Bank competition and risk taking revisited: A non-monotonic relationship

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Abstract

We re-examine the relationship between bank risk taking and competition when increased competition in loan market implies a flatter loan demand function, a closer approximation to perfect competition. This assumption generates two countervailing effects of an increase in the number of banks on risk taking implying a non-monotonic relationship between risk taking and bank competition. We further analyze the implications of capital regulation for bank risk taking.

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1 Introduction

When banks are able to invest their deposits in risky projects, increased degree of deposit market competition induces banks to take more risk (e.g. Allen and Gale, 2000). A lower intermediation margin, implied by an increased competition in deposit market, incentivizes banks to take more risk as riskier projects, if successful, yield higher returns. This is due to the implied moral hazard problem since if a project fails a bank is not required to repay its depositors since it is protected by limited liability. Boyd and De Nicoló (2005), in their seminal paper, show that when banks are able to invest their deposits only in loans without any controls over the choice of risk, the so-called positive association between competition and risk taking is reversed. In a lending relationship the borrowers are the ones who face moral hazard problems in the choice of risk, and incentive compatibility implies a positive association between the level of risk and loan rate. As increased competition induces a lower loan rate in equilibrium, it in turn weakens incentives for risk taking.

Boyd and De Nicoló (2005) analyze homogeneous Cournot competition both in the deposit and loan markets. An increase the number of banks, which affects both markets symmetrically, implies increased competition. The main objective of the present paper is to extend the model of Boyd and De Nicoló (2005) by incorporating an additional effect of increased competition. In a Cournot model of loan market, as noted by Hermalin (1994) in a different context, increasing the number of banks may also

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lead to a flatter loan demand function, a closer approximation to perfect competition (less market power for each bank). Apart from the standard *aggregate loan effect* of an increase in the number of banks, i.e., increased competition amplifies loan volume, and hence, lowers both the loan rate and risk shifting, there is an additional *business stealing effect*. A flatter inverse demand curve increases the loan rate that prevails in the market, and hence, enhances risk shifting. The net effect of intensified competition on risk taking thus depends on which of the two countervailing forces is stronger. We therefore establish a non-monotonic relationship between risk taking and the number of banks. In fact, when the second effect dominates the first one, greater competition implies more risk taking, a reversal of the result in Boyd and De Nicoló (2005). It is worth noting that, in our paper, a larger banking sector affects the deposit and loan markets asymmetrically as the deposit supply function remains unaltered.[1]

Our paper is related to the extant literature on the effect of enhanced product market competition on managerial incentives (e.g. Hermalin, 1994; Raith, 2003), although these models do not consider the interaction between two different markets. In fact, we model our Cournot competition as in Hermalin (1994) who establishes a non-monotonic relationship between product market competition and managerial incentives for cost reduction. Raith (2003) considers a spatial competition model of product market, and shows a positive association between competition and managerial incentives for cost reduction when managers are risk averse.

2 The Model

The economy consists of three classes of risk neutral agents – a large number of depositors and entrepreneurs (borrowers), and $n \geq 2$ banks. The deposit market is characterized by a linear upward-sloping inverse deposit supply function

$$r_D(Z) = Z \quad \text{where } Z = \sum_{i=1}^{n} D_i \tag{1}$$

with D_i being the total deposits of bank $i \in \{1, \ldots, n\}$. Each bank i invests its total deposits in loans made to the entrepreneurs. All deposits are insured for which each bank pays a flat premium which, without loss of generality, is normalized to zero. Each entrepreneur has access to a project of fixed size 1. If $y > 0$ dollars are invested in a project, it yields a stochastic cash flow which is given by:

$$\tilde{y} = \begin{cases} \theta y & \text{with probability } \pi(\theta) = 1 - a^{-1}\theta \quad \text{with } a > 0, \\ 0 & \text{otherwise,} \end{cases}$$

Note that $H(\theta) \equiv \theta\pi(\theta)$ is strictly concave function with $H(0) = H(a) = 0$ and reaches a maximum at $\theta = a/2$. Therefore, increasing θ on $[0, a/2]$ entails increases in both the probability of failure and expected cash flow. By contrast, increasing θ on $(a/2, a]$ implies a higher probability failure but a lower expected cash flow. We will refer to θ as the riskiness of a project. Banks cannot observe the borrowers' choice of risk, and thus have no direct control over this decision. Given a loan rate r_L, entrepreneurs choose θ to solve

$$\theta = \text{argmax}_{\hat{\theta} \in [0,a]} \, \pi(\hat{\theta})(\hat{\theta} - r_L) = \frac{1}{2}(a + r_L), \tag{IC}$$

[1]Our findings continue to hold if an increased number of banks also makes the deposit supply function flatter as long as the rates of changes in the deposit supply and loan demand functions are asymmetric.

which is the *incentive compatibility constraint* of the entrepreneurs – the higher the loan rate, the stronger is the incentives for risk taking. Let L denote the aggregate loan amount. The inverse demand for loan is given by:

$$r_L(L) = a - b(n)L \quad \text{with} \quad b'(n) < 0. \tag{2}$$

Here we depart from Boyd and De Nicoló (2005). The slope of the loan demand function, $b(n)$ depends inversely on the number of banks, n. In particular, following Hermalin (1994) we assume that $b(n) = n^{-\beta}$ where $\beta \in [0, 1]$. The above function captures the effect of increased banking competition. As the number of banks increases, the loan demand function becomes flatter. If $\beta = 0$, the above model reduces to that of Boyd and De Nicoló (2005) where both the deposit and loan markets are characterized by homogeneous Cournot competition.

Banks are assumed to have no equity, and hence, $L = Z$, i.e., aggregate loan demand equals aggregate deposit supply. In a Nash equilibrium, each bank i chooses the amount of deposits D_i to solve, subject to (IC), the following maximization problem:

$$\max_{D_i} \pi(\theta)(r_L(Z) - r_D(Z))D_i. \tag{3}$$

In a symmetric equilibrium, $D_i = Z/n$ for all $i = 1, \ldots, n$. From the first-order condition of the above maximization problem in a symmetric equilibrium we obtain the equilibrium values of aggregate loan and risk shifting, which are described in the following proposition.

Proposition 1 *The equilibrium (aggregate) loan size and risk shifting are respectively given by:*

$$Z^* \equiv Z(n) = \frac{an^{\beta}(n+1)}{\left(1+n^{\beta}\right)(n+2)}, \tag{4}$$

$$\theta^* \equiv \theta(n) = a - \frac{a(n+1)}{2\left(1+n^{\beta}\right)(n+2)}. \tag{5}$$

The above expressions are the aggregate bank loan and risk shifting as a function of the number of banks in a symmetric Nash equilibrium. We are interested in the sign of $\theta'(n)$, i.e., how the number of banks affects the equilibrium risk shifting.

Proposition 2 *There is a unique $\beta_0 \in (0, 1)$ such that*

(a) *the equilibrium risk shifting is monotonically decreasing in the number of banks, i.e., $\theta'(n) < 0$ if $\beta = 0$;*

(b) *The equilibrium risk shifting is non-monotonic with respect to the number of banks if $\beta \in (0, \beta_0)$. In particular, there is a unique $\bar{n}(\beta)$ with $\bar{n}'(\beta) < 0$ such that $\theta'(n) < (>)\, 0$ for all $n < (>)\, \bar{n}(\beta)$;*

(c) *The equilibrium risk shifting is monotonically increasing in the number of banks, i.e., $\theta'(n) > 0$ if $\beta \in [\beta_0, 1]$.*

The effect of increased competition on risk shifting can be decomposed into two forces. It is easy to show that

$$\text{sign}[\theta'(n)] = -\,\text{sign}\left[\frac{Z'(n)}{Z(n)} + \frac{b'(n)}{b(n)}\right].$$

The first term is positive because $Z'(n) > 0$, which we call the *aggregate loan effect*. The higher the number of banks, the higher is the aggregate loan, and hence, the lower is the equilibrium loan rate r_L. This in turn weakens the incentives of the entrepreneur for risk taking. This is the standard effect of increased competition in a Cournot market. The second term is negative because $b'(n) < 0$. As the loan demand curve becomes flatter following an increase in n, a small decrease in the loan rate now allows an individual bank to "steal" more borrowers from its rivals. The rivals are forced to lent a lower amount, and as a result, both the equilibrium loan rate and risk shifting increase. This is called the *business stealing effect*. When $\beta = 0$, the second effect is absent since the slope of the loan demand curve is constant. Therefore, the equilibrium risk shifting monotonically decreases with the number of banks (Boyd and De Nicoló, 2005, Proposition 2). For a positive β, the effect of increased competition on risk taking depends on which of the two countervailing forces is stronger. Note that higher values of the elasticity of the slope, $b(n)$ with respect to n, i.e., β make the business stealing effect stronger. Therefore, for $\beta > 0$, the aggregate loan effect dominates for low n. On the other hand, the business stealing effect is relatively stronger for high n. Finally, when β is close to 1, the second effect dominates the first one for all n, and hence, risk taking is monotonically increasing in the number of banks.

3 Effects of capital regulation

We now analyze the effects of a minimum capital requirement imposed by the prudential regulator on the equilibrium risk shifting.[2] Under a capital requirement $k \in [0, 1]$, the amount lent by each bank i is given by $L_i = (1+k)D_i$. Therefore, market clearing implies that $L = (1+k)Z$. The equilibrium risk shifting is given by:

$$\theta^* = a - \frac{a(n+1)(1+k)^2}{2\left[(1+k)^2 + n^\beta\right](n+2)}.$$

As expected, the higher the minimum capital requirement, k, the lower is the equilibrium risk shifting for all $n \geq 2$ and $\beta \in [0, 1]$. Also, for $\beta = 0$, $\theta'(n) < 0$ for all levels of k. A more interesting effect of capital regulation arises when the equilibrium risk shifting is non-monotonic with respect to the number of banks. A higher k increases the threshold level of competition, $\bar{n}(\beta)$. In other words, the range of values of n over which equilibrium risk shifting is monotonically decreasing in n expands following a tighter capital regulation. The reason is that a more stringent capital regulation strengthens the aggregate loan effect as the aggregate loan amount under capital regulation is $(1+k)Z > Z$ for all $k > 0$. Therefore, if the prudential regulator has the objective of permitting entry of new banks and yet maintaining the negative correlation between risk taking and competition, then a tighter capital regulation can achieve this goal.

4 Conclusion

In a Cournot loan market, the concept of increased competition is in general captured by an increase in the number of banks which does not affect the market demand curve. But increasing the number of banks does not imply a closer approximation to perfect competition as the banks do not become price takers in the limit. Following Hermalin (1994), we introduce this aspect of increased competition

[2] The proofs of the results in this section are available upon request.

by assuming that the inverse loan demand curve becomes flatter as the number of banks grows. This generates a business stealing effect which does not pull in the same direction as the standard aggregate loan effect ('output effect' in the context of product market competition) of enhanced competition. The result is a non-monotonic association between competition and risk shifting. The business stealing effect also arises in a Cournot competition in differentiated products as a result of varying degree of product substitutability. Therefore, an agenda for the future research is to analyze a similar question when the deposit market and/or loan market are characterized by competition in differentiated deposit and loan services.

Appendix

A Proof of Proposition 1

The first-order condition of bank i's maximization problem, (3) is given by:

$$[r_L(Z) - r_D(Z)](D_i + Z) = (1 + b(n))D_i Z. \tag{FOC$_i$}$$

In a symmetric Nash equilibrium, $D_i = Z/n$ for all $i = 1, \dots, n$. Substituting $L = Z$, $b(n) = n^{-\beta}$ and equations (1) and (2) into (FOC$_i$) we obtain the expression for $Z(n)$. It follows from the incentive constraint, (IC) that

$$\theta(n) = a - \frac{1}{2} b(n) Z(n). \tag{6}$$

Therefore, substituting the expression for $Z(n)$ into the above equation, we obtain the expression for $\theta(n)$.

B Proof of Proposition 2

Differentiating (4) with respect to n we get

$$\frac{Z'(n)}{Z(n)} = \frac{\beta}{n(1+n^\beta)} + \frac{1}{(n+1)(n+2)}.$$

On the other hand, $b'(n)/b(n) = -(\beta/n)$. Therefore,

$$\theta'(n) = -\frac{1}{2} b(n) Z(n) \left[\frac{Z'(n)}{Z(n)} + \frac{b'(n)}{b(n)}\right] = \frac{b(n)Z(n)}{2n[1+b(n)]} \underbrace{\left\{\beta - \frac{n(1+n^{-\beta})}{(n+1)(n+2)}\right\}}_{H(n;\beta)}$$

$$\implies \text{sign}[\theta'(n)] = \text{sign}[H(n;\beta)].$$

Now,

$$\begin{aligned}
\frac{\partial H}{\partial n} =& \frac{\beta(n+1)(n+2) + (n^2-2)(1+n^\beta)}{n^\beta (n+1)^2 (n+2)^2} > 0 \text{ for } n \geq 2 \text{ and } \beta > 0,\\
\frac{\partial H}{\partial \beta} =& 1 + \frac{n^{1-\beta} \log n}{(n+1)(n+2)} > 0.
\end{aligned}$$

Note that $H(n;0) = -\{2n/(n+1)(n+2)\} < 0$ and $\lim_{n\to\infty} H(n;\beta) = \beta = 0$, which implies $\beta = 0$. Therefore, $\theta'(n) < 0$ for $\beta = 0$. Let β_0 solves $H(2;\beta) = 0$ which is equivalent to $h(\beta) \equiv 6\beta - 1 - 2^{-\beta} = 0$. Note that $h(0) = -1 < 0$, $h(1) = 4.5 > 0$ and $h'(\beta) = 6 + 2^{-\beta}\log 2 > 0$. Therefore, by the Intermediate Value Theorem, there is a unique $\beta_0 \in (0, 1)$ such that $\beta > \beta_0$ implies $H(n;\beta) > 0$ for all n, and hence, $\theta'(n) > 0$. Since $\partial H/\partial\beta > 0$, for any $\beta \in (0, \beta_0)$ there is a unique $\bar{n}(\beta)$ such that $H(n;\beta) < (>) 0$ for all $n < (>) \bar{n}(\beta)$. Moreover, $\partial H/\partial\beta > 0$ implies that $\bar{n}'(\beta) < 0$. This proves Part (b) of the proposition. Finally, $\partial H/\partial\beta > 0$ implies that $H(n;\beta) > 0$ for all $\beta \in (\beta_0, 1]$, which proves Part (c). The above analysis is summarized in the following figure.

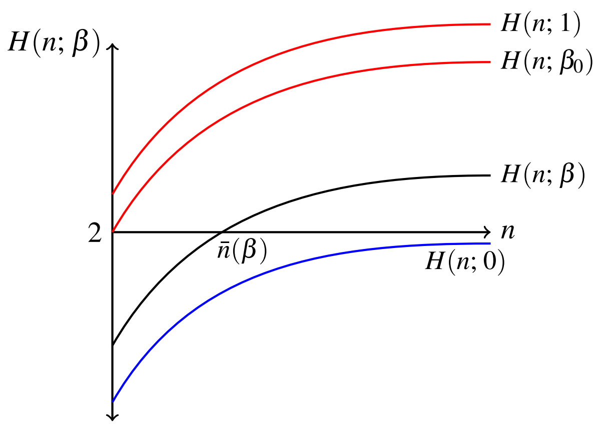

Figure 1: *For $\beta = 0$, $H(n;\beta) < 0$, and hence, $\theta'(n) < 0$. For any $\beta \in (0, \beta_0]$, $H(n;\beta)$ intersects the horizontal axis at a unique point $\bar{n}(\beta)$, i.e., $H(n;\beta) < (>) 0$ if $n < (>) \bar{n}(\beta)$, and hence, $\theta(n)$ is non-monotonic with respect to n. For any $\beta \in (\beta_0, 1]$, $H(n;\beta) > 0$, and hence, $\theta'(n) > 0$.*

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