference and Selection of Banks under Capital Adequacy Ratio Supervision, *Journal of Financial Research*, 2005 (7) (in Chinese)

[5] At extreme point β^*, $M_p - g(\beta^*) = 0$. The verification of the equation is subject to the fact that the order of the derivative and the integration of a function which has continuous derivative are commutative.

intersection of the bank's return and the risk-free return. Evaluate equation (7) at $\bar{\beta}$ gives

$$\varphi(M_p, \bar{\beta}) = M_p \int f(\bar{\beta})d\beta - \int f(\bar{\beta})g(\bar{\beta})d\beta = 0 \tag{9}$$

The following equation can then be derived according to the derivation rules for implicit functions.

$$\frac{\partial \bar{\beta}}{\partial M_p} = -\frac{\int f(\bar{\beta})d\beta}{f(\bar{\beta})\left(M_p - g(\bar{\beta})\right)} > 0^{6} \tag{10}$$

It indicates that as the credit scale is squeezed, the commercial banks' willingness to lend drops in general. And following the discussion at the end of section 3, since the loanable interval is cut short from the right, this lending squeeze falls completely on small businesses. That is, only small businesses are sensitive to the change in capital requirements. We conclude that:

PROPOSITION 3. Stronger capital requirements intensify commercial banks' lending discrimination against small businesses.

4.2 How to alleviate the discrimination

As a powerful means of financial regulation and supervision, capital adequacy requirements can effectively reduce the overall risks of banks. However, the side effects of such requirements do not encourage commercial banks to take risks, further intensifying the difficult situation small businesses face when intending to apply for a loan. Consequently, it would be more difficult for the government to implement macroeconomic adjustments, or such adjustments would be made at greater expense. So, the authority indeed needs to design a mechanism that not only controls the overall risks of commercial banks but also gives full consideration to the loan demands of small businesses for their further development.

Now, let's look back to the model. If a drop in M_p is inevitable as a result of capital requirements, we can prevent the extreme point $\beta^* = g^{-1}(M_p)$ from moving to the left by reducing $\frac{dg(\beta)}{d\beta}$. In the real world, with the increase of business risks, the probability of loan principal loss would rise. However, if the government enacts legislation and policy tailoring, offering more measurable and applicable collateral for small businesses to lure more private capital into the guarantee industry and re-guarantee industry, credit guarantee coverage for the small businesses would be broadened. The probability of loan principal loss arising from the high risks posed by small businesses can be minimized and, accordingly, commercial banks' willingness to lend to small business could climb sharply.

However, this is far from enough. That is because the reduction of $\frac{dg(\beta)}{d\beta}$ merely offsets the decrease in returns as a result of the reduction of M_p, and a bank's return may remain the same as before. Therefore, it should not be considered as an incentive-compatible stimulation mechanism. So $\frac{df(\beta)}{d\beta}$

[6] As $\bar{\beta} > \beta^*$, $\frac{dR}{d\bar{\beta}} = f(\bar{\beta})\left(M_p - g(\bar{\beta})\right) < 0$, this partial derivative is greater than zero.

needs to be increased so as to encourage commercial banks, especially small and medium-sized banks, to take on a small business' tolerable risk. In this way, the commercial bank can benefit on the whole after increasing loans to small businesses. Another way to see this is to look at $\frac{d^2R}{d\beta^2}$. In section 3 we have proved that the curvature of $R(\beta)$ governs the degree of small businesses discrimination. The smaller $\frac{d^2R}{d\beta^2}$ is, the higher the degree of discrimination exists. And our derivation shows that $\frac{d^2R}{d\beta^2}$ is positively related to $\frac{df(\beta)}{d\beta}$ and negatively related to $\frac{dg(\beta)}{d\beta}$. Therefore, a policy that increases $\frac{df(\beta)}{d\beta}$ and decreases $\frac{dg(\beta)}{d\beta}$ helps alleviate the discrimination.

How can this be done? In terms of monetary policy, the degree of interest rate liberation needs to be enhanced so that commercial banks can determine interest rates at their discretion according to the risks posed by businesses, and seek better returns. In terms of fiscal policy, providing governmental subsidies to small policy-oriented businesses could relieve the burden of small businesses. Undoubtedly, macroeconomic policy on the government level is far more effective than single policy adjustments implemented by banking regulators. We concluded that:

PROPOSITION 4. The government should comprehensively apply various policy instruments to encourage and motivate commercial banks to take tolerable risks so that the lending discrimination against small businesses can be effectively relieved.

5. AN EXAMPLE

5.1 Characteristics of model and function

The function below is given to simulate lending discrimination against small businesses under the premise of interest rate liberation:

$$\begin{cases} \frac{dR}{d\beta} = (r_0 + K_1\beta)(M_P - K_2 e^{\beta}) \\ R_0 = R\big|_{\beta=0} = M_p(1+r_0) \\ R \geq R_0 \end{cases} \tag{11}$$

The $CAPM$ model is applied to simulate the positive effects of risk on a bank's return, where r_0 is the interest rate of risk-free return and $K_1\beta$ is the risk premium of businesses whose value at risks is β. The main negative effect of risk on a bank's return is the possible loss of bank credit capital M_p. As a business' default risk increases, the probability of bank credit capital loss follows a nonlinear growth trend.

Hence, we introduce an exponential function with a constant coefficient to simulate such situation. Since the lower bound of banks' return is risk-free return $M_p(1+r_0)$, solving the above equation, we obtain

$$R = r_0 M_p \beta + \frac{K_1 M_p}{2}\beta^2 + (K_1K_2 - K_2 r_0 - K_1K_2\beta)e^{\beta} + (1+r_0)M_p + r_0K_2 - K_1K_2 \qquad (12)$$

Based on Chinese data, we set a one-year maturity treasury bond rate to 1.87%, and the annual extra-market rate of return to 10%, so $K_1 = 0.1$. Let constant coefficient $K_2 = 5$ and $M_p = 250$ and set the initial value to $\beta = 0$ and step to 0.001. We simulated the equation 5,089 times (because a bank's return on investment converges to risk-free return at the 5,089th time; beyond that point, the bank's return on investment would be substituted by risk-free rate of return). The diagram of the simulated bank's return function R(β) is obtained (the higher curve shown in Figure 1).

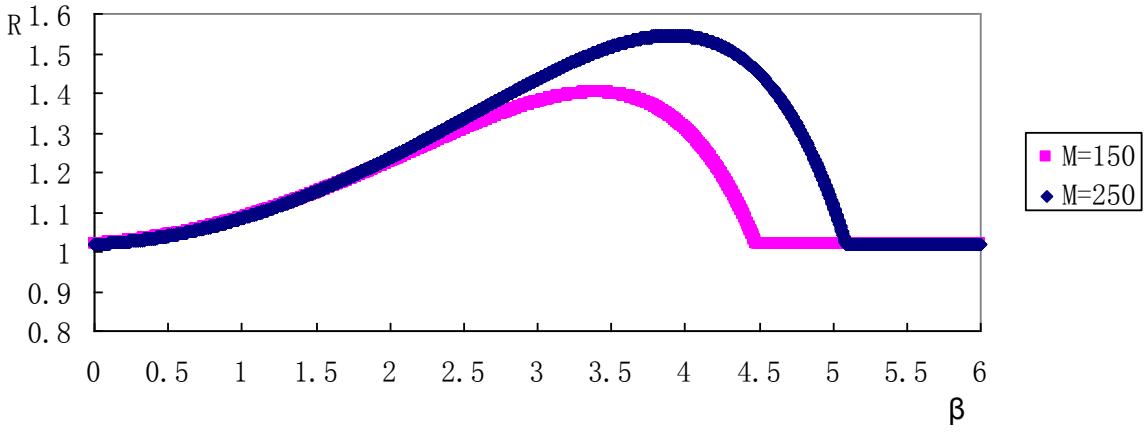

FIG. 1. Characteristics of bank lending (M＝250,150)

The curve intersects the R axis at 1.0187, reflecting the risk-free rate of return is 1.87%. The investment reaches its peak value at $\beta^* = 3.912$. The maximum return is 1.5455, indicating that the rate of abnormal return is 54.55%. For $\beta > \bar{\beta} = 5.089$, banks would give up lending money to businesses and invest all the money into the risk-free security.

The above figure clearly reflects the characteristics of the lending operations of commercial banks facing different business risks in the loanable interval $[0, \bar{\beta}]$ under the premise of interest rate liberalization.

$\beta = 0$ corresponds to the case in which the borrowers are super-large businesses. These borrowers possessing such a great ability to bargain always makes lending rates extremely low. If the interest rate were close to or even lower than risk-free interest rate, commercial banks would prefer to give up granting loans and invest all the money into the risk-free security.

For $\beta > 0$, the business' risk grows as β increases. Generally speaking, a business' risk negatively

correlates to its scale. Therefore, the β axis in the Figure 1 also represents the size of businesses. According to the figure, a bank's return increases with β and reaches its peak value at β^*.

However, the negative effect of risk dominates for $\beta > \beta^*$. As β increases and the sizes of businesses decrease, a bank's return declines at an accelerating rate. A small neighborhood δ can be taken near the extreme point to prove that the inequality $ABS\left(\left.\frac{dR}{d\beta}\right|_{\beta=\ln\frac{M_p}{K_2}-\delta}\right) < ABS\left(\left.\frac{dR}{d\beta}\right|_{\beta=\ln\frac{M_p}{K_2}+\delta}\right)$[7] holds. So the curve becomes increasingly steep on the right hand side of β^*, corresponding to the fact that $R(\beta)$ is concave for $\beta > \beta^*$.

For $\beta > \overline{\beta}$, as adverse selection and moral hazards bring about significant expected loss, commercial banks would rather invest all the money into the risk-free securities for a stable minimum return $M_p(1+r_0)$ than lending their money to small businesses with value at risk above $\overline{\beta}$. In this region, the bank's return curve is horizontal. Thus, we have shown that not all small businesses have access to bank loans.

5.2 Effect of strict capital requirements

Strict capital requirements effectively diminish the credit scale M_p of commercial banks in a short time. In the case of shrinking M_p, similar to what we have shown in our theoretical model, the following conclusions hold:

Because $\frac{dR_{\max}}{dM_p} > 0$, strict capital requirements would cause a decline in the profits of commercial banks.[8]

Because $\frac{d\ln\frac{M_p}{K_2}}{dM_p} > 0$, strict capital requirements would cause a decline in the optimum lending willingness of commercial banks.

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[7] Since $\frac{dR}{d\beta_{\left(\ln\frac{M_p}{K_2}-\delta\right)}} = K_1\left(\ln\frac{M_p}{K_2}-\delta\right)\left(1-e^{-\delta}\right)M_p$ and $\frac{dR}{d\beta_{\left(\ln\frac{M_p}{K_2}+\delta\right)}} = K_1\left(\ln\frac{M_p}{K_2}+\delta\right)\left(1-e^{\delta}\right)M_p$, it is proven that the absolute value of the former is smaller than that of the latter.

[8] $\frac{dR_{\max}}{dM_p} = r_0\ln\frac{M_p}{K_2} + \frac{K_1}{2}\left(\ln\frac{M_p}{K_2}\right)^2 > 0$

Because $\frac{d\bar{\beta}}{dM_p} > 0$[9], strict capital requirements would discourage commercial banks to take tolerable risks and thus more small businesses would have lost access to financial support. The loan difficulties of small businesses are further intensified.

We adjust M_p to be 150 and remain other settings unchanged. We then simulate this 4,486 times (because a bank's return on investment converges to risk-free rate of return at the 4,486th time) and obtain the lower curve as shown in Figure 1. The curve intersects the R axis at 1.0187, reflecting that risk-free rate of return at 1.87%. The investment reaches its peak value at $\beta^* = 3.401$. The maximum return is 1.3992, indicating that the rate of abnormal return is 39.92%. For $\beta > \bar{\beta} = 4.486$, banks would give up lending to businesses and invest all the money into the risk-free securities. It is quite clear that strict capital requirements squeeze the credit scale and investment returns of commercial banks and narrow the loanable interval, putting loans out of reach to small businesses.

A comparison between the two curves in Figure 1 clearly reveals that the lending squeeze, a result of the implementation of capital requirements, affects only small businesses. Indeed, a bank's return from large businesses with small β is essentially unchanged. Only small businesses with $\beta > \bar{\beta} = 4.486$ are squeezed out of the loanable interval. Therefore, this numerical example demonstrates that the burden of capital requirements falls disproportionally on small businesses and thus worsens the lending discrimination.

Corresponding to the implications of reducing $\frac{dg(\beta)}{d\beta}$ and increasing $\frac{df(\beta)}{d\beta}$ in our theoretical model, a policy that reduces K2 and increases K1 would enhance the willingness of commercial banks to take on as much tolerable risk as possible and provide an optimal amount of loans, thus increasing profits. Consequently, the lending discrimination against small businesses could be greatly mitigated.

6. EMPIRICAL ANALYSIS

It is difficult to measure the portion of small businesses that are discriminated against, or the level that capital requirements worsen this discrimination using data directly. This is because the relevant data are hard to obtain and it is difficult to quantify the level of discrimination. We can construct a proxy of the level of discrimination, however, by evaluating a bank's lending structure. Generally speaking, we should expect an increase in the degree of small business discrimination when banks switch to a lending structure where in the portion of large business and medium-sized business loans rises, and vice versa. In this part, a risk preference index is created to depict the variation of the lending structures in commercial banks; the effects of capital requirements on this index are analyzed using Chinese data. Since China is a typical developing

[9] As $\frac{d\bar{\beta}}{dM_p} = -\frac{r_0\beta + \frac{K_1}{2}\beta^2}{(M_p - K_2 e^{\beta})(r_0 + K_1\beta)} > 0$, the derivation rule for implicit function shall be applied here.

country, the conclusion we've drawn from China's example should apply to other developing countries.

6.1 Statistical Description

In 1988, the Basel Committee of the Bank for International Settlements brought forth the Basel Capital Accord I through the Group of Ten initiative, and began to perform strict supervision on the capital of member states. Later, the Basel Committee brought forth and improved the three editions of the Basel Capital Accord II in 2001, 2003, and 2004, respectively. It strictly defines the computational methods and functions of the capital adequacy ratio, specifies three complementary pillars, i.e. minimum capital requirements, supervisory review process and market discipline, and extends the scope of application to holding companies engaged primarily in the banking industry. The central banks of 27 major countries adopted the Basel Capital Accord III by consensus in 2010 after the global economic crisis. The new Basel Capital Accord III emphasizes cross-border implementations and puts forward stricter requirements on the composition and ratio of capital. Additionally, the new Accord incorporates capital conservation buffers and countercyclical buffers in the capital requirements.

As a typical developing country, China actively responded to the capital requirements set forth in the Basel Capital Accord and began to implement the strict capital adequacy requirements throughout the commercial banking industry during the first quarter of 2004. The data collected in this paper range from the first quarter of 2002 to the end of the second quarter of 2006. These data cover the area under the impact of capital requirement policies and can be used to analyze the change in the behavior of different types of banks.

From the second half of 2006, the world's economies, including China, have been increasingly overheated. Fearing inflation, most countries have implemented tight macroeconomic control policies. However, the financial crisis emerged in 2007 and the subsequent economic crisis hit the real economy severely. Consequently, most countries began to implement proactive monetary policies to stimulate economic recovery. Taking China as an example, the incremental Renminbi loan was up 9.63 trillion yuan[10] in 2009 compared with the previous year, largely due to macroeconomic policies. As a result, the lending behavior of Chinese commercial banks has been affected more by the macroeconomic policies after the second half of 2006 than by capital requirements. For this reason, we have excluded data occurring after the second half of 2006.

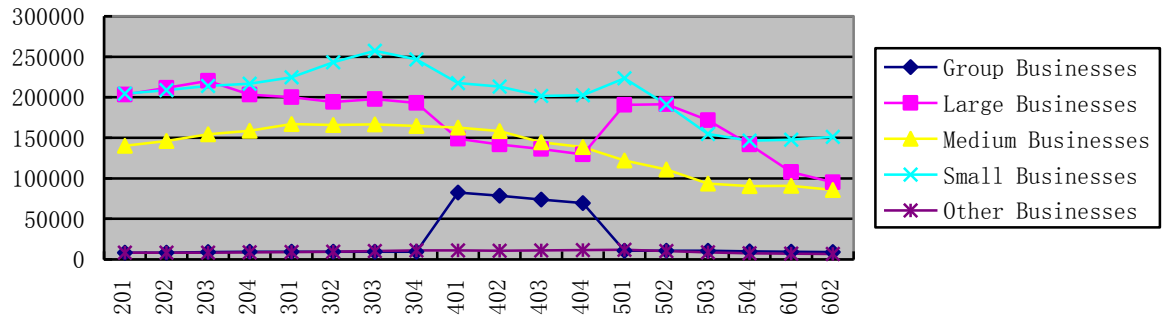

FIG. 2. Large banks' lending (Trillion Renminbi Yuan, 2002-2006)[11]

[10] Data from the website of the People's Bank of China

[11] For typesetting purpose, the tick marks on the X axis in the Figure 2, Figure 3 and Figure 4 mean the specific quarter of a specific year. For example, 404 refers to the 4th quarter of 2004. The rest can be done in the same manner.

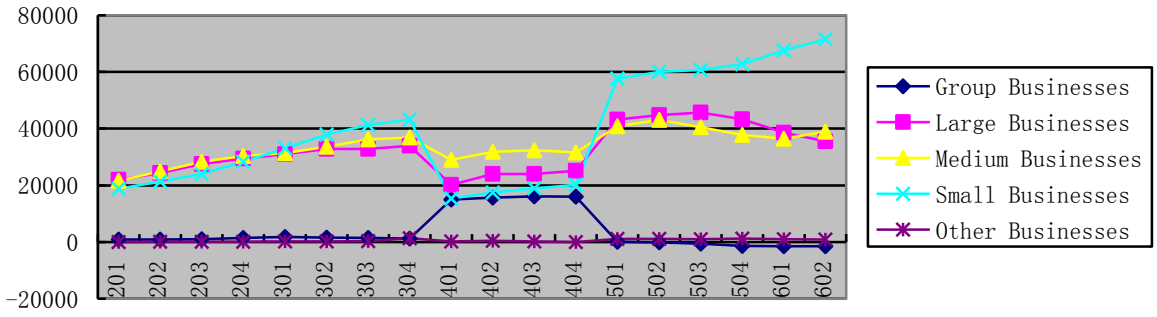

FIG. 3. Medium-sized banks' lending (Trillion Renminbi Yuan, 2002-2006)

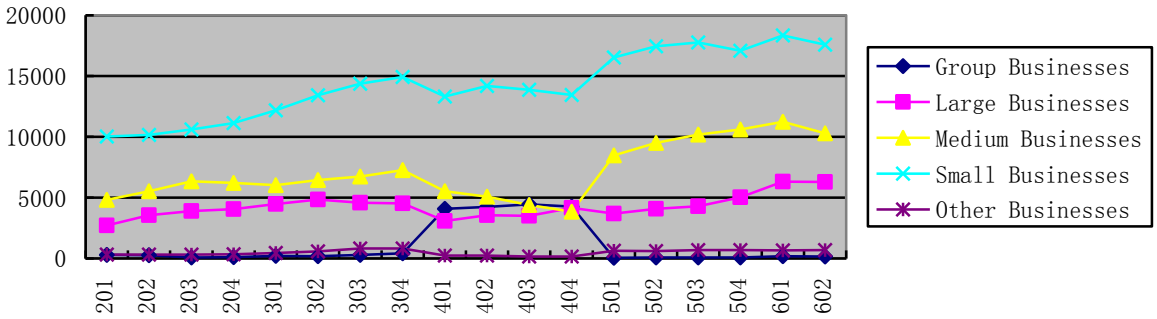

FIG. 4. Small banks' lending (Trillion Renminbi Yuan, 2002-2006)

In our empirical tests, the borrowers of commercial banks are classified into five groups: group businesses, large businesses, medium-sized businesses, small businesses, and other businesses. Twenty-nine banks are involved in our study, which covers almost all of China's banking industry[12]. In light of the different influence of banks with different capital scales, we have divided the 29 banks into three groups: major state-owned commercial banks (large banks), joint-equity commercial banks (medium-sized banks), and city commercial banks (small banks). Figure 2 to Figure 4 demonstrate their lending behavior during the sample period.[13]

It can be seen from the above figures that the loan balances of all three types of commercial banks show an obvious jump in 2004. Particularly, the balance of loans for group businesses presents a positive fluctuation while the balance of loans for small businesses presents a negative fluctuation. It suggests that there is an external factor contributing to the change in the behavior of commercial banks. In the first year of the Basel Capital Accord's implementation, most commercial banks decided to develop steadily and reduce high-risk credit operations due to the impact of capital adequacy requirements.[14]

[12] The 29 banks include Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank, Bank of Communications, China Citic Bank, Hua Xia Bank, China Everbright Bank, China Merchants Bank, Shanghai Pudong Development Bank, China Minsheng Bank, Guangdong Development Bank, Industrial Bank and various city commercial banks.

[13] The GDP data of China are taken from China Statistical Yearbook (over the years); the data of listed banks including Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank, Bank of Communications, China Citic Bank, Hua Xia Bank, China Everbright Bank, China Merchants Bank, Shanghai Pudong Development Bank, China Minsheng Bank, Industrial Bank, are from the quarterly reports disclosed by these banks; the data of non-listed banks are taken from the China Banking Regulatory Commission.

[14] The pulse fluctuations of other borrowers are not as strong as that of group business and small business because their sizes are in between. But they still reflect the behavior changes under the effects of external factors.

6.2 Variables and Data

We take the first quarter of 2002 as the base period, and use the Risk Index (Li M, et al, 2011[15]) to describe the credit preferences of different types of commercial banks in different periods as follows:

$$risk_t = \frac{\Delta L_{large,t}}{L_{large,0}} - \frac{\Delta L_{small,t}}{L_{small,0}} \tag{13}$$

where $L_{large,0}$ is the stock of loans to group businesses in the base period; $\Delta L_{large,t}$ is the increment of loans to group businesses relative to the base period (can be positive, negative, or zero); $L_{small,0}$ is the stock of loans to small businesses in the base period; $\Delta L_{small,t}$ is the increment of loans to small businesses relative to the base period (can be positive, negative, or zero).

The Risk Index has three features: Firstly, it is easy to obtain the relevant data. Secondly, it catches the most essential variables representing the credit preferences of different banks, namely the variation of loans to group businesses and the variation of loans to small businesses. Thirdly, it catches the banks' risk preference characteristics and makes the empirical results easy to interpret.

By changing the banks' credit structure, the variation of Risk Index falls into the following six cases in Table 1.

TABLE 1. Changes of Risk Index

	$\Delta L_{large,t}$	$\Delta L_{small,t}$	$\frac{\Delta L_{large,t}}{L_{large,0}}$ and $\frac{\Delta L_{small,t}}{L_{small,0}}$	meaning	$risk_t$
Case 1	>0	<0	No need to compare	Banks adjust to low-risk credit structure	>0
Case 2	<0	>0	No need to compare	Banks adjust to high-risk credit structure	<0
Case 3	>0	>0	$\frac{\Delta L_{large,t}}{L_{large,0}} > \frac{\Delta L_{small,t}}{L_{small,0}}$	Banks adjust to low-risk credit structure	>0
Case 4	>0	>0	$\frac{\Delta L_{large,t}}{L_{large,0}} < \frac{\Delta L_{small,t}}{L_{small,0}}$	Banks adjust to high-risk credit structure	<0
Case 5	<0	<0	$\frac{\Delta L_{large,t}}{L_{large,0}} > \frac{\Delta L_{small,t}}{L_{small,0}}$	Banks adjust to low-risk credit structure	>0
Case 6	<0	<0	$\frac{\Delta L_{large,t}}{L_{large,0}} < \frac{\Delta L_{small,t}}{L_{small,0}}$	Banks adjust to high-risk credit structure	<0

[15] Li M, Junxun Dai, Xian Huang, 2011, "Effect of capital constraints on risk preference behavior of commercial banks", *China Finance Review International,* Vol 1, No 2, pp. 168-186

As can be seen from Table 1, a greater value of the risk index represents a steadier credit structure of the banks and a lower level of risk that banks take, and vice versa. Therefore, $risk_t$ is a favorable indicator to describe the variation of credit structure and the risk preferences of commercial banks. Consequently, several variable series are obtained. The illustrative diagram of commercial banks' risk index in an aggregate manner and in a classified manner, and some statistical characteristics are shown in the Figure 5 and Table 2.

From Figure 5 and Table 1, we have the following discoveries. First, the risk choice of commercial banks either in an aggregate manner or in a classified manner presents an obvious jump in 2004, the time of the implementation of capital requirements. Secondly, capital adequacy requirements hit medium-sized commercial banks the hardest, resulting in a standard deviation as large as 8.321. Capital adequacy requirements have the least impact on large commercial banks, resulting in a standard deviation of 3.258. Thirdly, the spike of the whole commercial bank system is very similar to that of large commercial banks but quite different from that of other types of banks.

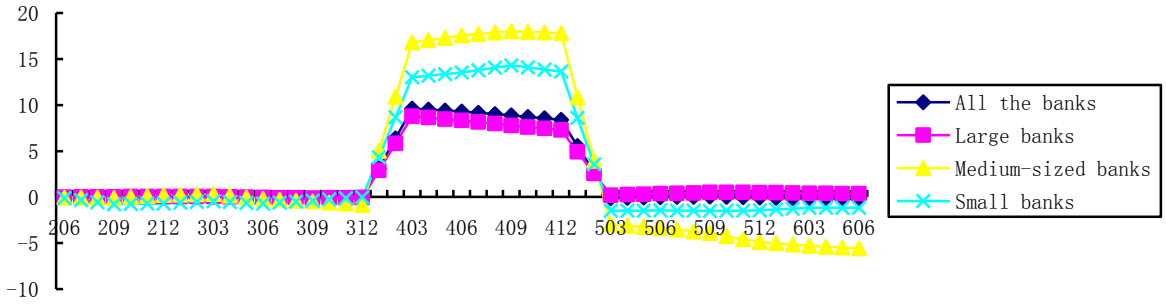

FIG. 5. Risk Index of Commercial Banks

TABLE 2. Statistical Characteristics of Risk Coefficients

	Mean value	Median	Max.	Min.	Standard deviation
Risk Index series of the banking industry	2.169	-0.003	9.603	-0.205	3.760
Risk Index series of large-size banks	2.090	0.371	8.768	-0.121	3.258
Risk Index series of medium-size banks	2.746	-0.072	18.013	-5.589	8.321
Risk Index series of small-size banks	2.659	-0.568	14.300	-1.511	6.025

To closely examine the effects of this policy shock, we introduce a dummy variable as follows:

$$Institute1 = \begin{cases} 0, \text{without capital requriements (before Jan., 2004)} \\ 1, \text{with capital requirements (after Jan., 2004)} \end{cases}$$

According to our theoretical model, the implementation of capital requirements causes a change in the credit structure of banks. The change is supposed to appear and maintain as long as such requirements exist. However, Chinese data reveal a different picture. The credit structures of commercial banks did change in 2004 with the implementation of capital requirements. Nevertheless, in the first quarter of 2005, credit structures began to resume their original states before the implementation of capital requirements, even though these requirements still existed (See Figure 2 to Figure 4). We believe that there must be a new factor that produced negative effects beginning in the first quarter of 2005, partially offsetting the positive

effect of capital requirements. To be exact, the negative effect is the loosening of the constraints of the Basel Capital Accord. There was a two-stage game. In the first stage, when the financial supervisory authority set forth strict capital requirements, commercial banks actively responded to such requirements based on their expected return. In the second stage, the Basel Capital Accord was found to be a loosening constraint, which would not result in terrible consequences if banks broke the Accord. Commercial banks then abandoned steady credit structures and sought maximum returns. As a result, banks reassumed their old credit structure.

The effectiveness of the capital adequacy requirements set forth in the Basel Capital Accord relies on a prerequisite, that is, the capital has to be relatively expensive. When capital adequacy ratio requirements are strengthened and commercial banks cannot easily raise capital, commercial banks will then be forced to adjust the scale or structure of gross capital to meet the requirements of the Basel Capital Accord. However, compared to their peers in developed countries with market economies, the capital cost of commercial banks in the developing countries is not as expensive. Most commercial banks in developing countries are under protection and supported by the government. As they have many ways to raise capital cheaply, it is not necessary for them to adjust the capital structure. Using China as an example, historically, replacement of non-performing assets, cancellation of bad debts, direct replenishment of cash capital, and capital market financing are all effective means Chinese commercial banks use to raise capital. As a result, Chinese commercial banks abandoned steady credit structures and turned back to high-risk lending operations after 2004.

Based on this, we define a new dummy variable,

$$Institute2 = \begin{cases} 0, \text{expected effectiveness of capital requirements (before Jan., 2005)} \\ 1, \text{actual loosening of capital requirements (after Jan., 2005)} \end{cases}$$

Meanwhile, we introduce other macro-economic variables potentially affecting the risk-taking behavior of commercial banks into the model, namely the gross domestic product (GDP), the money supply (M2), and the consumer price index (CPI). Pertinent data are sourced from the China Statistical Yearbook and the China Finance Yearbook.

6.3 Aggregate tests and classified tests

TABLE 3. Regression results of different-sized banks

	Model 1		Model 2		Model 3		Model 4	
Variables	$Risk_{all,t}$		$Risk_{large,t}$		$Risk_{medium,t}$		$Risk_{small,t}$	
Constant	49.76	(1.60)	37.1	(1.38)	172.51	(2.55)	45.12	(0.91)
$LogGDP_t$	0.38	(0.27)	0.11	(0.09)	2.46	(0.81)	1.96	(0.87)
$LogM2_t$	-4.5	(-1.47)	-3.18	(-1.20)	-16.79**	(-2.52)	-5.82	(-1.19)
$Institute1_t$	8.53***	(10.92)	7.5***	(11.08)	17.6***	(10.38)	12.59***	(10.15)
$Institute2_t$	-6.69***	(-7.68)	-5.7***	(-7.59)	-15.33***	(-8.01)	-11.43***	(-8.20)
CPI_t	0.24	(1.29)	0.19	(1.18)	0.6	(1.50)	0.45	(1.54)
u_{t-1}	0.47***	(3.00)	0.43***	(2.74)	0.62***	(4.33)	0.55***	(3.75)

Note: Regression coefficients are significant at: the level of *10, **5, and ***1 percent, numbers within parentheses are t-statistics.

In Model 1, the banking industry is analyzed as a whole. The series obtained are found to be nonstationary, prompting the question of whether there are co-integrations among them. Indeed, we found

co-integration relationships existing among several primary variables including *risk*, *institute*1, *institute*2, *GDP*, and *CPI*. Since the residuals follow an AR(1), we run a modified OLS regression of $Risk_t$ on *institute*1, *institute*2, *M2*, *GDP*, and *CPI*. The results are summarized in Table 3.

The new residual series is now stationary, indicating the autocorrelation problem has been corrected and the co-integration among variables is intact. The regression model is reasonable and can be applied to interpret economic phenomena.

In Model 1, all 29 Chinese commercial banks are aggregated as a whole. However, as individuals, commercial banks present significant idiosyncrasy in their operation. Their risk-taking behavior may vary under the same capital requirements changes. To explore this possibility, we classify banks into three groups according to their sizes, and conduct the same empirical tests on each group to find out their individual characteristics.

The three groups are large banks, medium-sized banks, and small banks, and $risk_{large,t}$, $risk_{medium,t}$, and $risk_{small,t}$ are their risk indices, respectively. The results of the tests on the three groups are given in Table 2 as Model 2, Model3, and Model4, respectively.

6.4 Result of empirical tests

The above regression models all fit the data well. The adjusted goodness of fit is above 0.99 after adjustment. AIC and SIC statistics are minimal. All the primary variables are significant. Similar to Model1, unit roots tests reveal that all new residual series are stationary, indicating that the problem of autocorrelation has been corrected.

According to the aggregate testing, capital requirements have enormous impact on the risk-taking behavior of commercial banks. The estimated coefficient of Institute1 in Model1 suggests that the implementation of capital adequacy requirements raises a bank's risk index by 8.53 on average, indicating a drop in the level of risk that banks take. As a result, the stricter the capital requirements are, the greater the credit structure adjustment of commercial banks is, the steadier the operation is, and the lower the risks that banks take. Moreover, the coefficient of Institute2 indicates that the loosening of capital adequacy requirements significantly and adversely affects the credit structure adjustment of commercial banks. The estimated coefficient implies on average a bank's risk index went down by 6.69 in 2005, making the negative effect offset almost 80% of the positive effect of capital adequacy requirements.

Model 2, 3, and 4 indicate that small and medium-sized banks are more sensitive to policy changes because their operation is more market driven. That the absolute value of the coefficients of Institute1 and Institute2 are larger for small and medium-sized banks than for big banks reflects the fact that small and medium-sized banks are more proficient at responding to policy environment shifts. On the contrary, large banks originating from a public ownership economy are not as sensitive. Therefore, banking supervision in China is more likely to influence small and medium-sized banks than large banks.

The rest of the empirical results have the following interpretations. Firstly, the coefficient of M2 is negative for all models, indicating that the risk index of banks negatively correlates with money supply. That is to say, banks prefer riskier behaviors as money supply increases. Secondly, the coefficients of LogGDP and CPI in all models are insignificant, implying that the risk-taking behavior of Chinese commercial banks hardly correlates to the macro-economy. Commercial banks in China still represent the features of a planned economy. The market reform on the commercial banking system needs to be further deepened.

In sum, the empirical tests show that the implementation of capital adequacy requirements has a

significant impact on China's banking industry. It makes banks reluctant to take on risk, even the risk is tolerable, and thus reduces lending to small businesses. As a result, lending discrimination against small businesses is intensified, in line with our conclusion from the theoretical model. Moreover, we discovered in our regression analysis that the effectiveness of the capital requirements has a time limit on China's banking industry.

7. CONCLUSION AND SUGGESTION

Our paper constructs a theoretical model framework of the lending behavior of different types of banks under both interest rate control and interest rate liberation. We have proven that commercial banks, no matter whether the interest rate is controlled or not, participate in lending discrimination against small businesses. The effects of the implementation of capital adequacy requirements were analyzed through this theoretical framework. We showed that lending discrimination against small banks is intensified once capital adequacy requirements are implemented. Then we conducted simulation and empirical tests on the model to identify the correlation between capital requirements and lending discrimination using Chinese data. The findings are largely in line with the theoretical model.

To effectively alleviate small business lending discrimination and protect small businesses from being marginalized in the financial service system, regulatory authorities should appropriately amend capital regulatory policies to encourage and motivate commercial banks to take on more risk. Concrete measures include: (1) small banks should calculate capital adequacy ratios on the basis of assets rather than on the basis of risky assets, reduce compliance costs, weaken the risk threshold auto-screening mechanism caused by the Basel Capital Accord, which would inevitably come into being on the basis of the risk measurement method, and eliminate the existing risk discrimination against small businesses; (2) the regulatory capital requirements on small business credit risks should be mitigated according to the probability of default of small business loan and actual loss after adjustment; (3) in light of the fact that independent operations and independent accounting prevail among commercial banks in developing countries, the regulatory capital coefficient of SME financial business should be measured by retail business; (4) it should be explicitly stipulated that the capital coefficient of small business loans below a certain scale should be measured by retail business so as to lower the capital coefficient standard for credit risk exposure of small businesses; (5) intangible assets, such as intellectual property, among acceptable mortgages and the minimum loss given default should be specified according to the real assets small businesses possess; (6) more efforts should be made to improve the participation of government capital at different levels as well as private capital. The guarantee climate shall be improved.

APPENDIX A

Time	$Risk_{all,t}$	$Institute1_t$	$Institute2_t$	$Risk_{big,t}$	$Risk_{medium,t}$	$Risk_{small,t}$	$LogGDP_t$	$LogM2_t$	CPI_t
200206	-0.01706	0	0	-0.01191	-0.04669	-0.11449	11.468	12.031	-0.8
200207	-0.01388	0	0	0.00037	-0.05950	-0.34116	11.454	12.038	-0.9
200208	-0.01069	0	0	0.01266	-0.07231	-0.56783	11.496	12.052	-0.7
200209	-0.00750	0	0	0.02494	-0.08512	-0.79451	11.558	12.074	-0.7
200210	0.00967	0	0	0.03226	0.02065	-0.76407	11.726	12.076	-0.8
200211	0.02686	0	0	0.03957	0.12642	-0.73363	11.746	12.090	-0.7
200212	0.04403	0	0	0.04690	0.23218	-0.7032	11.718	12.119	-0.4
200301	0.04864	0	0	0.04639	0.26130	-0.63129	11.516	12.149	0.4

200302	0.05324	0	0	0.04589	0.29042	-0.55937	11.461	12.147	0.2
200303	0.05783	0	0	0.04540	0.31954	-0.48746	11.444	12.170	0.9
200304	0.00926	0	0	0.00975	0.14822	-0.56198	11.521	12.178	1
200305	-0.03932	0	0	-0.02590	-0.02310	-0.6365	11.546	12.195	0.7
200306	-0.08789	0	0	-0.06154	-0.19441	-0.71104	11.571	12.221	0.3
200307	-0.11077	0	0	-0.08138	-0.29288	-0.60379	11.567	12.228	0.5
200308	-0.13365	0	0	-0.10122	-0.39135	-0.49655	11.615	12.249	0.9
200309	-0.15653	0	0	-0.12107	-0.48982	-0.38930	11.681	12.263	1.1
200310	-0.14508	0	0	-0.10014	-0.61036	-0.26191	11.853	12.267	1.8
200311	-0.13363	0	0	-0.07921	-0.73090	-0.13453	11.877	12.275	3
200312	-0.12218	0	0	-0.05828	-0.85144	-0.00714	11.853	12.298	3.2
200401	3.11966	1	0	2.88397	5.02829	4.32892	11.655	12.324	3.2
200402	6.36150	1	0	5.82623	10.90801	8.66497	11.607	12.333	2.1
200403	9.60334	1	0	8.76848	16.78774	13.0010	11.600	12.353	3
200404	9.50107	1	0	8.62052	17.04567	13.17680	11.694	12.361	3.8
200405	9.39880	1	0	8.47256	17.30360	13.35257	11.723	12.367	4.4
200406	9.29652	1	0	8.32461	17.56153	13.52834	11.749	12.382	5
200407	9.15704	1	0	8.14210	17.71216	13.78549	11.737	12.367	5.3
200408	9.01756	1	0	7.95959	17.86278	14.04264	11.782	12.387	5.3
200409	8.87807	1	0	7.77708	18.01341	14.29979	11.846	12.404	5.2
200410	8.71438	1	0	7.60551	17.94263	14.07877	12.017	12.404	4.3
200411	8.55069	1	0	7.43394	17.87185	13.85775	12.038	12.418	2.8
200412	8.38700	1	0	7.26235	17.80107	13.63673	12.011	12.442	2.4
200501	5.54512	1	1	4.90338	10.86940	8.59608	11.808	12.460	1.9
200502	2.70325	1	1	2.54441	3.93773	3.55543	11.755	12.466	3.9
200503	-0.13862	1	1	0.18545	-2.99394	-1.48523	11.744	12.486	2.7
200504	-0.10193	1	1	0.23968	-3.11693	-1.47855	11.837	12.495	1.8
200505	-0.06523	1	1	0.29391	-3.23992	-1.47188	11.861	12.503	1.8
200506	-0.02853	1	1	0.34813	-3.36292	-1.46520	11.881	12.527	1.6
200507	-0.00311	1	1	0.39656	-3.54769	-1.48045	11.851	12.532	1.8
200508	0.02232	1	1	0.44499	-3.73246	-1.49570	11.895	12.547	1.3
200509	0.04774	1	1	0.49341	-3.91724	-1.51094	11.964	12.569	0.9
200510	0.01447	1	1	0.48766	-4.24705	-1.48858	12.157	12.569	1.2
200511	-0.0188	1	1	0.48191	-4.57686	-1.46622	12.183	12.586	1.3
200512	-0.05207	1	1	0.47617	-4.90666	-1.44386	12.158	12.607	1.6
200601	-0.08463	1	1	0.44970	-5.04145	-1.35661	11.944	12.623	1.9
200602	-0.11720	1	1	0.42323	-5.17624	-1.26937	11.890	12.626	0.9
200603	-0.14976	1	1	0.39677	-5.31102	-1.18212	11.881	12.646	0.8
200604	-0.16814	1	1	0.38405	-5.40374	-1.17665	11.984	12.656	1.2
200605	-0.18651	1	1	0.37133	-5.49646	-1.17117	12.010	12.666	1.4
200606	-0.20489	1	1	0.35861	-5.58919	-1.1657	12.028	12.685	1.5

APPENDIX B

```
#include "stdio.h"
```

```
#include<math.h>
double R;
double r=0.0187;
double k1=0.1,k2=5;
double calculate(double x,float M)
{R=r*M*x+k1*M/2*x*x+(k1*k2-k2*r-k1*k2*x)*exp(x)+(1+r)*M+k2*r-k1*k2;
return R;}
void main()
{    double s;
     double x;
     for(x=0.001;x<5;x+=0.001)
     {    s=calculate(x,200);
          printf("r=0.0187,k1=0.1,k2=5,M=200,β=%f,R=%lf\n",x,s);}}
```

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