

## Is the International Convergence of Capital Adequacy Regulation Desirable?

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### ABSTRACT

The merit of international convergence of bank capital requirements in the presence of divergent closure policies of different central banks is examined. The lack of a complementary variation between minimum bank capital requirements and regulatory forbearance leads to a spillover from more forbearing to less forbearing economies and reduces the competitive advantage of banks in less forbearing economies. Linking the central bank's forbearance to its alignment with domestic bank owners, it is shown that in equilibrium, a regression toward the worst closure policy may result: The central banks of initially less forbearing economies also adopt greater forbearance.

I ANALYZE THE JOINT DESIGN of two bank regulatory mechanisms: minimum capital requirements, which are an ex ante mechanism to prevent bank failures, and closure policy, which is an ex post mechanism to manage the cost of bank failures. At the heart of the paper is a simple but fundamental point: Ex post policies affect ex ante incentives, and, hence, the design of an ex ante mechanism must take into account any feedback from the ex post policies. The optimal design of capital requirements is thus tied to the extent of forbearance exercised by the central bank's closure policy. This warrants a closer scrutiny of the merits of creating a "level playing field" in capital requirements across countries, as proposed and

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implemented by the Basel Accord of 1988. I show that, in general, such cross-border standardization is desirable only if accompanied by standardization of closure policies as well.

When banks operate across borders, a lack of overall standardization gives rise to international spillovers from more forbearing to less forbearing regimes. Banks in more forbearing regimes undertake greater risk, which reduces the profits of banks in less forbearing regimes. Since these latter banks might be forced to exit the banking system, their central banks also adopt greater forbearance. As a result, all central banks converge toward the worst level of forbearance. Moral hazard resulting from such excessive forbearance has the potential to destabilize the global banking system compared to the situation in which there is no convergence of regulatory mechanisms.

An infinite-horizon single-economy banking model is developed to illustrate the linkage between design of capital requirements and closure policy. Banks make profits through risky lending, but incur costs that depend upon their own scale and also that of the other banks. Bank owners are wealth constrained and raise funds in the form of deposits and costly outside equity. Since bank investment choices are not contractible, there is a conflict of interest between bank owners and other claimants: Banks may choose a level of risk that is greater than the optimal risk for the bank as a whole. The central bank designs regulation to maximize the total value of the bank, that is, the sum of the values of the bank's inside equity, outside equity, and deposits. The central bank can close or bail out the failed banks with some probability as a part of its bank closure policy. It can also require that banks hold a minimum level of capital in the form of outside equity.

I show the privately optimal level of bank capital decreases in the extent of regulatory forbearance. From the standpoint of bank owners, bank capital and regulatory forbearance are *strategic substitutes*. In contrast, from the regulatory standpoint, these are *strategic complements*; the optimal minimum capital requirement, when it binds, increases in the extent of forbearance practiced by the central bank. A higher level of forbearance induces greater moral hazard, which is counteracted with a greater minimum capital requirement. These results cast doubt over the desirability of uniform capital requirements across nations if their central banks maintain divergent closure policies.

To explore the implications of such a divergence, I employ a two-economy model of financial integration. Banks make loans and raise deposits across borders. They hold a uniform amount of capital, but are subject to the forbearance exercised by the central bank of their respective "home" countries. This gives rise to a spillover from the more forbearing to the less forbearing regime. In equilibrium, the risk-taking capacity of banks of one economy affects the competition faced by banks of the other economy and, in turn, their profit margins. Thus, as banks of the more forbearing regime take greater risk, the profit margins earned by banks of the less forbearing regime erode further, which further reduces their charter values. The magnitude of this spillover effect increases with both the heterogeneity in the closure regimes and the cost efficiency of banks. An example economy illustrates that banks of the less forbearing regime may also respond to the spillover by taking greater risk.

Some observers argue that the heterogeneity in regulatory forbearance which drives such spillover effects arises due to differences in the political economy of regulation. Central banks, in general, maximize a weighted average of the welfare of their domestic banks' owners and that of outside claimants.<sup>1</sup> Regulatory capture in the form of a greater weight on the welfare of its bank owners leads a central bank to exercise excessive forbearance, thereby inducing a spillover on the value of banks in other regimes. How does a central bank that is aligned less with its bank owners respond to this spillover when it is constrained to not adjust capital requirements?

I demonstrate that if heterogeneity in regulatory objectives across regimes is high, the resulting spillover either drives the banks of a less forbearing regime below their reservation values or leads them to take excessive risk. To avoid the exit of its domestic banks or to reduce the continuation value losses arising upon their default, the central bank of this regime adopts greater forbearance as well. Thus, in equilibrium, there is a "regression toward the worst forbearance." The resulting moral hazard exacerbates any risk-shifting behavior induced in these banks by the increased competition in lending.

The policy implication of the present study is that each country's regulator imposes an externality on the welfare of other countries, absent complete coordination among regulators. That is, coordination on policies such as capital requirements but not *also* on closure policies eliminates an important weapon from the arsenal of regulators who wish to counteract spillovers from poorly regulated foreign banks. Thus, reminiscent of the theory of the second-best, a less than full step toward complete coordination can be more harmful than no step at all. I present anecdotal evidence that supports this policy implication.

To my knowledge, this paper presents the first attempt to study under a unified framework the joint design of capital requirements and closure policy for banks in a single economy and in multiple economies.<sup>2</sup> Acharya and Dreyfus (1989) advocate a linkage between the design of closure policies and the deposit insurance premium scheme. Davies and McManus (1991) suggest that the extent to which a bank is monitored should be tied to the level of strictness of its closure policy. These papers do not consider capital requirements and are developed in a single-economy context.

My result on regression toward the worst regulation is closest in spirit to Dell'Ariccia and Marquez (2000) and Holthausen and Roende (2002); however,

<sup>1</sup> This political economy aspect of regulation has been well documented in the literature on bank regulation. Stigler (1971), Peltzman (1976), White (1982), Kane (1990), and Laffont and Tirole (1991) are some illustrative references.

<sup>2</sup> I abstract from the micromotives for banking. A summary of the seminal papers on regulation based on micro-theory of banks can be found in Dewatripont and Tirole (1993) and Freixas and Rochet (1997). In more recent work, Gorton and Winton (1999) delineate the private and social costs of bank capital in a general equilibrium model of bank regulation. Diamond and Rajan (2000) build a theory of bank capital based on the liquidity creation by banks, the costs of financial distress, and the incentive effects of capital on the amounts collected by banks from the borrowers. An alternative approach to bank regulation exploits the owner-manager conflict as in John, Senbet, and Saunders (2000).

these papers do not consider the interplay of different regulatory policies, which is central to my analysis. Dell'Ariccia and Marquez focus exclusively on competition among regulators in setting regulatory standards. They show that Nash competition reduces regulatory standards relative to a centralized solution. They take as given a reduced-form function that represents the regulatory objectives. In contrast, I model economies with banks and derive the regulatory objective functions in terms of endogenous bank choices. Holthausen and Roende, on the other hand, analyze a situation in which several local supervisors have complementary information about a bank's local assets. Since supervisors act in the interest of their respective local economies, in equilibrium, they do not reveal complete information about their local banks and thus lax closure decisions are taken.

The rest of this paper is organized as follows. Section I analyzes the single-economy model. Section II characterizes the relationship between the privately optimal level of bank capital and regulatory forbearance, and between the socially optimal minimum capital requirement and regulatory forbearance. Section III analyzes the multiple-economy model, deriving the results on international spillovers and regression toward the worst regulation. Section IV discusses the robustness of the results. Section V concludes. All proofs are contained in the appendixes.

### **I. Single-Economy Model**

My model is inspired by the Allen and Gale (2000a) model of bubbles and crises, a two-date single-economy model of risk shifting by investors who borrow money from lenders. I extend the Allen and Gale model to incorporate: (i) an infinite horizon with repeated one-period investments, (ii) closure policy and capital requirements as regulatory mechanisms, and, (iii) multiple economies. In this section, I describe the model for the single-economy case, which serves as a building block for the multiple-economy case.

**Banks and investors:** The economy consists of a single banking sector with a single consumption good at each date  $t=0, 1, \dots, \infty$ . There is a continuum of homogeneous banks, owned by risk-neutral intermediaries referred to as bank owners or inside equity holders who have no wealth of their own. Banks have access to investments in a safe asset and one risky asset. There is also a continuum of risk-neutral investors with  $D$  units of the good to invest in each period. Investors can invest in the safe asset, lend their goods to banks in the form of deposits, or invest in a bank's equity. Bank owners and investors have a common time preference rate of  $\beta \in (0, 1)$ .

**Safe and risky assets:** The safe asset in the economy is a storage technology that has constant returns to scale. Investments in the safe asset yield a fixed return  $r_S$  in each period to investors. The risky asset of a bank is to be interpreted as bank investments with variable returns. These are loans to entrepreneurs who supply a claim to their business profits to the bank in exchange. For simplicity, the risky investments of different banks are perfectly correlated. That is, each bank holds a well-diversified portfolio that bears only systematic risks. The risky

asset yields a constant return to scale  $R$  next period on a unit of investment this period, such that  $R \sim h(\cdot)$  over  $[0, R_{max}]$  with mean  $\bar{R}$ . The corresponding cumulative distribution function is denoted as  $H(x) = \int_0^x h(R) dR$ . I assume that there is a reward for bearing this risk, that is,  $\bar{R} > r_S$ . Note that both safe and risky assets are loans, and any short sales are ruled out.

Costs of risky investments: Bank owners incur nonpecuniary costs of investing in the risky asset. First, banks compete to make risky loans. As a result, the cost incurred increases with the extent of aggregate investment in the risky asset. This is consistent with the notion that finding additional good-quality loans is more and more costly on the margin as the aggregate supply of loans increases, since there are fewer and fewer good loans in the corporate sector. Banks must thus spend extra effort to make good-quality loans, or they must accept a lower return per loan.<sup>3</sup>

Second, the cost incurred increases with a bank's own investment, and at a growing rate. This is consistent with the documented evidence of diseconomies of scale in banking beyond a certain scale.<sup>4</sup> Moreover, this assumption may be justified on the basis of diseconomies of scope; if there is a limited supply of good-quality loans in the corporate sector, then expanding the loan base requires a bank to expand beyond its area of expertise, which in turn either requires extra screening effort or entails worse-quality loans. This argument has been theoretically motivated by Winton (1999) and empirically supported by Acharya, Hasan, and Saunders (2002). Also, if the supply of experienced lenders is limited, then making additional loans requires that a bank overexert its experienced lenders or recruit additional lenders with less experience.

To capture the above aspects, I model the cost function as  $f(\bar{x})c(x)$ , where  $\bar{x}$  is the aggregate risky investment,  $x$  is the bank's individual risky investment, and  $f(\bar{x})$  and  $c(x)$  satisfy the neoclassical assumptions:  $c(0) = 0$  and  $c'(0) = 0$ ;  $c'(x) > 0$  and  $c''(x) > 0$ ,  $\forall x > 0$  and  $c(x)$  continuous; and analogous behavior of  $f(\bar{x})$ . These costs generate diminishing returns to scale for banks' risky investments, and, in turn, bound the size of banks' portfolios. While pecuniary costs can be introduced only with some difficulty, nonpecuniary costs lead to a simple and succinct analysis.

Bank deposits: Deposits take the form of a simple debt contract with a promised deposit rate of  $r_{Dt}$  and a maturity of one period. The rate  $r_{Dt}$  is not contingent on the size of deposit nor on asset returns. Costly state verification, as in Townsend (1979) or Gale and Hellwig (1985), justifies such a simple debt contract.<sup>5</sup>

<sup>3</sup> Keeley's (1990) finding that the deregulation of the U.S. banking industry in the 1970s and 1980s led to an increase in competition and erosion of bank profits provides indirect evidence supporting this assumption.

<sup>4</sup> See Chapter 14 of Saunders (1999) and the references therein. While technological innovation has increased the range of bank sizes over which scale economies exist, there still exist agency-based diseconomies of scale as suggested by Cerasi and Daltung (2000) and Stein (2002).

<sup>5</sup> The lack of secondary trading in deposits also prevents deposit rates from being contingent on observable bank characteristics. This feature of deposits, as distinct from traded banknotes such as subordinated debt, has been noted by Gorton (1985) and Gorton and Mulineaux (1987).

Deposits are in excess supply, and banks can borrow deposits as long as the expected return on the deposits is at least equal to the return on the safe asset. Since depositors have access to the safe asset as well, this requirement ensures that it is individually rational for them to lend to banks. Finally, the deposit claim cannot be renegotiated so that a bank that fails to repay the promised payment to its depositors is in default.<sup>6</sup>

**Bank capital:** In addition to raising deposits, the wealth-constrained intermediaries who own the banks can raise capital by issuing outside equity. However, raising outside equity dilutes the value of a bank's inside equity, since bank owners are required to pay a higher than fair expected rate of return on equity. Such dilution constitutes a private cost of bank capital but not a social cost of bank capital, as it is a pure transfer from the existing equity holders to the new equity holders.

Theoretical analysis and empirical evidence of dilution costs arising from adverse selection are widely available.<sup>7</sup> While the theoretical dilution costs suggest an increasing and convex cost function, and thus diseconomies of scale in issuance, in practice there is also a fixed-cost component that gives rise to at least some economies of scale.

For simplicity, I do not model the process of equity issuance. Rather, I assume directly that the total value transferred from bank owners to new equity holders is  $\theta(K)$ , where  $K$  is the amount of new equity issued,  $\theta(K)$  is nondecreasing and continuous,  $\theta(0) = 0$ , and  $\theta(K) \geq r_S K$ ; the last assumption ensures that it is individually rational for depositors to invest in bank capital. These assumptions allow simultaneously for economies of scale in some regions and diseconomies of scale in others. However, to guarantee that banks do not choose to be entirely equity financed, the model requires that the marginal dilution cost is not "too low" (for a precise statement, see footnote 13).

Furthermore, to keep the model parsimonious, I assume that the set of investors who lend deposits and the set of investors who invest in bank capital are segmented. This partial equilibrium assumption allows me to ignore the optimal investment problem of investors which would be important in a general equilibrium setting. In contrast, Gorton and Winton (1999) and Bolton and Freixas (2000) employ the dilution cost approach to study models of banks and bank capital in which, in equilibrium, investors are endogenously indifferent about holding deposits, bank equity, and corporate bonds. Abstracting from this

<sup>6</sup> Diamond and Rajan (2000) justify such "hardness" by appealing to a collective action problem among dispersed depositors in the presence of a sequential service constraint.

<sup>7</sup> Rock (1986) suggests that the dilution cost must be borne by the issuer to ensure that uninformed investors purchase the issue in the presence of informed investors. A lemon's dilution cost arises due to asymmetric information in Leland and Pyle (1977) and Myers and Majluf (1984). Lee et al. (1996) document that the underpricing costs associated with raising new equity for U.S. firms exceed 10% of the market value of the issue for initial as well as seasoned public offerings. An alternative explanation based on the agency conflicts between the manager-entrepreneur and the external financiers is employed by Froot, Scharfstein and Stein (1993).

consideration enables me to focus exclusively on the investment problem of banks.

**Regulator:** Bank capital structure and investment choices maximize the value of bank owners, that is, the value of a bank's inside equity. Thus, in general, there is a conflict of interest between bank owners and investors. To mitigate the resulting agency costs, there is a bank regulator in the economy, such as the central bank, who designs regulatory mechanisms. The regulator's objective is to maximize the value of the bank as a whole, which is equal to the value of the bank's inside equity plus the value to investors from their bank deposits and public equity claims. The regulator weighs equally the welfare of all claimants. I ignore any deadweight costs of bank failures in the regulator's welfare computation: Incorporating such costs does not affect the qualitative nature of the results.

The regulator employs two mechanisms that are interesting from a theoretical as well as an institutional perspective: (i) a minimum capital requirement, which is the *ex ante* mechanism aimed at reducing the likelihood of bank failures, and (ii) a closure or bailout policy, which is the *ex post* mechanism designed to reduce continuation value losses arising from bank failures. In a multiperiod setting, the *ex ante* mechanism is employed in each period, and hence affects *ex post* continuation values. Similarly, the *ex post* mechanism has a feedback effect on *ex ante* investment choices. Neither the minimum capital requirement nor the closure policy can be explicitly contingent on the investment decisions of the bank. The regulator thus designs regulation in an environment of incomplete contractability. This renders the design problem nontrivial and realistic. However, regulators can verify the level of bank capital and can enforce a minimum capital requirement by levying sufficiently high penalties on any violators.<sup>8</sup>

**Capital requirement:** The wealth-constrained intermediaries who run the banks are required to hold a minimum of  $K_{min}$  units of capital in the form of outside equity.<sup>9</sup>

**Closure policy:** The model assumes that if a bank fails, its continuation value is dissipated unless the bank is rescued and continues to operate under the existing bank owners. While these assumptions of the uniqueness of each bank and the specificity of bank owners to their respective bank are strong, relaxing these assumptions involves several issues that are beyond the scope of the current paper. For instance, allowing the transfer of a failed bank's value to surviving banks alters the industrial organization of the banking sector over time unless bank entry is modeled in a way that ensures the sector's stationarity. Alternatively,

<sup>8</sup>Since banks are socially valuable, the enforcement of capital requirements may also lack credibility, as in Gorton and Winton (1999). I abstract from this consideration. In my model, the regulator has a rule and no discretion over the enforcement of capital requirements.

<sup>9</sup>This is designed to correspond to the Tier 1 capital required by the current regulation. For a description of what constitutes regulatory capital, see the Basel Accords of 1988 and 1996 at [www.bis.org](http://www.bis.org). In practice, regulators impose minimum capital requirements not on the absolute level of bank capital, but rather on the level of bank capital as a fraction of its suitably risk-adjusted assets. Since levels of bank investments are not contractible in my setup, it is natural instead to model minimum capital requirements on the absolute level of capital. A more detailed discussion of this point is contained in Section IV.

allowing bank ownership replacement requires modeling a labor market equilibrium of financial intermediaries. I simply assume that in order to reduce continuation value losses from bank closures, it may be optimal for the regulator to bail out banks. In the event of a bailout, the regulator pays the depositors of the failed banks in full and allows their bank owners to continue their lending activities. Thus, unlike the usual definition of explicit deposit insurance, depositors in the model are insured only in the event that a bailout takes place.

I model the above closure policy as  $p \in [0, 1]$ , the probability that a bank in default will be bailed out by the regulator. The choice of closure policy thus represents the extent of forbearance exercised by the regulator, with a higher value of  $p$  representing a more forbearing policy.<sup>10</sup> These assumptions along with the assumption that all banks hold perfectly correlated loan portfolios yield a stationary environment wherein all banks fail or survive in any given period. This leads to a tractable analysis of bank capital in this economy.

## II. Private and Social Levels of Bank Capital

In Section II.A, I treat the regulatory forbearance  $p$  as given and I study the behavior of both the privately optimal and the socially optimal levels of bank capital as  $p$  is varied. Later, in Section II.B, I endogenize the choice of  $p$ .

### A. Investment Choice of Banks

Consider the *symmetric competitive equilibrium*, in which all banks take the borrowing rate and aggregate investment as given, choose the same capital structure, and select the same portfolio of safe and risky investments, and all depositors are promised the same rate of interest. I assume that the bank's inside equity holders and outside investors consume in each period any profits generated in that period, and, similarly, that depositors consume in each period any return on their deposits in that period. This assumption permits the reduction of the infinite horizon repetition of each investment period to a stationary dynamic program; relaxing this assumption affects the tractability of the model significantly. The dynamic management of wealth by banks and its implications are discussed in some detail in Section IV.

Suppose the representative bank has a total investment of  $X$  and chooses to raise  $K \leq X$  units of capital and  $X - K$  units of deposits. Once the deposits are borrowed and the capital is raised, bank owners choose to allocate the funds between investments in the safe asset and the risky asset,  $X_S$  and  $X_R$ , respectively, where  $X = X_S + X_R$ . The promised return on deposits is denoted as  $r_D$ . Note that the stationarity of the investment problem enables the suppression of the time subscripts. Then, for a given capital structure  $K$ , the *equilibrium* is given by

<sup>10</sup>Such mixed strategies are referred to as "constructive ambiguity" in Freixas (1999). In practice, when banks fail, regulators adopt any of a wide variety of response mechanisms such as nationalization, bank sales, firing of managers, and so forth. These mechanisms suffer from a lack of regulatory commitment, as studied by Mailath and Mester (1994), which gives rise to greater forbearance in closure policy as compared to the optimal ex ante level.

$(X_S, X_R, r_D)$ , where (i)  $(X_S, X_R)$  maximizes the value to bank owners, given  $r_D$  and  $r_S$ ; (ii) the short-sales constraint is not violated, such that  $X_S, X_R \geq 0$ ; and (iii) the deposit rate  $r_D$  satisfies the individual rationality of depositors.

Consider the realization of returns on bank investments at the end of a representative period. The bank is in default whenever the realized risky return  $R$  is such that  $r_S X_S + R X_R < r_D (X_S + X_R - K)$ , that is, whenever  $R < R^c$ , where  $R^c$  is the critical or the threshold return on risky investment below which default occurs:

$$R^c(X_S, X_R, K) = (r_D - r_S) \frac{X_S}{X_R} + r_D \left( 1 + \frac{X_S}{X_R} - \frac{K}{X_R} \right). \tag{1}$$

Equity capital being a “soft” claim upon which defaults cannot occur buffers a bank by reducing the threshold point of default. When default occurs, independent of whether the bank is bailed out or not, the equity holders receive no return for that period. Hence, the expected payoff to the bank’s total equity in each period is as follows:

$$v(X_S, X_R, K) = \int_{R^c}^{R_{max}} [r_S X_S + R X_R - r_D (X_S + X_R - K)] h(R) dR - f(\bar{X}_R) c(X_R), \tag{2}$$

where  $R^c$  is given in equation (1) and  $\bar{X}_R$  is the aggregate investment in the risky asset.

Thus, net of private issuance costs, the expected payoff to bank owners is  $v(\cdot) - \theta(K)$ . Note that bank owners cannot commit to dynamic investment strategies and, hence, they treat their continuation value  $V$  as a lump-sum constant in solving for current period investments. Since upon default the bank is bailed out with probability  $p$  and closed with probability  $1 - p$ , the portfolio problem of bank owners in each period is as follows:

$$\max_{X_S, X_R \geq 0} v(X_S, X_R, K) - \theta(K) + \beta V [1 - (1 - p)H(R^c)]. \tag{3}$$

In equilibrium, symmetry implies that the aggregate investment  $\bar{X}_R$  must equal  $X_R$ , the risky investment of the representative bank. Furthermore, stationarity of the investment problem implies that the subgame perfect investment policy is identical in all periods. Hence, the lump-sum constant  $V$  must equal the continuation value of bank owners for an investment policy  $(X_S, X_R)$  in each period and is given by

$$V = [v(\cdot) - \theta(K)] [1 + \beta(1 - (1 - p)H(R^c)) + \beta^2(1 - (1 - p)H(R^c))^2 + \dots] = \frac{v(\cdot) - \theta(K)}{1 - \beta + \beta(1 - p)H(R^c)}. \tag{4}$$

I refer to this continuation value of the bank owners,  $V$ , as their *charter value*.

Finally, in equilibrium, the individual rationality of depositors implies that the risk-adjusted return to depositors equals their reservation return  $r_S$  from safe

investments,

$$r_S = r_D[1 - (1 - p)H(R^c)] + (1 - p) \int_0^{R^c} \left( \frac{r_S X_S + R X_R}{X_S + X_R - K} \right) h(R) dR, \quad (5)$$

since the depositors are fully insured with probability  $p$ . With the remaining probability  $(1 - p)$ , the bank is closed down with depositors claiming the entire return  $r_S X_S + R X_R$ .

Appendix A characterizes a set of sufficient conditions under which the symmetric competitive equilibrium described above exists. The equilibrium has the following properties:

(i) Since depositors lose their lent funds with positive probability, the cost of borrowing deposits is at least as high as the safe asset return:  $r_D \geq r_S$ .

(ii) Given  $r_D \geq r_S$ ,  $R^c(\cdot)$  increases in  $X_S$  and, hence, bank owners do not find it optimal to invest in the safe asset,  $X_S = 0$ . This implies, in turn, that banks make only risky investments,  $X = X_R$ , and raise both  $X_R - K$  units of deposits and  $K$  units of capital. The remaining goods,  $D - X_R$ , are invested in the safe asset by investors.

(iii) Deposit insurance induces moral hazard among banks: banks have an incentive to undertake excessive investment in risky assets to maximize the value of their option to default and get bailed out with probability  $p$ . The charter value of banks, however, induces a counteracting risk-avoidance incentive, as banks stand to lose their continuation value more often if they undertake a greater amount of risky investment. The risk-taking aspect of bank behavior is akin to the classic problem of "risk shifting" or "asset substitution" by equity holders, as studied in the corporate finance literature by Jensen and Meckling (1976), Green (1984), and John and John (1993). The risk-avoidance effect, on the other hand, is similar to that examined by Herring and Vankudre (1987), Keeley (1990), and Acharya (1996) in their analyses of the growth opportunities of banks, market power of banks, and optimal regulatory forbearance, respectively.

Thus, banks trade off the benefit of risky investments, the expected return of the investments including the option provided by deposit insurance, against the costs of making risky investments, the direct nonpecuniary costs and the expected loss of charter value. This is summarized in the following first-order condition:<sup>11</sup>

$$\frac{\partial v(\cdot)}{\partial X_R} = \beta(1 - p)V \frac{\partial H(R^c(X_R))}{\partial X_R}, \quad (6)$$

<sup>11</sup>In the partial derivative with respect to  $X_R$  in the first-order condition, the following variables are treated as constants by bank owners: capital level  $K$ , charter value  $V$ , cost of borrowing deposits  $r_D$ , and the aggregate risky investment  $\bar{X}_R$ . However, the effect of  $X_R$  on the threshold point of default  $R^c$  is taken into account by banks. I have substituted the symmetric equilibrium condition  $\bar{X}_R = X_R$  in the expression for  $\partial v(\cdot)/\partial X_R$ . The charter value  $V$  is as in equation (4).

where

$$R^c(X_R, K) = r_D \left( 1 - \frac{K}{X_R} \right), \tag{7}$$

$$v(X_R, K) = \int_{R^c}^{R_{max}} [RX_R - r_D(X_R - K)] h(R) dR - f(\bar{X}_R)c(X_R), \tag{8}$$

and

$$\frac{\partial v(\cdot)}{\partial X_R} = \bar{R} + \int_0^{R^c} (r_D - R)h(R) dR - r_D - f(X_R)c'(X_R). \tag{9}$$

Let the risky investment response of the banks characterized above be denoted as  $\hat{X}_R(K, p)$  for a given capital structure  $K$  and regulatory forbearance  $p$ . Then, it can be shown that as regulatory forbearance increases, banks take greater risk and the incidence of both bank defaults and bank bailouts rises as well. This is essentially a moral hazard effect—if bank owners anticipate being bailed out more often, then default is privately less costly.

PROPOSITION 1 (FORBEARANCE AND RISK): *The risky investment of bank owners,  $\hat{X}_R(K, p)$ , increases with forbearance  $p$ . The likelihood of bank default,  $H(R^c(\hat{X}_R))$ , and the probability of bank bailouts,  $pH(R^c(\hat{X}_R))$ , also increase with forbearance  $p$ .*

### B. Bank Capital and Regulatory Forbearance

The capital structure choice that banks face each period, subject to the minimum capital requirement, can be stated as follows:

$$\max_{K \leq \hat{X}_R(\cdot), K \geq K_{min}} v(\hat{X}_R, K) - \theta(K) + \beta V[1 - (1 - p)H(R^c)] \tag{10}$$

where, as before, the lack of ability to commit the capital structure choice over time implies that  $V$  is treated as a lump-sum constant that in equilibrium is given by equation (4). Furthermore, banks are price takers with respect to the deposit rate  $r_D$ , which, in equilibrium, is given by equation (5). This assumption is reasonable in this setting since there is a continuum of banks and the deposit market is competitive. It is also justifiable in a context characterized by a sequence of events in which deposits are issued first and capital is issued subsequently. The maximand in equation (10) is denoted as  $\hat{V}(K, p)$ .

Consider first the problem without the minimum capital requirement  $K \geq K_{min}$ . Denote the optimal capital structure under this unconstrained problem as  $\bar{K}(p)$ , the *privately optimal* level of bank capital. Then, the optimal capital structure under the constrained problem is  $\hat{K}(p) = \max(\bar{K}(p), K_{min}(p))$ , where the regulatory capital requirement that is in place,  $K_{min}(p)$ , may also be a function of regulatory forbearance  $p$ .

The optimal minimum capital requirement  $K_{min}(p)$  is designed by the regulator who maximizes the sum of the values of all bank claims, that is, the sum of the values of deposits, bank capital, and inside equity of the bank. Since the capital

requirement is a constraint, it could potentially be privately costly to the bank owners. To ensure that bank owners continue to perform the intermediation activities, I assume that bank owners must be guaranteed a reservation value of  $\bar{V}$ .

The sum of the expected payoff of all bank claims in each period, ignoring the constant term  $r_S D$ , which is realized each period independent of the bank's existence, is

$$w(X_R) = (\bar{R} - r_S)X_R - f(X_R)c(X_R). \quad (11)$$

The sum of the expected continuation value of all bank claims for an investment policy  $X_R$  in each period is

$$W(X_R, K) = \frac{w(X_R)}{1 - \beta + \beta(1 - p)H(R^c)}. \quad (12)$$

The socially optimal investment policy trades off the benefit to the economy from undertaking risk with the potential loss in the economy's continuation value for doing so.<sup>12</sup> However, the regulator cannot contract the bank's investment policy to this optimal investment policy. Thus, the regulator designs the capital requirement under the knowledge that the investment policy is a private choice of banks and subject to the constraint that banks earn at least their reservation values. This regulatory design problem is formalized below:

$$\max_{K_{min}} W(\hat{X}_R, K|\rho) \quad (13)$$

subject to the following constraints:

Incentive-Compatibility (IC)

$$\hat{X}_R \in \arg \max_{X_R} v(X_R, K) - \theta(K) + \beta V[1 - (1 - p)H(R^c(X_R))], \quad (14)$$

Minimum Capital Requirement (MCR)

$$K \in \arg \max_{K \leq \hat{X}_R(\cdot), K \geq K_{min}} v(\hat{X}_R, K) - \theta(K) + \beta V[1 - (1 - p)H(R^c(\hat{X}_R, K))], \quad (15)$$

Participation-Constraint (PC)

$$V(\hat{X}_R, K) \geq \bar{V}, \quad (16)$$

<sup>12</sup>I draw the reader's attention to the fact that throughout I have taken the costs of conducting depositor bailouts to be zero. This can be considered a mechanism such that funds for bailouts are obtained from the depositors themselves through taxes, and therefore represent intertemporal transfers in welfare. Alternatively, a deposit insurance premium can be introduced into the model. However, this would complicate the analysis and detract from this paper's main goal of studying the design of capital requirements and closure policy.

and Individual Rationality of Depositors (IR)

$$r_S = r_D[1 - (1 - p)H(R^c)] + (1 - p) \int_0^{R^c} \frac{RX_R}{X_R - K} h(R) dR; \quad (17)$$

$V(\cdot)$ ,  $v(\cdot)$ , and  $W(\cdot)$  are given by the equations (4), (8), and (12), respectively.

One can now ask the question that is of primary importance to this paper: How do the privately optimal bank capital and socially optimal bank capital levels,  $K(p)$  and  $K_{min}(p)$ , respectively, behave as a function of regulatory forbearance  $p$ ? Ceteris paribus, should a more forbearing regulator require greater capital for its banks? The next proposition establishes that as regulatory forbearance increases, the bank's privately optimal capital level falls whereas the minimum capital requirement level increases whenever the requirement binds.<sup>13,14</sup>

**PROPOSITION 2 (FORBEARANCE AND BANK CAPITAL LEVELS):** *The privately optimal bank capital level and regulatory forbearance behave as strategic substitutes:  $K(p)$  is decreasing in  $p$ . The optimal minimum capital requirement and regulatory forbearance are strategic complements:  $K_{min}(p)$  is increasing in  $p$ .*

The result in Proposition 2 on the privately optimal level of bank capital is intuitive. Note that a bank's likelihood of failure is determined by the critical return on loans,  $R^c$ , below which the bank defaults. Since  $R^c = r_D(1 - \frac{K}{X_R})$ , an increase in bank capital for a given level of risky investment reduces the bank's likelihood of failure, and in turn, leads to a reduced chance of the bank losing its charter value. The privately optimal level of bank capital trades off this benefit with the dilution cost of capital. Since forbearance also buffers bank owners from the loss of charter value, an increase in forbearance enables bank owners to reduce the dilution costs by choosing a lower level of capital. That is, bank capital and regulatory forbearance act as strategic substitutes from the standpoint of bank owners.

The result on the minimum capital requirement is also intuitive. Recall that as forbearance increases, bank owners undertake greater risk (Proposition 1). The role of the minimum capital requirement is to counteract this increase in moral hazard. The proof shows that when the minimum capital requirement binds, the

<sup>13</sup> If the dilution cost of bank capital  $\theta(K)$  is "sufficiently steep" as a function of  $K$ , then the bank's privately optimal capital level is interior:  $K < \hat{X}_R(K(p), p)$ . The condition is that  $\theta'(X_R^*)$  exceed  $\bar{R} - f(X_R^*)c'(X_R^*)$ , where  $X_R^*$  is the risky investment choice of an all-equity bank. The details are omitted here for brevity but are available upon request. This condition ensures that designing an all-equity bank is not in the interests of bank owners due to the high dilution cost of outside equity. An all-deposit bank is not optimal either, since having *some* equity capital reduces the likelihood of bank failure and prevents the loss in charter value.

<sup>14</sup> The minimum capital requirement need not bind in general. This issue is examined theoretically in Acharya (1996), Bhattacharya, Boot, and Thakor (1998), and Milne and Whaley (2001), and is discussed empirically in Keeley (1990), Saunders and Wilson (2001), and Flannery and Rangan (2002). The complete analysis of when minimum capital requirements bind is beyond the scope of this paper. Rather, it is assumed for the rest of the paper that minimum capital requirements bind at least some of the time, as in practice. Assuming otherwise renders the problems addressed in this paper uninteresting.

risky investment of banks decreases in the level of bank capital. If the participation constraint does not bind, then ex post forbearance is counteracted by requiring that banks hold greater capital ex ante. If the participation constraint does bind, then an increase in forbearance increases the charter value of banks, thereby relaxing the participation constraint. In either case, the level of the minimum capital requirement is raised and thus it complements the level of regulatory forbearance.

These results suggest that a lack of complementary variation between the minimum capital requirement and regulatory forbearance is likely to result in suboptimal bank capital structures in situations in which the minimum capital requirement binds. This follows from an immediate corollary of Proposition 2: If the minimum capital requirement binds at forbearance level  $p'$ , it also binds at greater forbearance levels  $p > p'$ . Further, an argument analogous to Proposition 1 shows that a lack of such complementary variation leads to greater risk taking by banks and is associated with a greater incidence of bank defaults and bank bailouts.

The policy implication of the above analysis is that one size of minimum capital requirements does not fit all countries. The closure policies adopted by central banks are highly divergent across countries. Dewatripont and Tirole (1993) document, for instance, that while U.S. and Nordic countries have stringent bank closure policies, Japan and most emerging economies have fairly lax closure practices. State-owned banks in several economies enjoy an almost 100% implicit safety net. The merit of the convergence in capital standards following the Basel Accord of 1988 should thus be examined with caution. Indeed, such convergence is unlikely to be meritorious unless it is accompanied by a convergence of other aspects of bank regulation, such as closure policies. For cases in which such accompanying convergence is infeasible, regulators may need to determine an appropriate divergence of capital requirements. Moreover, Acharya (2001) suggests that differences in the concentration of banking sectors may also accentuate such a need.

I illustrate below the potential ill effects on the global economy from a convergence on capital requirements among countries that practice divergent closure policies.

### III. Multiple-Economy Model

To study potential spillovers from one economy's regulations to other economies and their regulations, I extend the model to two *regimes*. Banks operate across regimes and have equal access to deposits and lending opportunities. The extent of competition that banks face in lending is affected by the aggregate level of risky investments, which in this model is comprised of the risky investments of banks in *both* regimes. Since a bank's risk-taking incentives are affected by the regulatory forbearance exercised in the regime where it is chartered, it follows that the equilibrium value of each regime's banks depends also on the forbearance of the other regime. Financial integration of the regimes thus generates a potential for spillover arising from regulatory practices.

Consider two regimes,  $A$  and  $B$ . The banking sector in each regime consists of a continuum of banks owned by risk-neutral and wealth-constrained intermediaries, a continuum of risk-neutral investors, and a regulator, as in the single-economy model of Section I. The regulators in the two regimes are constrained to enforce identical minimum capital requirements. I assume that banks are regulated on an internationally consolidated basis, or to be more precise, each bank is required to hold a minimum of  $K_{min}$  units of capital against its total risky investment, which is the sum of its domestic and foreign risky investments.

Similarly, upon a bailout of a bank by the regulator of its regime, both domestic and foreign depositors of the bank are bailed out. Furthermore, and this is crucial in the ensuing analysis, the closure or the bailout of a bank in regime  $i$  is governed *only* by the policy of regulator  $i$ ; the discussion in Section III.D below on “home” country versus “host” country regulation presents the implications of relaxing this assumption. Regulators may adopt, however, closure policies with different levels of forbearance toward banks chartered in their respective regimes. These forbearances are denoted by  $p_a$  and  $p_b$ , respectively.

The investor endowment in each regime in each period is  $D$ . There is a common return  $r_S$  on the safe asset, and a common return on the risky asset, denoted by  $R \sim h(\cdot)$  over  $[0, R_{max}]$ . However, the profit margins from risky lending may be heterogeneous across regimes. The cost structure facing a representative regime  $A$  bank is  $f(\bar{X}_{Ra} + \bar{X}_{Rb})c(X_{Ra})$ , where  $X_{Ra}$  is the bank's own risky investment, and  $\bar{X}_{Ra}$  and  $\bar{X}_{Rb}$  are the aggregate risky investment levels in regimes  $A$  and  $B$ , respectively. Note that both  $f(\cdot)$  and  $c(\cdot)$  are increasing and convex neoclassical cost functions as previously specified.

The cost structure faced by a representative regime  $B$  bank is, on the other hand,  $f(\bar{X}_{Ra} + \bar{X}_{Rb})\delta c(X_{Rb})$ , that is,  $\delta[f(\bar{X}_{Ra} + \bar{X}_{Rb})]c(X_{Rb})$ . For  $\delta > 1$ , the individual cost efficiency of regime  $B$  bank in administering loans is lower than that of regime  $A$  bank. The relative inefficiency of regime  $B$  banks may arise if increasing risky investments requires them to lend to sectors beyond their area of expertise, either because their scope is limited compared to that of regime  $A$  banks or because their area of expertise has fewer good loans to make. Following this argument, for a given level of lending, regime  $B$  banks have to either exert extra effort to find good-quality loans or accept a lower return. The relative inefficiency of regime  $B$  banks may also be attributable to the so-called *X-inefficiencies* of Berger and Mester (1997). These correspond to differences in managerial ability to control costs, operational inefficiency from employing excessive labor at branch offices, and other “hard-to-quantify” factors not directly linked to economies of scale or scope. In sum, the parameter  $\delta$  captures the relative inefficiency of regime  $B$  banks.

### A. International Spillovers

Under this multiple-economy setting, what is the effect of forbearance exercised toward regime  $A$  banks on the value of regime  $B$  banks? First, I assume  $\delta = 1$ , so that the regimes differ only in their regulatory forbearances. I show that the size of regime  $B$  banks, as measured by their charter values,  $V_b(p_a, p_b)$ , is

decreasing in the forbearance  $p_a$ . This effect is called the *spillover* from regime  $A$  to regime  $B$  banks. Essentially, the spillover arises whenever the size of the regime  $B$  banks shrinks. A heterogeneity across regimes in bank profit margins also results in a spillover. *Ceteris paribus*, this happens if  $\delta > 1$ , that is, if regime  $B$  banks run less efficiently than those in regime  $A$ .

PROPOSITION 3 (INTERNATIONAL SPILLOVER): *The charter value of regime B banks,  $V_b$ , is, ceteris paribus (i) decreasing in  $p_a$ , the forbearance exercised by the regulator of regime A; and (ii) decreasing in  $\delta$ , the relative inefficiency of regime B banks, at an increasing rate in  $p_a$ .*

I discuss these effects below.

Forbearance of regime  $A$ : Allowing for a difference in the forbearance between the two regimes captures the institutional reality that most central banks adopt vastly different closure policies. Another useful interpretation that I apply to empirical evidence involves two classes of banks within the same economy, such as state-owned and private banks, which are subject to different levels of forbearance from the regulator and thus belong conceptually to different regulatory regimes. Regardless of interpretation, as the forbearance of regime  $A$  increases, its banks find risky investments more attractive (Proposition 1). This, in turn, raises the competition in lending markets and lowers the profit margin of regime  $B$  banks, net the costs of lending activity. Since the risk-adjusted cost of borrowing for all banks is identical and equal to the risk-free rate, but regime  $B$  banks have a lower regulatory subsidy, the lowered profit margin gives rise to an international spillover. The greater the forbearance exercised by the regime  $A$  regulator, the greater is the spillover.

Two points are in order. First, in a world with uniform capital requirements, the regime  $B$  regulator cannot impose differential capital requirements on regime  $A$  banks to curb their risk-taking incentives. This lack of flexibility is the primary source of the spillover. Second, the regulation adopted by regime  $A$  has an externality on regime  $B$  banks. If each regulator is concerned only about maximizing the value of its own banking sector, this externality will, in general, not be internalized in the absence of coordination. Thus, the situation in which each regime increases its forbearance, and thereby produces welfare costs for other regimes, has the potential of being an equilibrium outcome. This intuition is formalized below in Section III.B.

Inefficiency of regime  $B$  banks: The spillover operates through an increase in the cost of the lending activities of regime  $B$  banks. As regime  $B$  banks' lending activities get more inefficient, the profit margins of regime  $B$  banks fall more sharply than those of the regime  $A$  banks for given levels of aggregate risky investments. Since the risky investment of regime  $A$  banks increases with the forbearance of the regime  $A$  regulator, the overall effect is to shrink the regime  $B$  banks—as  $\delta$  increases, so does the magnitude of the spillover, at a rate that increases in  $p_a$ .

The spillover characterized in Proposition 3 is essentially an implication on the size of the banking sector in regime  $B$ . What, however, are the implications of the spillover for the *stability* of the banking sector in regime  $B$ ? That is, while

regime  $B$  banks make smaller profits, do regime  $B$  banks become safer or riskier as a result of the international competition? Do regime  $B$  banks expand lending and increase their risk of default, given  $K$  is fixed and  $X_{Rb}$  is increasing, or do they cut back lending and reduce their risk? Somewhat interestingly, both of these cases can arise.

For the sake of illustration, consider the effect of varying  $p_a$ . On the one hand, an increase in the regulatory forbearance of regime  $A$  increases competition for regime  $B$  banks and makes lending less attractive. This is essentially a myopic effect; the current period profits from risk taking shrink as the costs of lending rise. Counteracting this myopic effect, however, is the intertemporal effect: As each period's profits shrink, the charter values of regime  $B$  banks shrink as well, inducing greater risk-taking behavior. That is, as profits shrink, banks stand to lose less upon failure and hence find lending more attractive.

Given the endogenous determination of bank charter values in the model, it is not tractable to come up with a general analytical characterization of the relative strengths of the above two effects. However, for the following example economy, such a characterization is feasible, and suggestive of likely scenarios in which one effect dominates the other.

*Example 1 (international spillover and risk):* Suppose  $c(x) = e^{\alpha x}$  with  $\alpha > 0$ ,  $R \sim \text{Unif}[0, R_{max}]$ ; there exists an internationally uniform minimum capital requirement,  $K_{min}$ .

- (i) There exists  $\alpha^* > 0$ , a high critical level of diseconomies of scale such that  $\forall \alpha > \alpha^*$ , regime  $B$  banks' risky investment,  $X_{Rb}$ , and likelihood of default,  $H(R_b^c(X_{Rb}))$ , are ceteris paribus decreasing in  $p_a$ , the forbearance exercised by the regime  $A$  regulator.
- (ii) There exists  $\alpha^{**}$ ,  $0 < \alpha^{**} < \alpha^*$ , a low critical level of diseconomies of scale such that  $\forall \alpha < \alpha^{**}$ , regime  $B$  banks' risky investment,  $X_{Rb}$ , and likelihood of default,  $H(R_b^c(X_{Rb}))$ , are ceteris paribus increasing in  $p_a$ , the forbearance exercised by the regime  $A$  regulator.

The general condition derived in Appendix B employs some endogenous variables of the model. In contrast, the critical levels  $\alpha^*$  and  $\alpha^{**}$  for the exogenous cost function are derived for the example economy such that the results above hold for all candidate aggregate cost functions  $f(\cdot)$  and all parameter values for  $\delta$ . As a consequence, the behavior of regime  $B$  banks in the region  $[\alpha^{**}, \alpha^*]$  is not characterized. Nevertheless, this example illustrates very succinctly the determinant of the relative strengths between the myopic risk-reducing effect and the intertemporal risk-inducing effect, as discussed below.

First, consider the case in which  $\alpha > \alpha^*$ . Here, the marginal cost of risk taking for regime  $B$  banks is high. As a result, the myopic risk-reducing effect of competition dominates the intertemporal risk-inducing effect. Thus, the regulatory spillover from regime  $A$  decreases the likelihood of default of regime  $B$  banks. In general, as the forbearance of regime  $A$  increases, regime  $A$  banks gain value and take greater risks, whereas regime  $B$  banks lose value and take lower risks.

One caveat to this case arises from the assumption that costs are nonpecuniary. Since costs are not a drain on pecuniary bank profits, the critical return on loans  $R_b^c$  below which a bank default occurs in a given period is unaffected by a change in the costs in that period. In a setting in which these costs are pecuniary, the myopic effect could also induce greater risk for banks in regime *B*, as higher costs increase  $R_b^c$  and drive the equity option of bank owners deeper “out-of-the-money.” This can induce a perverse risk-taking incentive as in the models of bank competition studied by Allen and Gale (2000b, Chapter 8). In contrast, the earlier results, that an increase in the home regulator’s forbearance leads to greater risk taking and greater charter values (Proposition 1, Lemma 2), and that an increase in the foreign regulator’s forbearance leads to smaller charter values (Proposition 3), are robust to this assumption.

Next, consider the case in which  $\alpha < \alpha^{**}$ , that is, the marginal increase in costs incurred by regime *B* banks upon an increase in risk taking is small. This could arise if banks are capitalizing on scale or scope economies, or on a reduction in diseconomies, unbundled by technology. In this scenario, the myopic risk-reducing effect is weak and is dominated by the intertemporal risk-inducing effect. Thus, the regulatory spillover from regime *A* increases the likelihood of default of regime *B* banks. To summarize, in this case, regime *A* banks gain value, regime *B* banks lose value, and banks of both regimes undertake greater risk. The increased forbearance of regime *A* is thus destabilizing not just for its own banks, but also for the banking sector in regime *B*. This case is especially perverse for regime *B*—not only does its banking sector shrink, but the shrinkage brings along with it greater financial instability.

Based on this intuition and the caveat raised above, I conjecture that the international spillover of a foreign regime’s regulation is quite likely to undermine the financial stability of other regimes. The effect would be stronger for those regimes that are characterized by banks that operate at low diseconomies of scale or scope, and in periods when bank lending experiences a reduction in diseconomies due, for example, to technological progress.

### *B. Regression toward the Worst Regulation*

An important assumption made in the analysis of spillovers thus far is that of *ceteris paribus*: All else remains equal. When regulators have discretionary mechanisms such as bank closure policy at their disposal, they respond to the regulatory choices of other regulators. If regulators adopt their closure policies in an uncoordinated fashion, but indeed coordinate on capital requirements, what equilibrium results? Is coordination on some but not all regulatory policies a desirable step for integrated regimes and the financial stability of each?

I explore these questions below. I allow for a difference in regulatory objectives that endogenizes the exercised levels of forbearance. I then study how one regulator responds to the spillover from excessive forbearance by another regulator.<sup>15</sup>

<sup>15</sup> I am grateful to the anonymous referee for suggesting that I examine the political economy effect of forbearance in one regime on forbearance in other regimes.

Indeed, the results that follow demonstrate that there is a robust and economically plausible set of regulatory objectives under which regulator  $B$  responds to regulator  $A$ 's increase in forbearance by increasing his own forbearance. In particular, if regulatory objectives are sufficiently divergent across regimes, then, in equilibrium, there may be a "regression toward the worst regulation"—a central bank aligned more with the interests of its own bank owners exercises greater forbearance, and other central banks respond with similar behavior.

This finding suggests that in addition to the myopic and the intertemporal effects of a spillover on risk taking by regime  $B$  banks, there is a third potentially important effect. The moral hazard induced by the increase in regulator  $B$ 's forbearance makes lending more attractive for regime  $B$  banks compared to the situation in which this forbearance is assumed to be exogenous. The answer to the last question posed above may thus be in the negative: A regulatory "race to the bottom" could be worse for financial stability than no coordination on any policies at all.

I begin my analysis in this section by appealing to the fact that regulators are aligned to varying degrees with the normative objective of overall bank value maximization. This political economy of regulation implies that some regulators are more closely aligned with an interest group, such as bank owners. This characterization is not unrealistic: Laffont and Tirole (1991) provide a theoretical analysis of such regulatory capture; Kane (1990) documents empirical evidence of the same during the resolution of the S&L crisis in the United States; and White (1982), in his account of the evolution of banking regulation in the United States from the Civil War to the Great Depression (1864–1929), notes the considerable regulatory influence wielded by the political coalition of unit banks.<sup>16</sup>

Accordingly, I generalize the regulator's objective to one that maximizes the weighted average  $W_\lambda$  of the welfare of bank owners and the welfare of outside claimants of its domestic banks, with weights  $\lambda$  and  $(1 - \lambda)$ , respectively. Thus,

$$W_\lambda = \lambda V + (1 - \lambda)(W - V), \quad (18)$$

where  $V$  is the value of the bank's inside equity given by equation (4) and  $W$  is the total value of the bank inclusive of all its claims, given by equation (12). Thus,  $(W - V)$  represents the sum of the values of claims held by depositors and outside equity holders.

The parameter  $\lambda$  above can be thought of as the regulatory alignment parameter. If  $\lambda = \frac{1}{2}$  then  $W_\lambda = \frac{1}{2}W$ , which corresponds to the normative case of bank value maximization described thus far in this paper;  $\lambda > \frac{1}{2}$  reflects a greater weight on the interests of bank owners whereas  $\lambda < \frac{1}{2}$  represents greater alignment with the interests of a bank's outside claimants. Given the time inconsistency in enforcing ex ante optimal regulatory policies, which typically benefits

<sup>16</sup> White (1982) observes that "Changes in banking regulation were the product of protracted political struggles among different interest groups seeking to influence the structure of the industry. In this paper, the evolution of banking regulation from the Civil War to the Great Depression is analyzed by examining the actions of the three interested parties: the banks, the public, and the government regulators. These were not homogeneous groups but were categorized by divergent economic interests."

bank owners, many regulators would be classified as having a weight of  $\lambda > \frac{1}{2}$  in their objectives. Furthermore, government ownership of banks and government influence on central bank decisions also produce a greater regulatory alignment with bank owners.

I next assume that  $\delta = 1$  so that banks in different regimes face identical cost structures, and thus, the only difference between the regimes arises from a difference in their regulatory weights,  $\lambda_a$  and  $\lambda_b$ , respectively. In particular, to model the heterogeneity in regulatory objectives,  $\lambda_b$  is treated as fixed and  $\lambda_a$  is allowed to increase. As before, there is an international convergence of minimum capital requirements at a level  $K_{min}$ . Each regulator then solves a design problem that is a variant of the one specified in equations (13)–(16). Regulator *A*'s problem is as follows:

$$\max_{p_a} W_{\lambda_a}(\hat{X}_R | K, p_a) \tag{19}$$

subject to the following constraints:

Incentive-Compatibility (IC)

$$\hat{X}_R \in \arg \max_{X_R} v(X_R, K) - \theta(K) + \beta V[1 - (1 - p_a)H(R^c(X_R))], \tag{20}$$

Minimum Capital Requirement (MCR)

$$K \in \arg \max_{K \leq \hat{X}_R(\cdot), K \geq K_{min}} v(\hat{X}_R, K) - \theta(K) + \beta V[1 - (1 - p_a)H(R^c(\hat{X}_R, K))], \tag{21}$$

Participation-Constraint (PC)

$$V(\hat{X}_R, K) \geq \bar{V}, \tag{22}$$

and Individual Rationality of Depositors (IR)

$$r_S = r_D[1 - (1 - p_a)H(R^c)] + (1 - p_a) \int_0^{R^c} \frac{RX_R}{X_R - K} h(R) dR, \tag{23}$$

where, for simplicity, I have suppressed the subscript *a* on all terms other than  $p_a$  and  $\lambda_a$ . Regulator *B*'s problem is specified similarly. The interaction of these two design problems arises from the fact that banks of regime *i* face an equilibrium cost of making loans of  $f(\bar{X}_{Ra} + \bar{X}_{Rb})c(X_{Ri})$ , which is increasing in the aggregate level of lending activity,  $(\bar{X}_{Ra} + \bar{X}_{Rb})$ ; note, *i* takes on the values *A* and *B*, respectively, according to the regime in question. Denote the forbearances of the two regulators as  $p_a(\lambda_a)$  and  $p_b(\lambda_b)$ , respectively.

I now show that as  $\lambda_a$  increases,  $p_a$  increases as well—a greater alignment of the regulator's objective with its bank owners makes forbearance more attractive to the regulator.

LEMMA 1 (REGULATORY CAPTURE AND FORBEARANCE): *Ceteris paribus, the forbearance of regulator A,  $p_a(\lambda_a)$ , increases in its alignment with its bank owners,  $\lambda_a$ .*

Thus, an increase in regulatory capture  $\lambda_a$  leads to a corresponding increase in exercised forbearance  $p_a$ , but the capital requirement  $K_{min}$  is constrained to stay

the same. This gives rise to greater risk taking by regime *A* banks, which in turn produces a spillover on regime *B* banks. The spillover, if large enough, forces the charter values of regime *B* banks to fall below their reservation values or leads the banks of regime *B* to take excessive risk. In response, the regulator of regime *B* is also forced to adopt greater forbearance. This occurs whenever the regulatory capture of regulator *A* is sufficiently high relative to that of regulator *B*.

**PROPOSITION 4 (REGRESSION TOWARD THE WORST):** *In equilibrium, the regime B regulator increases forbearance upon an increase in the capture of the regime A regulator; that is, both forbearances  $p_a$  and  $p_b$  increase in  $\lambda_a$  if  $(\lambda_a - \lambda_b)$  is greater than a critical threshold  $\Delta\lambda \geq 0$ .*

In the proof in Appendix B, I show that if both  $\lambda_a$  and  $\lambda_b$  are sufficiently low, then  $p_a$  and  $p_b$  are sufficiently low such that the participation constraint (PC) binds for the design problems of both regulators, and thus, locally, a small increase in  $\lambda_a$  does not shift the equilibrium. On the other hand, if  $\lambda_b$  is low relative to  $\lambda_a$  such that PC binds for regime *B* banks but does not bind for regime *A* banks, then an increase in  $\lambda_a$  induces a spillover—regime *B* banks' charter values are driven below their exit point unless they are compensated through greater forbearance by their regulator. Thus, the regulator of regime *B* is forced to behave as though its effective alignment with bank owners is greater than  $\lambda_b$  and somewhat more like  $\lambda_a$ , that is, regulatory capture in one of the regimes induces regulatory capture in the other regime as well.

Note, if  $\lambda_a$  and  $\lambda_b$  are such that PC does not bind for both regimes' banks, then two cases can arise. As shown before, the spillover of regime *A*'s regulation affects both the charter values and the risk taking of regime *B* banks. In the first case, an increase in forbearance of regime *A* reduces risk taking by regime *B* banks or, more generally, does not sufficiently increase risk taking by regime *B* banks (as characterized in the proof). The relevant spillover in this case is the reduction in the charter values of regime *B* banks. If  $\lambda_a > \lambda_b > \frac{1}{2}$ , then the regime *B* regulator is also more aligned with bank owners than with other bank claimants and responds to the induced spillover by increasing its forbearance. On the other hand, if  $\lambda_b \leq \frac{1}{2}$ , then the regime *B* regulator is more conservative and responds initially by lowering its forbearance. However, the combined effect of a decrease in  $p_b$  and an increase in  $p_a$  is to eventually drive the regime *B* banks' charter values below their exit point. A sufficient amount of heterogeneity in the regulatory objectives thus forces the conservative regulator of regime *B* to start exhibiting greater forbearance toward its shrinking banks.

In the second case, an increase in forbearance of regime *A* does increase risk taking by regime *B* banks sufficiently. In this case, even a conservative regime *B* regulator with alignment  $\lambda_b \leq \frac{1}{2}$  responds by increasing its forbearance. The relevant spillover now is the effect on risk taking by regime *B* banks. The spillover of regime *A*'s forbearance leads to a greater incidence of defaults by regime *B* banks, and the regime *B* regulator increases its forbearance in order to reduce the continuation value losses upon their default. To summarize, in all cases, a substantial heterogeneity in regulatory objectives leads the less-captured

regulator to also exhibit greater forbearance upon an increase in the capture of the other regulator.

I call this perverse phenomenon a “regression toward the worst” or a “race to the bottom.” By exercising lower forbearance, a regulator also enables other regulators to exercise lower forbearance. However, this externality is not taken into account by regulators when they take uncoordinated actions. The spillover from one regime’s regulation to the other regime’s banks is the driving force behind this result. Recall that such spillover also increases in the relative inefficiency of the integrated banking sectors. It follows that a lack of coordination in closure policies is more likely to lead to a race to the bottom for those banking sector integrations for which (i) banks operate at different levels of cost efficiency across sectors, and (ii) regulators of these sectors differ substantially in the extent to which they are aligned with their domestic banks. The first condition implies that the externality of one regime’s policies on other regimes is likely to be high; the second suggests that these externalities are likely to remain uninternalized, resulting in a regression to the worst regulation.

Consider next the effect of regression toward the worst regulation on financial stability. While an increase in a foreign regulator’s forbearance and thus in international competition need not always lead to an increase in risk taking by banks, an increase in a home regulator’s forbearance always leads to an increase in risk taking as shown in Proposition 1. In particular, note that

$$\frac{\partial X_{Rb}}{\partial \lambda_a} = \left[ \frac{\partial X_{Rb}}{\partial p_b} \frac{\partial p_b}{\partial p_a} + \frac{\partial X_{Rb}}{\partial \bar{X}_{Ra}} \frac{\partial \bar{X}_{Ra}}{\partial p_a} \right] \frac{\partial p_a}{\partial \lambda_a}, \quad (24)$$

where the partial derivatives are employed to signify that  $\lambda_b$  stays constant. The first set of terms inside  $[\cdot]$  on the right-hand side (RHS) captures the effect on the risk of regime *B* banks of the regulatory response of the regime *B* regulator to an increase in the regime *A* regulator’s capture. The second set of terms captures the effect of international competition explored in Example 1. When regression toward the worst closure policy occurs, the first effect is positive. In other words, risk taking induced in regime *B* banks by international competition in lending is exacerbated. It follows that the region of cost parameter  $\alpha$  in Example 1 over which there is an increase in both the risk and the likelihood of regime *B* bank failures is larger if  $(\lambda_a - \lambda_b) > \Delta\lambda$ , as compared to the case in which regime *B*’s forbearance is taken to be exogenous.

Based on this analysis, I conjecture that the effect of regression to the worst closure policy on financial stability will be more perverse in periods during which banks face lower diseconomies of scale in lending. In this case, both the moral hazard effect stemming from the home regulator’s forbearance and the risk-inducing effect of competition stemming from the foreign regulator’s forbearance act in the same direction.

In principle, a central authority in financial integration, such as the European Central Bank in the European Monetary Union, could deviate from conformity with the minimum capital requirements as follows. Capital requirements would be designed in conjunction with the closure policy to take the form  $(K_a, p_a)$  for

regime *A* banks and  $(K_a, p_b)$  for regime *B* banks. From Proposition 2, the optimal capital requirement increases with an increase in forbearance, so  $K_a > K_b$  if  $p_a > p_b$ . This increase in minimum capital requirement would counteract the excessive risk taking by regime *A* banks, reduce the spillover to regime *B*, and, in turn, reduce regulator *B*'s incentives to converge toward regulator *A*'s forbearance. It thus appears that the theoretical prescription for international convergence of capital adequacy regulation is a rule that includes complementary variation between the capital requirement and the closure policy.

### *C. Supporting Empirical Evidence*

Evidence supporting international spillovers can be found in Peek and Rosengren (1997, 2000). These authors document that by 1990, Japanese banks had a deep penetration in the commercial and industrial (C&I) lending markets in the United States, with lending by their U.S. branches and subsidiaries amounting to a proportion as high as 18% of all C&I loans made to U.S. borrowers. This level of market penetration significantly eroded the market share of even the large U.S. banks. What caused such extensive penetration of Japanese banks in the United States? Evidence suggests that the regulatory subsidies enjoyed by Japanese banks at least partially explain this fact. Indeed, one of the ostensible purposes of the Basel Accord of 1988 was to "level the playing field" by eliminating a funding cost advantage conferred to the Japanese banks by their regulators. Wagster (1996) finds, however, that this purpose was not achieved after the passage of the Basel Accord, though the Accord did effectively harmonize the bank capital requirements. Scott and Iwahara (1994) attribute this finding to advantages enjoyed by Japanese banks that stemmed from non-Basel policies such as safety nets and their discretionary enforcement.

Another recent case is that of the state subsidy provided to Credit Lyonnais by the French government and its effect on the bank's competitors. Under the leadership of Jean-Yves Haberer, Credit Lyonnais undertook an aggressive growth strategy during the period 1988 to 1993, expanding its property lending in the United States, Europe, and France alike. Much of this lending was reckless and remained uncurbed due to lax supervision and generous infusions of equity by the French government. As a result of this government-subsidized expansion, Credit Lyonnais became the largest non-Japanese bank to significantly erode the market share of its non-French and French competitors. Thomas Financial's league tables, which list the market shares of banks by number of deals and volume of loans to U.S. borrowers, reveal that Credit Lyonnais jumped from a rank not among the top 40 issuers prior to 1985 to the eighth rank for the period 1985 to 1995. During this period, Credit Lyonnais overtook banks such as Credit Suisse First Boston, ABN AMRO, Fleet Boston Financial Corp., Toronto Dominion Securities Inc., Societe Generale, and BNP Paribas.

Since Credit Lyonnais' French competitors did not have access to similar regulatory forbearance, they belonged to less forbearing regulatory regimes. Strikingly, on July 26, 1995, the day after the bailout of Credit Lyonnais was approved for 9.3 billion USD, Standard & Poor's downgraded Societe Generale's debt

because of the stiffer competition and loss of market share anticipated following Credit Lyonnais' bailout. Although the European Commission eventually required that the French government privatize Credit Lyonnais, this move occurred only after the total cost of Credit Lyonnais' bailouts in the period 1994 to 1996 had amounted to 25 billion USD.<sup>17</sup>

It is relatively harder to find empirical support for the effect of international competition on bank risk taking discussed in Example 1. A simultaneous empirical analysis of cost frontiers, risk taking, and competition is unavailable for banks at an international level. It is interesting to observe, however, that liberalization is often accompanied by a simultaneous improvement in cost efficiency, an increase in competition, and a rise in financial instability for banks of the liberalized economies, as noted by Hellmann, Murdock, and Stiglitz (2000). This lends some support to the channel explored in the second case of the example, wherein banks take greater risk when faced with international competition.

The link between regulatory capture and forbearance is perhaps the most-documented aspect of the political economy of bank regulation. Its many examples include the following bailouts: those of Credit Lyonnais, as discussed above; the bailouts of the S&Ls in the United States, driven by regulatory capture and reputation considerations as documented by Kane (1990); and the bailouts of banks during the more recent East Asian crisis, as summarized in Bongini, Claessens, and Ferri (1999).

This paper's policy implications are necessarily forward-looking with regard to the financial integration under way within the European Union. However, some historical evidence exists to support the claim that bank regulators compete on discretionary mechanisms resulting in a regulatory race to the bottom. For instance, White (1982) documents the weakening of the legal constraints on banks due to competition between state and federal regulators during the dual banking system in the United States following the National Banking Act of 1864. To attract bank induction, Congress levied a 10% tax on all nonnational banknotes and sought to permit some form of interstate branching to national banks. Anticipating the vigorous competition from national banks, all but one state (Massachusetts) that had minimum capital requirements above the new federal level reduced their requirements to maintain their competitive advantage. This prevented the exit of many state-chartered banks from the regulatory regime of the states. While White's paper does not establish a causality relationship, the period from 1864 through 1929 was also one of the most turbulent and crisis-prone eras in the history of U.S. banking.

More recent evidence includes the previously stated findings of Wagster (1996) and Scott and Iwahara (1994), which suggest that Japanese regulators counteracted any harmful effect of the Basel Accord of 1988 on the Japanese banks by relaxing their non-Basel policies. The empirical record exemplifies the theoretical response derived in this paper. Further evidence on such competition amongst regulators in the context of international securities markets is provided by White (1996).

<sup>17</sup>The Credit Lyonnais saga is covered in the *Economist* articles "Discredit Lyonnais" (September 26, 1992), "The Big Squeeze" (June 17, 1995), and "Shrinking" (July 29, 1995).

#### D. Proposals for Regulation of International Banks

I propose two possible remedies to prevent the spillovers discussed above.

**Complete coordination of regulation:** This solution seems apt for the European Monetary Union (EMU). A central issue since the EMU's formation has been to what extent should the policies of member nations be harmonized. The Single Market Act has allowed both branches and subsidiaries to be opened by every bank in each country, but a bank is subject only to the regulations of its home country. This is the so-called "home-country control" rule specified in the European Union directives, as documented, for example, in Iakova (2000). However, while banks are required to meet the 8% Basel capital requirement, no explicit rules exist to determine which authority should bail out a failed bank. The EMU is still debating whether there should be a central lender-of-last-resort in Europe. My analysis suggests that the answer is yes, provided it leads to a complete harmonization. Otherwise, given that different countries' banks are all subject to the same Basel capital requirements, national regulators may favor their own country's banks by exercising high levels of regulatory forbearance and low levels of regulatory supervision.

**Host-country regulation:** This solution has been adopted by the United States. The International Banking Act (IBA) of 1978 sought to extend national treatment in the United States to foreign banks. However, poor foreign supervisory standards led to a series of undesirable outcomes: the collapse of the Bank of Credit and Commerce International (BCCI), unauthorized lending by the Italian Banca Nazionale del Lavoro, and unauthorized borrowing by the Greek National Mortgage Bank. Such outcomes led to the passage of the Foreign Bank Supervision Enhancement Act (FBSEA) of 1991. I view the measures taken by the FBSEA, such as the enhanced powers of the federal regulators over the entry, closure, examination, deposit taking, and activity powers of foreign banks, as a step toward complete regulatory insulation of the U.S. banking sector from foreign regulation.

In particular, FBSEA requires that a foreign bank entering the U.S. banking sector must be subject to comprehensive supervision on a consolidated basis by a home regulator. Furthermore, that home regulator must furnish all the information needed by the Federal Reserve to evaluate the application. The Federal Reserve can close a foreign bank's U.S. offices if its home-country supervision is inadequate, if it has violated U.S. laws, or if it has engaged in unsound and unsafe practices.<sup>18</sup> Finally, the Federal Reserve has the power to examine each office of a foreign bank, and each branch or agency is to be examined at least once a year.

Note that it is virtually impossible for a host-country regulator to dictate all regulations that govern foreign banks' activities, since some of these activities may be performed remotely. Host-country regulation can nevertheless induce incentives for more appropriate levels of risk taking in the foreign banks if it is

<sup>18</sup> An account of a recent U.S. investigation against Credit Lyonnais, *Economist*, January 13, 2001, reports: "... the Federal Reserve Bank of New York, which oversees the activities of foreign banks in America, is in the process of deciding whether it should suspend Credit Lyonnais's banking license. This penalty, which is rarely invoked, is the most serious that can be inflicted on a bank."

accompanied by supervision and a credible threat of closure of local activities of these banks.<sup>19</sup> While I have not allowed for this possibility in the models presented in this paper, it is a plausible way to counteract regulatory spillovers.

#### IV. Robustness of the Model and Results

##### A. *Absolute Level of Bank Capital versus Capital Ratio*

In practice, capital requirements are not imposed as a required absolute level of bank capital, but rather as a required ratio of bank capital to suitably risk-adjusted assets. In light of this fact, can the implications of the models I have presented be applied directly to the existing regulations? I claim that indeed there is a mapping between these two settings.

In the model, the *level* of risky investment by banks is not contractible. Hence, it is endogenously consistent to assume that regulators cannot implement capital ratios. In reality, even though the level of risky investment is contractible, the *exact risk* of different risky assets is not contractible. For example, current capital requirements against nontraded risks divide all risky assets into coarse risk buckets. Banks thus have incentives to overinvest in the riskier assets within each bucket. The role played by the level of risky investment in my model is, in this setting, the analog of these riskier assets. The model's regulatory spillover arises due to an increase in risky lending by banks of the more-forbearing regime and the fact that these banks are not required to hold more capital against their increased risk. Similarly, in the setting with coarse risk buckets, banks of the more-forbearing regime can increase their investments in the riskier assets within each risk bucket, which would result in these banks securing a competitive edge by increasing the size of such investments and thereby eroding profits from similar investments by banks of the less-forbearing regime.

Thus, through a qualitatively similar channel, I believe that the implications of the model also apply to the capital ratio setting, as long as there is incompleteness in contracting on some dimension of risk. The model can thus be viewed as a metaphor for the residual risk-shifting problem or for the residual incompleteness in regulatory contracts.

##### B. *Dynamic Management of Bank Capital*

In practice, banks do not pay out all profits and issue new capital each period. This leads to suboptimal dilution costs, since inside equity lies at the top of the pecking order. Note, however, that whether capital should be issued in single or multiple issuances depends crucially on the issuance cost structure: Convex

<sup>19</sup> Between 1993 and 1995, federal bank supervisors issued 40 formal enforcement actions against foreign banks operating in the United States. The most noticeable case was that against Daiwa bank (in 1996), which was forced to close its U.S. activities following Daiwa management's concealment from the U.S. regulator of trading losses of over 1 billion USD. Eventually, Daiwa's U.S. bank assets were sold to Sumitomo Bank of Japan, and Daiwa had to pay a fine of 340 million USD to the U.S. authorities for the settlement of legal charges against the bank.

issuance costs will lead to a smaller size but a greater number of issuances. Empirically, the cost structure appears to be a fixed cost plus a convex component, whereby there might be an optimal frequency as well as an optimal size of capital issuance. Nevertheless, how does relaxing my myopic assumption affect the qualitative nature of these results?

My conjecture is that when banks make profits, they employ their retained earnings to build up their capital levels; the need to preserve their enhanced charter values provides them with further incentive to build up capital. On the other hand, when banks make losses, their capital cushion is wiped out and they are forced to incur dilution costs as they restore their capital levels through equity issuance. The lowered charter values would reduce, however, the incentive of banks to invest in capital in these states. Furthermore, if costs of equity issuance are countercyclical, then banks will raise more capital in “good” times to transfer it to “bad” times, when capital issuance is more costly. The result that minimum capital requirements increase with regulatory forbearance should hold, even though the optimal level of capital required may vary across different points of the cycle.

## V. Conclusion

In this paper, I have illustrated an application to bank regulation of a simple but fundamental point: Ex post policies affect the optimality of ex ante incentives, and thus an ex ante optimal regulatory design must take into account this feedback effect. Such a result is likely to apply in many banking and corporate finance settings. Some examples include the link between the effectiveness of bank supervision or enforcement and capital requirements, or, the effect of debtor-friendly versus creditor-friendly bankruptcy codes on risk-taking incentives and thus the capital structure of firms.

There is currently no satisfactory theory of organizational structure and regulation of international financial institutions. Countries and their regulators face the task of answering difficult design questions as they move toward international harmonization. My hope is that the model presented here provides some insight into the kind of issues that one needs to tackle to make progress in these relatively untapped, but apparently promising, lines of inquiry.

Finally, there is a parallel between the results in this paper and several strands of economic literature. One parallel concerns the need for including protection of intellectual property rights (IPRs) in multilateral trade agreements. Goh and Olivier (2001) examine the interaction between trade policies and the protection of IPRs as strategic substitutes and the consequences of the lack of international cooperation on both. I conjecture that such parallels will arise in many situations characterized by multiple policy instruments and harmonization amongst heterogeneous economies. Other recent examples include the talks regarding the harmonization of taxes and bankruptcy codes within the European Union and the concern regarding a race to the bottom in environment control policies, given the soft stance of countries whose firms have lost their competitive edge to foreign firms due to the home country's stricter domestic controls.

### Appendix A: Existence of Equilibrium

I characterize the conditions under which the symmetric competitive equilibrium discussed in Section I exists and has interior investment choices.

PROPOSITION 5: *A symmetric competitive equilibrium of the economy in which banks hold capital  $K$  exists whenever (i) there is reward for bearing some risk, that is,  $\bar{R} > r_S$ ; and (ii) the costs of making risky investments are sufficiently steep, that is,  $f(D)c'(D) > \int_{r_S}^{R_{max}} (R - r_S)h(R)dR$ . In equilibrium, (i)  $r_D \geq r_S$ ; (ii)  $X_S = 0$ ; and (iii)  $X_R < D$ .*

*Proof:* From the individual rationality of depositors in equation (5), it follows that

$$\frac{r_S}{r_D} = 1 - (1 - p)H(R^c) + (1 - p) \int_0^{R^c} \frac{r_S X_S + R X_R}{r_D (X_S + X_R - K)} h(R) dR. \quad (A1)$$

From the definition of  $R^c$  in equation (1), it follows that whenever  $R < R^c$ , the last integrand, namely,  $(r_S X_S + R X_R) / [r_D (X_S + X_R - K)]$  is less than one. Thus, the right-hand side of equation (A1) is always less than or equal to one. It follows that  $r_S \leq r_D$  always.

Next, whenever  $r_D \geq r_S$ , it can be readily verified from equations (1) and (2) that

$$\frac{\partial R^c}{\partial X_S} > 0, \quad \frac{\partial v}{\partial X_S} < 0, \quad \frac{\partial v}{\partial R^c} < 0,$$

and hence

$$\frac{dv}{dX_S} = \frac{\partial v}{\partial X_S} + \frac{\partial v}{\partial R^c} \frac{\partial R^c}{\partial X_S} < 0.$$

Furthermore, since  $V$  is a lump-sum constant in the bank owners' maximization, it also follows that

$$\begin{aligned} \frac{\partial}{\partial X_S} [\beta V (1 - (1 - p)H(R^c))] &= -\beta(1 - p)V \frac{\partial H(R^c)}{\partial X_S} \\ &= -\beta(1 - p)V h(R^c) \frac{\partial R^c}{\partial X_S} < 0. \end{aligned} \quad (A2)$$

From the bank owners' maximization in equation (3), it can be inferred that the first-order derivative of the maximand with respect to (w.r.t.)  $X_S$  is always negative. This combined with the short sales constraint  $X_S \geq 0$  implies that  $X_S = 0$  in equilibrium. Then, substituting  $X_S = 0$  in equation (3) and optimizing the reduced problem w.r.t.  $X_R$  yields the first-order conditions (6)–(9).

The first-order condition (6) can be written in the simplified form:

$$\int_{R^c}^{R_{max}} (R - r_D)h(R)dR = f(X_R)c'(X_R) + \beta(1 - p)Vh(R^c) \frac{\partial R^c}{\partial X_R}. \quad (A3)$$

It is clear from the equation (A3) that if  $X_R = 0$ , which implies  $r_D = r_S$  and  $R^c = 0$ , then, since  $c'(0) = 0$  and  $f(0) = 0$ , there is an incentive to invest in risky assets as long as  $\bar{R} > r_S$ , that is, as long as there is reward for bearing at least some risk.

The next step is to identify conditions under which the choice of  $X_R$  is interior:  $X_R < D$ . Since  $\partial R^c / \partial X_R = r_D K / X_R^2 > 0$ , a sufficient condition to obtain  $X_R < D$  is that  $\int_{r_D(1-K/D)}^{R_{max}} (R - r_D)h(R)dR < f(D)c'(D)$ . Since  $\int_{r_D(1-K/D)}^{r_D} (R - r_D)h(R)dR \leq 0$ , the sufficient condition can be weakened to have  $\int_{r_D}^{R_{max}} (R - r_D)h(R)dR < f(D)c'(D)$ . The left-hand side of this condition is decreasing as a function of  $r_D$ , and, since  $r_D \geq r_S$  in equilibrium, it is maximized for  $r_D = r_S$ . It follows that a sufficient condition to obtain an interior equilibrium with  $X_R < D$  is  $f(D)c'(D) > \int_{r_S}^{R_{max}} (R - r_S)h(R)dR$ , that is, the cost functions are sufficiently steep. □

### Appendix B: Proofs

I first prove two intermediate results to be used in the proofs that follow. Throughout, I employ the notation  $Z = 1 - \beta + \beta(1 - p)H(R^c)$ .

LEMMA 2: *Bank charter values increase with forbearance (for a given capital level).*

*Proof:* From equation (4),

$$\frac{dV}{dp} = \frac{\partial V}{\partial X_R} \frac{dX_R}{dp} + \frac{\partial V}{\partial p} = \frac{\partial V}{\partial p} = \frac{1}{Z} \beta V H(R^c) > 0,$$

since  $\partial V / \partial X_R = 0$  at  $X_R = \hat{X}_R(K, p)$ , given by equation (6). Note that the derivative of  $V$  with respect to  $p$  is taken assuming a constant value of  $K$ . □

LEMMA 3:  $\frac{d}{dp} [(1 - p)V] < 0$  (for a given capital level).

*Proof:* Note that  $(\frac{d}{dp})[(1 - p)V] = -V + (1 - p)(dV/dp)$ , where  $dV/dp = \frac{1}{2} \beta V H(R^c)$  from Lemma 2. Then,  $d/dp [(1 - p)V] = -\frac{1}{2} (1 - \beta) V < 0$ . Note again that the derivative of  $V$  with respect to  $p$  is taken assuming a constant value of  $K$ . □

*Proof of Proposition 1:* Since  $\partial \hat{V} / \partial X_R = 0$  at  $X_R = \hat{X}_R(K, p)$ , the envelope theorem yields the strategic interaction condition,

$$\text{sign} \left( \frac{dX_R}{dp} \right) = \text{sign} \left( \frac{\partial^2 \hat{V}}{\partial p \partial X_R} \right)$$

From equation (10),

$$\begin{aligned} \frac{\partial \hat{V}}{\partial X_R} &= \frac{\partial v}{\partial X_R} - \beta(1 - p)V \frac{\partial H(R^c(X_R))}{\partial X_R} \\ &= \int_{R^c}^{R_{max}} (R - r_D)h(R)dR - f(X_R)c'(X_R) - \beta(1 - p)Vh(R^c) \frac{r_D K}{X_R^2}. \end{aligned} \tag{B1}$$

Taking the partial derivative of  $\partial \hat{V} / \partial X_R$  above w.r.t.  $p$ ,

$$\frac{\partial^2 \hat{V}}{\partial p \partial X_R} = -\beta h(R^c) \frac{r_D K}{X_R^2} \frac{\partial}{\partial p} ((1-p)V) > 0. \tag{B2}$$

The last inequality follows from Lemma 3 (recognizing that the partial derivative w.r.t. forbearance  $p$  above is employed to separate out the effect of  $p$  on capital  $K$ ). This implies that  $\hat{X}_R(K, p)$  is increasing in  $p$ . Next, note that

$$\frac{\partial H(R^c(\hat{X}_R))}{\partial p} = h(R^c) \frac{\partial R^c(\hat{X}_R)}{\partial p} = h(R^c) \frac{r_D K}{X_R^2} \frac{\partial \hat{X}_R}{\partial p} > 0 \tag{B3}$$

(recognizing that the partial derivative of  $\hat{X}_R$  w.r.t. forbearance  $p$  above is employed to separate out the effect of  $p$  on capital  $K$ ). In turn,  $pH(R^c(\hat{X}_R))$  is also increasing in  $p$ . □

*Proof of Proposition 2:* Consider first the privately optimal bank capital level  $K(p)$ . Denoting the maximand in the bank’s maximization problem in equation (10) as  $\hat{V}$ , the first-order condition w.r.t. capital  $K$  (taking forbearance  $p$  as given) becomes

$$\frac{\partial \hat{V}}{\partial K} + \frac{\partial \hat{V}}{\partial X_R} \frac{dX_R}{dK} = 0, \tag{B4}$$

where  $X_R = \hat{X}_R(K, p)$ . Since  $\partial \hat{V} / \partial X_R = 0$  at  $X_R = \hat{X}_R(K, p)$ , this condition reduces to

$$\begin{aligned} \frac{\partial \hat{V}}{\partial K} &= \frac{\partial v}{\partial K} - \theta'(K) - \beta(1-p)V \frac{\partial H(R^c)}{\partial K} \\ &= r_D[1 - H(R^c)] - \theta'(K) + \beta(1-p)Vh(R^c) \frac{r_D}{X_R} = 0. \end{aligned} \tag{B5}$$

Next, the envelope theorem yields the strategic interaction condition:

$$\text{sign} \left( \frac{dK}{dp} \right) = \text{sign} \left( \frac{\partial^2 \hat{V}}{\partial K \partial p} \right) = \text{sign} \left[ \beta h(R^c) \frac{r_D}{X_R} \frac{\partial}{\partial p} ((1-p)V) \right] < 0, \tag{B6}$$

where the last inequality follows from Lemma 3 (recognizing that the partial derivative w.r.t. forbearance  $p$  above is employed to separate out the effect of  $p$  on capital  $K$ ). It follows that  $K$  and  $p$  behave as strategic substitutes for bank owners. Note that although bank owners take their continuation value  $V$  as given while solving each period’s investment problem, the equilibrium value of  $V$  changes with regulatory forbearance  $p$ . This effect has been taken into account in the analysis above.

The following lemma characterizes the condition under which the minimum capital requirement binds, and is employed toward proving the second part of Proposition 2 which concerns the optimal minimum capital requirement  $K_{min}(p)$ .

LEMMA 4: *If  $\hat{X}_R(K, p)$  is the risky investment at the privately optimal capital level  $K$ , then the minimum capital requirement,  $K_{min}$ , exceeds  $K$  whenever  $\hat{X}_R(K, p)$  is decreasing in  $K$ .*

*Proof:* Consider the regulatory design problem in equations (13)–(17). Assume that the participation constraint is slack. Then, the first-order derivative of regulatory objective is

$$\begin{aligned} \frac{dW}{dK} &= \frac{\partial W}{\partial K} + \frac{\partial W}{\partial r_D} \frac{dr_D}{dK} + \frac{\partial W}{\partial X_R} \frac{dX_R}{dK} \\ &= \frac{\partial W}{\partial K} + \frac{\partial W}{\partial r_D} \frac{\partial r_D}{\partial K} + \left( \frac{\partial W}{\partial X_R} + \frac{\partial W}{\partial r_D} \frac{\partial r_D}{\partial X_R} \right) \frac{dX_R}{dK}, \end{aligned} \tag{B7}$$

where  $W$  is given by equation (12) and  $X_R = \hat{X}_R(K, p)$  is given by equation (6). Note that unlike an individual bank’s owners, the regulator takes into account the effect of bank capital on the equilibrium cost of borrowing for banks, as well as on the induced aggregate investment. Both of these effects are taken as given by individual banks that act as price takers.

Using the individual rationality of depositors as stated formally in equation (17), it is straightforward to show that  $\partial r_D / \partial K < 0$  and  $\partial r_D / \partial X_R > 0$ . The other terms can be obtained using equations (6) and (12) to yield the following results:

$$\frac{\partial W}{\partial K} = \frac{1}{Z} \beta (1 - p) Wh(R^c) \frac{r_D}{X_R} > 0, \tag{B8}$$

$$\frac{\partial W}{\partial r_D} = -\frac{1}{Z} \beta (1 - p) Wh(R^c) \left( 1 - \frac{K}{X_R} \right) < 0, \tag{B9}$$

and

$$\begin{aligned} \frac{\partial W}{\partial X_R} &= \frac{1}{Z} \left[ \bar{R} - r_S - f(X_R)c'(X_R) - f'(X_R)c(X_R) - \beta(1 - p)Wh(R^c) \frac{r_D K}{X_R^2} \right] \\ &< \frac{1}{Z} \left[ \bar{R} - r_S - f(X_R)c'(X_R) - \beta(1 - p)Vh(R^c) \frac{r_D K}{X_R^2} \right] \\ &= \frac{1}{Z} \left[ (1 - p) \int_0^{R^c} \left( r_D - \frac{RX_R}{X_R - K} \right) h(R) dR - \int_0^{R^c} (r_D - R)h(R) dR \right] \\ &< 0, \end{aligned} \tag{B10}$$

where I have employed  $X_R = \hat{X}_R(K, p)$ . These are simply the results that, ceteris paribus, an increase in capital reduces borrowing cost, whereas an increase in risk increases borrowing cost, an increase in capital increases the value of the bank as a whole, and an increase in the cost of deposits reduces the value of the bank as a whole (due to the greater likelihood of default). Finally, bank owners have risk-shifting incentives due to moral hazard arising from deposit insurance and, hence, invest more in risky assets than is socially optimal.

In particular, the above analysis holds if  $K$  is chosen to be the privately optimal capital level of the bank,  $K(p)$ . Combining the above facts, I conclude that if  $dX_R/dK < 0$  at  $K(p)$ , then  $dW/dK > 0$  so that  $K_{min}(p) > K(p)$ , that is, the minimum capital requirement binds. Note that if the participation constraint (PC) were to bind (in contrast to it being slack as assumed above), it follows that  $dW/dK > 0$  and again one obtains the result that  $K_{min}(p) > K(p)$ .  $\square$

Consider next the behavior of  $K_{min}(p)$  as a function of  $p$ . It suffices to examine the case in which the requirement binds. For this case, Lemma 4 implies that  $\partial X_R/\partial K < 0$ . Again, use has been made of the partial derivative to separate the effect of  $p$  on  $X_R$ .

(i) If PC does not bind, then the analysis of Lemma 4 shows that  $dW/dK > 0$ , and thus  $K_{min}(p)$  is set to its maximum possible value  $K_{min}(p) = \hat{X}_R(K_{min}(p), p)$ . Note that this is a fixed-point condition that when differentiated w.r.t.  $p$  yields

$$\frac{dK_{min}}{dp} \left[ 1 - \frac{\partial X_R}{\partial K} \right] = \frac{\partial X_R}{\partial p}. \tag{B11}$$

Since  $\partial X_R/\partial K < 0$  by Lemma 4 (minimum capital requirement binds) and  $\partial X_R/\partial p > 0$  by Proposition 1 (recognizing that the partial derivative w.r.t. forbearance  $p$  is employed to separate out the effect of  $p$  on capital  $K$ ), it follows that  $K_{min}(p)$  is increasing in  $p$ .

(ii) On the other hand, if PC binds, then  $V(K_{min}(p), p) = \bar{V}$  must hold, and stress is again placed on the dependence of minimum capital requirement  $K_{min}$  on forbearance  $p$ . Note that although bank owners take future continuation values as given and optimize  $\hat{V}(\cdot)$  w.r.t.  $X_R$ , where  $\hat{V}$  is as defined in equation (10), the stationarity of the problem nevertheless implies the envelope condition  $\partial V/\partial X_R = 0$ . Then, differentiating the equation  $V(K_{min}(p), p) = \bar{V}$  w.r.t.  $p$  and using this envelope condition gives

$$\frac{\partial V}{\partial p} + \frac{\partial V}{\partial K} \frac{dK_{min}}{dp} = 0. \tag{B12}$$

From Lemma 2,  $\partial V/\partial p > 0 \forall p$ . Furthermore,  $\partial V/\partial K < 0$ , since the minimum capital requirement binds. It follows that  $dK_{min}/dp > 0$ . □

*Proof of Proposition 3:* Note that in order to analyze the spillover, the effect of aggregate investment  $\bar{X}_{Ra}(p_a)$  on  $V_b$  must be considered, where  $V_b$  is given by equation (4) and is suitably modified for the multiple-economy case. Since  $\bar{X}_{Ra}(p_a) \equiv X_{Ra}(p_a)$  in the symmetric equilibrium, this latter notation will be used. Then, using the envelope condition  $\partial V_b/\partial X_{Rb} = 0$ , I obtain

$$\frac{\partial V_b}{\partial p_a} = \frac{\partial V_b}{\partial X_{Ra}} \frac{dX_{Ra}}{dp_a} < 0, \tag{B13}$$

since  $dX_{Ra}/dp_a > 0$  by Proposition 1, and

$$\frac{\partial V_b}{\partial X_{Ra}} = \frac{1}{Z_b} \frac{\partial v_B}{\partial X_{Ra}} = -\frac{1}{Z_b} f'(X_{Ra} + X_{Rb}) \delta c(X_{Rb}) < 0. \tag{B14}$$

Furthermore, differentiating  $V_b$  w.r.t.  $\delta$  and employing the envelope condition  $\partial V_b/\partial X_{Rb} = 0$  gives

$$\frac{\partial V_b}{\partial \delta} = \frac{1}{Z_b} \frac{\partial v_b}{\partial \delta} = -\frac{1}{Z_b} f(X_{Ra} + X_{Rb}) c'(X_{Rb}) < 0. \tag{B15}$$

As  $\delta$  increases,  $V_b$  decreases, giving rise to a spillover. Further, since  $f'(\cdot) > 0$  and  $dX_{Ra}/dp_a > 0$ , it follows that  $\partial^2 V_b / \partial p_a \partial \delta < 0$ : The spillover is greater for a greater forbearance of regime A. □

*Proof of Example 1:* Note that

$$\frac{\partial X_{Rb}}{\partial p_a} = \frac{\partial X_{Rb}}{\partial X_{Ra}} \frac{\partial \bar{X}_{Ra}}{\partial p_a}.$$

Under the symmetric equilibrium,

$$\frac{\partial \bar{X}_{Ra}}{\partial p_a} \equiv \frac{\partial X_{Ra}}{\partial p_a} > 0$$

by Proposition 1. Next, by the envelope theorem, one obtains the strategic interaction condition,

$$\text{sign} \left( \frac{\partial X_{Rb}}{\partial X_{Ra}} \right) = \text{sign} \left( \frac{\partial^2 \hat{V}_b}{\partial \bar{X}_{Ra} \partial X_{Rb}} \right) \equiv \text{sign} \left( \frac{\partial^2 \hat{V}_b}{\partial X_{Ra} \partial X_{Rb}} \right).$$

From a variant of equation (B1) for the multiple-economy case, it follows that

$$\begin{aligned} \frac{\partial \hat{V}_b}{\partial X_{Rb}} &= \int_{R_b^c}^{R_{max}} (R - r_D) h(R) dR - f(\bar{X}_{Ra} + \bar{X}_{Rb}) \delta c'(X_{Rb}) - \beta(1 \\ &\quad - p_b) V_b \frac{\partial H(R_b^c)}{\partial X_{Rb}}. \end{aligned} \tag{B16}$$

Taking the partial derivative w.r.t.  $X_{Ra}$ , and employing both  $\bar{X}_{Ri} \equiv X_{Ri}$  and equation (B14),

$$\begin{aligned} \frac{\partial^2 \hat{V}_b}{\partial X_{Ra} \partial X_{Rb}} &= -\delta f'(X_{Ra} \\ &\quad + X_{Rb}) \left[ c'(X_{Rb}) - \frac{1}{Z_b} \beta(1 - p_b) c(X_{Rb}) h(R_b^c) \frac{r_{Db} K_{min}}{X_{Rb}^2} \right] \end{aligned} \tag{B17}$$

In the following,  $K_{min}$  is considered as invariant to the parameter  $\alpha$  since varying  $\alpha$  is to be interpreted as examining a different regime  $B$  subject to the same capital requirement and international spillover (from regime A). Consider the example economy:  $c(x) = e^{\alpha x}$  and  $h(R) = 1/R_{max}$ . Then, using the results  $Z_b > 1 - \beta$ ,  $r_{Db} < R_{max}$ , and  $K_{min} < X_{Rb}$ , it follows that the term inside  $[\cdot]$  in equation (B17) is greater than  $e^{\alpha X_{Rb}} [\alpha - (\beta(1 - p_b)) / (K_{min}(1 - \beta))]$ . Hence,  $\forall \alpha > \alpha^* \equiv [\beta(1 - p_b)] / [K_{min}(1 - \beta)]$ , it is the case that  $\partial^2 \hat{V}_b / \partial X_{Ra} \partial X_{Rb} < 0$ , and, in turn,  $\partial X_{Rb} / \partial p_a < 0$ . This corresponds to part 1 of the example.

Next, using the results  $Z_b < 1$ ,  $X_{Rb} < D$ , and  $r_{Db} > r_S$ , it follows that the term inside  $[\cdot]$  in equation (B17) is smaller than  $e^{\alpha X_{Rb}} [\alpha - [(\beta(1 - p_b) r_S K_{min}) / R_{max} D^2]]$ . Hence,  $\forall \alpha < \alpha^{**} \equiv [(\beta(1 - p_b) r_S K_{min}) / R_{max} D^2]$ , it is the case that  $\partial^2 \hat{V}_b / (\partial X_{Ra} \partial X_{Rb}) > 0$ , and in turn,  $\partial X_{Rb} / \partial p_a > 0$ . This corresponds to part 2 of the example. The facts that  $r_S < R_{max}$ ,  $K_{min} < D$ , and  $\beta < 1$  imply that  $\alpha^{**} < \alpha^*$ . □

*Proof of Lemma 1:* Consider regulator  $A$ 's design problem in equations (19)–(22). Since  $p_b$  is constant for this design problem, it is suppressed in the notation below. I show first that the unconstrained optimum  $p_a^{uc}(\lambda_a)$  is strictly increasing in  $\lambda_a$ . The first-order condition yields

$$\frac{\partial W_\lambda}{\partial p_a} = (2\lambda_a - 1) \frac{\partial V}{\partial p_a} + (1 - \lambda_a) \frac{\partial W}{\partial p_a} = 0, \tag{B18}$$

where  $\partial V/\partial p_a$  and  $\partial W/\partial p_a$  are written as partial derivatives to separate the effect of  $\lambda_a$  below. These derivatives include the effect of  $p_a$  on  $X_R$ . Then,

$$\frac{\partial W}{\partial p_a} = \frac{1 - 2\lambda_a}{1 - \lambda_a} \frac{\partial V}{\partial p_a}.$$

Taking the partial derivative of the first-order condition w.r.t.  $\lambda_a$  gives the following strategic interaction condition:

$$\frac{\partial^2 W_\lambda}{\partial p_a^2} \frac{dp_a}{d\lambda_a} + \frac{\partial^2 W_\lambda}{\partial \lambda_a \partial p_a} = 0. \tag{B19}$$

From the second-order condition for  $p_a$  to be optimal,  $\partial^2 W_\lambda/\partial p_a^2 < 0$ . Furthermore,

$$\frac{\partial^2 W_\lambda}{\partial \lambda_a \partial p_a} = 2 \frac{\partial V}{\partial p_a} - \frac{\partial W}{\partial p_a} = \frac{1}{1 - \lambda_a} \frac{\partial V}{\partial p_a} > 0$$

The last equality follows from the fact that

$$\frac{\partial W}{\partial p_a} = \frac{1 - 2\lambda_a}{1 - \lambda_a} \frac{\partial V}{\partial p_a}$$

and the last inequality is due to  $\partial V/\partial p_a > 0$  from Lemma 2. It follows that  $dp_a/d\lambda_a > 0$  if  $p_a = p_a^{uc}(\lambda_a)$ .

Suppose that PC in equation (22) does not bind at a specific value of  $\lambda_a$ . Then it will not bind at  $\lambda'_a > \lambda_a$ , since  $p_a^{uc}(\lambda_a)$  is strictly increasing in  $\lambda_a$  and  $\partial V/\partial p_a > 0$ . On the other hand, if (PC) binds at  $\lambda_a$ , then let  $p_a^c$  be such that  $V(p_a^c) = \bar{V}$ . Then,  $p_a = \max[p_a^c, p_a^{uc}(\lambda_a)]$  is the optimal design. Since  $p_a^c$  is independent of  $\lambda_a$ ,  $p_a$  is (weakly) increasing in  $\lambda_a$ .  $\square$

*Proof of Proposition 4:* The following cases are possible as  $\lambda_a$  is increased beyond  $\lambda_b$ :

(i) PC binds for both regimes at  $(\lambda_a, \lambda_b)$ : In this case,  $p_a = p_b = p$ , such that  $V(p_a, p_b) = V(p, p) = \bar{V}$ . Then equilibrium is locally unaffected as  $\lambda_a$  changes. Strictly speaking, PC should bind for regulator  $A$ 's problem at  $\lambda_a + \varepsilon$ ,  $\forall \varepsilon$ ,  $0 < \varepsilon < \bar{\varepsilon}$ , where  $\bar{\varepsilon}$  is arbitrarily small.

(ii) PC binds for regime  $B$  banks, but not for regime  $A$  banks at  $(\lambda_a, \lambda_b)$ : Denote the equilibrium as  $(p_a, p_b)$ , where  $p_a$  is the unconstrained optimum for regulator  $A$  and  $p_b$  is such that  $V_b(p_a, p_b) = \bar{V}$ . Then, differentiating w.r.t.  $\lambda_a$ , the following is obtained:

$$\frac{\partial V_b}{\partial p_b} \frac{dp_b}{d\lambda_a} + \frac{\partial V_b}{\partial p_a} \frac{dp_a}{d\lambda_a} = 0. \tag{B20}$$

Since  $\partial V_b/\partial p_b > 0$  by Lemma 2,  $\partial V_b/\partial p_a < 0$  by the spillover result of Proposition 3, and  $dp_a/d\lambda_a > 0$  by Lemma 1, it follows that  $dp_b/d\lambda_a > 0$ . In other words, the regulator of regime *B* must increase  $p_b$  to ensure that PC is not violated for its banks.

(iii) PC does not bind for either regime *A* or regime *B* banks at  $(\lambda_a, \lambda_b)$ : In this case, both  $p_a$  and  $p_b$  are unconstrained and the following strategic interaction condition must be examined:

$$\text{sign}\left(\frac{dp_b}{d\lambda_a}\right) = \text{sign}\left(\frac{\partial^2 W_{\lambda_b}}{\partial p_a \partial p_b} \frac{dp_a}{d\lambda_a}\right)$$

From Lemma 1,  $dp_a/d\lambda_a > 0$ . Hence, from Lemma 2 and the fact that  $Z_b = 1 - \beta + \beta(1 - p_b)H(R_b^c)$ , the following is obtained:

$$\begin{aligned} \frac{\partial^2 W_{\lambda_b}}{\partial p_a \partial p_b} &= \frac{1 - 2\lambda_b}{1 - \lambda_b} \frac{\partial^2 V_b}{\partial p_a \partial p_b} \\ &= \frac{1 - 2\lambda_b}{1 - \lambda_b} \frac{\partial}{\partial p_a} \left[ \frac{1}{Z_b} \beta V_b H(R_b^c) \right] \\ &= \frac{1 - 2\lambda_b}{1 - \lambda_b} \left[ \frac{\beta}{Z_b} \frac{\partial V_b}{\partial p_a} H(R_b^c) + \frac{\beta V_b}{Z_b} \frac{\partial H(R_b^c)}{\partial p_a} - \frac{\beta V_b}{Z_b^2} \frac{\partial Z_b}{\partial p_a} H(R_b^c) \right] \\ &= \frac{1 - 2\lambda_b}{1 - \lambda_b} \left[ \frac{\beta}{Z_b} \frac{\partial V_b}{\partial p_a} H(R_b^c) + \frac{\beta(1 - \beta)V_b}{Z_b^2} h(R_b^c) \frac{\partial R_b^c}{\partial X_{Rb}} \frac{\partial X_{Rb}}{\partial p_a} \right] \end{aligned} \tag{B21}$$

Note that  $\partial V_b/\partial p_a < 0$  by Proposition 3,

$$\frac{\partial R_b^c}{\partial X_{Rb}} = \frac{r_{Db} K_{min}}{X_{Rb}^2} > 0,$$

and the sign of  $\partial X_{Rb}/\partial p_a$  depends upon the cost function faced by regime *B* banks (as illustrated in Example 1).

Thus, if the term inside  $[ \cdot ]$  in equation (B21) is negative (which always holds if  $\partial X_{Rb}/\partial p_a < 0$ ), then for  $\lambda_b > \frac{1}{2}$ ,  $p_b$  is increasing in  $\lambda_a$ —regulator *B* is captured and increases forbearance to compensate its banks from induced spillover. However, for  $\lambda_b \leq \frac{1}{2}$  the regulator of regime *B* responds to the induced spillover by first reducing its forbearance  $p_b$ . Note, as  $p_b$  decreases and  $p_a$  increases,  $V_b$  decreases (from Lemma 2 and Proposition 3). Thus for  $\lambda_b$  sufficiently below  $\frac{1}{2}$  and  $\lambda_a$  sufficiently high,  $p_b$  would be low enough and  $p_a$  would be high enough so as to obtain  $V_b = \bar{V}$ . When this occurs, the analysis reverts to case (ii) above with the result that  $p_b$  must be raised to prevent the exit of regime *B* banks.

Next, if the term inside  $[ \cdot ]$  in equation (B21) is positive (as can arise if  $\partial X_{Rb}/\partial p_a$  is positive and sufficiently large in magnitude compared to  $\partial V_b/\partial p_a$ ), then for  $\lambda_b \leq \frac{1}{2}$  the regulator of regime *B* responds to the induced spillover by increasing forbearance  $p_b$ . Since regime *B* banks take greater risk, regulator *B* bails out more often to reduce continuation value losses. In either case,  $p_b$  increases in  $\lambda_a$  if  $\lambda_a$  is sufficiently greater than  $\lambda_b$ . □

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