

# Competition, Stability, and Efficiency in Financial Markets \*

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## **Abstract**

We find that (1) an intensification of competition increases the efficiency and fragility of banks; (2) economies can avoid the fragility costs of competition by enhancing bank governance and tightening leverage requirements; and (3) the monetary transmission mechanism is materially shaped by bank competition in that bank lending responds more aggressively to central bank induced changes in interest rates in more competitive environments. Our research stresses the importance of (a) regulations that improve bank governance because they boost efficiency and stability and (b) explicitly accounting for the endogenous structure of the banking system when assessing regulatory and monetary policy.

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# 1 Introduction

Policymakers and researchers often stress that there is a tradeoff between competition and stability in the banking industry. They emphasize that although competition boosts efficiency, it reduces banking system stability by squeezing profits, lowering bank valuations, and encouraging bankers to make riskier investments because they have less to lose. From this *competition-fragility* perspective, policymakers must make decisions about – and researchers should provide guidance on – (1) the degree of competition that appropriately balances the efficiency benefits and the fragility costs of competition and (2) the use of other supervisory and regulatory policies to mitigate the fragility repercussions of competition.

Based on this competition-fragility view, policy debates about the appropriate degree of competition intensified following the global financial crisis. The Economist magazine noted in 2009 [45] that, “[T]here is clearly some tension between financial stability goals and the tenets of competition policy, which hold that oligopolies are inefficient and serve consumers badly”, and also observed that, “... many policymakers seem to think that some curbs on competition may be a price worth paying to improve stability.” For example, in discussing the Dodd-Frank Act, Federal Reserve Governor Tarullo argued in 2012 [44] that, “... the primary aim of those 849 pages can fairly be read as a reorientation of financial regulation towards safeguarding ‘financial stability’ ” ... and explains how the act encourages the Federal Reserve to consider financial stability, not just competition and efficiency, in making decisions about proposed bank mergers and acquisitions.

The Economist, however, argued against accepting less competition and efficiency in return for greater stability. Rather, it asserted that, “[I]f competition in banking leads to too much risk taking, the right remedy is better supervision.” Thus, without rejecting the view that greater competition reduces stability, the Economist argued for the adoption of other policies that would allow economies to enjoy the efficiency benefits of competition without suffering its destabilizing costs. In line with this view, policymakers, regulatory institutions,

and international financial institutions have expressed both concern that banking systems are becoming excessively concentrated and interest in developing policies that foster stability without impeding competition.

Many, however, reject the view that competition reduces stability. A large body of empirical research finds that more competitive banking systems tend to be more efficient *and* more stable. This can arise for several reasons. Competition might spur improvements in the screening of potential borrowers, the governance of funded projects, and the management of bank risk. These improvements, in turn, enhance the efficiency and stability of banking systems. In addition, efficiency-boosting competition tends to lower interest rates that banks charge to firms and these lower rates can reduce firm bankruptcies and enhance bank stability. From this *competition-stability* perspective, therefore, policymakers and researchers should focus on identifying and reducing impediments to competition because competition will enhance efficiency *and* stability. Clearly, the *competition-fragility* and *competition-stability* views offer markedly different perspectives on the impact of competition on bank stability.

Based on new research, we make three arguments in this paper about bank competition and stability. First, there is a *competition-stability* tradeoff: the removal of regulatory impediments to competition increases the fragility of the banking system. By squeezing bank profit margins and lowering franchise values, competition boosts risk as banks increase lending to riskier firms. The other side of the tradeoff also holds: competition boosts bank efficiency. Regulatory reforms that facilitate competition (a) lower interest margins as banks compete for clients on both sides of the balance sheet, (b) spur financial innovations that improve banking services, and (c) induce banks to become more transparent as they compete in capital markets to issue securities. These last findings - that competition fosters innovation and transparency - can mitigate the long-run impact of competition on fragility, but they do not reverse the result that a regulatory-induced intensification of competition has a net, negative impact on banking system stability. Consistent with the *competition-fragility* view,

these new findings highlight the value of research that helps policymakers choose policies that maximize the efficiency benefits, while minimizing the fragility costs, of competition.

Second, policymakers can mitigate the fragility repercussions of lowering barriers to competition by enhancing bank governance and tightening leverage requirements. With respect to improving bank governance, we mean regulatory policies that either directly or indirectly encourage bank executives to focus more on the long-run value of the bank and less on shorter-run concerns, such as inducing a temporary surge in stock prices that triggers large executive bonuses. To enhance bank governance, policy analysts have proposed, *inter alia*, regulatory policies that (a) encourage the selection of boards of directors at banks that reflect the long-term interests of shareholders and not the shorter term interests of executives, (b) foster the adoption of executive compensation schemes that foster sound executive incentives, including the potential use of executive claw back provisions, and (c) compel the decision makers in banks, which includes bank executives and influential owners, to have material skin-in-the-game, so that those determining bank risk have a sufficient proportion of their personal wealth exposed to those risks. In this paper we do not examine any particular regulatory policy associated with executive incentives. Rather, we explore the impact of regulatory policies in general that enhance the governance of banks.

Our analyses indicate that policies that improve bank governance by incentivizing executives to focus more on the long-run value of the bank reduce excessive risk-taking that could jeopardize the bank's health. Moreover, policies that improve bank governance tend to lessen traditional principal-agent frictions between owners and managers, boosting banking system efficiency. These findings advertise the win-win-win effects of regulatory reforms that improve bank governance: They boost bank stability; they enhance bank efficiency; and they mitigate the risk-increasing effects of regulatory reforms that intensify bank competition.

With respect to leverage requirements, our research suggests that tightening leverage requirements (*i.e.*, raising non-risk-based capital requirements) reduces bank risk taking. The

intuition is as follows. If tightening leverage requirements increases the amount of personal wealth that owners have at risk, then owners will have stronger incentives to constrain excessive bank risk taking. Moreover, we find that tightening leverage requirements has a bigger risk-reducing effect in well governed banks. That is, if a tightening of leverage requirements induces owners to want the bank to take less risk, then the actual reduction in risk will be larger when bank executives act in the long-term interests of the owners. The opposite also holds. If executives don't care about the long-term interests of shareholders (the case in poorly governed banks), then leverage requirements that induce shareholders to want less risk will have little effect on actual risk taking.

There are two bottom-line policy messages on competition, leverage requirements, and bank governance. First, policymakers can mitigate the fragility repercussions of lowering barriers to competition by tightening leverage requirements and enhancing bank governance. Thus, policymakers can get the efficiency benefits of intensifying competition without increasing banking system fragility.

Second, bank capital requirements and governance are inextricably linked: The impact of capital requirements and governance on bank investment and risk decisions cannot be usefully separated. To see this, consider two extreme examples: (1) a bank that is financed only with equity (100% capital requirements), has only small shareholders who cannot effectively govern the bank's manager who is compensated with an option contract that provides a big bonus when bank returns are high but does not materially penalize the manager for poor performance and (2) a bank that is highly levered and has a single owner, who is also the only manager, so that there are none of the standard governance frictions between owners and managers. Even though the first bank is fully financed with equity, it might take excessive risk because of the incentives of the manager and the governance frictions within the bank. Similarly, even though the second bank does not have an owner-manager governance problem, the owner might induce the bank to take excessive risk due to limited

liability and government insurance of the bank's debt holders. Thus, capital requirements and governance combine to shape bank lending and risk. Regulatory reforms that encourage bank executives to focus on the long-run value of the bank increase efficiency, reduce fragility, and increase the effectiveness of capital requirements in reducing excessive risk taking.

Our third argument is that monetary policy will have a bigger effect on lending in more competitive banking systems. In more competitive banking systems with narrower profit margins, contractionary monetary policy triggers a sharper balance sheet response than in banking systems in which banks have large profit margins to cushion the effects of monetary policy on lending. Although policy analysts typically ignore the structure of the banking system in evaluating the effects of monetary policy, our analysis emphasizes the value of accounting for the competitiveness of the banking system in assessing the monetary transmission mechanism.

We rely on two research methods to make these arguments. First and foremost, we develop a dynamic model of the banking system in an imperfectly competitive environment and use this model to examine (1) how competition shapes risk, (2) how policymakers can use regulations on executive incentives, leverage requirements, and bank competition policies to achieve greater efficiency and stability, and (3) how the structure of the banking sector influences the impact of monetary policy on bank lending and risk taking. Building on Corbae and D'Erasmus ([16], [17], [18]), the model has several novel and valuable features. First, it allows for differing degrees of executive myopia, where by executive myopia we mean the degree to which executives focus on their short-run objectives and not on the long-run charter value of the bank. Therefore, the model allows us to explore how regulations that improve bank governance by reducing executive myopia influence bank efficiency and stability. Second, the structure of the banking sector is endogenous; that is, new banks emerge when bank owners expect that entry is profitable. This is valuable because it allows us to examine how bank regulations and monetary policy influence banking industry market

structure (i.e., the endogenous degree of competition). Finally, we introduce “monetary” policy which we model as an exogenous change in the marginal cost of funds (such as a change in the Federal Funds rate). This allows us to assess how monetary policy interacts with the competitiveness of the banking market to influence the aggregate economy. Thus, within a unified analytical framework, the model provides a tool for evaluating the effects of bank regulatory reforms and monetary policy changes on efficiency and stability.

Second, we use regression analyses based on U.S. data to evaluate several key predictions emerging from the model. In particular, we use the methods developed by Jiang, Levine, and Lin ([32], [33], [34], henceforth JLL), who identify exogenous changes to the competitive environment facing individual banks across the United States and examine the impact of competition on bank transparency and risk. The key advantage of using the JLL approach is that it addresses a key limitation with many existing studies: it better identifies exogenous shocks to the competitive environment facing individual banks. The endogeneity challenge is that low risk environments might encourage new banks to enter, generating a positive correlation between competition and stability. This positive correlation, however, might reflect the impact of stability on competition, not the impact of competition on stability. JLL address the endogeneity challenge by identifying shocks to the competitive environment facing individual banks. They then can trace the causal impact of competition on bank risk taking. Thus, we use the JLL approach to test – and confirm – the model’s key predictions. Then, having validated the model’s key predictions, we have greater confidence in the model’s simulations.

The main messages emerging from our research are consistent with the argument advanced by The Economist in 2009: The right strategy for confronting a situation in which an intensification of competition increases efficiency and fragility is not less competition; the right remedy is to implement regulatory and supervisory reform packages that yield the efficiency benefits from lowering regulatory barriers to bank competition while counterbalancing

the impact of competition on bank risk. In particular, regulatory reform packages that (1) facilitate bank competition, (2) improve bank governance by reducing executive myopia, and (3) tighten leverage requirements will tend to foster both bank efficiency and stability.

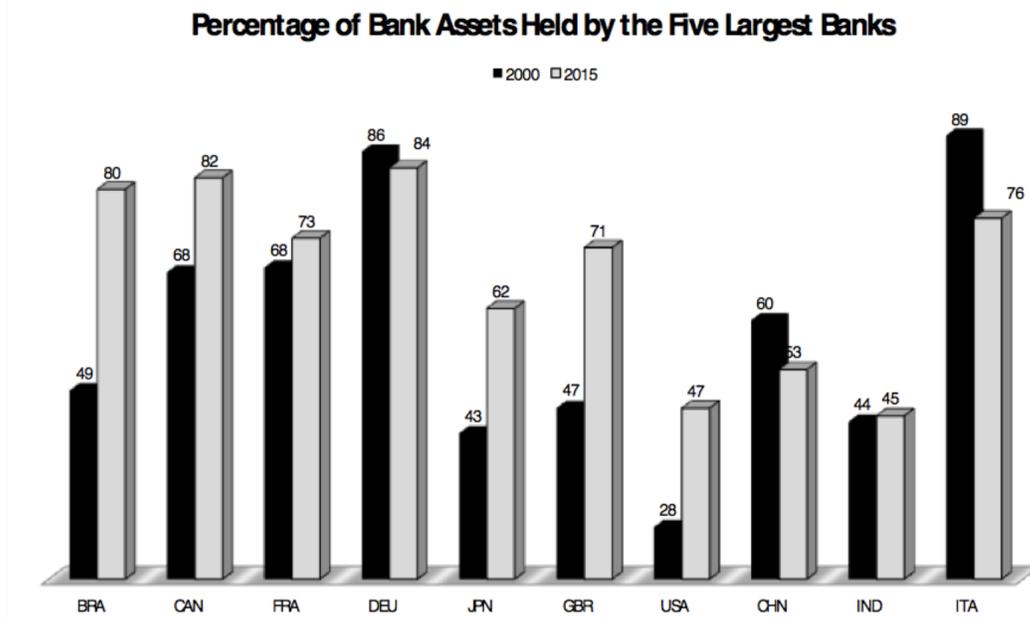
Our work also offers more nuanced messages about bank supervision and regulation. Policies often have repercussions beyond their intended effects. For example, regulatory reforms that reduce executive myopia not only reduce excessive bank risk, they also tend to encourage the efficiency-enhancing entry of new banks. As another example, removing barriers to bank competition not only spurs improvements in banking system efficiency, a more competitive banking market also (a) increases the efficacy of leverage requirements in constraining excessive risk taking and (b) enhances the responsive of the bank lending channel to monetary policy. As a final example, tightening leverage requirements are especially effective at constraining excessive risk taking when bank executives are excessively focused on short-run metrics. These findings emphasize the importance of considering the full ramifications of reforms to bank supervisory and regulatory policies and highlight the value of considering packages of policies. By carefully combining reforms, our research suggests that policymakers can better achieve the goals of an efficient banking system that foster economic prosperity without undue risk to the economy.

Another nuanced message from our research is that the short-run effects of a policy can be the opposite of its long-run effects when the market structure of the banking industry can endogenously respond to the policy. In our model, the short-run is defined as the period when market structure is given, i.e., before banks can enter or exit the market, while the long-run is after the structure of the banking industry responds endogenously to the policy. We show, for example, that if the Fed tightens monetary policy, making it more costly for banks to obtain funds, this squeezes profit margins and spurs banks to increase risk in the short-run. In the long-run, however, lower profitability encourages banks to exit from the market, reducing both competition and incentives for risk taking. Thus, contractionary

monetary policy can lead to short-run fragility and long-run stability.

A third nuanced message is that more risk is not necessarily bad. When we use the term “excessive” risk in this paper, we mean risk that is greater than the amount of risk that an altruistic social planner would choose. For example, with limited liability and government insurance on some of a bank’s liabilities, our model delivers the standard moral hazard result: the banks owners want the bank to take excessive risk. However, our model also shows that high barriers to entry can create a highly uncompetitive banking system that fosters too little risk taking. Thus, we assess whether a particular mixture of policies creates an economy with too little or too much risk relative to the socially optimal level of risk.

Figure 1: International Bank Concentration Across Time



Source: World Bank Global Financial Development Database.

Finally, since one of our major objectives is to offer a model of the banking system that can be used to examine the ramifications of implementing an array of policies, we emphasize the practical importance of allowing for dynamic and imperfectly competitive banking systems. To do this, we illustrate the evolution of bank concentration in the ten largest economies. Figure 1 graphs the percentage of banking system assets controlled by

the five largest banks in 2000 and 2015 (*5 Bank Concentration*). Besides the considerable variability of bank concentration values across countries, we highlight two features. First, six out of the ten countries had *5 Bank Concentration* greater than 70% in 2015. Thus, we build a model that allows for highly concentrated, potentially noncompetitive banking industries. Second, *5 Bank Concentration* grew by over 60% in Brazil and the United States and shrunk by over 10% in China and Italy from 2000 to 2015. Thus, we build a dynamic model of the banking system in which a variety of policies can trigger endogenous changes in the competitiveness of the banking industry.

The paper is organized as follows. Section 2 provides a simple dynamic model of an imperfectly competitive banking system that roughly captures some key features of U.S. data. We then use the calibrated model to make predictions about the relation between competition, stability, and efficiency as well as study the impact of policies in both the short and long run. Section 3 tests some of these predictions using detailed U.S. data.

## 2 Model

### 2.1 Non-Technical Overview of the Model and Results

In this section, we build a model so that we can examine conceptually and evaluate empirically (1) the impact of bank competition on risk taking and efficiency, (2) how policymakers can use regulations on bank leverage requirements and executive incentives to maximize the efficiency benefits of competition while minimizing any increases in bank risk, and (3) how the competitiveness of an economy's banking sector alters the effectiveness of monetary policy.

To increase the usefulness of the model in assessing the impact of regulatory and monetary policies, we include several key attributes. In particular, we develop a dynamic model of the banking system in an imperfectly competitive environment. The model allows for regulations

that shape (a) the costs of entering the banking industry, (b) leverage requirements, which are equivalent to non-risk weighted capital requirements, and (c) the governance of banks. The model is novel in that it combines all of these features with the goal of generating more informative insights on, and a more accurate quantification of, the effects of banking and monetary policies. It accomplishes all this in a tractable framework (three equations in three endogenous unknowns: bank risk, bank lending, and bank market structure).<sup>1</sup>

These attributes are appealing and important along three key dimensions. First, the structure of the banking sector evolves dynamically and endogenously, as banks enter or leave in response to policies, regulations, and expected profits. This is important because it allows us to examine how (1) policies shape the structure, competitiveness, efficiency, and riskiness of the banking industry over time and (2) policies can differentially impact the short-run (before banks enter or leave in response to the policy) and the long-run as the structure of the banking industry changes.

Second, policies shape executive incentives; i.e., policies shape the degree to which a banks executives and influential owners focus on short-run profits or the long-charter value of the bank. By explicitly incorporating agency conflicts into our model, we can assess (1) the impact of governance policies on bank risk and efficiency and (2) how the effectiveness of other policies, including leverage requirements, monetary policy, and regulatory impediments to the entry of new banks, depend on policies that shape the governance of banks.

Third, the model considers efficiency and risk. While some models evaluate the impact of bank regulatory policies on bank efficiency, and others focus on risk, we jointly assess how policies and regulations shape efficiency and risk. This is important because we can use the model to assess how competition policies, leverage requirements, regulations on executive incentives, and monetary policy combine to shape both efficiency and risk. This provides a tool for policymakers seeking to make choices about the combination of regulatory policies

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<sup>1</sup>Alternatively, one can think of the endogenous variables from a corporate finance perspective: bank risk, bank debt, and bank equity.

that yield the appropriate mixture of efficiency and risk for the economy.

After developing the analytical model, we focus on making the model quantitatively useful. To accomplish this, we first select the value of parameters in the analytical model so that the model roughly matches key features of the U.S. banking industry. By calibrating the model to U.S. data, we transform the analytical model into a quantitative tool for evaluating the impact of different policies on the U.S. economy. The calibration could be modified to fit the features of other economies (e.g. other market structures). Second, we assess the model's quantitative usefulness by econometrically testing some of the model's specific predictions. In particular, we show below that (1) the impact of the removal of barriers to bank competition across the United States on bank risk and efficiency matches the predictions emerging from the model and (2) bank risk, leverage, and executive incentives covary in ways suggested by the model. Besides providing direct evidence on the tradeoff between competition and risk, these results help validate the model as a useful tool for evaluating the impact of bank regulatory and monetary policies on the economy.

As we will develop formally below, the model yields several policy-relevant predictions. We conclude this non-technical introduction by emphasizing three of those findings.

1. There is a competition-stability tradeoff. Lowering barriers to competition tends to reduce bank stability and increase bank efficiency, as measured by interest rate spreads and profit margins.
2. Regulatory reforms that (a) induce bank executives to focus more on the long-run value of the bank and less on shorter-run considerations and (b) tighten leverage requirements can offset the risk increasing effects of competition, generating a win-win effect: a more efficient and more stable banking system. Critically, we find that the risk-reducing effects of tighter leverage (capital) requirements are magnified when bank decision makers behave in a less myopic manner.
3. The economy is more sensitive to changes in monetary policy when the banking sys-

tem is more competitive. That is, the structure of the banking system influences the effectiveness of monetary policy.

## 2.2 Relation to the Literature

Our model generalizes the work of Allen and Gale [5] and Boyd and DeNicolo [12] along several important dimensions: (i) Dynamics, (ii) Agency Conflicts, (iii) Endogenous Market Structure, and (iv) Optimal Regulatory and Monetary Policy. Our model is a simplified version of Corbae and D’Erasmus ([16],[18]) which provides a quantitative dynamic structural model of an imperfectly competitive banking industry along the methodological lines of Ericson and Pakes [24] and Gowrishankaran and Holmes [27] using the simulation methodology of Ifrach and Weintraub [28]. A related structural banking model with imperfect competition in the deposit market is by Egan, Hortascu, and Matvos [23]. Our results on the effectiveness of monetary policy across different market structures is related to work by Kashyap and Stein [36]. In particular, the idea in their paper that small banks face higher financing costs with contractionary policy than big banks is consistent with higher funding costs in a more competitive industry in our model.

In particular, solving the bank’s dynamic optimization problem allows us to connect to the literature on bank charter values. Agency conflicts, modeled along the lines of Acharya and Thakor [1] where an executive decision maker may be more myopic than shareholders, provide another rationale for policy intervention. Endogenous market structure arises out of a “free entry” condition whereby shareholders make an initial equity injection to cover entry costs pinning down the equilibrium number of banks. Finally, we provide regulatory tools (modeled as control over bank entry, governance, and leverage constraints) and monetary tools (modeled as the marginal cost of bank funding) for a policymaker to minimize both the deviation of decentralized risk taking and expected output from their efficient levels.

Since market structure is endogenous in our model, a change in policy can affect compe-

tition. Analogous to regulatory arbitrage (where a change in policy affects competition from shadow banks *across* the financial system), here a change in policy can affect competition *within* the banking system. This allows us to avoid the Lucas critique within the banking system.

One of the important insights from the model links the executive's choice of the riskiness of the bank's loan portfolio to interest margins and agency weighted leverage, both of which depend on banking industry concentration. We contrast the market predictions for risk taking with the efficient level of risk taking for our environment and ask whether a policymaker may be able to implement the efficient levels through regulatory or monetary policies. This allows us to focus on the competition, stability, and efficiency properties of the banking industry.

## 2.3 Model Environment

There is a risky technology indexed by  $S \in [0, 1]$ . For each unit input, the technology yields  $A \cdot S$  with probability  $p(S)$  and yields 0 otherwise. The technology exhibits a risk-return tradeoff (i.e., higher return projects are less likely to succeed) since  $p'(S) < 0$ . We make the following parametric assumption  $p(S) = 1 - S^2$ .<sup>2</sup> If  $Z \geq 0$  units are invested in the technology, then expected output is  $p(S) \cdot S \cdot A \cdot Z$ . The (opportunity) cost of the input is given by  $\tilde{\gamma} \cdot Z^2$ , which generates an interior solution.

In the decentralized version of this economy, there are  $N$  banks that Cournot compete for insured deposits. After an initial equity injection,  $E_i$ , to finance the fixed entry costs  $\kappa$  of starting bank  $i$ , loans are financed by deposits as there are no seasoned equity injections (i.e., for bank  $i$ ,  $L_i = D_i$ ).<sup>3</sup> The total supply of deposits is given by  $Z = \sum_{i=1}^N D_i$  with inverse deposit supply function given by  $r_D(Z) = \gamma Z$ . Bank  $i$  can use its deposits as an

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<sup>2</sup>One can introduce a more general probability distribution, such as  $p(S) = 1 - S^\eta$ , which by choosing high enough  $\eta > 2$  can be used to raise the probability of success.

<sup>3</sup>One can interpret the fixed entry costs  $\kappa$  as covering the initial tangible and intangible capital of the bank. Thus, the bank  $i$  balance sheet is given by assets =  $L_i + \kappa$  and liabilities =  $D_i + E_i$ .

input (or loan) into the risky technology. A bank manager chooses the riskiness of the loan portfolio  $S_i$  and its scale  $D_i$  to maximize the discounted profits of the bank subject to a leverage constraint that  $\frac{D_i}{E_i} \leq \lambda$ . The manager discounts cash flows at rate  $\beta$ . There is deposit insurance, for which bank  $i$  pays  $\hat{\alpha}$  per deposit when the bank is solvent. Limited liability implies that if a bank is insolvent, it does not pay its depositors.<sup>4</sup> More generally, we introduce a parameter  $\alpha$  to capture *both* this deposit insurance cost as well as a government policy parameter controlling the marginal cost of obtaining funds (which may be interpreted as a Fed Funds rate). Shareholders with linear preferences and discount factor  $\delta$  make an initial equity injection to cover the entry cost (i.e.,  $E_i = \kappa$ ). The possibility of agency conflicts between the manager and equity holders is captured by  $\delta \geq \beta$ . We assume a large number of managers, so they take compensation as given. Managers receive a constant fraction  $f$  of the earnings of the bank while equity holders receive a fraction  $1 - f$ . Static preferences of the manager are given by  $u(c_M) = \psi_M c_M$  while preferences of equity holders are given by  $u(c_E) = \psi_E c_E$ . For simplicity we take  $\psi_M = f^{-1}$  and  $\psi_E = (1 - f)^{-1}$ .

## 2.4 Planner's problem

To obtain the “efficient” level of risk taking for our model economy, we first solve the planner's problem in a frictionless economy. The planner chooses the level of risk  $S$  and the amount of investment  $Z$  to maximize expected output. The planner's problem is given by

$$\max_{S,Z} \mathcal{O} = p(S) \cdot A \cdot S \cdot Z - \tilde{\gamma} Z^2 \quad (1)$$

An interior solution to (1) is given by

$$S^* = \frac{1}{\sqrt{3}}, \quad Z^* = \frac{A}{3 \cdot \sqrt{3} \cdot \tilde{\gamma}}. \quad (2)$$

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<sup>4</sup>Here, as in the Allen and Gale [5] and Boyd and DeNicolò [12] environments, the entire portfolio either succeeds or fails for simplicity. The general case where there are aggregate and idiosyncratic shocks is considered in Martínez-Miera and Repullo [37].

At the allocation in (2), we have

$$p(S^*) = \frac{2}{3}.$$

Henceforth, we will term an “efficient” allocation of risk and investment the  $(S^*, Z^*)$  chosen by a social planner in a frictionless economy solving problem (1).

## 2.5 Decentralized Cournot Equilibrium

Here we solve for a Cournot equilibrium in a decentralized banking industry with limited liability and agency frictions. Given such frictions, there is a role for policy to mitigate these frictions and bring the decentralized allocation closer to the “efficient” levels of risk and investment chosen by the social planner in the previous section. The literature on optimal linear taxation with commitment has termed the choice of a given set of policy tools in a decentralized economy a “Ramsey equilibrium”. In particular, we will solve for a symmetric Markov Perfect Cournot Equilibrium where

- a. Taking government policy and the number  $N$  of incumbent banks as given, in each period the manager of incumbent bank  $i$  chooses a level of risk taking  $S_i$  and deposits  $D_i$  to maximize the present discounted value of profits taking into account they must Cournot compete with the other  $N - 1$  incumbent banks for their deposits at rate  $r_D(Z)$ .
- b. After incumbent bank exit has occurred, shareholders can make an initial equity injection  $E_i$  to pay for the entry cost  $\kappa$  to start new bank  $i$ .
- c. The regulatory budget constraint must be satisfied in expectation (i.e., payments (proportional to the deposit insurance “tax”  $\hat{\alpha}$ ) by solvent banks and external funds  $F$  must cover deposit insurance on failing banks). We assume that an individual incumbent bank does not internalize that they may affect the “tax” ( $\hat{\alpha}$  they pay to the deposit insurance fund).<sup>5</sup>

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<sup>5</sup>A version of that problem is considered by Davila and Walther [19].

- d. The policymaker commits to a choice of policy parameters  $(\kappa, \beta, \alpha, \lambda)$  to minimize the weighted distance between the decentralized level of risk taking from the planner's level as well as deviations of the decentralized level of expected output from the planner's level given a symmetric Cournot equilibrium.

Note we will call a solution to (a) and (c) a “short-run” Cournot equilibrium (i.e.,  $N$  is taken as given in the short run) while (a), (b), and (c) can be considered a “long-run” Cournot Equilibrium, and finally we call a solution to (a)-(d) a Ramsey equilibrium. For simplicity, our paper focuses on stationary equilibria.

### 2.5.1 Bank Problem

We begin by stating condition (a) in our environment (since  $N$  is taken as given to an incumbent bank). Bank  $i$ 's static profit function is given by<sup>6</sup>

$$\pi_i(N) = p(S_i) [A \cdot S_i - (r_D(Z) + \alpha)] D_i. \quad (3)$$

Since an incumbent manager maximizes the present value of the solvent bank at discount rate  $\beta$ , the dynamic problem of bank  $i$  is given by<sup>7</sup>

$$V_i(N) = \max_{S_i, D_i} \pi_i(N) + \beta p(S_i) V_i(N'), \quad (4)$$

subject to

$$\frac{D_i}{E_i} \leq \lambda, \quad (5)$$

where  $N'$  denotes the number of banks next period. For a given number  $N$  of incumbent banks, the first order conditions from (4)-(5) provide two equations in two unknowns

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<sup>6</sup>It is evident from (3) that if  $\gamma = \frac{\tilde{\gamma}}{p(\tilde{S}^*)}$  and  $\alpha = 0$ , then the aggregate costs of funds in a symmetric decentralized equilibrium is the same as the planner's cost.

<sup>7</sup>The static reward in equation (4) follows since the manager's preferences are given by  $u(c_M) = \frac{c_M}{f}$  and  $c_M = f \cdot \pi$ .

$(S^C, Z^C)$  in a symmetric Cournot equilibrium.<sup>8</sup>

Recognizing a given manager solves problem (4)-(5) to generate a sequence of cash flows  $\pi_i^C(N)$  each period, condition (b) in our definition of equilibrium requires that shareholders with discount rate  $\delta$  will inject equity to fund bank  $i$  entry provided

$$E_i(N) \equiv \frac{\pi_i^C(N)}{1 - \delta p(S_i^C)} \geq \kappa. \quad (6)$$

This free entry condition (i.e., (6) with equality) pins down  $N^C$  in a symmetric equilibrium.

Note that in a symmetric equilibrium (4) and (6) with equality implies

$$V(N^C) = \frac{[1 - \delta p(S^C)]}{[1 - \beta p(S^C)]} \cdot E(N^C), \quad (7)$$

so that there is a wedge  $w(S^C) \equiv \frac{[1 - \delta p(S^C)]}{[1 - \beta p(S^C)]}$  between managerial value of the firm and shareholder value. In particular, when managers are myopic relative to shareholders (i.e.  $\beta < \delta$ ), the wedge  $w(S^C) < 1$  and shareholders value the firm more than the manager (i.e.,  $V(N^C) < E(N^C)$ ).

There are policy-relevant advantages to modeling separately the incentives of executives ( $\beta$ ), the incentives of shareholders ( $\delta$ ), and the wedge between the two ( $w$ ). First, as stressed above, executive compensation schemes, claw back provisions, etc. can all influence the degree of executive myopia. Our model then shows how executive myopia can influence bank risk, lending, and the influence of other policies on the economy. Second, limited liability and too-big-to-fail policies can insulate bank owners from the repercussion of failed investments, inducing owners to put less weight on the future downside implications of risky ventures. In turn, our model shows how a reduction in  $\delta$  tends to increase bank risk taking. Third, many laws and regulations influence the degree to which owners compel executives

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<sup>8</sup>As in many dynamic IO models (see Doraszelski and Pakes [22]), we follow a traditional static-dynamic breakdown whereby a price or quantity decision affects static profitability but not the dynamics of the entire industry.

to act in the best interests of owners. In our model,  $w$  reflects the gap between the owners and executives weighting of the long-run value of the bank.

These agency conflicts have implications for how leverage affects risk taking. In particular, the two first order conditions for problem (4) in an equilibrium where the leverage requirement is non-binding can be written

$$p(S_n^C) = -\frac{p'(S_n^C)}{A} \cdot \left[ R_n^C + \beta \cdot \frac{E(N_n^C)}{D_n^C} \cdot w(S_n^C) \right], \quad (8)$$

$$R_n^C = \frac{r'_D(Z_n^C)}{N_n^C} \cdot Z_n^C, \quad (9)$$

where  $R_n^C \equiv A \cdot S_n^C - (r_D(Z_n^C) + \alpha)$  denotes the interest margin and the subscript “n” denotes “non-binding”. Since  $-p'(S_n^C) > 0$ , (8) implies that ceteris paribus the probability of success is inversely related to leverage and agency conflicts. Further, (8) shows there is an interaction between leverage and agency. Finally, (8) implies that, ceteris paribus, constraints on the amount of leverage the bank can take on (i.e., leverage requirements) will raise the likelihood of success. Finally, equation (9) says that, for a given  $Z$ , the interest margin  $R$  is declining in competition since  $\frac{r'_D(Z)}{N} = \frac{\gamma}{N}$ .

In an equilibrium where the leverage requirement is binding, first order condition (8) is unchanged but (9) becomes

$$R_b^C = \frac{r'_D(Z_b^C)}{N_b^C} \cdot Z_b^C + \frac{\mu}{p(S_b^C)\kappa}, \quad (10)$$

where  $\mu$  is the multiplier on the leverage constraint (5) and the subscript “b” denotes “binding”. Since  $\mu > 0$  when binding, (10) implies that tighter leverage constraints requires higher interest margins (in the short run when  $N$  is fixed) relative to the unconstrained equilibrium. Further, since the constraint binds, we know  $D_b^C = \lambda \cdot \kappa$  which when substituted into (8)

yields

$$p(S_b^C) = -\frac{p'(S_b^C)}{p(S_b^C)} \cdot \frac{w(S_b^C)}{A\lambda}. \quad (11)$$

As in (8) for the non-binding case, (11) shows that ceteris paribus a tight leverage requirement can increase the probability of success while agency conflicts decrease the probability of success. Note, however, that (11) implies that the probability of failure is independent of market structure  $N$  when leverage requirements are binding.

### 2.5.2 Government Budget Constraint

Condition (c) requires that the expected inflows to the deposit insurance fund equal expected outflows, so that<sup>9</sup>

$$F + \hat{\alpha} \cdot p(S^C) \cdot Z^C = (1 - p(S^C)) \cdot r_D(Z^C) \cdot Z^C. \quad (12)$$

The left hand side of (12) represents the flows into the fund from solvent bank being charged  $\hat{\alpha}$  per unit of funds and outside funding sources  $F$  (e.g. tax revenues) to cover the payments to depositors at insolvent banks on the right hand side of (12).

### 2.5.3 Policymakers Problem

Condition (d) endogenizes government policy with commitment as a variant of a “Ramsey Equilibrium”. In particular, the policymaker chooses policy parameters  $(\kappa, \beta, \alpha, \lambda)$  to minimize the weighted distance between the decentralized level of risk taking from the planner’s level (with weight  $1 - \phi$ ) as well as deviations in expected output (with weight  $\phi$ ). The policymaker’s problem is given by

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<sup>9</sup>Note that here we require balance in expectation. Since there is a finite number of banks with independent draws for their portfolio, probabilities are not equal to the actual fraction of solvent and insolvent banks. Only when  $N$  grows to infinity will the law of large numbers kick in.

$$\min_{\{\kappa, \beta, \alpha, \lambda\}} (1 - \phi) \cdot |S^C - S^*| + \phi \cdot |Y^C - Y^*| \quad (13)$$

where  $Y = p(S) \cdot A \cdot S \cdot Z$ .

#### 2.5.4 Calibration

Next we calibrate the model to U.S. data that will form the basis of our empirical work. The model has two sets of parameters. One set are those associated with preferences and technologies  $(A, \tilde{\gamma}, \delta)$ . The second set are those associated with government policy  $(\kappa, \beta, \lambda, \alpha)$ .

The benchmark model we calibrate assumes (a) there are agency conflicts and (b) leverage requirements are non-binding. Taking a model period to be one year, we set  $\delta = 0.99$ . Since the leverage constraint is non-binding, we set  $\lambda$  arbitrarily large. We consider a “tight” monetary environment, setting the marginal cost of a unit of external funds to 4% ( $\alpha = 0.04$ ). Roughly, the FDIC charges solvent banks  $\hat{\alpha} = 1\%$  on their deposits.

The remaining parameters are chosen to match summary statistic data in Table 2 of Jiang, Levine, and Liang [33]. In particular, mean bank concentration of 0.33 implies we target  $N = 3$ .<sup>10</sup> Mean net return on assets of 0.02 implies we target  $\frac{\pi}{D} = 0.02$ . The mean coefficient of variation on assets is constructed from the volatility of assets implied from the Merton [38] model normalized by the gross return on assets to give a scale-free measure of bank profit volatility which is 0.203 while in the model the standard deviation of loan returns normalized by the gross return on assets yields 0.032. Mean leverage of 14.83 in the last year of our sample implies we target  $\frac{D}{E} = 14.83$ . Mean log of total deposits of 22.46 implies we target  $\log(D) = 22.46$ .<sup>11</sup> Table 1 presents the model generated moments relative to the data while Table 2 presents the parameters (those chosen outside the model on top and those chosen within the model below). While the model overestimates bank leverage

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<sup>10</sup>Concentration is measured as the summation of squared bank holding company asset shares (i.e., the Herfindahl index).

<sup>11</sup>It can be shown that  $\tilde{\gamma}$  is uniquely identified by this moment.

and underestimates variation in the return on assets, it does fairly well on other moments.

Table 1: Data and Benchmark Model Moments

|                                             | <b>Data</b> | <b>Model</b> |
|---------------------------------------------|-------------|--------------|
| <b>Concentration</b> ( $\frac{1}{N}$ )      | 0.33        | 0.33         |
| <b>Return on Assets</b> ( $\frac{\pi}{D}$ ) | 0.020       | 0.026        |
| <b>Coefficient of Variation in ROA</b>      | 0.203       | 0.032        |
| <b>Leverage</b> ( $\frac{D}{E}$ )           | 14.83       | 21.88        |
| <b>Deposits</b> ( $\log(D^*)$ )             | 22.46       | 22.33        |

Table 2: Parameters

|                  | <b>values</b> |
|------------------|---------------|
| $\alpha$         | 0.04          |
| $\delta$         | 0.99          |
| <b>A</b>         | 0.40          |
| $\beta$          | 0.90          |
| $\tilde{\gamma}$ | 9e-12         |
| $\kappa^*$       | 226.76        |

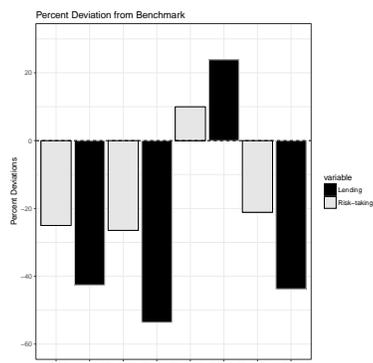
\* In millions. Table 2: Parameters above the line are chosen outside the model.  
Parameters below are chosen inside the model.

### 2.5.5 Model Predictions about Competition, Stability, and Efficiency

Having chosen model parameters to roughly match key U.S. banking data moments, we now use the calibrated model (what we call the “benchmark” where  $N = 3$ ) to make predictions about competition, stability, and efficiency. In the benchmark model, individual banks make noncooperative decisions in a decentralized environment with limited liability and agency conflicts (as opposed to a social planner selecting optimal levels of risk and lending in a frictionless environment). Figure 2a depicts percentage deviations of risk taking ( $S$ ) and aggregate lending ( $Z$ ) from the benchmark vis-a-vis levels (a) chosen by the social planner, (b) that arise in a less competitive economy (where  $N = 1$ ), (c) that arise in a more competitive economy (where  $N = 5$ ). Furthermore, it shows the percentage deviations of risk taking and aggregate lending that arise when a policy maker optimally chooses entry barriers ( $\kappa$ ) to minimize equally-weighted ( $\phi = 0.5$ ) deviations of bank risk taking and output from the social planner’s efficient levels.

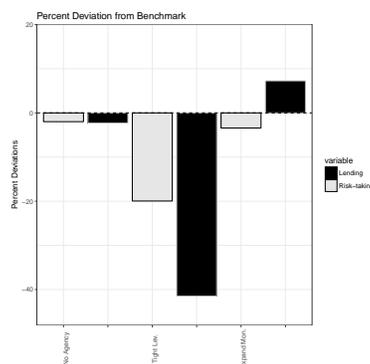
What are the predictions from the changes in market structure depicted in Figure 2a (and presented in more detail in Table A1 in the Appendix)? In these experiments, we choose the level of entry costs  $\kappa$  consistent with a given market structure. For example,  $\kappa$  is lower for the benchmark with  $N = 3$  than the  $\kappa$  consistent with the monopoly case where  $N = 1$ .

Figure 2: Risk-Taking and Aggregate Lending Across Short-Run Policy Interventions



(a) Varying Competition

Percent deviations from the benchmark ( $N=3$ ), Social Planner, Less Competitive ( $N=1$ ), More Competitive ( $N=5$ ), Optimal Policy ( $N=1.3$ ). See Table A1 for details.



(b) Varying Alternative Policies

Percent deviations from the benchmark. No agency ( $\delta = \beta = .99$ ), Tight Leverage ( $\lambda = 7$ ), Monetary ( $\alpha = 0.01$ ). See Table A2 for details.

First, there is a monotonic relation between competition  $N$  and risk taking  $S$ . That is, risk taking in a less competitive ( $N = 1$ ) economy is 27% lower than the benchmark while risk taking is 10% higher in a more competitive ( $N = 5$ ) economy. These choices translate into a 67% higher probability of success in the less competitive economy and a 31% lower probability of success in the more competitive economy.

Second, relative to the social planner’s choice of risk taking, despite the agency problems and limited liability, banks in the less competitive economy actually take less risk 27% versus 25% lower for the social planner relative to the benchmark. Since the choices of the decentralized bank differ from the social planner’s choice, there is a role for a policymaker to intervene.

Third, relative to the social planner, there is “over-investment” ( $Z$ ) in the benchmark and more competitive economies. The social planner chooses a level of  $Z$  which is 43% lower than the benchmark and the more competitive economy, where  $N = 5$ , has 24% higher investment than the benchmark. The less competitive economy, where  $N = 1$ , has 54% lower investment than the benchmark and “under-invests” even relative to the social planner.

Fourth, leverage is monotonically increasing in the degree of competition. That is, lever-

age is 76% lower in the less competitive economy than in the benchmark while banks in the more competitive economy choose 134% higher leverage than the benchmark.

Fifth, interest margins ( $R \equiv A \cdot S - (r_D(Z) + \alpha)$ ) are monotonically decreasing in the level of competition. That is, interest margins are 39% higher in the less competitive economy while they drop by 26% relative to the benchmark when  $N = 5$ . Expected static ( $\pi$ ) and long run profits ( $\kappa = E$ ) are decreasing in the level of competition.

Finally, since risk taking is increasing in competition, expected expenditures to finance failures ( $F/Y$ ) is also rising. Competition increases the likely payout from the deposit insurance agency.<sup>12</sup>

Given that there is excessive risk taking and over-investment in the benchmark, there is room for a policy-maker to adjust entry barriers to help alleviate this inefficiency. As evident from the previous findings, the less competitive market structure ( $N = 1$ ) has risk taking and lending closer to those levels chosen by a social planner in a frictionless economy. To analyze how policy makers would choose the optimal entry barriers, we need to define “optimal”. Here, we have the policy maker choose the level of entry barriers that minimizes deviations from the levels of risk taking and output chosen by the social planner. We give equal weight to deviations from risk taking and output, so that the policymaker chooses  $\kappa$  to solve problem (13) where  $\phi = 0.5$ ). It is clear from Figure 2a and Table A1 that by choosing a higher entry barrier ( $\kappa$  rises by 343% inducing the “number” of banks to fall by 57%), the policy results in risk taking and investment which converge towards the efficient level chosen by the social planner.<sup>13</sup> Further, Table A1 makes clear that the optimal policy induces banks to take on much less leverage (i.e., 70% lower) than the benchmark. This

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<sup>12</sup>Interestingly, intermediated output is not monotonically increasing in competition. In particular, the less competitive economy has 43% lower output than the benchmark as well as 5% lower in the more competitive economy than the benchmark. Table A1 also presents the coefficient of variation in output across market structures. That measure is monotonic; the coefficient of variation is 82% lower in the less competitive economy and 65% higher in the more competitive economy.

<sup>13</sup>For our benchmark calibration, these results are robust to setting  $\phi = 1$ , so that the policymaker has the same objective as the social planner.

completes the description of a “Ramsey” equilibrium for our environment.

### 2.5.6 Model Predictions with Alternative Policy Interventions

We now use the model to make predictions about competition and stability across a set of possible alternative policy interventions. We do so by computing equilibria under the following alternative parameterizations: (a) policies designed to eliminate agency conflicts (i.e., we increase the manager’s discount factor  $\beta = .90$  to that of the shareholders  $\delta = .99$ ), (b) impose binding leverage constraints (i.e., we drop  $\lambda$  from an arbitrarily large number to 7, which is a binding constraint relative to the benchmark), and (c) implement expansionary monetary policy (i.e., we reduce the marginal cost of funds to  $\alpha = 0.01$ ).

We first conduct the experiments maintaining a given market structure  $N$ , interpreting it as the “short-run” impact of a change. To maintain a given market structure, we alter the entry cost,  $\kappa$ , to maintain that market structure. In Figure 2b and Table A2 in the Appendix we present these “short-run” deviations from the benchmark  $N = 3$  associated with alternative policies. In Figure 3a and Table A2 in the Appendix we solve for the “long-run” equilibrium associated with the policy intervention using the benchmark level of entry costs. The “long-run” equilibrium allows the industry structure to change in response to policy interventions.

#### Short-Run Equilibria

First, we analyze the impact of agency conflicts in the first two bars of Figure 2b (and column 2 of Table A2). Better governance policies that induce a manager to be less myopic engender less risk ( $S$  drops by 2% relative to the benchmark) resulting in a 6% increase in success probability. Less myopic managers “under-lend/under-invest” relative to the benchmark and take on less leverage (i.e.,  $Z$  drops by nearly 2% and D/E drops by over 7%). Interest margins drop by nearly 2% (because the manager takes on less risky lower return projects) while short run profitability and equity value of the bank rise ( $\pi$  increases by 1%

while  $\kappa$  jumps by 5%). Thus, myopia actually lowers the value of the bank to the manager.

Second, we analyze the impact of tightening leverage requirements (to a level which is binding relative to the unconstrained benchmark) in the second set of bars in Figure 2b (and column 4 in Table A2). Tighter leverage requirements lead to less risk taking ( $S$  falls by 12% relative to the benchmark) resulting in a higher success probability ( $p(S)$  rises by over 34%). Tighter leverage constraints reduce lending/investment relative to the benchmark ( $Z$  falls by 27%). Thus, tighter leverage requirements drive the economy toward the risk and lending levels selected by the social planner. Interest margins rise by 23% and short run expected profitability and the equity value of the bank rise ( $\pi$  rises by about 21% while  $\kappa$  rises 57%).

Third, we analyze the impact of a policy which reduces the marginal cost of funds in the last set of bars in Figure 2b (and column 6 of Table A2). One way to interpret this is expansionary monetary policy (i.e., a drop in the Fed Funds rate). A drop in the marginal cost of funds leads banks to take on less risk ( $S$  drops by 3% relative to the benchmark) resulting in a higher success probability ( $p(S)$  rises by over 10%). Expansionary monetary policy leads to more aggregate lending/investment relative to the benchmark ( $Z$  increases by over 7%). While individual bank lending rises, it rises by less than equity values so that leverage declines at the individual bank level (D/E drops by 21%). Interest margins, short run profits, and the equity value of the bank all rise ( $R$  rises by 7% while  $\kappa$  rises by nearly 35%).

Finally, we emphasize that the same policy change may interact with other features of the economy to magnify the effectiveness of the policy. For instance, a tightening of leverage constraints can be expected to alter the risk-taking of managers whose incentives are aligned to that of shareholders differently than those with significant agency frictions (due perhaps to lax governance). Owing to the highly non-linear elasticity of our agency wedge  $w(S_n^C)$  with respect to risk-taking  $S_n^C$  in (8), leverage and managerial myopia do

not generate cross-partials of the same sign everywhere in the parameter space. However, if we restrict ourselves to relatively small agency conflicts, the interaction of tightening leverage (reducing  $\lambda$ ) and decreasing agency conflicts (increasing  $\beta$ ) will *magnify* the reduction in risk-taking. Denote  $S(\lambda, \beta)$  to be the equilibrium risk-taking with leverage constraint  $\lambda$  and manager discount factor  $\beta$  holding all other parameters constant. We have computed a counterfactual where *both* leverage constraints are tightened and agency conflicts are solved (i.e., setting  $\lambda = 7$  and  $\beta = 0.99$ ). Under our benchmark calibration, we find that the percentage change in risk-taking from tighter leverage requirements is  $\Delta(S; \beta_L = 0.90) = \frac{S(\lambda_L, \beta_L) - S(\lambda_H, \beta_L)}{S(\lambda_H, \beta_L)} = \frac{0.616 - 0.770}{0.770} = -19.96\%$  while in an environment where there is no agency conflict the percentage change in risk-taking induced by the tightening of leverage requirements is  $\Delta(S; \beta_H = .99) = \frac{S(\lambda_L, \beta_H) - S(\lambda_L, \beta_H)}{S(\lambda_H, \beta_H)} = \frac{0.592 - 0.755}{0.755} = -21.61\%$ . That is, we find an 8% higher interaction effect when agency conflicts are mitigated than in the baseline case. This finding motivates our empirical analysis in Section 3.4.

### Long-Run Equilibria

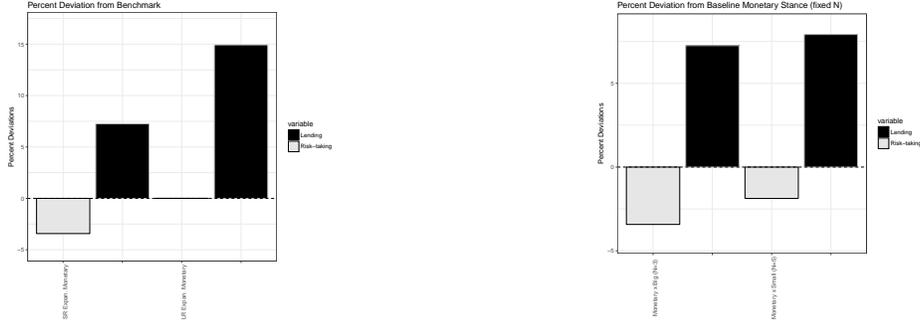
We now consider the long-run. To do this, we fix the level of entry costs,  $\kappa$ , at its benchmark level and allow banks to enter or exit in response to a given policy change. For example, if the Fed follows an expansionary monetary policy (decreasing the Fed Funds rate lowering the marginal cost of obtaining funding), then profitability is expanded. In the long run however, higher profitability increases the incentive for bank entry thereby leading to more competition which increases the incentives to take on more risk. Thus, an expansionary monetary policy, for instance, could lead to short run stability and long run in-stability.

Figure 3a illustrates the potential differences between short and long run implications of a change in monetary policy.<sup>14</sup> The figure documents that there can be substantial differences between short and long run responses to policy. The short run effect of expansionary

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<sup>14</sup>Table A2 provides information on our other policy changes - eliminating agency conflicts and tightening leverage requirements.

Figure 3: Monetary Policy Interventions



(a) Short-Run vs. Long-Run Monetary policy (b) Monetary policy across market concentration

Percent deviations from levels of same market size. See Table A3 for details.

monetary policy (seen in more detail in the Appendix, Table A2) is to lower risk taking  $S$  by 3% (and hence increase success probability  $p(S)$  by 10%). In the long run, however, higher profitability induces entry, increasing the “number” of banks in the market by nearly 17%. Rising competition, which *ceteris paribus* leads banks to take more risk, offsets the short run decrease in risk taking so that there is a zero long-run impact on risk taking (relative to the benchmark). Further, the short-run increase in aggregate lending is magnified in the long-run (i.e.,  $Z$  is 7% higher than the benchmark in the short run while it is 15% higher in the long run. In summary, the short run and long run impacts of expansionary policy on risk taking go in opposite directions so that there is essentially no long run effect on risk taking.

### Monetary Transmission and Competition

In Figure 3b (and Table A3 in the Appendix), we consider the impact of expansionary monetary policy in two different market structures. In particular, we ask what is the effect of reducing  $\alpha$  to 0.01 from 0.04 in the benchmark ( $N = 3$ ) market structure versus a more competitive economy ( $N = 5$ )? This is relevant for thinking about the monetary transmission mechanism that was studied in Kashyap and Stein [36]. They found that contractionary monetary policy lowered lending by smaller banks ( $N = 5$ ) more than larger banks ( $N = 3$

in our environment). Here we simply conduct the counterfactual that expansionary monetary policy raises lending by smaller banks more than larger banks.

The results in Figure 3b (and Table A3 in the Appendix) confirm that our model is consistent with the results of Kashyap and Stein. In particular, smaller banks increase their lending by 8% while larger banks expand their lending by 7% in response to a drop in  $\alpha$  from 0.04 to 0.01.<sup>15</sup> While the monetary transmission mechanism is stronger in less concentrated markets, the positive effect of expansionary policy on raising success probabilities is stronger in more concentrated industries (i.e.,  $S$  is reduced by 3% by big banks while it is reduced by 2% by small banks).

### 3 Empirical Results and Model Validation

In this section, we evaluate empirically whether an intensification of the competitive environment facing a bank (1) reduces the bank’s franchise (charter) value and (2) increases bank fragility. That is, we test a key set of predictions emerging from the model: By squeezing bank profit margins and depressing bank valuations, competition encourages bankers to make riskier investments, boosting bank fragility. As detailed below, our empirical evaluation follows directly from JLL [33].

#### 3.1 Empirical Challenges to Evaluating the Impact of Competition on Stability

We are not the first – by far – to assess the relationship between competition and fragility empirically. An extensive academic literature examines the competition-stability nexus, offering conflicting results. Consistent with the competition-fragility view, for example, Keeley [35], Gan [26], Beck, Demirguc-Kunt, and Levine [9], Berger, Klapper, and Turk-

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<sup>15</sup>This is because the percentage change in  $Z = N \cdot D$  equals the percentage change in  $D$  since  $N$  is fixed as we vary  $\alpha$ .

Ariss [10], Beck, De Jonghe, and Schepens [10], and Buch, C., C. Koch, and M. Koetter [14] find that banks with more market power tend to be more stable. In contrast, an influential line of research discover evidence that supports the competition-stability view, e.g., Barth, Caprio, and Levine [6], De Nicolo et. al. [20], Petersen and Rajan [39], Zarutskie [46], Schaeck, Cihak, and Wolfe [41], Boyd, De Nicolo, and Jalal [13], Houston et. al. [31], Fu, Lin, and Molyneux [25], and Akins et. al. [4](2016).

Statistical and measurement challenges help account for these conflicting findings. The statistical challenges include endogeneity and, relatedly, omitted variable bias. For example, more stable banking markets might attract new banks to enter those markets. This could generate a positive correlation between stability and competition and lead observers to erroneously conclude that competition boosts stability. In terms of omitted variables, there might be factors that drive both competition and stability. For example, improvements in the regulatory environment might attract new banks and foster stability. Unless researchers account for those improved regulations in their analyses, the data will reveal a positive relationship between competition and stability and could lead observers to erroneously conclude that competition enhances stability.

Complexities with measuring competition also make it difficult to draw confident inferences about the relationship between bank competition and stability. Indeed, there is no universally accepted measure of competition. Many use bank concentration, but concentration does not gauge the contestability of banking markets and therefore might ignore an important feature of the competitive pressures facing banks. As example of the danger of using concentration as a measure of competition, consider the U.S. banking system during the 1970s. There were over 30,000 banks. This large number of banks, however, reflected regulations that protected local monopolies; the low bank concentration metrics did not reflect intense competition. In this case, regulations produced low concentration and low competition.

Measuring bank risk is also not trivial. Many researchers use accounting-based measures, such as nonperforming loans, loan loss provision, loan charge-offs, profit volatility, risk-weighted assets, or a bank's the Z-score, but these accounting-based measures are subject to manipulation, as shown by JLL [32], and may vary across regulatory jurisdictions and over time as accounting rules change. An additional concern with using accounting-based risk measures relates to timing. A policy shock to the competitive environment that increases the riskiness of bank loans could take many years to affect nonperforming loans, loan losses, charge-offs, etc. The complex lag between changes in competition and accounting entries on bank balance sheets makes it difficult to match the timing of the shock to competition with accounting-based risk measures. As JLL argue, therefore, there are advantages to using market-based risk measures, since securities prices are more likely to reflect immediately the expected present value of the regulatory-induced change in the competitive environment facing a bank and not accounting-based measures which are subject to manipulation, regulatory changes, and timing concerns.

### **3.2 The JLL Empirical Methodology**

JLL [33] address both the statistical and measurement challenges, thereby offering new evidence on the impact of bank competition on bank risk. In this subsection, we describe their strategies for computing exogenous, regulatory-induced changes in the competitive environment facing individual banks and for measuring bank risk. We then define their market-based measures of risk that avoid the shortcomings associated with accounting-based risk metrics.

There are two key building blocks to JLL's construction of time-varying measures of the regulation-induced competitive pressures facing each bank holding company (BHC) in the United States over the 1982 to 1995. First, in a chaotic sequence of unilateral, bilateral, and multilateral reciprocal agreements over more than a decade, states lowered barriers to cross-

state banking, increasing the competitiveness of banking markets. Specifically, for most of the 20th century, each state prohibited banks from other states from establishing affiliates within its borders. Starting in 1982, individual states began removing these restrictions. States started removing restrictions in different years and followed different dynamic paths in removing restrictions with different states over time. Some states unilaterally opened their borders. Most signed a series of bilateral and multilateral reciprocal agreements with other states, where the timing of these agreements differed by state-pairs and groups of states. This state-specific process of interstate bank deregulation continued until the Riegle-Neal Act effectively eliminated restrictions on well-managed, well-capitalized BHCs acquiring BHCs and bank subsidiaries in other states after September 1995. Earlier studies simply coded a state as “closed” or “open”, and defined a state as open for all years after it first deregulated with any other state. JLL exploit the heterogeneity of each state’s dynamic pattern of interstate bank deregulation. Thus, for each state and each year, they determine which other state’s BHCs can establish subsidiaries in its borders.

The second key building block differentiates among BHCs within the same state and year. To do this, JLL use the gravity model of investment. It assumes that the costs to a firm or bank of establishing and effectively managing an affiliate increase with the geographic distance between the BHC’s headquarters and the affiliate. Consistent with this gravity view of bank behavior, Goetz, Laeven, and Levine ([29],[30]) show that BHCs are more likely to expand into geographically close markets. The gravity model has important implications for the competitive pressures triggered by interstate bank deregulation. The gravity model predicts that a BHC  $b$  headquartered in state  $k$  will experience a greater intensification of competition from BHCs in state  $j$  if BHC  $b$  is geographically closer to state  $j$  because it is less costly for state  $j$ ’s BHCs to establish subsidiaries closer to BHC  $b$ . That is, when Wyoming relaxes interstate banking restrictions with Montana, BHCs in northern Wyoming (e.g., banks in Sheridan) will experience a sharper increase in competition than BHCs in

southern Wyoming (e.g., banks in Cheyenne).

JLL then combine these building blocks to create time-varying measures of the competitive pressures facing each BHC. First, for each bank subsidiary in each year, identify those states banks that can enter the subsidiary's state and calculate the distance between the subsidiary and those states. Second, use the inverse of this distance as an indicator of the competitive pressures facing the subsidiary. Finally, calculate the competitive pressures facing each BHC by weighting these subsidiary-level competition measures by the percentage of each subsidiary's assets in the BHC. By employing different methods for calculating the distance between each subsidiary and each of the other states, JLL construct several competition measures. For example, they use the distance between the subsidiary and the capitol of other states. They also construct synthetic measures of the geographic center of banking activity in each state and use this synthetic geographic location to compute the distance between the subsidiary and each other state. The results hold across the different distance measures. In our analyses, we use *Competition*, which is based on the distance between the subsidiary and the capitol of the other states.

The time-varying, BHC-specific competition measure that we employ addresses several measurement and statistical concerns. First, it measures the contestability of markets, and therefore avoids the complications associated with inferring competition from market structure. Second, by combining the dynamic process of interstate bank deregulation with the geographic location of each bank, the competition measure differs by BHC and time. This addresses key endogeneity and omitted variable concerns as the statistical analyses can now control for time-varying state-year characteristics, such as changes in accounting rules, other regulatory reforms, changes in tax systems, economic conditions, etc. Thus, by employing this new competition measure, the analyses can now include state-year and BHC fixed effects that reduce the possibility that omitted variables that vary simultaneously with interstate bank deregulation drive the results.

JLL also address a key measurement concern with standard risk measures. Rather than using accounting-based risk measures, they employ several market-based measures. In particular, they examine an assortment of individual bank risk measures based on stock return volatility, tail risk, and the residuals from asset pricing models. They find consistent results across the different risk measures. In our analyses, we focus on *Bank Risk*, which equals the natural logarithm of the standard deviation of daily stock returns. Besides studying individual bank risk, JLL also examine measures a bank’s contribution to overall systemic risk based on the work by Adrian and Brunnermeier [3] and Acharya et al [2]. They find competition also increases systemic risk. Given our slightly different regression specification, we confirm all of the JLL results but do not report them here for brevity. These results on competition and systemic risk and the other results from JLL discussed below using our specification are available on request.

Given these inputs, we assess the impact of competition on bank franchise (charter) value and bank risk using the following regression specification:

$$Y_{bst} = \gamma_C \cdot Competition_{bst} + \gamma'_X \cdot \mathbf{X}_{bst-1} + \theta_b + \theta_{st} - \varepsilon_{bst} \quad (14)$$

For BHC  $b$ , headquartered in state  $s$ , in year  $t$ ,  $Y_{bst}$  is either *Charter Value*, which equals the natural logarithm of the market value of the bank divided by the book value of assets or *Bank Risk*, which equals the natural logarithm of the standard deviation of daily stock returns.  $Competition_{bst}$  is the measure of regulatory-induced competitive pressures facing BHC  $b$  in state  $s$ , in year  $t$  that is defined above. In addition, we include several time-varying BHC-level controls. Specifically,  $\mathbf{X}_{bst-1}$  represents a vector of time-varying BHC traits, measured in period  $t-1$ , where  $Log(Total Assets)-Lagged$  equals the natural logarithm of the BHC’s total assets one-year lagged, and  $Leverage - Lagged$  equals the BHC’s debt to equity ratio one-year lagged. Finally, the regressions control for bank ( $\theta_b$ ) and state-year ( $\theta_{st}$ ) fixed effects, and  $\varepsilon_{bst}$  is the error term. We report heteroskedasticity-consistent standard

errors, clustered at the state level.

In evaluating the impact of competition on franchise value and risk, we focus on the estimate of  $\gamma_C$ . For example, consider the regression when the dependent variable is *Bank Risk*. If the estimated value of  $\gamma_C$  is greater than zero, this indicates that a regulatory-induced intensification of competition boosts bank risk. The regression also includes *Leverage – Lagged*. Although the model developed in Section 2 provides predictions about the impact of leverage requirements on bank risk taking, care must be taken in interpreting the coefficient estimate on Leverage through the lens of the model. The model focuses on the maximum leverage ratio imposed by regulators, while the regression includes the actual debt-equity ratio of the BHC in year  $t-1$ . Thus, while the regression provides information on the relationship between leverage and risk, it does not quantify the impact of an exogenous change in the leverage requirement on risk.

### 3.3 The Impact of Competition

We find that an intensification of competition reduces charter value. As shown in column (1) of Table 3, *Competition* enters negatively and significantly in the *Charter Value* regression. Furthermore, the estimated economic impact of competition on BHC profits and franchise value is large. For example, consider a BHC that experiences a change in *Competition* from the 25<sup>th</sup> percentile to the 75<sup>th</sup> percentile of the sample distribution, which implies an increase in regulation-induced competition of 0.82. Then, the coefficient estimate from column (6) indicates that *Charter Value* would fall by about 50%. Furthermore, JLL [33] show that competition squeezes bank profit margins. These results on charter value and profits are crucial because they validate the mechanisms underlying the competition-fragility view: competition reduces profits and charter value, which in turn incentivizes bankers to take greater risks.

Moreover, we find that an intensification of competition increases bank risk. Thus, we

Table 3

| Competition, Leverage, Executive Myopia, and Bank Risk |                        |                       |                        |                        |
|--------------------------------------------------------|------------------------|-----------------------|------------------------|------------------------|
|                                                        | Charter Value          | Bank Risk             |                        |                        |
|                                                        | (1)                    | (2)                   | (3)                    | (4)                    |
| Bank Competition                                       | -0.6050**<br>(0.2285)  | 0.6774***<br>(0.1619) | 0.5994***<br>(0.1778)  | 0.6265***<br>(0.1787)  |
| Leverage-Lagged                                        | -0.0320***<br>(0.0077) | 0.0245***<br>(0.0047) | 0.0119**<br>(0.0048)   | 0.0142**<br>(0.0056)   |
| % Institutional Ownership                              |                        |                       | -1.1725***<br>(0.1968) |                        |
| Leverage*Institutional Ownership                       |                        |                       | 0.0497***<br>(0.0129)  |                        |
| Blockholders Top 10                                    |                        |                       |                        | -1.1070***<br>(0.2414) |
| Leverage*Blockholders-Top 10                           |                        |                       |                        | 0.0599***<br>(0.0174)  |
| Ln(Bank Assets)-Lagged                                 | -0.3152***<br>(0.1109) | -0.1914**<br>(0.0749) | -0.1919**<br>(0.0748)  | -0.1968**<br>(0.0742)  |
| BHC fixed effects                                      |                        | yes                   | yes                    | yes                    |
| State-year fixed effects                               |                        | yes                   | yes                    | yes                    |
| Observations                                           |                        | 1996                  | 1996                   | 1996                   |
| R-squared                                              |                        | 0.7913                | 0.7945                 | 0.7919                 |

Notes: This table presents regression results of bank charter value and bank risk on bank competition and other banking traits. In column (1), the dependent variable is Charter Value, which equals the natural logarithm of market value of bank assets divided by the bank's book value of assets. In columns (2) - (4), the dependent variable is Bank Risk, which equals the natural logarithm of the standard deviation of daily stock returns. Bank Competition is the time-varying, BHC-specific measure of competition defined in the text. As indicated, all of the regressions control for Leverage-Lagged, which equals the one-year lagged value of the BHC's debt to equity ratio, Ln(Bank Assets)-Lagged, which is the lagged value of the log of total bank assets, and Leverage-Lagged, which equals the one-year lagged value of the log the total assets of the BHC, as well as BHC and state-year fixed effects. In the last two columns, two proxies for the degree to which the bank has a large, institutional owner, and its interaction with leverage are included.. Specifically, % Institutional ownership equals the percentage of shares held by institutional investors and Blockholders Top 10 equals the percentage of shares held by the 10 largest institutional investors in this bank. We interpret larger values of these concentrated ownership indicators as signaling less executive myopia under the assumption that large, concentrated owners should be able to exert more effective governance over executives. The sample consists of BHC-year observations from 1987 through 1995. The dependent variable is Bank Risk. Bank Competition is the time-varying, BHC-specific measure of competition defined in the text. Heteroskedasticity robust standard errors clustered at the state level are reported in parentheses. \*, \*\*, and \*\*\* indicate significant at 10%, 5%, and 1%, respectively.

confirm the findings in JLL [33] using a regression specification derived from the model presented above. As shown in column (2) of Table 3, a regulatory-induced intensification of the competitive pressures facing a bank increases the riskiness of the bank (*Bank Risk*). The estimated impact is economically large. For example, again consider a BHC that experiences a change in *Competition* from the 25<sup>th</sup> percentile to the 75<sup>th</sup> percentile of the sample distribution, i.e., an increase of 0.82. The column (2) estimates suggest that the *Bank Risk* would be 56% greater in the more highly competitive environment.

With respect to the other explanatory variables, the results confirm the predictions of our

model. Consistent with the views that larger banks are better diversified (Goetz, Laeven, and Levine [30]) and perhaps also too-big-to-fail, we find that bank size, *Log(Total Assets)–Lagged*, is inversely related to risk. Consistent with the view that more levered banks are more fragile, we find that *Leverage–Lagged* is positively associated with risk.

Banks can increase risk in several ways. They might increase lending to riskier clients, expand the maturity mismatch between assets and liabilities, become less diversified, or increase investments in non-loan activities and securities. JLL [33] show that a regulatory-induced intensification of competition boosts bank lending to riskier firms as measured by less profitable firms and firms closer to default. Although these results do not suggest that banks increase risk-taking only through this “lending to riskier firms” mechanism, these findings are consistent with our model, which predicts that competition induces banks to lend to riskier firms.

### **3.4 How Leverage and Governance Interact to Shape Bank Risk**

As discussed above, the model offers insights into how leverage requirements and regulations on executive incentives interact to shape excessive risk taking by banks. In particular, the model explains how (under plausible parameterizations) a tightening of leverage requirements will have a bigger risk-reducing effect when bank executives are more concerned about the long-run profitability of the bank and hence less myopic. The intuition is as follows: forcing banks to be equity financed will reduce the excessive risk taking more if bank executives are more concerned about the equity value of the bank. The model also indicates that regulations that induce bank executives to focus less on short-run bonuses and more on the longer-run charter value of the bank will have a larger risk-reducing effect when the bank is less levered. The policy implication is potentially first-order: The result stresses that leverage requirements and regulations on executive incentives are reinforcing. It is not just that each independently reduces excessive risk taking; it is that each policy also magnifies the

impact of the other policy. Put differently, tightening leverage requirements in the presence of myopic executives will have much weaker effects on bank stability than tightening leverage requirements when bank executives have less distorted incentives.

In this subsection, we turn to the data and assess whether empirical proxies for bank risk, leverage, and executive incentives co-move in ways consistent with these predictions from the model. Unlike the examination of competition, we do not evaluate the causal impact of leverage requirements, regulations on executive incentive, and the interactions of these policy levers on risk. Rather, we assess whether the patterns in U.S. data align with model simulations.

To conduct this assessment, we face a major challenge: constructing an empirical proxy for the degree to which bank executives maximize the long-run charter value of the bank. To construct this proxy, we would benefit from having data on executive “claw back” provisions, the degree to which each bank’s board of directors reflects the interests of shareholders relative to those of executives, the details of executive compensation schemes, each executive’s personal wealth exposure to the bank as a proportion of the executive’s total wealth, etc. Such information, however, is not widely available for a large number of U.S. banks and their executives over a long time period.

We use a measure of the extent to which banks have large and informed owners who can effectively compel bank executives to maximize the long-run value of the bank. We use (1) *% Institutional Ownership*, which equals the percentage of shares held by institutional investors and (2) *Blockholders Top 10*, which equals the percentage of shares held by the ten largest institutional investors in this bank. We assume (a) institutional investors are more informed than individual investors and (b) larger, more concentrated ownership teams can more effectively exert influence over bank executives. Thus, we interpret larger values of *% Institutional Ownership* and *Blockholders Top 10* as signaling that bank executives will have greater incentives to maximize the long-run charter value of the bank.

To examine empirically the relationship bank risk, leverage, and executive incentives, we modify the regressions in Table 3 and include measures of executive incentives, either *% Institutional Ownership* or *Blockholders Top 10*, and the interaction between bank leverage (*Leverage-Lagged*) and these proxies for executive incentives. Our model predicts that

1. *% Institutional Ownership* and *Blockholders Top 10* will enter negatively: More concentrated, institutional ownership will incentivize executives to focus more on the long-run, lowering risk.
2. *Leverage-Lagged* will enter positively: More levered banks are riskier.
3. *% Institutional Ownership\*Leverage-Lagged* (and *% Institutional Blockholders Top 10\*Leverage-Lagged*) will enter positively: Fluctuations in leverage have a bigger impact on risk when executives have a longer-term focus than when executives are more focused on short-run performance metrics.

As shown in Table 3, the regression results are fully consistent with these predictions. That is, the regression results suggest that a tightening of leverage (or capital) requirements will have a bigger risk-reducing effect when other regulatory policies effectively induce bank executives to focus more on the long-run value of the bank and less on short-run performance metrics.

### 3.5 Summary

There are two big messages emerging from the regression analyses. First, an intensification of the competitive environment facing a bank lowers its franchise value and increases risk taking. There is a material tradeoff between competition and stability. The second message is that key predictions of the model developed in Section 2 hold in the data. Not only do the data confirm the model's predictions that intensifying competition lowers franchise value and increases risk, the empirical results are also consistent with the model's predictions

about how leverage and executive incentives shape bank risk. The consistency between the models predictions and the economic results is valuable because it increases confidence in the findings that emerge from calibrating the model and running policy simulations.

## 4 Conclusion

In this paper, we addressed three questions: Does bank competition reduce bank stability? How can policymakers use available regulatory tools to maximize the efficiency benefits while minimizing any adverse risk effects of competition? How does the effectiveness of monetary policy depend on bank competitiveness?

Based on an analytical model that is calibrated to reflect the U.S. banking industry and econometric evidence, we discover the following.

1. An intensification of bank competition tends to (a) squeeze bank profit margins, reduce bank charter values, and spur lending and (b) increase the fragility of banks. There is a competition-stability tradeoff.
2. Policymakers can get the efficiency benefits of competition without the fragility costs by enhancing bank governance and tightening leverage requirements. In particular, we find that (a) legal and regulatory reforms that induce a bank's decision makers (executives and influential shareholders) to focus more on the long-run value of the bank and less on shorter-run objectives tend to increase both efficiency and stability; (b) tightening leverage requirements also increases bank stability; and (c) combining policies that enhance the governance of banks with those that tighten leverage has a positive, multiplicative effect that materially boosts bank efficiency and stability.

These findings highlight the enormous welfare benefits of legal and regulatory reforms that improve the incentives of bank decision makers, i.e., that improve bank governance. Such reforms improve bank efficiency, reduce bank fragility, allow for a more

competitive banking system without increasing bank fragility; and bolster the effectiveness of capital requirements.

3. Competition intensifies the impact monetary policy on bank lending. In uncompetitive banking environments where banks enjoy large interest rate spreads and profit margins, banks can cushion the effects of monetary policy on bank lending. However, in more competitive banking markets, small interest spreads and profit margins forces banks to respond more aggressively to monetary policy changes. The structure of the banking system is an important consideration in assessing the likely effects of monetary policy on the economy. This is important since many models that central banks use to assess the impact of monetary policy assume competitive banking markets, while most banking markets are highly concentrated.

Besides these policy messages, this paper offers a tool to central banks and other analysts. We develop a dynamic model of the banking system in an imperfectly competitive environment that allows for regulations that influence (a) the costs of entering the banking industry, (b) leverage requirements, and (c) bank governance. While other models include subsets of these features, our model combines them all, so that we can quantify the likely effects of bank regulatory and monetary policies on the economy. In this paper, we have calibrated the model to the U.S. banking industry. This calibration, however, could be modified to fit other economies and thereby provide a tool for quantifying the impact of bank regulatory and monetary policies on those economies.

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# Appendix

## A Planner's Solution

### A.1 First Order Conditions

An interior solution to (1) is given by the first order conditions:

$$\begin{aligned}\frac{\partial \mathcal{O}}{\partial S} &= 0 : p'(S) \cdot A \cdot S \cdot Z + p(S) \cdot A \cdot Z = 0, \\ \frac{\partial \mathcal{O}}{\partial Z} &= 0 : p(S) \cdot A \cdot S - 2\tilde{\gamma}Z = 0.\end{aligned}$$

Solving these two equations in two unknowns yields  $(S^*, Z^*)$  in (2) of Section 2.4.

### A.2 Second Order Conditions

Necessary and sufficient conditions for a local interior maximum in the Planner's problem are: (I)  $O_{ZZ} < 0$ , and (II)  $\det = O_{ZZ}O_{SS} - O_{ZS}^2 > 0$ .

First  $O_{ZZ} = -2\gamma < 0$  for any  $\gamma > 0$  so (I) is always satisfied. Second, using the solution for  $S^*$ , at the optimum  $O_{ZS}^* = A(1 - 3/3) = 0$  and hence  $\det > 0 \iff O_{SS} < 0$ . Since  $O_{SS} = -6ASZ$  it follows that for any interior solution we have an interior maximum.

## B Decentralized Solution

### B.1 Bank Manager's First Order Conditions

At the time the  $(S_i, D_i)$  choice is taken, entry has already occurred so  $E_i = \kappa$  and  $N$  is taken as given. In that case, attaching a multiplier  $\mu$  to constraint (5), the first order conditions

from problem (4)-(5) are given by

$$S_i : p(S_i) \cdot A \cdot D_i + p'(S_i) \cdot R_i \cdot D_i + p'(S_i) \cdot \beta \cdot V_i(N') = 0, \quad (15)$$

$$D_i : p(S_i) \cdot R_i - p(S_i) \cdot r'_D(Z) \cdot D_i - \frac{\mu_i}{\kappa_i} = 0 \quad (16)$$

where  $R_i \equiv (A \cdot S_i - (r_D(Z) + \alpha))$  denotes the interest margin. The first benefit term in (15) is the expected revenue from taking a more risky scale in successful states while the second two cost terms (since  $p'(S_i) < 0$ ) are the decrease in the likelihood of success both on current profits and the possible loss of future charter value. The first benefit term in (16) is the interest margin on all existing deposits while the second and third cost terms are the loss in revenue from having to pay more to attract deposit funding as well as tightening the leverage constraint, respectively.

In a symmetric stationary equilibrium where  $Z = N \cdot D$  and  $V(N)$  satisfies the fixed point in (4), we have that (15) and (16) provide 2 equations in 2 unknowns ( $S, Z$ ). Given the entry condition in (6), further manipulation of these first order conditions yield (8) and (9) in the body of the paper for the case of a non-binding leverage constraint or (8) and (10) for the case where the leverage constraint is binding.<sup>16</sup> Thus, the first order conditions (15) and (16), along with the free entry condition (6), determine  $(S^C, Z^C, N^C)$  from which all other equilibrium values can be derived.

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<sup>16</sup>In the non-binding case (16) can be simplified to yield

$$N_n^C (A S_n^C - (\gamma Z_n^C + \alpha)) = \gamma \cdot Z_n^C \iff Z_n^C = \frac{N_n^C (A \cdot S_n^C - \alpha)}{\gamma \cdot (N_n^C + 1)} \quad (17)$$

while in the binding case we know

$$Z_b^C = \lambda \kappa N_b^C. \quad (18)$$

## B.2 Second Order Conditions

We begin with the case where the leverage constraint is non-binding. Let  $F(S, Z) = \pi(S, Z) + \beta p(S)V$ . Then, the second derivatives are:

$$\begin{aligned} F_{SS} &= p''(S) \cdot R(S, Z) \cdot D + p'(S) \cdot A \cdot D + p'(S) \cdot A \cdot D + \beta \cdot p''(S) \cdot V \\ F_{DD} &= -p(S) \cdot \gamma - p(S) \cdot \gamma = -2\gamma p(S) < 0 \\ F_{SD} &= p'(S) \cdot R(S, Z) - p'(S) \cdot \gamma \cdot D + p(S) \cdot A = p(S) \cdot A \end{aligned}$$

where we used  $p'(S) = -2S$  and  $p''(S) = -2$  for the first inequality, and the last equality above follows from Eq. (16). The necessary condition for a local optimum is then

$$F_{SS} \cdot F_{DD} - F_{DS}^2 > 0 \quad (19)$$

Inequality (19) places restrictions on the set of parameters we need to ensure a local maximum.

When the leverage constraint is binding, notice here that the constraint is linear in  $D$  alone, so the determinant bordered hessian condition (see Theorem 5.5 in Sundaram [43]) for a constrained local max reduces to requiring  $F_{SS} < 0$ .

Numerical checks of all local maxima (and boundaries) ensures global optimality.

## B.3 Non-Linear Interaction of Binding Leverage Constraints and Manager Myopia

In Section 2.5.6, we found numerically that the differential impact of tightening leverage constraints with different levels of manager myopia  $\Delta(S; \beta_L = 0.90) < \Delta(S; \beta_H = .99)$ . However, there can be cases where the sign is reversed. Here we provide a discussion of those countervailing forces.

Totally differentiating the first order condition for  $S$  in the leverage constrained region

given by (11) with respect to  $\lambda$  and  $\beta$  yields:

$$\frac{dS}{d\lambda} = -\frac{Ap(S)^2}{den} > 0$$

$$\frac{dS}{d\beta} = \frac{-p'(S)p(S)w(S)}{den \times (1 - \beta p(S))} < 0$$

where

$$den = [2A\lambda p'(S)p(S) + p''(S)w(S) + w'(S)p'(S)] < 0 \quad (20)$$

with

$$w'(S) = \frac{-p'(S)}{[1 - \beta p(S)]^2}(\delta - \beta) > 0. \quad (21)$$

Then the local interaction effect is given by

$$\frac{\partial^2 S}{\partial \lambda \partial \beta} = -\frac{-p'(S)p(S)w(S)}{(1 - \beta p(S)) \times den^2} (-2SAp(S)) > 0.$$

This expression implies a complementarity in tightening leverage constraints and reducing agency costs, when it occurs. The non-monotonic relation arises when switching from an unconstrained equilibrium to a leverage constrained equilibrium.

## C Supplementary Model Tables

Table A1: Variation in Market Structure

|              | Planner | Less competitive | Benchmark (levels) | More competitive | Optimal Entry Barriers |
|--------------|---------|------------------|--------------------|------------------|------------------------|
| <b>N</b>     | NA      | 1                | 3                  | 5                | 1.3                    |
| <b>S</b>     | -25%    | -27%             | 0.77               | 10%              | -21%                   |
| <b>Z</b>     | -43%    | -54%             | 14888.74*          | 24%              | -44%                   |
| <b>D/E</b>   | NA      | -76%             | 21.89              | 134%             | -70%                   |
| <b>p</b>     | 64%     | 67%              | 0.41               | -31%             | 55%                    |
| <b>R</b>     | NA      | 39%              | 0.07               | -26%             | 34%                    |
| $\pi$        | NA      | 223%             | 135.37*            | -62%             | 178%                   |
| $\kappa$     | NA      | 489%             | 226.76*            | -68%             | 343%                   |
| <b>V</b>     | NA      | 427%             | 213.65*            | -67%             | 309%                   |
| <b>F/Y</b>   | NA      | -84%             | 0.92               | 100%             | -75%                   |
| <b>Y</b>     | -53%    | -43%             | 1866.88*           | -5%              | -31%                   |
| <b>cv(Y)</b> | -76%    | -82%             | 2718.81*           | 65%              | -72%                   |

Except for benchmark, all columns are percent deviations from benchmark.

\* In millions.  $Y = p(S) \cdot A \cdot S \cdot Z$ .

Table A2: Policy Counterfactuals: Short-Run versus Long-Run

|                   | Eliminating agency SR | Eliminating agency LR | Tightening Leverage SR | Tightening leverage LR | Expansionary monetary policy SR | Expansionary monetary policy LR |
|-------------------|-----------------------|-----------------------|------------------------|------------------------|---------------------------------|---------------------------------|
| <b>N (levels)</b> | 3                     | 3.1                   | 3                      | 5.5                    | 3                               | 3.5                             |
| <b>S</b>          | -2%                   | -1%                   | -20%                   | -20%                   | -3%                             | 0%                              |
| <b>Z</b>          | -2%                   | -1%                   | -42%                   | -42%                   | 7%                              | 15%                             |
| <b>D/E</b>        | -7%                   | -3%                   | -68%                   | -68%                   | -21%                            | 0%                              |
| <b>p</b>          | 6%                    | 4%                    | 52%                    | 52%                    | 10%                             | 0%                              |
| <b>R</b>          | -2%                   | -3%                   | 33%                    | 33%                    | 7%                              | 0%                              |
| $\pi$             | 1%                    | -3%                   | 18%                    | -35%                   | 26%                             | 0%                              |
| <b>E</b>          | 5%                    | 0%                    | 83%                    | 0%                     | 35%                             | 0%                              |
| <b>V</b>          | 12%                   | 6%                    | 70%                    | -7%                    | 34%                             | 0%                              |
| <b>F/Y</b>        | -10%                  | -7%                   | -73%                   | -73%                   | -6%                             | 16%                             |
| <b>Y</b>          | 1%                    | 2%                    | -29%                   | -29%                   | 14%                             | 15%                             |
| <b>cv(Y)</b>      | -8%                   | -5%                   | -70%                   | -70%                   | -3%                             | 15%                             |

Percent deviations from benchmark.  $\kappa^* = 226.76$  million.

Table A3: Monetary Transmission Mechanism Across Market Structures

|                   | <b>Expansionary<br/>monetary<br/>policy<br/>Benchmark</b> | <b>Expansionary<br/>monetary<br/>policy<br/>More<br/>competitive</b> |
|-------------------|-----------------------------------------------------------|----------------------------------------------------------------------|
| <b>N</b> (levels) | 3                                                         | 5                                                                    |
| <b>S</b>          | -3%                                                       | -2%                                                                  |
| <b>Z</b>          | 7%                                                        | 8%                                                                   |
| <i>D/E</i>        | -21%                                                      | -18%                                                                 |
| <b>p</b>          | 10%                                                       | 9%                                                                   |
| <b>R</b>          | 7%                                                        | 8%                                                                   |
| $\pi$             | 26%                                                       | 27%                                                                  |
| <i>E</i>          | 35%                                                       | 32%                                                                  |
| <b>V</b>          | 34%                                                       | 32%                                                                  |
| <b>F/Y</b>        | -6%                                                       | -3%                                                                  |
| <i>Y</i>          | 14%                                                       | 16%                                                                  |
| <b>cv(Y)</b>      | -3%                                                       | 2%                                                                   |

Percent deviations of monetary policy expansion holding market size fixed at  $N = 3$  where  $\kappa^* = 226.76$  million and  $N = 5$  where  $\kappa^* = 72.56$  million, respectively.