8. CAPITAL CONSTRAINTS AND THE CREDIT STRUCTURE OF COMMERCIAL BANKS: EVIDENCE FROM CHINA[1]

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Abstract

This study focuses on the impact of capital constraints on the credit structure of commercial banks. Through theoretical modeling and optimization process, this study draws the conclusions that large-sized banks would grant more loans to large-sized enterprises and fewer loans to small-sized enterprises under capital constraints, but small-sized banks would grant more loans to large-sized enterprises just under the liberalization of interest rates and capital constraints. This study also makes empirical tests using the 2002-2012 yearly panel data from commercial banks in China and panel estimations with SYS-GMM to examine the changes in the credit structures of commercial banks under capital constraints. The evidence from China indicate that the estimated impact of capital constraints on the change in the credit structures is greater for the small-sized banks than for the large-sized banks.

Keywords: credit structure, capital constraints, Basel Accord, SYS-GMM, commercial banks

JEL Classification: G21, G28, G43

1. Introduction

With the successive implementation of Basel I and Basel II, capital constraints have become the main trend in global banking supervision. One of the considerations that raised serious concerns among the industry members and national regulators was the treatment of bank credit to small- and medium-sized enterprises in terms of the related minimum capital requirements. Because regulatory capital requirements are a binding constraint on bank behavior (i.e. they are set higher than the level of prudential capital that banks would choose in the absence of any capital requirements), they would lead the commercial banks towards reducing the incentives for risk taking, which may determine the commercial banks to decrease loans to the small- and medium-sized

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enterprises. Because the small- and medium-sized enterprises represent the backbone of the economy and make a significant contribution to the GDP, it is of great theoretical and practical significance to analyze the impact of capital constraints on the credit structure of commercial banks.

Economists have made several researches on the impact of capital constraints on the lending behavior and the credit structure of commercial banks, but the conclusions are not consistent with each other. The study of Keely and Furlong (1990) suggested that capital constraints would not lead to change in the credit size and risk preference of the commercial banks. Bernanke and Lown (1991) find that a one percentage point increase in the capital/asset ratio increased the growth rate of loans by 2.6 percentage points by linking bank loan growth to bank capital ratios and employment. Hancock and Wilcox (1993, 1995) find that each $1 that banks fell short of regulatory capital reduced bank credit by $3, based on estimated models relating changes in individual banks' loan growth to measures of loan demand and bank capital. Francis and Osborne (2009) apply Hancock and Wilcox's approach to the U.K. commercial bank data. They find relatively modest effects of bank capital shortfalls on lending. Gianetti and Simonov (2010) find a relevant role for capital in determining loan volumes using Japanese data. Jiménez, Ongena and Peydró (2010), who use Spanish data, and Albertazzi and Marchetti (2010), who use data on Italy, both foud sizeable effects of low bank capitalization and scarce liquidity on credit supply. Elliot (2010) used simulation-based techniques and finds small effects of higher capital ratios on loan pricing and loan volumes of the U.S. banks. Carlson, Shan and Warusawitharana (2011) examined the impact of bank capital ratios on bank lending by comparing differences in loan growth to differences in capital ratios at sets of banks that are matched based on geographic area, as well as size and various business characteristics. They found that the effect of capital ratios on loan growth varies by type of loan, with some of the strongest effects in the recent years being for commercial real estate loans. From the above-mentioned researches, it seems that the lending behavior and the credit structure of commercial banks under capital constraints reveal a large uncertainty. In fact, the propositions whether and how capital constraints would affect the credit structure of commercial banks have not been solved.

Ma, Dai and Huang (2011) used multilateral game to deduce the loan characteristics of banks, and used vectors and void coordinates to analyze the behavior preferences of commercial banks under capital constraints, but the empirical tests were limited because of the lack of data. Based on Ma, Dai and Huang (2011), this study revises the theoretical models with more reasonable assumption and more effective reasoning. In addition, this study makes empirical tests using the 2002-2012 yearly panel data from commercial banks in China and panel estimations with SYS-GMM to examine the changes in the credit structures of commercial banks under capital constraints, focused on the difference between large-sized banks and small-sized banks.

This paper is organized as follows: Section 1 summarizes related literature and describes the significance and innovation of the topic. Section 2 analyzes the commercial banks' lending behavior and credit structure without capital constraints using a revenue function. Section 3 studies the changes in the credit structures of

commercial banks under capital constraints using vectors and dummy coordinates. Section 4 makes empirical tests using the 2002-2012 yearly panel data from commercial banks in China and panel estimations with SYS-GMM. It is followed by conclusions.

2. Credit Structures of Commercial Banks without Capital Constraints

According to Ma, Dai and Huang (2011), commercial banks of different sizes have a certain preference when they grant loans. A large-sized bank has two choices: loans to large-sized enterprises, or small-sized enterprises. A small-sized bank has two choices, too: loans to small-sized enterprises, or large-sized enterprises by forming a consortium.

Assume that a large-sized bank is faced with two choices: loans to a large-sized enterprise, or loans to several small-sized enterprises. Assume that loan to a large-sized enterprise L_L is equal to loans to several small-sized enterprises nL_S, the interest rate of the loan to a large-sized enterprise is r_L and the interest rate of the loans to several small-sized enterprises is r_S. Assume that the fixed cost of each loan is C_f and the variable cost of each loan is C_v (including the cost of credit risk), that is to say, $C_f = C$, $C_v = f(L)$.

When the large-sized bank lends to a large-sized enterprise, its expected return E_{toL} is:

$$E_{toL} = L_L r_L - C_f - C_v \tag{1}$$

When the large-sized bank lends to several small-sized enterprises, its expected return E_{toS} is:

$$E_{toS} = n(L_S r_S - C_v) - C_f = nL_S r_S - nC_v - C_f \tag{2}$$

Under the control of interest rates, the interest rates of the loans to large-sized enterprises is equal or approximately equal to the interest rates of the loans to small-sized enterprises, that is $r_L \approx r_S$, and $L_L = nL_S$, so $E_{toL} > E_{toS}$. In this case, the large-sized bank will tend to lend to large-sized enterprises and refuse lending to small-sized enterprises.

Under the liberalization of interest rates, because of credit risk premium, the interest rates of the loans to large-sized enterprises are much lower than the interest rates of the loans to small-sized enterprises, that is $r_L << r_S$. In this case, the large-sized bank's expected return is as follows:

If $r_S - r_L > \frac{(n-1)C_v}{L_L}$, because the economy of scale is exceeded by the interest rate margin, the large-sized bank's expected return received from the loan to a large-sized enterprise E_{toL} is lower than its expected return received from the loans to several

small-sized enterprises, E_{toS}. That is to say, $E_{toL} < E_{toS}$, the large-sized bank will give up lending to large-sized enterprises and turn to small-sized enterprises.

Conversely, if $r_S - r_L < \frac{(n-1)C_V}{L_L}$, namely, $E_{toL} > E_{toS}$, the large-sized bank will give up lending to small-sized enterprises and turn to large-sized enterprises.

According to the above analysis, we can obtain:

Proposition 1: A large-sized bank has loan preference to large-sized enterprises, but large-sized banks would also lend to small-sized enterprises if the economy of scale is exceeded by the interest rate margin.

Now, we turn attention to the small-sized bank. Due to the constraints on lending capacity, a single small-sized bank cannot lend to large-sized enterprises. Then, the small-sized bank has two choices: lending to small-sized enterprises alone, or lending to a large-sized enterprise by forming a consortium.

When the small-sized bank lends to a small-sized enterprise alone, its expected return E_{toS} is:

$$E_{toS} = L_S r_S - C_V - C_f \quad (3)$$

When the small-sized bank lends to a large-sized enterprise by forming a consortium, assuming each small-sized bank's lending capacity corresponds to a small-sized enterprise, and the consortium's loan to a large-sized enterprise L_L is equal to loans to several small-sized enterprises, nL_s provided by the same amount by small-sized banks, its expected return E_{toL} is:

$$E_{toL} = \frac{L_L r_L - C_V - nC_f}{n} = (\frac{L_L}{n}) r_L - C_V - C_f + (n-1)(\frac{C_V}{n} - C_f) \quad (4)$$

Under the control of interest rates, as $L_S = \frac{L_L}{n}$ and $r_L \approx r_S$, the small-sized banks' loan preferences depend on $(n-1)(\frac{C_V}{n} - C_f)$. In this formula, $C_f = C$, and $n > 1$. Thus, there is a $n^* = \frac{C_V}{C_f}$, when $n > n^* = \frac{C_V}{C_f}$, then $\frac{C_V}{n} - C_f < 0$ and $E_{toL} < E_{toS}$。 Under such conditions, small-sized banks would not lend to large-sized enterprises by forming a consortium.

Under the liberalization of interest rates, r_L is lower than r_S. When $r_S - r_L < \frac{(\frac{n-1}{n})C_V - (n-1)C_f}{L_L}$, small-sized banks have loan preferences to large-sized enterprises by forming a consortium; when $r_S - r_L > \frac{(\frac{n-1}{n})C_V - (n-1)C_f}{L_L}$, small-sized banks would lend to small-sized enterprises in their individual capacity. The above analysis suggests that small-sized banks may have impulse to form a consortium to strive for large-sized enterprises. Whether this impulse can be realized, depends on the size of the large-sized enterprise and the interest rate margin. According to the above analysis, we can obtain:

Proposition 2: A single small-sized bank can only loan to small-sized enterprises within its capacity, but small-sized banks have the preference to form a consortium to strive for a large-sized enterprise.

From the above-mentioned, one may see that commercial banks of different sizes have different loan preferences and their loan preferences would be affected by the costs and risk premium. Thus, the commercial banks of different sizes have different credit structure. In the following, this study examines whether the loan preferences of different commercial banks would be affected by the capital constraints and, therefore, their credit structure would be changed.

3. The Credit Structure of Commercial Banks under Capital Constraints

Since the implementation of Basel I and Basel II, the commercial banks seeking to avoid a breach of capital requirements will have incentives to reduce their exposures to risk, even when capital standards themselves are only crudely aligned with the portfolio risks. That is to say, the commercial banks can adjust capital and asset portfolios to reduce the probability of a breach of capital requirements. In this section, we try to use vectors and dummy coordinates to describe the behavioral changes and credit structures of commercial banks under capital constraints based on Ma, Dai and Huang (2011).

Assuming that under the liberalization of interest rates, the loan portfolios of commercial banks consist of loans to large-sized enterprises, L_L, and loans to small-sized enterprises, L_S at the beginning[3]. Their interest rates are r_L and r_S, respectively, and $r_S >> r_L$. The expected return of commercial banks is $E = L_L r_L + L_S r_S$, which should be optimized. Considering (L_L, L_S, E) as a three dimensional coordinate (space), point O represents the origin of the coordinate, and the axes OL_L,OL_S ,OE represent the distribution of loans to large-sized enterprises, L_L, loans to small-sized enterprises, L_S and the expected return of commercial banks. $E = L_L r_L + L_S r_S$ is equivalent to a plane which is through the origin and whose slope is r_L in OL_L's direction and r_S in OL_S's direction. This plane is described as "the credit structure plane of commercial bank". Owing to $r_S >> r_L$, the credit structure plane of commercial bank is downward to the left and upward to the right.

Point A on the space represents the credit structure of commercial banks at the beginning, then $\vec{OA} = \vec{i}L_S + \vec{j}L_L + \vec{k}E$. In other words, the distance of point A to the plane $L_S E$ represents loans to small-sized enterprises at the beginning, and the distance of point A to the plane $L_L E$ represents loans to large-sized enterprises at the beginning,

[3] In fact, large-sized commercial banks will grant loans to small-sized enterprises and small-sized commercial banks will grant loans to large-sized enterprises because of risk diversification.

and the distance of point A to the plane L_SL_L represents the income of commercial banks at the beginning. Line HF represents all the constraints to the lending of commercial banks and points B and C on the Line HF represent some of such constraints.

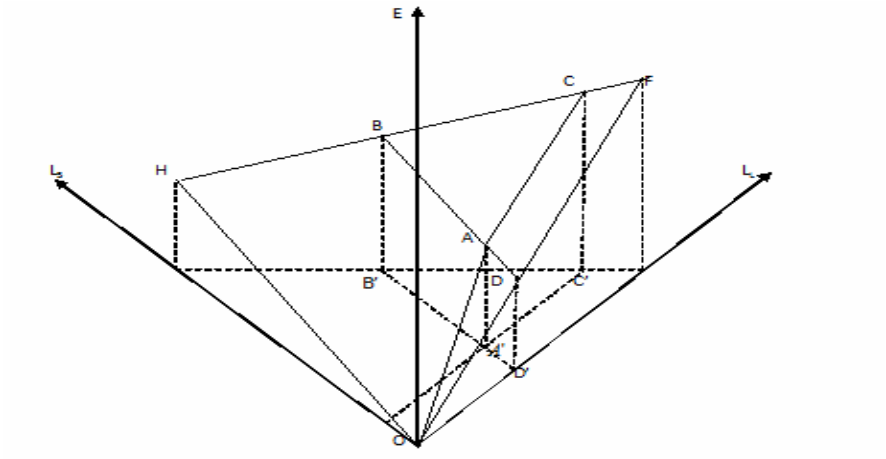
Now, we need to discuss how the credit structure of commercial banks would change under capital constraints, due to the reducing incentives for risk taking of commercial banks[4]. This is equivalent to the mathematical problem:

$$\begin{cases} \max E = \left\| \vec{OA} \right\| \sin\theta \\ s.t. \{\Delta L_S \left| \Delta L_S \geq 0 \right\} \bigcup \{\Delta L_L \left| \Delta L_L \geq 0 \right\} \end{cases} \text{ or } \begin{cases} \max E = \left\| \vec{OA} \right\| \sin\theta \\ s.t. \{\Delta L_S \left| \Delta L_S \leq 0 \right\} \bigcup \{\Delta L_L \left| \Delta L_L \leq 0 \right\} \end{cases} \quad (5)$$

where: $\left\| \vec{OA} \right\|$ is the norm of vector $\vec{OA}$ and θ is the angle of $\vec{OA}$ and plane L_SL_L. The change in commercial bank's credit scale which results from capital constraints is a plane that is perpendicular to L_SL_L and intersects the commercial bank's credit structure plane at line HF. The change in commercial bank's credit scale L is unpredictable, but $L = L_L + L_S$. Assume an increase in loan ΔL, then $\Delta L = \Delta L_L + \Delta L_S$. Moving the origin from O to A, obviously $\Delta L_S = -\Delta L_L + \Delta L$, which represents a plane to perpendicular to L_SL_L in the dummy coordinates system.

Figure 1

Effect of Capital Constraints on the Credit Structure of Commercial Banks (under the Liberalization of Interest Rates)



[4]The incentives for risk taking of large-sized commercial banks and small-sized commercial banks would be affected differently under capital constraints.

First, this study examines the credit structure of commercial banks under capital constraints when the credit scale is expanded. The expansion of credit scale is represented by point *A'*, which is the projection of point *A* and we get the plane $A'B'C'$. Then, the plane $A'B'C'$ is the projection of plane ABC, which is a subfield of the credit structure plane of commercial banks in the plane $L_S L_L$. The ABC subfield is important to the commercial banks, because commercial banks will not make loan portfolio out of the ABC subfield. If commercial banks make loan portfolio beyond the ABC subfield, there are two disadvantages: either $\left\|\vec{OA}\right\|$ and *E* are decreased, or L_L and L_S are decreased. Both of them would make difficult to achieve an optimum, while in the ABC subfield, the boundary $\vec{AC}$ is optimal. Because *A* is a moving point and $\left\|\vec{OA}\right\| = \frac{L_L}{\cos\theta}$, only the points on $\vec{AC}$ guarantee the largest L_L and the smallest $\cos\alpha$ in the change process, while ensuring θ maximum. Thus, with the expansion of credit scale, vector $\vec{OA}$ that moves along $\vec{AC}$ will ensure that $E = \left\|\vec{OA}\right\| \sin\theta$ always gets the maximum value. That is to say, loans to large-sized enterprises would be increased more quickly than those to small-sized enterprises under capital constraints with the expansion of credit scale.

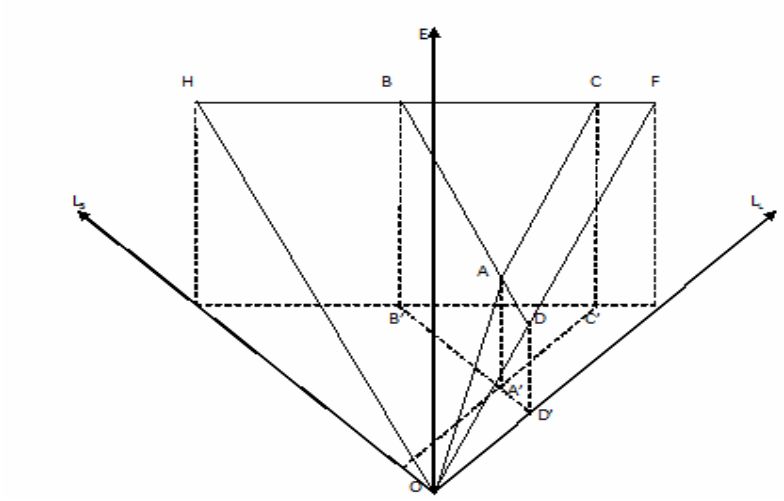
Next, we examine the credit structure of commercial banks under capital constraints when the credit scale is decreased. Point *D* on the plane *OHF* represents the beginning of the credit structure of commercial banks. We can get a broken line $\vec{AD}$ and $\vec{DO}$ by connecting *A* and *D*, and $\left\|\vec{OA}\right\| = \frac{L_L}{\cos\theta}$. In the case of $|\Delta L| < \left\|\vec{AD}\right\|$, when point *A* moves along $\vec{AD}$, L_L would not be decreased and, thereby, $\left\|\vec{OA}\right\|$ would decline slowly. In the case of $|\Delta L| > \left\|\vec{AD}\right\|$, L_L must be decreased. In such a case, if we move point *A* along $\vec{DO}$, as the direction cosine formed by $\vec{DO}$ and axis OL_S is the smallest vector on the *ADO* plane, $E = \left\|\vec{OA}\right\| \sin\theta$ would decline more slowly. In other words, loans to large-sized enterprises would be decreased more slowly than those to small-sized enterprises under capital constraints with the decrease in the credit scale.

Synthesizing the above two cases, we name $\vec{AC} + \vec{AD} + \vec{DO}$ the efficiency broken line of the credit structure of commercial banks caused by capital constraints under the liberalization of interest rates. From the above-mentioned, we can obtain:

Proposition 3: Under the liberalization of interest rates, capital constraints would lead to asymmetric changes in loans to large-sized enterprises and small-sized enterprises. In the controls of interest rates, commercial banks can only obtain equal or nearly equal interest rates from different-sized enterprises. As $r_L \approx r_S$, the credit structure of commercial banks is even from right to left.

Figure 2

Effect of Capital Constraints on the Credit Structure of Commercial Banks (under the Controls of Interest Rates)



First, we examine the credit structure of commercial banks under capital constraints and the controls of interest rates when the credit scale is expanded. By taking the same method as before, we get an *ABC* area, whose projection on $L_S L_L$ plane is the *A'B'C'* plane. Different from the conditions under the liberalization of interest rates, the side of the triangular prism under the controls of interest rates is a rectangle, $BCB'C'$[5]. It means that the return points would move in line *BC* and there would be no difference between them when the credit structure point moves along the *B'C'* line. Adding all these indifferent return curves together, we get a plane, *ABC*. That is to say, the credit structure of commercial banks has a large uncertainty under capital constraints with the expansion of credit scale.

Using the same method, we examine the credit structure of commercial banks under capital constraints and the controls of interest rates when the credit scale is decreased. We can get a plane, *ADO* , by adding all the indifferent return curves together when the credit scale is decreased. We name *ABC+ADO* the efficiency plane of the credit structure of commercial banks caused by capital constraints under the controls of interest rates. In other words, the credit structure of commercial banks has

[5] Under the liberalization of interest rates, the side of the triangular prism is lower on the left and higher on the right.

a large uncertainty under capital constraints with the decrease in the credit scale, too. From the above-mentioned, we can obtain:

Proposition 4: Under the controls of interest rates, capital constraints will lead to the credit structures of commercial banks with large uncertainties.

Proposition 3 and proposition 4 explain the changes in the credit structures of commercial banks under capital constraints. Combined with proposition 1 and proposition 2, we can draw the following propositions:

Proposition 5: Large-sized banks would grant more loans to large-sized enterprises and fewer loans to small-sized enterprises under capital constraints.

Proposition 6: Small-sized banks would grant more loans to large-sized enterprises under the liberalization of interest rates and capital constraints, but their loan preference would have a large uncertainty under the controls of interest rates and capital constraints.

From the above-mentioned propositions, we can draw the conclusion that it is not good news for loans to small-sized enterprises under capital constraints in any case.

4. Empirical Tests: Evidence from China

In China, the Basel Accord has been implemented strictly since 2004 and all commercial banks had to meet the requirements of capital constraints until 2007. That is to say, the banking in China has gone through a complete adjustment process under capital constraints. In addition, the liberalization of lending rates also occurred in 2004. In order to examine the changes in the credit structures of commercial banks under capital constraints and the liberalization of lending rates, we plan to do empirical tests using the panel data from commercial banks in China. We use panel estimations with SYS-GMM in the empirical tests, which could exclude variables' bias, the existence of measurement errors, and the possibility of potential endogeniety problem[6]. In order to ensure the effectiveness and robustness of estimates of regression equations, we also make two essential tests: (1) the Sargan test to verify the validity of instrumental variables; (2) the interference autocorrelation test.

In addition to the presentation of model and data, the empirical tests include two parts: (1) empirical tests using the full sample set to examine wether capital constraints lead to the changes in the credit structures of commercial banks; (2) empirical tests using the sub-sample set to examine the difference between large-sized banks and small-sized banks in the changes in the credit structures of commercial banks under capital constraints.

4.1 Empirical Models and Data

To assess whether there is a significant change in the credit structures of commercial banks under capital constraints, we use the following regression models:

$$CSI_{ij} = C_1 + C_2 * CSI(ini)_{ij} + C_3 * B_{ij} + C_4 * RGDP_j + C_5 * LR_j + \varepsilon_{ij} \quad (6)$$

[6] This methodology takes into accounts possibility of: the time dimensions of the data, non-observable country specific effects, inclusion of lagged dependent variable among the explanatory variables and the problem of enodogeniety among all explanatory variables.

$$CSI_{ij} = C_1 + C_2 * CSI_{ij-1} + C_3 * CSI(ini)_{ij} + C_4 * B_{ij} + C_5 * RGDP_j + C_6 * LR_j + \varepsilon_{ij} \quad (7)$$

where: (6) is employed for cross-section estimation with OLS and (7) is employed for panel estimation with SYS-GMM, the dependent variable CSI denotes the credit structure index of commercial banks, the sub indices i and j denote commercial bank and time, respectively.

In order to reflect the credit structures of commercial banks, we designed an index according to Ma, Dai and Huang (2011). The index is called the credit structure index of commercial banks, (CSI), which is given by:

$$CSI = \frac{\Delta L_L}{L_{L0}} - \frac{\Delta L_S}{L_{S0}} \quad (8)$$

where: L_{L0} is loans to large-sized enterprise in the base period, ΔL_L is an increment of the loans to large-sized enterprises compared with those in the base period, L_{S0} is loans to small-sized enterprises in the base period, and ΔL_S is an increment of the loans to small-sized enterprises compared with those in the base period. The CSI index can be a positive value, negative value or zero. The larger the value is, the commercial bank credit structure is more robust and its risk is lower; while the smaller the value is, the commercial bank credit structure is more active and its risk is higher. Thus, the CSI index is a good indicator to describe the changes in the credit structure of commercial banks and their risk preference. Because the data period is from 2002 to 2012, 2002 can be defined as the base period and the yearly CSI index of each commercial bank can be obtained.

The independent variable B in (6) and (7) denotes the microeconomic characteristics variables of commercial banks, including commercial bank's capital adequacy ratio (CAR)[7], commercial bank's return on assets (ROA), the natural logarithm of commercial bank's asset size ($\ln AS$), the natural logarithm of commercial bank's loans, ($Ln(L)$). The independent variable $RGDP$ denotes the growth rate of gross domestic product in China, and LR denotes the benchmark of lending rate in China; both of them are control variables.

There are 4 large-sized banks and 15 small-sized banks in the full sample set.[8] The data from commercial banks include loans to large-sized enterprise (L_L), loans to small-sized enterprise (L_S), total loans (L), asset size (AS), capital adequacy ratio (CAR) and return on assets (ROA). According to (8), we can get CSI using the above data. In addition to these microeconomic data, macroeconomic data include the growth rate of gross domestic product in China ($RGDP$) and the average benchmark of lending rate (LR). All data is from 2002 to 2012, yearly[9] .

[7] Commercial bank's capital adequacy ratio can be taken as the indicator of capital constraints.

[8] Large-sized banks include Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, *and China Construction Bank*. Small-sized banks include Bank of Communications, China Citic Bank, Huaxia Bank, China Everbright Bank, China Merchants Bank, SPD Bank, China Minsheng Banking Corporation, Guangdong Development Bank, *Industrial Bank* and a number of city commercial banks, some of them are medium-sized banks.

[9] All microeconomic data are coming from Bankscope, and all macroeconomic data are coming from China's National Bureau of Statistics.

The statistical characteristics of relevant variables are as follows. In order to avoid the influence of outliers, we have done the abnormal value finishing processing in 95% confidence level.

Table 1

The Statistical Characteristics of Relevant Variables

Indicators	Symbol	Observations	Mean	Standard deviation	Minimum	Maximum
Loans to large-sized enterprise, billion RMB	L_L	209	6.543	13.121	0.920	212.131
Loans to small-sized enterprise, billion RMB	L_S (billion)	209	4.015	14.041	0.705	154.014
Total loans, billion RMB	L (billion)	209	15.131	42.047	2.067	387.185
Credit structure index	CSI	209	0.157	0.327	-0.924	4.948
Capital adequacy ratio	CAR	209	0.108	0.174	0.045	0.146
Return on assets	ROA	209	0.018	0.016	-0.035	0.044
Natural logarithm of commercial bank's asset size	$Ln\ AS$	209	5.021	6.689	4. 917	8.033
Growth rate of gross domestic product	$RGDP$	11	0.088	0.036	0.062	0.141
Average benchmark of lending rate	LR	11	0.068	0.016	0.053	0.073

4.2 Empirical Test for the Full Sample Set

The results of empirical test using the full sample set are presented in Tables 2 and 3. To uncover the nature of relationship between the microeconomic characteristics variables and the credit structures of commercial banks, first we carry cross sectional analysis and the results are presented in Table 2. The baseline model, which only includes control variables, shows that all the explanatory variables have the expected signs (see column 1 in Table 2). The initial condition of the credit structures of commercial banks ($CSI(ini)$) has a positive coefficient, which shows the continuity of credit structures of commercial banks. $RGDP$ has a positive and statistically significant coefficient, indicating a close relationship between banks' credit preferences and the economic cycle. LR has positive but insignificant impact on economic growth, indicating that China's commercial banks are not sensitive to the price of money.

From columns 2 to 5 in Table 2, we test whether the microeconomic characteristics variables play a significant role in the change in the credit structures of commercial banks. We find a positive relationship between various microeconomic characteristics variables (CAR, $lnAS$, lnL) and the change in the credit structures of commercial banks, but ROA has a negative relationship with the change in the credit structures of commercial banks. All of them are statistically significant, which implies that the microeconomic characteristics variables are important in changing the credit structures of commercial banks in China. More specifically, we find that $\ln AS$ and $\ln L$ are the significant determinants.

Table 2

Cross-section OLS Estimation (2002-2012)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
CSI(ini)	0.124* (0.113)	0.147* (0.137)	0.121 (0.156)	0.142 (0.148)	0.121 (0.144)
RGDP	3.392** (0.519)	3.400** (0.523)	3.389** (0.599)	4.351** (0.528)	4.387** (0.504)
LR	4.057 (0.027)	3.589 (0.027)	3.773 (0.026)	3.471 (0.026)	4.088 (0.025)
CAR		0.863** (1.198)			
ROA			-1.121* (1.192)		
lnAS				3.157* (1.178)	
lnL					2.041** (1.192)
Constant	-1.456 (2.081)	-1.456 (2.204)	-1.674 (2.851)	-1.497 (2.008)	-1.492 (1.977)
Observations	19	19	19	19	19
R-squared	0.403	0.420	0.405	0.404	0.407

*Note: Robust standard errors are presented in the parentheses, * p<0.1, **p<0.05, *** p<0.01.*

Panel estimation is carried out using SYS-GMM estimations. The results of SYS-GMM using the full sample set are presented in Table 3. The outcomes of the estimation of the baseline model are given in column 1. All the explanatory variables have the expected sign in the baseline model. Looking at the panel estimates in Table 3, we find a positive and statistically significant impact of *CAR* on the change in the credit structures of commercial banks, which implies that capital constraints lead to the changes in the credit structures of commercial banks in the long run. The higher the intensity of capital constraints, the more the commercial banks would grant loans to large-sized enterprises.

Table 3

Panel Estimation for Full Sample (1996-2008)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
CSI(ini)	0.019* (0.078)	0.017* (0.087)	0.011* (0.096)	0.012 (0.108)	0.018 (0.094)
CSL_{-1}	0.109* (0.078)	0.107* (0.087)	0.101* (0.096)	0.112 (0.108)	0.098 (0.094)
RGDP	4.132** (1.411)	4.612** (1.723)	4.315** (1.556)	3.912** (1.418)	4.143** (1.635)
LR	3.121 (0.027)	2.654 (0.027)	2.154 (0.026)	2.171 (0.026)	2.431 (0.025)
CAR		0.591* (1.159)			
ROA			-2.034 (1.043)		

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
lnAS				0.312* (3.184)	
lnL					0.063** (3.306)
Constant	-1.123 (3.081)	-1.098 (3.154)	-1.132 (2.865)	-1.154 (2.901)	-0.992 (2.917)
Observations	209	209	209	209	209
Sargan test	25.124 (0.000)	34.420 (0.000)	38.120 (0.000)	37.329 (0.000)	42.104 (0.000)
AR（2）	0.491	0.597	0.684	0.636	0.577

*Note: Robust standard errors are presented in the parentheses, * p<0.1, **p<0.05, *** p<0.01.*

4.3 The Difference between Large-sized Banks and Small-sized Banks

To test the hypothesis whether the impact of capital constraints on the changes in the credit structures varies with the size of commercial banks, we re-estimate the panel for large-sized banks and small-sized banks. The results for panel estimates are presented in Table 4.

Results show that the microeconomic characteristics variables are important for the loan preferences of large-sized banks and small-sized banks. The estimated coefficient of CAR is 1.532 (significant at 5 percent) for large-sized banks, which means the higher the intensity of capital constraints under the liberalization of interest rates, the more the large-sized banks would grant loans to the large-sized enterprises. That is to say, the changes in the credit structures of large-sized banks under capital constraints are consistent with the hypothesis 5. At the same time, the estimated coefficient of CAR is 4.163 (significant at 5 percent, too) for small-sized banks, which means that the estimated impact of CAR on the change of credit structures is greater on the small-sized banks than that on the large-sized banks. In other words, the changes in the credit structures of small-sized banks under capital constraints and the liberalization of interest rates are consistent with the hypothesis 6.

Table 4

Panel Estimation for Large-sized Banks Sample and Small-sized Banks Sample (2002-2012)

Variables	Large-sized Banks Sample					Small-sized Banks Sample				
	Model1	Model2	Model3	Model4	Model5	Model1	Model2	Model3	Model4	Model5
CSI(ini)	0.021* (0.178)	0.024* (0.161)	0.031* (0.163)	0.028 (0.158)	0.027 (0.149)	0.012 (0.081)	0.012 (0.089)	0.014* (0.092)	0.013 (0.083)	0.011 (0.087)
CSI_{-1}	0.141* (0.138)	0.156* (0.127)	0.139* (0.136)	0.148 (0.113)	0.128 (0.125)	0.099 (0.057)	0.087* (0.082)	0.113* (0.072)	0.108 (0.68)	0.128* (0.084)
RGDP	6.123* (3.487)	5.412** (3.511)	5.316** (3.479)	4.871** (3.465)	4.927** (3.531)	2.422** (3.519)	2.352** (3.501)	2.329** (3.479)	2.251** 3.488)	2.154** 3.472)
LR	2.257 (0.017)	2.438 (0.019)	2.139 (0.021)	2.429 (0.022)	2.167 (0.019)	6.057 (0.051)	5.781 (0.047)	5.890 (0.046)	6.291 (0.049)	6.115 (0.045)
CAR		1.532** (2.543)					4.163** (2.212)			
ROA			-4.453 (1.182)					-6.327 (1.136)		

Variables	Large-sized Banks Sample					Small-sized Banks Sample				
	Model1	Model2	Model3	Model4	Model5	Model1	Model2	Model3	Model4	Model5
$\ln AS$				0.217 (2.118)					0.313 (1.125)	
$\ln L$					0.117** (2.915)					0.082** (2.224)
Constant	-1.359 (3.105)	-1.278 (3.232)	-1.421 (3.491)	-1.189 (3.632)	-1.328 (2.977)	-0.732 (1.351)	-0.826 (1.571)	-0.879 (1.715)	-0.791 (1.809)	-0.891 (1.927)
Obser.	44	44	44	44	44	165	165	165	165	165
Sargan test	45.128 (0.000)	47.012 (0.000)	48.118 (0.000)	47.092 (0.000)	41.182 (0.000)	18.329 (0.000)	24.123 (0.000)	28.331 (0.000)	27.802 (0.000)	22.704 (0.000)
AR（2）	0.521	0.567	0.532	0.536	0.546	0.345	0.412	0.485	0.486	0.492

*Note: Robust standard errors are presented in the parentheses, * p<0.1, **p<0.05, *** p<0.01.*

5. Conclusions

This study focuses on the impact of capital constraints on the credit structure of commercial banks.

By constructing a revenue function to reflect the lending behavior of commercial banks and optimizing the lending behavior of commercial banks, in this study we draw the proposition about the loan preference of large-sized banks, namely that a large-sized bank has loan preference to large-sized enterprises, but large-sized banks would also lend to small-sized enterprises if the economy of scale is exceeded by the interest rate margin. We also draw the proposition about the loan preference of small-sized banks, namely that a single small-sized bank can only loan to small-sized enterprises within its capacity, but small-sized banks have the preference to form a consortium to strive for a large-sized enterprise. To study whether and how commercial banks adjust capital and asset portfolios under capital constraints, we use vectors and dummy coordinates to describe the behavioral changes and credit structures of commercial banks. We found that the capital constraints would lead to asymmetric changes in loans to large-sized enterprises and small-sized enterprises under the liberalization of interest rates, and capital constraints would lead to the credit structures of commercial banks with large uncertainties under the controls of interest rates. Thus, one may draw the conclusion that large-sized banks would grant more loans to large-sized enterprises and fewer loans to small-sized enterprises under capital constraints, but small-sized banks would grant more loans to large-sized enterprises only under the liberalization of interest rates and capital constraints.

In order to examine the changes in the credit structures of commercial banks under capital constraints and the liberalization of lending rates, in the study we make empirical tests using the 2002-2012 yearly panel data from commercial banks in China and panel estimations with SYS-GMM. By the panel estimates using the full sample set, we found that the higher the intensity of capital constraints, the more the commercial banks would grant loans to large-sized enterprises in China. By the panel estimates using the large-sized banks sample and the small-sized banks sample respectively, we found that the estimated impact of capital constraints on the change in the credit structures is greater for the small-sized banks than for the large-sized

banks. That is to say, the evidence from China indicated that the changes in the credit structures of commercial banks under capital constraints and the liberalization of interest rates are consistent with the hypotheses. Due to the change in the credit structures of commercial banks under capital constraints, loans to small- and medium-sized enterprises would decrease when the Basel Accord was implemented.

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