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Competition and risk taking in the banking industry
The case of capital requirements

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Abstract

This article examines how stricter capital requirements affect competition and risk-taking incentives in the banking industry. When banks choose their risk profiles by solving portfolio problems, there is a clear trade-off between competition and risk taking: stricter capital requirements restrict risk taking but soften competition for deposits. The clear trade-off disappears when banks compete in a loan market rather than choose their risk profiles directly. In this case, stricter capital requirements will lead to less risk taking only if they also lead to stronger competition in the loan market.

JEL: G20; G28; L13.

Keywords: banking; capital requirements; competition; risk taking; stability.

1 Introduction

The potential trade-off between competition and stability in the banking sector continues to be the subject of substantial academic and public debate.[1] Capital requirements are regulatory measures intended to increase stability in the banking industry. Forcing banks to hold more capital may help them to remain solvent if the value of their assets were to decline. The current paper examines how stricter capital requirements may also affect the riskiness of the banks' assets and the intensity of their competition for customers. Following Boyd and De Nicolo (2005), I first consider a model in which the banks directly affect the riskiness of their assets by choosing investment portfolios, followed by a model in which they compete in a loan market and only indirectly (through the equilibrium interest rate) affect the riskiness of the projects that they finance.

The main conclusions are as follows. When banks choose their risk levels directly, there is a clear trade-off between risk taking and competition: stricter capital requirements imply that the banks have a greater stake in the game when they are choosing their investment portfolios, which leads to less risky behavior.[2] On the other hand, stricter capital requirements lead to less intense competition for deposits because they raise the amount of equity that banks have to hold per extra

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[1] See Vives (2016) for an overview of the arguments.

[2] This effect is referred to as a capital-at-risk effect by Hellmann et al. (2000).

unit of deposits. This clear trade-off disappears when banks are competing in a loan market (rather than directly choosing investment portfolios). In this case, higher loan rates will give the borrowers an incentive to take more risk. Therefore, stricter capital requirements will restrict risk taking if and only if they lead to a more competitive loan market.

Theoretical work on capital requirements and risk taking has tended to focus on situations where banks directly determine the riskiness of their assets through solving a portfolio problem.[3] Hellmann et al. (2000) argue that the effect of capital requirements on banks' risk taking is ambiguous. Although stricter capital requirements will reduce incentives to choose risky investment portfolios, because more equity is at stake, they also reduce the franchise values of the banks, thereby encouraging more risk taking.[4] The current article illustrates that when banks compete in a loan market, stricter capital requirements may be counterproductive, not because they negatively affect the franchise values of the banks, but because they may soften competition in the loan market, thereby encouraging risk taking by firms that are financing their projects through this market.

2 Competition for deposits

The following model extends the framework used by Boyd and De Nicolo (2005, Section III) and Allen and Gale (2000, Chapter 8) by introducing equity as a source of funds and capital requirements set by a regulator.

Assume that N banks have no initial resources, but access to a set of risky technologies, with constant returns to scale, indexed by S. Given an input level y, the risky technology yields Sy with probability $p(S)$ and 0 otherwise.

Assumption 1. *$p(S)$ satisfies: $p(0) = 1$, $p(\bar{S}) = 0$, $p' < 0$ and $p'' \leq 0$ for all $S \in [0, \bar{S}]$.*

Bank i has two sources of funds: deposits D_i and equity capital E_i. The bank is required by a regulator to hold $k \leq 1$ units of equity per unit of deposits. The total supply of deposits is represented by an upward sloping inverse supply curve, denoted by $r_D(\cdot)$.

Assumption 2. *$r_D(\cdot)$ satisfies: $r_D(0) \geq 0, r'_D > 0, r''_D \geq 0$.*

Deposits are insured at a fixed rate $\alpha \geq 0$. The equity capital is traded in a market in which the banks are price takers. Let r_E be the price at which equity is available.

Banks compete for deposits in a Nash fashion in a two-period economy. The interest rate on deposits is a function of total deposits: $r_D = r_D(\sum_i D_i)$. Assume that the equity constraint is binding in equilibrium, implying that the amount of equity for bank i will be given by $E_i = kD_i$. In a Nash equilibrium, each bank then chooses a pair (S_i, D_i) to maximize:

[3] See, for example, Lam and Chen (1985) and Rochet (1992) for early contributions.

[4] Repullo (2004) considers an explicit model and finds that when intermediation margins are small, a flat-rate capital requirement can ensure prudential behavior.

$$-kD_i + \frac{p(S_i)}{r_E}\left(S_i(1+k)D_i - r_D(\sum_i D_i)D_i - \alpha D_i\right). \tag{1}$$

The first term in this expression is the equity contribution of the shareholders in period 0. The second term is the discounted value of the equity in period 1.

The necessary conditions for an interior equilibrium are:

$$\frac{p'(S_i)}{r_E}\left(S_i(1+k)D_i - r_D(\sum_i D_i)D_i - \alpha D_i\right) + \frac{p(S)}{r_E}(1+k)D_i = 0, \tag{2}$$

$$\frac{p(S_i)}{r_E}\left(S_i(1+k) - r_D(\sum_i D_i) - r'_D(\sum_i D_i)D_i - \alpha\right) - k = 0. \tag{3}$$

In a symmetric interior equilibrium, letting $Z \equiv ND$, the first-order conditions reduce to:

$$p'(S)\left(S(1+k) - r_D(Z) - \alpha\right) + p(S)(1+k) = 0, \tag{4}$$

$$S(1+k) - r_D(Z) - r'_D(Z)\frac{Z}{N} - \alpha - \frac{kr_E}{p(S)} = 0. \tag{5}$$

We obtain the following proposition (all proofs are relegated to the Appendix).

Proposition 1. *In a symmetric interior equilibrium, the equilibrium level of the risk-shifting parameter S is strictly increasing in N. The equilibrium level of total deposits Z is strictly increasing in N.*

More competitors (a higher N) in the bank market lead to more deposits (and, consequently, higher interest rates for the depositors), but also to more risky investments by the banks. This confirms that Proposition 1 in Boyd and De Nicolo (2005) also holds in a situation where the banks have equity capital as an additional source of funds and are subject to binding capital requirements.

Capital requirements result in the same trade-off between risk taking and competition as did more competitors:

Proposition 2. *In a symmetric interior equilibrium, the equilibrium levels of both the risk-shifting parameter S and total deposits Z are strictly decreasing in k.*

Stricter capital requirements lead to less risk taking by the banks. This is intuitive because stricter capital requirements imply that the banks have a greater stake in the game when they are choosing their investment portfolios, which naturally leads to less risky behavior. On the other hand, stricter capital requirements lead to less intense competition for deposits because they raise the amount of (expensive) equity that the banks have to raise per extra unit of deposits.

In this model, the regulator faces a clear trade-off when choosing the level of the capital requirements. Stricter capital requirements discipline the banks and lead to less risky investments, but they also dampen the competition for depositors, thereby reducing the level of total deposits and the interest rates received by the depositors.

3 Competition for deposits and loans

So far, I have assumed that banks allocate their assets by choosing an investment portfolio, thereby directly determining their risk profiles. However, banks do supply investors with loans used to finance risky projects. This section follows Boyd and De Nicolo (2005, Section IV) by letting the banks compete in a loan market rather than choosing investment portfolios. In such a setting, a bank will only indirectly choose the riskiness of its assets (by affecting the borrowing rate).

Consider a situation with many entrepreneurs who have access to projects of a fixed size, normalized to one, with the return structure described above. After borrowing from the banks, the entrepreneurs choose the riskiness of their projects, which the banks do not observe. Given a loan rate r_L, the entrepreneurs choose $S \in [0, \bar{S}]$ to maximize:

$$p(S)(S - r_L). \tag{6}$$

An interior solution to the problem is given by the first-order condition:

$$h(S) \equiv S + \frac{p(S)}{p'(S)} = r_L. \tag{7}$$

Note that an increase in the interest rate on loans will lead to an increase in the risk-shifting parameter S.

Let L denote the total amount of loans and assume the following:

$$r_L(0) > 0, r_L' < 0, r_L'' \leq 0 \text{ and } r_L(0) > r_D(0). \tag{8}$$

This condition ensures the existence of the equilibrium. The rate of interest on loans is a function of total loans: $r_L = r_L(L)$.

The balance sheet identity requires that $L = (1 + k) \sum_i D_i$. In a Nash equilibrium, each bank chooses deposits (and implicitly, equity) taking the choices of its competitors as given and taking the entrepreneurs' choice of S into account. Thus, bank i chooses D_i to maximize:

$$-kD_i + \frac{p(S)}{r_E}\left(r_L(\sum_i D_i(1+k))D_i(1+k) - r_D(\sum_i D_i)D_i - \alpha D_i\right), \tag{9}$$

subject to:

$$h(S) \equiv S + \frac{p(S)}{p'(S)} = r_L(\sum_i D_i(1+k)). \tag{10}$$

Let $S(\sum_i D_i(1+k))$ denote the function implicitly defined by the constraint. Then, bank i chooses D_i to maximize:

$$-kD_i + \frac{p(S(\sum_i D_i(1+k)))}{r_E}\left(r_L(\sum_i D_i(1+k))D_i(1+k) - r_D(\sum_i D_i)D_i - \alpha D_i\right), \tag{11}$$

subject to:

$$0 \leq S(\sum_i D_i(1+k)) \leq \bar{S}. \tag{12}$$

Using $Z \equiv ND$, the necessary and sufficient conditions for a symmetric interior equilibrium are:

$$h(S) = r_L(Z(1+k)), \tag{13}$$

$$\begin{aligned} f(Z,N,k) \equiv & \\ & \left[\frac{p'(S(Z(1+k)))S'(Z(1+k))}{r_E}\frac{Z}{N}(1+k) + \frac{p(S(Z(1+k)))}{r_E}\right](r_L(Z(1+k))(1+k) - r_D(Z) - \alpha) \\ & + \left[\frac{p(S(Z(1+k)))}{r_E}\frac{Z}{N}\right](r'_L(Z(1+k))(1+k)^2 - r'_D(Z)) - k = 0, \end{aligned} \tag{14}$$

$$f_1(Z,N,k) < 0. \tag{15}$$

The following proposition confirms that the conclusion of Boyd and De Nicolo (2005), reached when considering the existence of a loan market, also applies when banks hold equity according to binding capital constraints.

Proposition 3. *In a symmetric interior equilibrium, the equilibrium levels of both total deposits Z and total loans $Z(1+k)$ are increasing in N, while that of the risk-shifting parameter S is decreasing in N.*

The effect of stricter capital requirements on the level of total deposits is described in the following proposition.

Proposition 4. *In a symmetric interior equilibrium, the equilibrium level of total deposits Z is decreasing in k if and only if $f_3(Z, N, k)$ is negative.*

As long as stricter capital requirements make attracting deposits less profitable (on the margin), they will soften the banks' competition for deposits, thereby reducing the interest rate received by the depositors.[5]

How then, do stricter capital requirements affect the equilibrium level of the risk-shifting parameter S? S is decreasing in the equilibrium level of total loans $Z(1 + k)$. Consequently, when stricter capital requirements lead to a decrease in total deposits, they also lead to more risk taking by the borrowers in the loan market. Note also that, even if stricter capital requirements were to reduce the equilibrium level of deposits, Z, they would still result in more equity per unit of deposits. Consequently, stricter capital requirements may lead to an increase in the amount of loans $Z(1 + k)$ (and, consequently, a decrease in the risk-shifting parameter), even if they reduce the total amount of deposits Z.

It is worth noting that, in the loan market, there is no trade-off between competition (higher loan volumes and lower interest rates) and risk taking. Risk taking is only reduced by stricter capital requirements if they lead to an increase in the volume of loans (and a decrease in the interest rate). Therefore, stricter capital requirements will result in either a more competitive outcome in the loan market and more risky projects, or a less competitive outcome in the loan market and less risky projects. We obtain the following:

Proposition 5. *In a symmetric interior equilibrium, an increase in k leads to either increases in the total amount of loans $Z(1 + k)$ and the risk-shifting parameter S, or decreases in the total amount of loans and the risk-shifting parameter.*

4 Conclusion

Hellmann et al. (2000) argue that capital requirements may have perverse effects on the risk profiles of banks because they encourage risky behavior by reducing the franchise values of the banks. The current article highlights that if banks only indirectly affect the riskiness of their assets (through competition in a loan market), then capital requirements may also lead to more risky assets in a static setting in which the banks have no franchise values to protect through affecting the risk-taking incentives of firms that finance their projects through the loan market.

[5] The assumptions made do not allow us to determine whether stricter capital requirements decrease the marginal profitability of attracting deposits.

This article illustrates that choosing a level of capital requirements does not necessarily result in a trade-off between competition and stability. When banks compete in a loan market, there is no trade-off between competition (in the loan market) and risk-taking incentives: Stricter capital requirements lead to less risk taking only when they also lead to stronger competition in the loan market.

Appendix

Proof of Proposition 1. Let $h(S) \equiv S + \frac{p(S)}{p'(S)}$ and let $Z \equiv ND$. Then, the first-order conditions can be rewritten as:

$$h(S)(1+k) - r_D(Z) - \alpha = 0, \tag{16}$$

$$S(1+k) - r_D(Z) - r'_D(Z)\frac{Z}{N} - \alpha - \frac{kr_E}{p(S)} = 0. \tag{17}$$

Totally differentiating with respect to Z and S gives:

$$h'(S)(1+k)dS - r'_D(Z)dZ = -h(S)dk, \tag{18}$$

$$\left(1 + k + \frac{p'(S)kr_E}{(p(S))^2}\right)dS - \left(r'_D(Z)(1+1/N) + r''_D(Z)\frac{Z}{N}\right)dZ = -r'_D(Z)\frac{Z}{N^2}dN + \left(\frac{r_E}{p(S)} - S\right)dk. \tag{19}$$

As $h'(S) = 2 - \frac{p(S)p''(S)}{(p'(S))^2} > 2$, the determinant of this system, denoted by Δ, satisfies:

$$\begin{aligned}\Delta &= -h'(S)(1+k)\left(r'_D(Z)(1+1/N) + r''_D(Z)\frac{Z}{N}\right) + r'_D(Z)\left(1 + k + \frac{p'(S)kr_E}{(p(S))^2}\right) \\ &= r'_D(Z)(1+k)\left(1 + \frac{p'(S)kr_E}{(p(S))^2(1+k)} - h'(S)\right) - \frac{h'(S)}{N}\left(r'_D(Z) + r''_D(Z)Z\right) < 0.\end{aligned} \tag{20}$$

To evaluate the effect of changes in N, we set $dk = 0$ in equations (18) and (19) and apply Cramer's rule to obtain the following:

$$\frac{dS}{dN} = -\frac{1}{\Delta}(r'_D(Z))^2\frac{Z}{N^2} > 0, \tag{21}$$

and

$$\frac{dZ}{dN} = -\frac{1}{\Delta}h'(S)(1+k)r'_D(Z)\frac{Z}{N^2} > 0. \tag{22}$$

Proof of Proposition 2. To evaluate the effect of changes in k, consider equations (18) and (19) and set $dN = 0$. Note that $r_E \geq p(S)S$ because otherwise, bank i would want to increase its level of equity, which contradicts the assumption that the capital requirements are binding. Then, Cramer's rule yields:

$$\frac{dS}{dk} = \frac{1}{\Delta}\left(h(S)\left(r'_D(Z)(1+1/N) + r''_D(Z)\frac{Z}{N}\right) + r'_D(Z)\left(\frac{r_E}{p(S)} - S\right)\right) < 0. \tag{23}$$

That is, stricter capital requirements lead to less risk taking. Further:

$$\frac{dZ}{dk} = \frac{1}{\Delta}\left(h'(S)(1+k)\left(\frac{r_E}{p(S)} - S\right) + \left(1 + k + \frac{p'(S)kr_E}{(p(S))^2}\right)h(S)\right). \tag{24}$$

From Equation (16), this last expression can be written as:

$$\frac{dZ}{dk} = \frac{1}{\Delta}\left(h'(S)(1+k)\left(\frac{r_E}{p(S)} - S\right) + \left(1 + \frac{p'(S)kr_E}{(p(S))^2(1+k)}\right)(r_D(Z) + \alpha)\right). \tag{25}$$

Equation (16) and the definition of $h(S)$ imply that $\frac{p'(S)}{p(S)} = \frac{1+k}{r_D(Z)+\alpha-S(1+k)}$. Using this, we obtain:

$$\frac{dZ}{dk} = \frac{1}{\Delta}\left(h'(S)(1+k)\left(\frac{r_E}{p(S)} - S\right) + \left(1 + \frac{kr_E}{p(S)(r_D(Z) + \alpha - S(1+k))}\right)(r_D(Z) + \alpha)\right). \tag{26}$$

$1 + kr_E/(p(S)(r_D(Z) + \alpha - S(1+k))) > 0$ whenever $S(1+k) - r_D(Z) - \alpha > kr_E/p(S)$, which holds by condition (17). Therefore, we conclude that $\frac{dZ}{dk} < 0$, that is, that stricter capital requirements lead to a reduction in the total amount of deposits.

Proof of Proposition 3. Totally differentiating $f(Z, N, k)$ yields:

$$f_1(Z, N, k)dZ + f_2(Z, N, k)dN + f_3(Z, N, k)dk = 0. \tag{27}$$

To consider the effect of N, we set $dk = 0$, which gives the following:

$$\frac{dZ}{dN} = -\frac{f_2(Z, N, k)}{f_1(Z, N, k)}, \tag{28}$$

which has the same sign as $f_2(Z, N, k)$. Next, observe that:

$$f_2(Z,N,k) = -\frac{p'(S(Z(1+k)))S'(Z(1+k))}{r_E}\frac{Z}{N^2}(1+k)\left(r_L(Z(1+k))(1+k) - r_D(Z) - \alpha\right) \quad (29)$$
$$- \frac{p(S(Z(1+k)))}{r_E}\frac{Z}{N^2}\left(r'_L(Z(1+k))(1+k)^2 - r'_D(Z)\right).$$

The right-hand side has, from (14), the same sign as:

$$\frac{p(S(Z(1+k)))}{r_E}(r_L(Z(1+k))(1+k) - r_D(Z) - \alpha) - k, \quad (30)$$

which is positive because, otherwise, the equilibrium profit of bank i would be negative. Thus, we conclude that $f_2(Z,N,k) \geq 0$ and, consequently, that $\frac{dZ}{dN} \geq 0$.

As the total amount of loans is given by $Z(1+k)$, it follows immediately that the total amount of loans is increasing in N. Totally differentiating equation (13) gives the following:

$$\frac{dS}{dN} = \frac{r'_L(Z)}{h'(S)}\frac{dZ}{dN}(1+k) \geq 0. \quad (31)$$

Proof of Proposition 4. To consider the effect of k, we again totally differentiate $f(Z,N,k)$ and then set $dN = 0$. This gives the following:

$$\frac{dZ}{dk} = -\frac{f_3(Z,N,k)}{f_1(Z,N,k)}. \quad (32)$$

This has the same sign as $f_3(Z,N,k)$. However, the assumptions in the model do not allow us to determine the sign of $f_3(Z,N,k)$.

Proof of Proposition 5. To consider the effect of k on S, we totally differentiate equation (13) to obtain:

$$\frac{dS}{dk} = \frac{r'_L(Z)}{h'(S)}\frac{d(Z(1+k))}{dk}, \quad (33)$$

which has the same sign as $\frac{d(Z(1+k))}{dk}$.

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