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RESEARCH ARTICLE

Welfare and bank risk-taking

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Abstract
Our study investigates a model of general equilibrium banking that incorporates moral hazard and incentive mechanisms for bank risk-taking, with a particular focus on deposit market competition. Our findings reveal that when banks compete perfectly in the deposit market, it leads to maximal welfare and an optimal level of bank failure risk. This outcome remains valid even if the risk of failure for competitive banks is higher than that of banks with monopoly rents, and it is not affected by social costs associated with bank failures. Our model suggests that there is no trade-off between bank competition and financial stability. Our results support the empirical findings of Carlson, Correia, and Luck (J Polit Econ 130(2): 462–520, 2022).

Keywords General equilibrium · Bank competition · Financial stability

JEL Classification D5 · G21

1 Introduction

The issue of whether bank competition is detrimental for financial stability and should be restrained has a long history in the bank regulatory debate, having resurfaced in the aftermath of the financial crisis and post-crises perspectives.[1] Yet, the relatively large theoretical banking literature does not offer a clear guidance to this debate, since it has primarily focused on the relationship between competitive condition and banks' risk of failure using partial equilibrium set-ups, as in Jermann and Xiang, (2023) obtaining contrasting results.

In models where limited liability banks raise funds from insured depositors, choose the risk of their investment portfolio, and this choice is not observable, more competition results in a higher risk of bank failure, since higher funding costs erode banks'

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[1] For an overview of this debate, see Boyd and De Nicolò (2005), Tarullo (2011), Vives (2019) and Carlson, Correia and Luck (2022).

charter values (expected profits), prompting banks to choose riskier investments (see e.g. Keeley 1990, Matutes and Vives 1996, Hellmann et al. 2000, Cordella and Levi-Yeyati 2002, and Repullo 2004, Xu et al 2019, Jermann and Xiang 2023 among others). However, when banks compete a là Cournot in both loan and deposit markets and loan returns are perfectly correlated, these results are reversed: banks' risk of failure declines as competition increases (Boyd and De Nicolò, 2005). On the other hand, if loan returns are not perfectly correlated, there might exist a U-shaped relationship between the number of banks and banks' risk of failure (Martinez-Miera and Repullo 2010). Most importantly, these partial equilibrium set-ups are not equipped to address the key normative issue of whether there is a trade-off between bank competition and financial stability. Is a lower level of risk of bank failure necessarily undesirable in a welfare sense? More generally, what are the welfare-maximizing levels of bank competition and the relevant optimal levels of banks' risk of failure? Addressing this question is the main objective of this paper.

Policy prescriptions suggesting that bank competition should be restrained seem at variance with the welfare results of some general equilibrium banking models. Yet, these general equilibrium models do not feature the type of moral hazard in investment associated with financing choices considered by the partial equilibrium banking literature. This motivates our explicit consideration of these features in a general equilibrium set-up.

In our model, the size of the banking sector and the resource allocated to productive investment are determined endogenously, as risk-neutral agents choose to become either bankers or depositors, with banks established as coalitions of bankers financed by depositors. An important feature of our model is that setting up banks has a resource cost. As a result, any welfare criterion will balance the costs of bank intermediation with the benefits of increasing available resources for productive investment. This novel feature is absent in general equilibrium constructs where either the distribution of initial resources or the partition of agents in banks or depositors is exogenous (see e.g. Holmstrom and Tirole 1997, or Morrison and White 2005).

As in the partial equilibrium literature, banks in our model choose the riskiness of their investment incurring higher effort costs to select lower risk investments. As is standard, we interpret these costs as characterizing an intermediation technology that embeds screening and/or monitoring costs. Furthermore, bank risk choices are not observable; hence, there is moral hazard, with depositors considering banks' optimal risk choices in their decision to accept deposit terms. Differences in competitive conditions in the economy are simply modeled assuming that banks can choose to operate as monopolists or competitive banks, while depositors incur switching costs to be served by competitive banks. Thus, different degrees of bank competition are indexed by the fractions of bank deposit contracts in the economy priced monopolistically and competitively.

We consider the model under no deposit insurance, as well as the case where a "government" sets-up a deposit insurance scheme that is resource-feasible and partially or totally insures the principal of depositors' investment in a bank. Although there is no explicit rationale for deposit insurance in our model—as there is none in all existing partial equilibrium models, we are aware of[2]—we wish to assess whether the presence of an arguably realistic deposit insurance scheme affects the welfare ranking of competitive conditions.

The key result of this paper is that perfect bank deposits competition maximizes welfare. This result holds under no deposit insurance and with deposit insurance as well. Notably, perfect bank competition maximizes welfare even though competitive banks exhibit a level of risk of failure higher than banks enjoying monopoly rents: this shows that a particular ranking of banks' risk of failure obtained in partial equilibrium set-ups is neither necessary nor sufficient for welfare maximization. In addition, perfect bank competition maximizes welfare even in the presence of social costs that fulfill the property of being consistent with the existence of bank intermediation and are not internalized by banks. Thus, a general equilibrium economy with investment choices subject to moral hazard delivers implications qualitatively similar to those obtained by Boyd et al. (2004) in general equilibrium set-ups that lack these features.

The mechanism that delivers the welfare maximizing property of perfect bank competition is simple and intuitive. An increase in bank competition triggers a resource re-allocation mechanism that we term the *general equilibrium effect* of bank competition. As bank competition for funds increase, the relative return of deposits versus that of shares of bank ownership increases, prompting a larger (smaller) fraction of agents to become depositors (bankers). This shift depicts stylistically an economy-wide shift of resources from investment in costly bank intermediation to investment in productive assets intermediated by banks. The resulting increase in economy-wide investment in productive assets generates an increase in expected output (net of monitoring and production costs) large enough to offset any reduction in the expected return due to the comparatively higher risk of failure of banks operating under more intense competition.

We obtain further results that are of independent interest. The introduction of deposit insurance *increases* banks' risk of failure in the competitive sector since it forces banks to increase the offered deposit rate. The resulting increase in banks' cost of funds decreases their profits, inducing them to choose riskier investments. By contrast, deposit insurance decreases banks' risk of failure in the monopolistic sector, since it increases monopoly rents, which in turn inflate bank profits, inducing banks to choose safer investments. However, different degrees of deposit insurance coverage do not affect the welfare-maximizing property of perfect bank competition.

The remainder of the paper is composed of three sections. Section II describes the model. Section III the bank problems, and Section IV equilibrium and welfare. Section V concludes. Proofs are in the Appendix.

2 The model

There are two dates, 0, and 1, and a continuum of risk neutral agents on $[0, A]$. Agents are endowed with 1 unit of the date 0 good and with effort, they derive disutility from

[2] Most partial equilibrium models assume the existence of deposit insurance either for the sake of realism, or under the implicit assumption that deposit insurance corrects some not explicitly modeled coordination failures, such as the occurrence of runs.

effort, and have preferences over final date consumption. All agents have access to a safe (risk-free) technology which yields $\rho > 1$ per unit invested. At date 0 agents decide either to become bankers or depositors.

2.1 Banks

If an agent chooses to become a banker, she forgoes her initial endowment in exchange of the ability to form coalitions, called banks, which operate a risky project. The choice set of risky projects is indexed by the probability of success $P \in [\underline{P}, 1]$. Investing an amount of resources z in a risky project yields Xz with probability P and 0 otherwise. We assume that the expected return of any risky project with $P \in (\underline{P}, 1]$ is higher than that of the safe technology, i.e.

$$\underline{P}X = \rho. \tag{A1}$$

Banks choose P and z(project scale or demand for funds) at an effort cost. The transformation of effort into a probability of project success $P \in [\underline{P}, 1]$ is interpreted as representing an *intermediation technology* that embeds banks' project screening and/or monitoring. The bank effort cost function is given by $m(P) = \frac{1}{2\alpha}P^2 z$. Therefore, the bank intermediation technology exhibits constant returns to scale, as the effort cost to implement P is linearly related to z.[3] The effort cost of operating the project at a scale z is $c(z) = \frac{1}{2\beta}z^2$. Thus, the transformation of effort into project scale is a standard *production technology.*

2.2 Competition

To introduce different degrees of competition for funds, we assume that the agents who have chosen to be bankers can move at no cost to one of two unconnected locations, labeled M and C.

In location M, bankers are either unrestricted to communicate and choose to behave cooperatively or are endowed with the power to set up local monopolies. Thus, each bank in M acts as a monopolist, choosing project risk and deposit rates so as to maximize expected profits subject to depositors' participation constraints. Location M represents the monopolistic banking sector. In location C, bankers do not communicate and compete for depositors' funds à la Bertrand that is more competitive that location M. They set up competitive banks that choose project risk to maximize expected profits and deposit rates that maximize depositors' expected returns. Location C represents the competitive banking sector. As bankers do not incur any cost in moving to either location, there is free entry in the monopolistic and competitive banking sectors. Moreover, banks in both locations distribute profits to bankers in equal shares and, as in Dick (2008) depositors benefit substantially from higher welfare in the competitive deposit market.

[3] The assumption of constant returns to scale in monitoring is fairly standard in the banking literature (see e.g. Dell'Ariccia and Marquez 2006).

For simplicity, we assume that project risks are independent *across* locations, but perfectly correlated *within* locations. Denote with P_C and P_M the risk choices in the competitive and monopolistic sectors respectively. Then, projects are successful in both sectors with probability $P_C P_M$, successful only in the competitive sector with probability $P_C(1 - P_M)$, successful only in the monopolistic sector with probability $(1 - P_C)P_M$, and fail in both sectors with probability $(1 - P_C)(1 - P_M)$.

2.3 Depositors

If an agent chooses to be a depositor, he will move to location C with probability σ, and to location M with probability $1 - \sigma$. Since the remuneration of deposits in the monopolistic sector will be lower than in the competitive banking sector, agents are exposed to the risk of depositing in the monopolistic banking sector. Parameter σ can be viewed as indexing depositors' switching costs to move to the competitive banking sector, where they can get a better return, and is akin to traveling costs to bank locations in the Salop tradition used in several papers (see, e.g. Park and Pennacchi 2009). Thus, higher values of parameter σ index an increase in funding market competition. We assume that relocation risks are independent, so that σ is also the fraction of depositors moving to location C. This models the real-world model of segmented deposit markets.

2.4 Deposit insurance

Deposit insurance (DI) is pre-funded by taxation of initial resources A. The tax revenues are invested in the safe technology that yields ρ. Let τ denote the tax rate. The total "end-of-period" assets of the deposit insurance fund (DIF) are equal to $\tau A\rho$.

Denote with Z_C and Z_M total investment (deposits) in the competitive and monopolistic banking sectors respectively. A guarantee per unit of deposits $g \in (0, 1]$ implies that the DIF will have contingent liabilities as follows. It will pay depositors nothing with probability $P_C P_M$, gZ_M with probability $P_C(1 - P_M)$, gZ_C with probability $P_M(1 - P_C)$, and $g(Z_C + Z_M)$ with probability $(1 - P_M)(1 - P_C)$. Note that if $g = 0$ there is *no* deposit insurance. If $g \in (0, 1)$, then there is a *partial* guarantee on a fraction g of the principal, whereas $g = 1$ corresponds to a full guarantee that repays the entire principal. Whatever is left in the DIF after payments to depositors is distributed lump-sum to all agents in equal shares.

The DIF must have total assets whose value covers the worst-case payment outlays. Clearly, the DIF will not invest more than what is necessary to honor insurance in the worst-case outcome where all banks fail: doing that would be inefficient since the safe technology is dominated in rate of return by the risky technology. Hence, deposit insurance is feasible if the DIF can credibly guarantee payments in every contingency. This requires that total DIF assets equal total payments in the worst outcome, that is, $\tau A\rho = g(Z_C + Z_M)$.

Table 1 Sequence of decisions and determined variables

Time	Agents' sequence of decisions	Determined variables
t = 0	If $g \in (0, 1]$, the deposit insurance fund (DIF) is established by taxing initial resources	$x(1-x)$: fraction of bankers in C (M)
	Agents choose to become bankers or depositors	A_B: measure of bankers
	Bankers choose to locate in M or in C	$A - A_B$: measure of depositors
	Depositors' locate in M or C according to their location draw	σ: fraction of depositors in C
	The number of banks and the debt equilibrium are determined	n_C, n_M: number of banks in C and M
		Z_C, Z_M: total supply of funds (deposits) in the competitive and monopolistic sectors
t = 1	Banks choose project scale (fund demand)	z_C, z_M
	Debt contract terms between the bank and depositors are determined	R_C, R_M: deposit rates in the competitive and monopolistic sectors
	Banks choose risk	Z_C, Z_M: total investment in the competitive and monopolistic sectors
	Projects' output is realized and agents' consumption follows	P_C, P_M: risk choices in the competitive and monopolistic sectors
	The DIF pays out depositors (if necessary) and distributes remaining funds in equal shares to all agents	

2.5 Contracts and sequence of decisions

Depositors finance the bank with simple debt contracts that pay a fixed amount R per unit invested if the outcome of the investment is successful and 0 otherwise. *Moral hazard* is introduced by assuming that bank choices of P are not observable by depositors. However, depositors take bank's optimal choice of P into account in their decision to accept the deposit terms offered by the bank.

Denote with x the *fraction* of bankers in C, with A_B the measure of bankers, with n_i the number of banks, with z_i bank size (capacity), and with R_i the deposit rates, for $i \in \{C, M\}$. Table 1 summarizes the sequence of decisions and the determined variables in the model.

3 Bank problems

We solve backward, starting with the competitive and monopolistic bank problems.

3.1 Competitive banks

The representative competitive bank chooses P_C to maximize

$$P_C(X - R_C)z_C - \frac{1}{2\alpha}P_C^2 z_C - \frac{1}{2\beta}z_C^2 \tag{1}$$

The optimal interior solution is given by:

$$P_C^* = \alpha(X - R_C) \tag{2}$$

We focus on interior solutions assuming the following sufficient condition for $P_C^* \in \left(\underline{P}, 1\right)$:

$$\underline{P} < \alpha X \leq 1. \tag{A2}$$

Bertrand competition implies that R_C maximizes depositors' expected return, with depositors taking into account the optimal bank risk decision given by (2). Depositors' expected return is therefore:

$$P_C^* R_C + \left(1 - P_C^*\right) g = \alpha(X - R_C)(R_C - g) + g. \tag{3}$$

This expected return is a strictly concave function of the deposit rate R_C, with the maximum reached at:

$$R_C^* = \frac{X + g}{2} \tag{4}$$

Substituting (4) in (2), the optimal risk choice of the competitive bank is:

$$P_C^* = \alpha\left(\frac{X - g}{2}\right) \tag{5}$$

Using (4) and (5), the competitive bank expected profits are:

$$\Pi^C(z_C) \equiv \alpha \frac{(X - g)^2}{8} z_C - \frac{1}{2\beta} z_C^2 \tag{6}$$

Let $\pi_C \equiv \alpha \frac{(X-g)^2}{8}$. The optimal bank choice of capacity (or fund demand) z_C is

$$z_C = \beta \pi_C \tag{7}$$

The expected per-unit bank profits are given by:

$$\frac{\Pi^C}{z_C} = \frac{\pi_C}{2} \tag{8}$$

3.2 Monopolistic banks

The representative monopolistic bank chooses (P_M, R_M) to maximize

$$\Pi^M \equiv \left(P_M(X - R_M) - \frac{1}{2\alpha}P_M^2\right)z_M - \frac{1}{2\beta}z_M^2 \tag{9}$$

subject to the depositors' participation constraint

$$P_M^* R_M + \left(1 - P_M^*\right)g \geq \rho, \tag{10}$$

where $P_M^* \in \arg\max \Pi^M$ is given by:

$$P_M^* = \alpha(X - R_M), \tag{11}$$

Since the monopolistic bank profit function is strictly decreasing in the deposit rate R_M, constraint (10) is satisfied at equality, which can be written as:

$$(X - R_M)R_M - g(X - R_M) + \alpha^{-1}(g - \rho) = 0, \tag{12}$$

Equation (12) is equivalent to the quadratic equation:

$$R_M^2 - (X + g)R_M + \left(gX - \alpha^{-1}(g - \rho)\right) = 0 \tag{13}$$

The smaller root of this equation, if it is non-negative, is the solution of the monopolistic bank deposit rate. This root is given by:

$$R_M^* = \frac{X + g - \sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g + 4\alpha^{-1} - 2X\right)}}{2} \tag{14}$$

A necessary condition for existence of equilibriums with banks is a strictly positive deposit rate, which holds if $X + g > \sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g + 4\alpha^{-1} - 2X\right)}$. This inequality can be easily shown to be equivalent to $\rho > g$, which is satisfied since $\rho > 1$ holds.

To ensure well-defined deposit rates and existence of equilibriums with monopolistic banks, we introduce the following parametric assumptions First, since $g\left(g + 4\alpha^{-1} - 2X\right) \geq 0$ by assumption (A2), a sufficient condition for a non negative determinant of the solution to the quadratic equation for all $g \in [0, 1]$ is

$$X^2 - 4\alpha^{-1}\rho > 0, \tag{A3}$$

Combining (A2) and (A3), the parameter α lies in the interval $\left[4\rho X^{-2}, X^{-1}\right]$. This interval is non-empty assuming

$$X > 4\rho. \tag{A4}$$

The optimal risk choice of the monopolistic bank is thus:

$$P_M^* = \alpha\left(X - R_M^*\right) = \alpha \frac{X - g + \sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)}}{2} \tag{15}$$

Using (14) and (15), the expected profits of the monopolistic bank are:

$$\Pi^M \equiv \alpha \frac{\left(X - g + \sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)}\right)^2}{8} z_M - \frac{1}{2\beta} z_M^2 \tag{16}$$

Let $\pi_M \equiv \alpha \frac{\left(X - g + \sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)}\right)^2}{8}$. The optimal bank scale choice (or fund demand) z_M is

$$z_M = \beta \pi_M, \tag{17}$$

The bank expected per-unit profits are given by:

$$\frac{\Pi^M}{z_M} = \frac{\pi_M}{2} \tag{18}$$

3.3 Comparing bank optimal choices

Recall that the risk of failure of the competitive and the monopolist banks are respectively $P_C^* = \alpha\left(X - R_C^*\right)$ and $P_M^* = \alpha\left(X - R_M^*\right)$. From Eqs. (4) and (14), we see that:

$$R_M^* \equiv R_C^* - \frac{\sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g + 4\alpha^{-1} - 2X\right)}}{2}, \tag{19}$$

where the term $\frac{\sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g + 4\alpha^{-1} - 2X\right)}}{2}$ captures monopoly rents. Thus, we obtain:

Lemma 1 *For all $g \in [0, 1]$, $P_C^* < P_M^*$.*

Lemma 1 says that the risk of failure of competitive banks is always strictly higher than that of the monopoly banks. This is the standard result implied by risk-shifting in Martinez-Miera and Repullo (2010). Note that this result holds both under no deposit insurance ($g = 0$), and with deposit insurance ($g \in (0, 1]$).

However, the relationship between deposit insurance coverage and bank risk differs for competitive and monopolistic banks. From Eq. (5) we obtain:

Lemma 2 *The risk of failure of competitive banks increases monotonically with deposit insurance coverage.*

By contrast, as it is evident from Eq. (15), the risk of failure of the monopolistic bank has the first term decreasing in g, while the second term—which represents monopoly rents—increases in g, since $g + 4\alpha^{-1} - 2X > 0$ by assumption (A2). It turns out that the net effect of an increase in deposit insurance coverage on bank risk is negative, as shown in:

Lemma 3 The *risk of failure of monopolistic banks declines monotonically with deposit insurance coverage.*

Proof See Appendix.

As a result of Lemmas 2 and 3, the difference in bank risk of failures of competitive and monopolistic banks increases with deposit insurance coverage. Yet, as we show below, different levels of deposit insurance coverage do not affect the welfare ranking of equilibriums indexed by the competition parameter σ.

4 Equilibrium and welfare

For any given competition parameter $\sigma \in [0, 1]$, and given banks' optimal choices of risk, deposit rates and their demand for funds $\left(P_i^*, R_i^*, z_i^*\right)_{i\in(C,M)}$ we have just determined, we complete the characterization of equilibriums by determining the seven-tuple $\left(\tau, x, A_B, (n_i, Z_i)_{i\in(C,M)}\right)$, using correspondingly seven equilibrium conditions.

The first two of equilibrium conditions establish equality between the demand for funds to the supply of funds of all banks in each sector:

$$n_i z_i = Z_i \text{ for } i \in \{C, M\} \tag{20i}$$

The third equilibrium condition establishes free-entry by bankers in the competitive and monopolistic sectors. Free entry implies that the returns of shares of bank ownership in the two sectors are equalized:

$$\frac{n_C \Pi^C}{x A_B} = \frac{n_M \Pi^M}{(1 - x) A_B} \tag{21}$$

Specifically, Eq. (21) says that the return of owning a bank share in the competitive sector, given by total profit $n_C \Pi^C$ divided by the number of bankers in that sector $x A_B$, equals the return of owning a bank share in the monopolist sector, given by total profit $n_M \Pi^M$ divided by the number of bankers in that sector $(1 - x) A_B$.

The fourth equilibrium condition establishes the fraction of agents who decide to become bankers. This condition is determined by equalization of the return of shares of bank ownership with the expected return of deposits:

$$\frac{n_C \Pi^C}{x A_B} = \sigma(P_C R_C + (1 - P_C)g) + (1 - \sigma)(P_M R_M + (1 - P_M)g) \equiv r(\sigma, g) \tag{22}$$

Note that in (22), the term $r(\sigma, g)$ denotes the expected return on deposits of an agent who has chosen to be a depositor *prior to relocation* to the C or M locations.

The next two equilibrium conditions establish the supply of funds in the two sectors:

$$Z_C = \sigma(A(1-\tau) - A_B) \tag{23}$$

$$Z_M = (1-\sigma)(A(1-\tau) - A_B) \tag{24}$$

Finally, the seventh equilibrium condition determines the tax rate charged to set up the deposit insurance fund (DIF):

$$\rho\tau A = g(Z_C + Z_M) \Leftrightarrow \tau = \frac{gZ}{\rho A} \Rightarrow 1-\tau = \frac{\rho A - gZ}{\rho A} \tag{25}$$

The seven Eqs. (20i)–(25) form a linear system that can be easily solved by substitution. Inserting (20i) in (21), and using (8) and (18), we obtain the equilibrium fraction of bankers who choose to operate in the competitive sector:

$$x = \frac{\pi_C Z_C}{\pi_C Z_C + \pi_M Z_M} \tag{26}$$

Equation (26) has a natural interpretation, as it says that the fraction of bankers choosing to operate as owners of a competitive bank is increasing in the ratio of total bank profits in the competitive sector $\pi_C Z_C$ to total bank profits $\pi_C Z_C + \pi_M Z_M$.

Inserting (26) in (22) yields the equilibrium measure of bankers:

$$A_B = \frac{\pi_C Z_C + \pi_M Z_M}{2r(\sigma, g)}. \tag{27}$$

The measure of bankers is an increasing function of total bank profits $\pi_C Z_C + \pi_M Z_M$, and a decreasing function of the expected return of becoming a depositor.

Inserting (27) in (23) and (24), we obtain:

$$Z_C = \sigma\left(A(1-\tau) - \frac{\pi_C Z_C + \pi_M Z_M}{2r(\sigma, g)}\right) \tag{28}$$

$$Z_M = (1-\sigma)\left(A(1-\tau) - \frac{\pi_C Z_C + \pi_M Z_M}{2r(\sigma, g)}\right) \tag{29}$$

The total supply of deposits (investment) in the banking sectors is $Z \equiv Z_C + Z_M$, where $Z_C = \sigma Z$ and $Z_M = (1-\sigma)Z$. Summing (28) and (29), using $Z_C = \sigma Z$ and $Z_M = (1-\sigma)Z$, and solving for Z, we obtain:

$$Z(\sigma, g) = \frac{2r(\sigma, g)\rho}{2r(\sigma, g)(\rho + g) + \big(\pi_C\sigma + \pi_M(1-\sigma)\big)\rho} A \tag{30}$$

Equation (30) shows that total investment in the banking sector can be expressed as a fraction of total available resources A, where the coefficient of proportionality depends on linear combinations of depositors' returns and profits in the competitive and monopolistic banking sectors.

An important implication of the model is summarized by the following Lemma:

Lemma 4 For all $g \in [0, 1]$, $\frac{\partial Z}{\partial \sigma} > 0$.

Proof See Appendix.

Lemma 4 says that an increase in bank competition increases intermediated investment (total deposits), at the same time reducing the amount of resources used in setting up banks. This occurs because an increase in the remuneration of bank-intermediated investment (deposits) resulting from an increase in competition (i.e. a decrease in the cost to access the competitive sector) prompts a larger fraction of agents to prefer to become depositors rather than bankers. As detailed momentarily, this mechanism is key for the determination of the general equilibrium effect of bank competition on welfare.

4.1 Welfare

As all agents are risk neutral, the welfare metric associated with an equilibrium for a given competition parameter $\sigma \in [0, 1]$ and a given level deposit insurance coverage $g \in [0, 1]$ is expected total output net of total effort costs. Thus, if expected output net of total effort costs associated with an equilibrium corresponding to a given pair (σ, g) is higher than that associated with an equilibrium corresponding to a different pair (σ', g'), then the equilibrium corresponding to (σ, g) Pareto-dominates the equilibrium corresponding to (σ', g'). The welfare function indexed by the pair (σ, g) is defined by:

$$\begin{aligned} Y(\sigma, g) \equiv & P_C P_M X(Z_C + Z_M) + P_C(1 - P_M) X Z_C + (1 - P_C) P_M X Z_M \\ & - \left(\frac{1}{2\alpha} P_C^2 Z_C + \frac{1}{2\alpha} P_M^2 Z_M \right) - (n_C c(z_C) + n_M c(z_M)) + \rho \tau A \end{aligned} \tag{31}$$

The first term is expected output in the competitive and banking sectors, the second and third terms are the sum of monitoring and capacity costs in the two sectors respectively, and the fourth one is the investment of tax receipts of the DIF.

Using the equilibrium conditions (20i)–(25), the welfare function of Eq. (31) can be written as:

$$Y(\sigma, g) = \left[\left(P_C X - \frac{1}{2\alpha} P_C^2 - \frac{1}{2}\pi_C \right) \sigma + \left(P_M X - \frac{1}{2\alpha} P_M^2 - \frac{1}{2}\pi_M \right) (1 - \sigma) + g Z(\sigma, g) \right] \tag{32}$$

The terms $P_C X - \frac{1}{2\alpha} P_C^2 - \frac{1}{2}\pi_C$ and $P_M X - \frac{1}{2\alpha} P_M^2 - \frac{1}{2}\pi_M$ are the expected outputs net of monitoring and production costs per unit of investment of the competitive and the monopolistic banking sectors respectively. Observe that:

$$\frac{\partial Y}{\partial \sigma} = \left[\left(P_C X - \frac{1}{2\alpha}P_C^2 - \frac{1}{2}\pi_C\right) - \left(P_M X - \frac{1}{2\alpha}P_M^2 - \frac{1}{2}\pi_M\right)\right] Z(\sigma, g) + \left[\left(P_C X - \frac{1}{2\alpha}P_C^2 - \frac{1}{2}\pi_C\right)\sigma + \left(P_M X - \frac{1}{2\alpha}P_M^2 - \frac{1}{2}\pi_M\right)(1-\sigma) + g\right]\frac{\partial Z}{\partial \sigma} \tag{33}$$

If $P_C X - \frac{1}{2\alpha}P_C^2 - \frac{1}{2}\pi_C > P_M X - \frac{1}{2\alpha}P_M^2 - \frac{1}{2}\pi_M$, the welfare function would be strictly increasing in the competition parameter as a direct consequence of Lemma 4. However, it is easy to generate numerical examples for which the above inequality is reversed. When this occurs, the expected outputs (*net* of monitoring and production costs) per unit of investment of the monopolistic sector may be *higher* than that in the competitive banking sector. Nevertheless, independently of the direction of the above inequality, we obtain the following.

Proposition 1 *For all* $g \in [0, 1]$, $\frac{\partial Y}{\partial \sigma} > 0$*: perfect competition (*$\sigma = 1$*) maximizes welfare.*

Proof See Appendix.

Proposition 1 is valid even though banks risk of failure under perfect competition is higher than under imperfect competition, and even in the case the expected net output under competition might be lower than under monopoly. Indeed, the implied level of bank risk of failure and the overall resource allocation under perfect bank competition turn out to be optimal.

The quantitative dominance of the general equilibrium effect of bank competition—, which is captured by the increase in intermediated investment prompted by more competition illustrated in Lemma 4—drives this result. Specifically, an increase in the expected returns on deposits due to an increase in competition increases the measure of agents that choose to be depositors and correspondingly decreases the measures of agents choosing to be bankers. The increase in the supply of funds and the decrease in resources employed in setting up banks results in higher *total* expected output net of monitoring and production costs. In other words, there is a shift in the allocation of investment from bank intermediation to intermediated investment, which is generated endogenously by agents' optimal occupational choices and free entry into the banking sectors.

4.2 Social costs of bank failures

Restrictions on competition, as well as several regulations in banking, are typically justified by the existence of social costs associated with bank failures that are not internalized by banks. Would the welfare ranking of competitive conditions we obtained change by introducing social costs?

Assume that social costs are an increasing and convex function of intermediated investment as follows: they are 0 with probability $P_C P_M$, CZ_M^γ with probability $P_C(1 - P_M)$, CZ_C^γ with probability $P_M(1 - P_C)$, and $C(Z_C^\gamma + Z_M^\gamma)$ with probability $(1 - P_M)(1 - P_C)$, with $\gamma \geq 1$ and $C > 0$.

Therefore, expected social costs from bank failures are given by:

$$\begin{aligned} SC(\sigma, g) &\equiv P_C(1-P_M)CZ_M^{\gamma} + (1-P_C)P_M CZ_C^{\gamma} + (1-P_M)(1-P_C)C\big(Z_C^{\gamma} + Z_M^{\gamma}\big) \\ &= C\big[(1-P_M)(1-\sigma)^{\gamma} + (1-P_C)\sigma^{\gamma}\big]Z(\sigma, g)^{\gamma} \end{aligned} \tag{34}$$

A welfare function augmented with social cost is thus defined by:

$$W(\sigma, g) \equiv Y(\sigma, g) - SC(\sigma, g) \tag{35}$$

However, social costs cannot be assumed arbitrarily large, since they need to be consistent with the existence of bank intermediation. Thus, we must require that social costs are not greater than what an economy could achieve by just investing in the safe asset. Without this requirement, it might be optimal to invest all resources in the safe asset, making bank intermediation inessential. This requirement implies an upper bound on the social cost function, which must hold for all competitive conditions and all levels of deposit insurance coverage. This upper bound is a function of these parameters, and is implicitly defined by the following inequality:

$$W(\sigma, g) \equiv Y(\sigma, g) - SC(\sigma, g) \geq \rho A \text{ for all } \sigma \in [0, 1] \text{ and } g \in [0, 1] \tag{36}$$

A social cost function that satisfies (36) is called *admissible*.

The following result establishes the welfare maximizing property of perfect bank competition in the presence of social costs of bank failures:

Proposition 2 *For any admissible social cost function that is increasing and convex in investment (deposits), for all* $g \in [0, 1]$, $\frac{\partial W}{\partial \sigma} > 0$*: perfect competition* $(\sigma = 1)$*maximizes welfare.*

Proof See Appendix

5 Conclusion

We studied a general equilibrium model in which banks make their investment and financing decisions under moral hazard. The model exhibits all features of a large partial equilibrium banking literature which obtains contrasting results with respect to the ranking of bank's risk of failure according to competitive conditions but does not address the key normative issue of whether there exists a trade-off between bank competition and financial stability.

We showed that perfect competition in banking maximizes welfare, even though the risk of failure of a competitive bank may be higher than that of a bank operating in imperfect competition, and even when social costs are considered. Welfare implications derived from partial equilibrium modeling are likely to result in unwarranted normative prescriptions.

A general equilibrium perspective on desirable banking systems' structures and welfare-improving bank regulation has only slowly entered the current policy discourse, with theoretical explorations still limited in numbers. While capturing the essential features of several set-ups studied in a large partial equilibrium banking literature, our model is still highly stylized. Studying richer models of bank intermediation may be fruitful and this task is already part of our research agenda.

Yet, the financial crisis and post-crises era provide a stark example of the dichotomy between a general and a partial equilibrium view of the world: under a partial equilibrium perspective, banks are evaluated just as individual entities and not as part of a system. General equilibrium modeling of intermediation appears an essential tool to throw light on the desirable level of financial stability and systemic risk in an economy, and how it could be attained.

Appendix

Lemma 3 The risk of failure of the monopolistic bank declines monotonically with deposit insurance coverage.

Proof Differentiating Eq. (14) with respect to g we get:

$$\frac{dR_M^*}{dg} = \frac{1}{2}\left(1 - \frac{1}{2}\left(X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)\right)^{-1/2}\left(2g - 2X + 4\alpha^{-1}\right)\right)$$

Therefore, $sign\left\{\frac{dR_M^*}{dg}\right\} = sign\left\{1 - \frac{1}{2}\left(X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)\right)^{-1/2}\right.$ $\left.\left(2g - 2X + 4\alpha^{-1}\right)\right\}$.

$\frac{dR_M^*}{dg} < 0$ is equivalent to the following inequalities:

$$\begin{aligned}
1 <& \frac{1}{2}\left(X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)\right)^{-1/2}\left(2g - 2X + 4\alpha^{-1}\right)\\
&\Leftrightarrow 2\left(X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)\right)^{1/2} < 2g - 2X + 4\alpha^{-1}\\
&\Leftrightarrow 4\left(X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)\right) < \left(2(g - X) + 4\alpha^{-1}\right)^2\\
&\Leftrightarrow 4X^2 - 16\alpha^{-1}\rho + 4g\left(g - 2X + 4\alpha^{-1}\right) < 4(g - X)^2 + 16\alpha^{-2} + 16(g - X)\alpha^{-1}\\
&\Leftrightarrow 4X^2 - 16\alpha^{-1}\rho + 4g^2 - 8gX + 16g\alpha^{-1} < 4g^2 + 4X^2 - 8gX + 16\alpha^{-2} + 16\alpha^{-1}g - 16X\alpha^{-1}\\
&\Leftrightarrow -16\alpha^{-1}\rho < 16\alpha^{-2} - 16X\alpha^{-1} \Leftrightarrow\\
&-\rho < \alpha^{-1} - X
\end{aligned}$$

By (A1), $\alpha^{-1} - X \geq 0$. Therefore, $\frac{dR_M^*}{dg} < 0$, which implies $\frac{dP_M^*}{dg} > 0$ by Eq. (15). □

Lemma 4 For all $g \in [0, 1]$, $\frac{\partial Z}{\partial \sigma} > 0$.

Proof

$$\begin{aligned}
\frac{\partial Z}{\partial \sigma} =& \frac{2A}{(.)^2}\left(\frac{\partial r}{\partial \sigma}\rho\left[2r(\sigma, g)(\rho + g) + \left(\pi_C\sigma + \pi_M(1 - \sigma)\right)\rho\right] - r(\sigma, g)\rho\left[2\frac{\partial r}{\partial \sigma}(\rho + g) + \rho\left(\pi_C - \pi_M\right)\right]\right)\\
&\Leftrightarrow \frac{2A\rho}{(.)^2}\left(\frac{\partial r}{\partial \sigma}\left(\pi_C\sigma + \pi_M(1 - \sigma)\right) - r(\sigma, g)\rho\left(\pi_C - \pi_M\right)\right)
\end{aligned}$$

The term $\frac{\partial r}{\partial \sigma}\big(\pi_C\sigma + \pi_M(1-\sigma)\big) - r(\sigma, g)\rho\big(\pi_C - \pi_M\big)$ is strictly positive for all $g \in [0, 1]$, since $\frac{\partial r}{\partial \sigma} = P_C R_C - \rho + g(P_M - P_C) > 0$ and $\pi_C < \pi_M$. Thus, $\frac{\partial Z}{\partial \sigma} > 0$. □

Proposition 1 *For all* $g \in [0, 1]$, $\frac{\partial Y}{\partial \sigma} > 0$*: perfect competition (*$\sigma = 1$*) maximizes welfare.*

Proof Using the bank profit functions in the two sectors, we can write:

$$P_C X - \frac{1}{2\alpha}P_C^2 = \pi^C + P_C R_C \tag{a}$$

$$P_M X - \frac{1}{2\alpha}P_M^2 = \pi^M + \rho \tag{b}$$

Hence, expected output net of monitoring and production costs in the two sectors are:

$$P_C X - \frac{1}{2\alpha}P_C^2 - \frac{1}{2}\pi_C = P_C R_C + \frac{1}{2}\pi_C \tag{c}$$

$$P_M X - \frac{1}{2\alpha}P_M^2 - \frac{1}{2}\pi_M = \pi^M + \rho - \frac{1}{2}\pi_M = \rho + \frac{1}{2}\pi_M \tag{d}$$

Substituting (c) and (d) in (32), and using (30), we can write:

$$\begin{aligned} Y(\sigma, g) &\equiv \left[\left(P_C X - \frac{1}{2\alpha}P_C^2 - \frac{1}{2}\pi_C\right)\sigma + \left(P_M X - \frac{1}{2\alpha}P_M^2 - \frac{1}{2}\pi_M\right)(1-\sigma) + g\right] Z(\sigma, g) \\ &= \frac{[2(P_C R_C\sigma + (1-\sigma)\rho) + \pi_C\sigma + \pi_M(1-\sigma) + g]r(\sigma, g)\rho}{2r(\sigma, g)(\rho + g) + \big(\pi_C\sigma + \pi_M(1-\sigma)\big)\rho} A \end{aligned}$$

Let $g = 0$. Then

$$Y(\sigma, 0) = \frac{[2(P_C R_C\sigma + (1-\sigma)\rho) + \pi_C\sigma + \pi_M(1-\sigma)]r(\sigma, 0)}{2r(\sigma, 0) + \big(\pi_C\sigma + \pi_M(1-\sigma)\big)} A$$

Since $r(\sigma, 0) = \sigma P_C R_C + (1-\sigma)\rho$, $Y(\sigma, 0)$ can be written as:

$$Y(\sigma, 0) = \frac{[2(\sigma P_C R_C + (1-\sigma)\rho) + \pi_C\sigma + \pi_M)(1-\sigma)]r(\sigma, 0)}{2(\sigma P_C R_C + (1-\sigma)\rho) + \big(\pi_C\sigma + \pi_M(1-\sigma)\big)} A = r(\sigma, 0)A$$

Thus, $\frac{\partial Y}{\partial \sigma} = \frac{\partial r}{\partial \sigma}(\sigma, 0)A = (P_C R_C - \rho)A > 0$, since $P_C R_C > \rho$.
Let $g \in (0, 1]$ and re-write:

$$Y(\sigma, g) = h(\sigma) f(\sigma) A,$$

where

$$f(\sigma) \equiv \frac{r(\sigma, g)\rho}{2r(\sigma, g)(\rho + g) + \big(\pi_C\sigma + \pi_M(1-\sigma)\big)\rho}$$

$$h(\sigma) \equiv 2(P_C R_C \sigma + (1-\sigma)\rho) + \pi_C \sigma + \pi_M (1-\sigma) + g$$

Next, we show that both functions $f(\sigma)$ and $h(\sigma)$ are monotonically increasing in σ.

Consider

$$\begin{aligned} f'(\sigma) = & \frac{1}{\left(2r(\sigma,g)(\rho+g) + \left(\pi_C\sigma + \pi_M(1-\sigma)\right)\rho\right)^2} x \\ & \frac{\partial r}{\partial \sigma}\rho\left(2r(\sigma,g)(\rho+g) + \frac{\partial r}{\partial \sigma}\rho\left(\pi_C\sigma + \pi_M(1-\sigma)\right)\rho\right) \\ & - r(\sigma,g)\rho 2r'(\sigma,g)(\rho+g) - r(\sigma,g)\rho\left(\pi_C - \pi_M\right)\rho \\ = & \frac{\left(\frac{\partial r}{\partial \sigma}\rho\left(\pi_C\sigma + \pi_M(1-\sigma)\right)\rho\right) - r(\sigma,g)\rho\left(\pi_C - \pi_M\right)\rho}{\left(2r(\sigma,g)(\rho+g) + \left(\pi_C\sigma + \pi_M(1-\sigma)\right)\rho\right)^2} \end{aligned}$$

By Lemma 3, $\frac{\partial r}{\partial \sigma}\rho\left(\left(\pi_C\sigma + \pi_M(1-\sigma)\right)\rho\right) - r(\sigma,g)\rho\left(\pi_C - \pi_M\right)\rho\right) > 0$, hence $f'(\sigma) > 0$.

Now consider:

$$h'(\sigma) \equiv 2(P_C R_C - \rho) + \pi_C - \pi_M$$

Using equilibrium values, this derivative can be written as:

$$\begin{aligned} h'(\sigma) &= 2(P_C R_C - \rho) + \pi_C - \pi_M \\ &= 2\alpha\left(\frac{X-g}{2}\right)\frac{X+g}{2} + \left(\alpha\frac{(X-g)^2}{8} - \alpha\frac{\left(X - g + \sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)}\right)^2}{8}\right) \end{aligned}$$

Therefore:

$$\begin{aligned} h'(\sigma) \Leftrightarrow\ & 2\alpha\left(\tfrac{X-g}{2}\right)\tfrac{X+g}{2} \\ > \ & \alpha\left(\tfrac{X^2 - 4\alpha^{-1}\rho + g\left(g-2X+4\alpha^{-1}\right) + 2(X-g)\sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g-2X+4\alpha^{-1}\right)}}{8}\right) + 2\rho \end{aligned} \quad (*)$$

By (A1):

$$\begin{aligned} & \sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)} < X + g \\ & \Leftrightarrow X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right) < (X+g)^2 \end{aligned}$$

Therefore:

$$\alpha\frac{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right) + 2(X-g)\sqrt{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right)}}{8}$$

$$< \frac{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right) + 2(X-g)(X+g)}{8}$$

Hence, inequality (*) is satisfied if:

$$2\alpha\left(\frac{X-g}{2}\right)\frac{X+g}{2} > \left(\frac{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right) + 2(X-g)(X+g)}{8}\right) + 2\rho \quad (**)$$

Note that if (**) holds, we can write it as:

$$\begin{aligned}
2\alpha\left(\frac{X-g}{2}\right)\frac{X+g}{2} &> \frac{X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right) + 2(X-g)(X+g)}{8}\Bigg) \\
&\Leftrightarrow 4\left(X^2 - g^2\right) > X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right) + 2\left(X^2 - g^2\right) + 16\rho \\
&\Leftrightarrow 2X^2 - 2g^2 > X^2 - 4\alpha^{-1}\rho + g\left(g - 2X + 4\alpha^{-1}\right) + 16\rho \\
&\Leftrightarrow X^2 > -4\alpha^{-1}\rho + 2g^2 + g\left(g - 2X + 4\alpha^{-1}\right) + 16\rho \\
&\Leftrightarrow X^2 + 4\alpha^{-1}(\rho - g) + g(2X - g) > 2g^2 + 16\rho \\
&\quad X^2 + 4\alpha^{-1}(\rho - g) + g2X > 3g^2 + 16\rho
\end{aligned}$$

By (A4) and (A1), $g2X > 3g^2$, since $X > 4\rho > \frac{3}{2}g$, and by (A3)$X^2 > 16\rho$, which implies that inequality (**) holds, since $X^2 + 4\alpha^{-1}(\rho - g) + g2X > 3g^2 + 16\rho$. Hence, $h'(\sigma) > 0$.

In conclusion, $Y(\sigma, g) = h(\sigma) f(\sigma) A$ is strictly increasing in σ since both component functions are increasing in σ. □

Proposition 2 *For any admissible social cost function that is increasing and convex in investment (deposits), for all $g \in [0, 1]$, $\frac{\partial W}{\partial \sigma} > 0$: perfect competition ($\sigma = 1$) maximizes welfare.*

Proof The welfare function (35) can be written as:

$$\begin{aligned}
W(\sigma, g) =& Z(\sigma, g)\left[(P_C R_C \sigma + \rho(1-\sigma)) + \frac{1}{2}\pi_C \sigma + \frac{1}{2}\pi_M (1-\sigma) + g\right] + \\
& - C\left[(1 - P_M)(1-\sigma)^\gamma + (1 - P_C)\sigma^\gamma\right] Z(\sigma, g)^\gamma
\end{aligned}$$

The upper bound defined by inequality (36) for all $\sigma \in [0, 1]$ and $g \in [0, 1]$ implies:

$$
\begin{aligned}
W(\sigma, g) =& Z(\sigma, g)\left[(P_C R_C \sigma + \rho(1-\sigma)) + \frac{1}{2}\pi_C \sigma + \frac{1}{2}\pi_M (1-\sigma) + g\right] + \\
& - C\big[(1-P_M)(1-\sigma)^\gamma + (1-P_C)\sigma^\gamma\big] Z(\sigma, g)^\gamma \geq \rho A \Rightarrow \\
& C \leq \frac{Z(\sigma, g)\big[(P_C R_C \sigma + \rho(1-\sigma)) + \frac{1}{2}\pi_C \sigma + \frac{1}{2}\pi_M (1-\sigma) + g\big] - \rho A}{[(1-P_M)(1-\sigma)^\gamma + (1-P_C)\sigma^\gamma] Z(\sigma, g)^\gamma} \\
& \equiv \overline{C}(\sigma, g)
\end{aligned}
$$

Function $\overline{C}(\sigma, g)$ is the highest level of social costs consistent with the existence of essential intermediation. Thus, a *lower* bound to any welfare function can be defined as:

$$
\begin{aligned}
\underline{W}(\sigma, g) =& Z(\sigma, g)\left[(P_C R_C \sigma + \rho(1-\sigma)) + \frac{1}{2}\pi_C \sigma + \frac{1}{2}\pi_M (1-\sigma) + g\right] + \\
& - \overline{C}(\sigma, g)\big[(1-P_M)(1-\sigma)^\gamma + (1-P_C)\sigma^\gamma\big] Z(\sigma, g)^\gamma = Z(\sigma, g) g + \rho A
\end{aligned}
$$

If $g > 0$, then $\frac{\partial W}{\partial \sigma} > 0$ by Lemma 4. If $g = 0$, then $\frac{\partial W}{\partial \sigma} = 0$ since $\underline{W}(\sigma, g) = \rho A$. But in this case investing all resources in the safe asset would be best, which would make bank intermediation inessential. Thus, $\frac{\partial W}{\partial \sigma} > 0$ for any admissible social cost function. Therefore, perfect bank competition ($\sigma = 1$) maximizes welfare. $\square$

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