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 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 make empirical tests using the 2002-2012 yearly panel data from commercial banks in China and panel estimations with SYS-GMM to examine the changes of credit structures of commercial banks under capital constraints. The evidence from China indicated the estimated impact of capital constraints on the change of credit structures is greater on small-sized banks than that on large-sized banks.

Keyword: Credit structure, Capital constraints, Basel Accord, SYS-GMM, Commercial banks

JEL Classification: G21, G28, G43

I. Introduction

With the successive implementation of Basel I and Basel II, capital constraints have become the main trend of global banking supervision. One of the considerations that raised serious concerns among 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 commercial banks to reduce incentives for risk taking, which may lead commercial banks to decrease loans to small- and medium-sized enterprises. Due to small- and

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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 credit structure of commercial banks.

Economists have done a few of 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 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 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 for 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 recent years being for commercial real estate loans. From above researches, it seems that the lending behavior and the credit structure of commercial banks under capital constraints have 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 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 make empirical tests using the 2002-2012 yearly panel data from commercial banks in China and panel estimations with SYS-GMM to examine the changes of 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 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 of 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. And 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 is equal to loans to several small-sized enterprises , the interest rate of the loan to a large-sized enterprise is and the interest rate of the loans to several small-sized enterprises is . Assume that the fix cost of each loan is and the variable cost of each loan is (including the cost of credit risk), that's to say, , .

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

(1)

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

(2)

Under the control of interest rates, the interest rates of the loans to large-sized enterprises equal or approximately equal to the interest rates of the loans to small-sized enterprises, that is , and , so . 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 . In this case, the large-sized bank's expected return is as the following:

If , due to the economy of scale is exceeded by interest rate margin, the large-sized bank's expected return received from the loan to a large-sized enterprise is lower than its expected return received from the loans to several small-sized enterprises . That's to say, , the large-sized bank will give up lending to large-sized enterprises and turn to small-sized enterprises.

Conversely, if , that's to say, ,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 interest rate margin.

Now we turn to the small-sized bank. Due to the constraints on lending capacity, a single small-sized bank can't 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:

$$E_{toS} \quad L_S r_S^{\sim} \quad C_v^{\sim} \quad C_f \tag{3}$$

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 small-sized banks, its expected return E_{toL} is:

$$E_{toL} \quad \frac{L_L r_L^{\sim} \quad C_v^{\sim} \quad nC_f}{n} \quad (\frac{L_L}{n}) r_L^{\sim} \quad C_V^{\sim} \quad C_f. \quad (n^{\sim} \quad 1)(\frac{C_V^{\sim}}{n} \quad C_f) \tag{4}$$

Under the control of interest rates, as $L_S \quad \frac{L_L}{n}$ and $r_L \quad r_S$, the small-sized banks' loan preferences depends on $(n^{\sim} \quad 1)(\frac{C_V^{\sim}}{n} \quad C_f)$. In this formula, $C_f \quad C$, and $n \quad 1$. So there is a $n^* \quad \frac{C_v}{C_f}$, When $n \quad n^* \quad \frac{C_v}{C_f}$, then $\frac{C_V^{\sim}}{n} \quad C_f \quad 0$ and $E_{toL} \quad E_{toS}$。Under such conditions, small-sized banks wouldn't lend to large-sized enterprises by forming a consortium.

Under the liberalization of interest rates, r_L is lower than r_S. When $r_S^{\sim} \quad r_L \quad \frac{(\frac{n^{\sim} \quad 1}{n})C_V^{\sim} \quad (n^{\sim} \quad 1)C_f}{L_L}$, small-sized banks have loan preferences to large-sized enterprises by forming a consortium; when $r_S^{\sim} \quad r_L \quad \frac{(\frac{n^{\sim} \quad 1}{n})C_V^{\sim} \quad (n^{\sim} \quad 1)C_f}{L_L}$, 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. But 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 above, it can be seen that commercial banks of different sizes have different loan preferences and their loan preferences would be affected by the costs and risk premium. So, commercial banks of different sizes have different credit structure. Now, this study want to know 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, 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 portfolio risks. That's to say, 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).

Assumed 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[2]. Their interest rates are respectively r_L and r_S, 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. Considered (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 represents 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 "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 $\overrightarrow{OA}$ $\vec{i}^{L_S}$. $\vec{j}^{L_L}$. $\vec{k}^{E}$. That's to say, 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, and the distance of point A to the plane $L_S L_L$ represents the income of commercial banks at the beginning. Line HF represents all of the constraints to the lending of commercial banks, and Point B and C on the Line HF represent some of them.

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[2] 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.

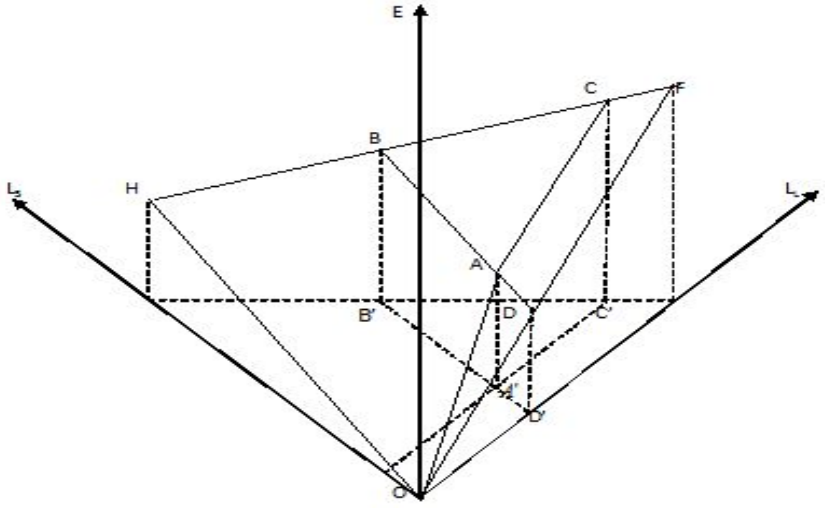
Now we need to discuss how the credit structure of commercial banks would change under capital constraints, due to the reducing incentives for risk taking of commercial banks[3]. This is equivalent to the mathematical problem:

$$\max E \quad \left\| \overset{\bullet}{OA} \right\| \sin \qquad \text{or} \quad \max E \quad \left\| \overset{\bullet}{OA} \right\| \sin \tag{5}$$
$$s.t. \{ L_S \mid L_S \quad 0\} \cup \{ L_L \mid L_L \quad 0\} \qquad s.t. \{ L_S \mid L_S \quad 0\} \cup \{ L_L \mid L_L \quad 0\}$$

Where: $\left\| \overset{\bullet}{OA} \right\|$ is the norm of vector $\overset{\bullet}{OA}$, and is the angel of $\overset{\bullet}{OA}$ and plane $L_S L_L$. The change of commercial bank's credit scale which results from capital constrains is a plane that is perpendicular to $L_S L_L$ and intersects the commercial bank's credit structure plane at line HF. Though the change of commercial bank's credit scale L is unpredictable, but $L \quad L_L. \quad L_S$. Assume an increase of loan L, then $L \quad L_L. \quad L_S$. Move the origin from O to A, obviously $L_S \quad \tilde{} \quad L_L. \quad L$, which represents a plane to be perpendicular to $L_S L_L$ in the dummy coordinates system.

Figure 1

Effect of Capital Constraints on the Credit Structure of Commercial Banks (under the liberalization of interest rates)



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 plane $A'B'C'$. Then plane $A'B'C'$ is the projection of plane ABC, which is a subfield of credit structure plane of commercial banks in plane $L_S L_L$. The subfield ABC is important to commercial

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

banks, because commercial banks will not make loan portfolio out of subfield ABC . If commercial banks make loan portfolio beyond subfield ABC , there are two disadvantages: either $\|\dot{OA}\|$ and E are decreased, or L_L and L_S are decreased. Both of them would make it difficult to achieve optimum. While in subfield ABC , the boundary $\dot{AC}$ is optimal. For A is a moving point and $\|\dot{OA}\|$ $\frac{L_L}{\cos}$, only the points on $\dot{AC}$ guarantee the largest L_L and the smallest $\cos$ in the change process, while ensuring maximum. So with the expansion of credit scale, vector $\dot{OA}$ that moves along $\dot{AC}$ will ensure that E $\|\dot{OA}\|\sin$ always get the maximum value. That's 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 $\dot{AD}$ and $\dot{DO}$ by connecting A and D , and $\|\dot{OA}\|$ $\frac{L_L}{\cos}$. In the case of $|L|$ $\|\dot{AD}\|$, when point A moves along $\dot{AD}$, L_L wouldn't be decreased and thereby $\|\dot{OA}\|$ would decline slowly. In the case of $|L|$ $\|\dot{AD}\|$, L_L must be decreased. In such a case, if we move point A along $\dot{DO}$, as the direction cosine formed by $\dot{DO}$ and axis OL_L is the smallest vector on the plane ADO , E $\|\dot{OA}\|\sin$ would decline more slowly. That's to say, loans to large-sized enterprises would be decreased more slowly than those to small-sized enterprises under capital constraints with the decrease of credit scale.

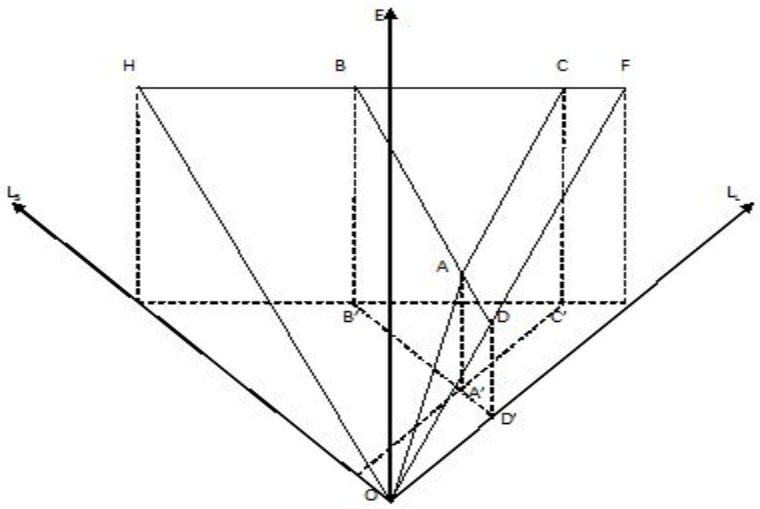
Synthesizing the above two cases, we name $\dot{AC}$ $\dot{AD}$ $\dot{DO}$ the efficiency broken line of the credit structure of commercial banks caused by capital constraints under the liberalization of interest rates. From above, we can obtain:

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 size enterprises. As r_L r_S , 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 area ABC whose projection on plane $L_S L_L$ is plane $A'B'C'$. 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 $BCB'C'$ [4]. 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 line $B'C'$. Adding all these indifferent return curves together, we get a plane ABC. That's 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. That's to say, the credit structure of commercial banks has a large uncertainty under capital constraints with the decrease of credit scale too. From above, 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 of credit structures of commercial banks under capital constraints. Combined with proposition 1 and proposition 2, we can draw such proposition as following:

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

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 its loan preference would have a large uncertainty under the controls of interest rates and capital constraints.

From above 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 must meet the requirements of capital constraints until 2007. That's to say, the banking in China has gone through a complete adjustment process under capital constraints. In addition, the liberalization of lending rates was taken place in 2004 too. In order to examine the changes of 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 will 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.[5]In order to ensure the effectiveness and robustness of estimates of regression equations, we also make two essential tests: (1) Sargan test to verify the validity of instrumental variables; (2) 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 weather capital constraints lead to the changes of 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 of credit structures of commercial banks under capital constraints.

4.1 Empirical Models and Data

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

$$CSI_{ij} \quad C_1. \quad C_2 CSI(ini)_{ij}. \quad C_3 B_{ij}. \quad C_4 RGDP_j. \quad C_5 LR_j. \quad _{ij} \qquad (6)$$

$$CSI_{ij} \quad C_1. \quad C_2 CSI_{ij\square 1}. \quad C_3 CSI(ini)_{ij}. \quad C_4 B_{ij}. \quad C_5 RGDP_j. \quad C_6 LR_j. \quad _{ij} \qquad (7)$$

(6) is employed for cross-section estimation with OLS and (7) is employed for panel estimation with SYS-GMM. Where 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 credit structure index of commercial banks (CSI), which is given by:

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[5] 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.

$$CSI \quad \frac{L_L}{L_{L0}} \quad \frac{L_S}{L_{S0}} \tag{8}$$

Where L_{L0} is loans to large-sized enterprise in the base period, L_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 L_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 less; while the smaller the value is, the commercial bank credit structure is more active and its risk is greater. So, the CSI index is a good indicator to describe changes on 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.

And where the independent variable B in (6) and (7) denote the microeconomic characteristics variables from commercial banks, including commercial bank's capital adequacy ratio (CAR)[6], 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.[7] 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 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.[8]

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

Table 1

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

[7] 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.

[8] 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

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 table 2-3. 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 results are presented in table 2. The baseline model which only includes control variables shows that all the explanatory variables have expected signs (see column 1 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 closely 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.

Table 2

Cross-section Estimation OLS (2002-2012)

Variables	Model1	Model2	Model3	Model4	Model5
$CSI(ini)$	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)		
$\ln AS$				3.157* (1.178)	
$\ln L$					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.

From column 2 to 5 in Table 2, we test whether the microeconomic characteristics variables play significant role in the change of credit structures of commercial banks. We find a positive relationship between various microeconomic characteristics variables (CAR, $\ln AS$, $\ln L$)and the change of credit structures of commercial banks, but ROA have a negative relationship with the change of credit structures of commercial banks. All of them are statistically significant, which implying 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.

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 expected sign in baseline model. Looking at the panel estimates in Table 3, we find a positive and statistically significant impact of CAR on the change of credit structures of commercial banks, which implying that capital constraints lead to the changes of credit structures of commercial banks in the long run. The higher the intensity of capital constraints, the more commercial banks would grant loans to large-sized enterprises.

Table 3

Panel estimation for full sample (1996-2008)

Variables	Model1	Model2	Model3	Model4	Model5
$CSI(ini)$	0.019* (0.078)	0.017* (0.087)	0.011* (0.096)	0.012 (0.108)	0.018 (0.094)
CSI_{-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)		

ln *AS*				0.312* (3.184)	
ln *L*					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 of credit structures varies with the size of commercial banks, we re-estimate the panel for large-sized banks and small-sized banks. Results for panel estimates are presented in Table 4.

Results show that the microeconomic characteristics variables are important for 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 large-sized banks would grant loans to large-sized enterprises. That's to say, the changes of credit structures of large-sized banks under capital constraints are consistent with the hypothesis 5. While the estimated coefficient of *CAR* is 4.163 (significant at 5 percent too) for small-sized banks, which means the estimated impact of *CAR* on the change of credit structures is greater on small-sized banks than that on large-sized banks. That's to say, the changes of 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				
	Model	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)		
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 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, this study draw the proposition about the loan preference of large-sized banks 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 interest rate margin. This study also draw the proposition about the loan preference of small-sized banks 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, this study use vectors and dummy coordinates to describe the behavioral changes and credit structures of commercial banks. This study found that 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 will lead to the credit structures of commercial banks with large uncertainties under the controls of interest rates. So this study can draw 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.

In order to examine the changes of credit structures of commercial banks under capital constraints and the liberalization of lending rates, this study 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, this study found that the higher the intensity of capital constraints, the more 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, this study found that the estimated impact of capital constraints on the

change of credit structures is greater on small-sized banks than that on large-sized banks. That's to say, the evidence from China indicated the changes of credit structures of commercial banks under capital constraints and the liberalization of interest rates are consistent with the hypothesis. Due to the change of credit structures of commercial banks under capital constraints, loans to small- and medium-sized enterprises would be decreased when the Basel Accord was implemented.

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