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ABSTRACT

Is the International Convergence of Capital Adequacy Regulation Desirable?*

The merit of having international convergence of bank capital requirements in the presence of divergent closure policies of different central banks is examined. While the privately optimal level of bank capital decreases with regulatory forbearance (they are strategic substitutes), the socially optimal level of bank capital increases with regulatory forbearance (they are strategic complements). Hence, in optimal regulatory design, the level of minimum bank capital requirement increases with the forbearance in central bank closure policy. The lack of such linkage 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 bankowners, it is shown that in equilibrium a regression towards the worst closure policy may result: the central banks of initially less forbearing economies have to adopt greater forbearance as well.

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1 Introduction

In this paper, we analyze the joint design of two bank regulatory mechanisms: capital requirements which are an ex-ante mechanism to prevent bank failures, and closure policy which is an ex-post mechanism designed 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 calls into question the merits of creating a "level–playing field" in capital requirements across countries, as proposed and implemented by the Basel Accord of 1988. Such cross–border standardization is, in general, desirable only if accompanied by standardization of closure policies as well.

When banks operate across borders, lack of overall standardization gives rise to international spillovers from more forbearing (in terms of the adopted bank closure policy) regimes to less forbearing regimes. Banks in more forbearing regimes have greater risk–taking incentives, which in equilibrium reduces the profits of banks in less forbearing regimes. Since these latter banks might be forced to "exit," their central banks have to adopt greater forbearance as well. The result is a "race to the bottom" where all central banks converge towards the worst level of forbearance. This outcome thus has the potential to destabilize the global banking system compared to the one in which there is no convergence of regulatory mechanisms.

An infinite–horizon single–economy banking model is developed to show the linkage between design of capital requirements and closure policy. Bankowners (inside equityholders) 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 bankowners 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, the regulator, designs regulation to maximize the total value of the bank, i.e., the sum of the values of 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. The central bank can also require that banks hold a minimum level of capital in the form of outside equity. In choosing the optimal regulatory design, the central bank takes into account both the effect of regulation on the risk–taking incentives of bankowners and on the losses arising from bank closures.

On the one hand, bank bail outs induce moral hazard in the form of excessive risk–taking behavior. On the other hand, they increase the continuation payoff or "charter–value" of bankowners thereby inducing risk–avoidance incentives. The presence of outside equity in the bank's capital structure "buffers" the bank from failures. However, the issuance of such outside equity leads to (private) dilution costs for the bankowners. We show that the privately optimal level of bank capital, i.e., the amount of outside equity banks issue in the absence of a minimum capital requirement, decreases in the extent of regulatory forbearance. From the bankowners' standpoint, bank capital and regulatory forbearance are *strategic substitutes*.

Next, we provide a characterization of when is the privately optimal level of bank capital "too low," i.e., lower than the socially optimal level for the bank as a whole. Banks with high risk of default have low continuation values and remain under–capitalized, whereas relatively safer banks with high continuation values may in fact be over–capitalized. Crucially, the optimal minimum capital requirement when it binds is increasing in the extent of forbearance practised by the central bank. From the regulatory standpoint, bank capital and regulatory forbearance are *strategic complements.* A higher level of forbearance induces greater moral hazard which is counteracted with a greater minimum capital requirement. This result casts doubt over the desirability of uniform capital requirements across nations even as their central banks adopt divergent closure policies.

To explore the implications of such a divergence, we employ a two–economy model of financial integration. Banks operate across borders in making loans and in raising deposits. They hold a uniform amount of capital, but enjoy the forbearance exercised by the central bank of their "home" country. We show that this gives rise to a *spillover* from more forbearing regime to the less forbearing one. 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. As banks of the more forbearing regime take greater risk, the profit margins earned by banks of the less forbearing regime erode further reducing their charter–values. The magnitude of this spillover increases with an increase in the heterogeneity amongst different banking sectors according to their (i) regulatory forbearance; (ii) the effect of competition on bank profits; and (iii) the efficiency of banks in terms of profit margins earned.

It is argued that such heterogeneity in regulatory forbearance can arise due to a "regulatory capture".[1] Central banks, in general, maximize a weighted average of the welfare of "interest groups," i.e., bankowners and outside claimants. A greater weight on the welfare of its bankowners 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 aligned less with its bankowners respond to this spillover when constrained not to adjust capital requirements? We demonstrate that if heterogeneity in regulatory objectives across regimes is high, the resulting spillover drives the banks of less forbearing regime below their reservation values. In order to avoid their exit, the central bank of this regime adopts greater forbearance as well. Thus, in equilibrium, there is a "regression towards the worst" forbearance.

The essence of the paper's policy implications is that each country's regulator imposes

[1]This political economy aspect of regulation has been well-documented in finance and economics literature, especially in the context of bank regulation. Stigler (1971), Peltzman (1976), Kane (1990), and, Laffont and Tirole (1991) are some illustrative references.

an externality on the welfare of other countries. This externality persists in the absence of a complete coordination amongst regulators. Importantly, coordination on some parts of regulation (such as capital requirements) but not on others (such as closure policy) eliminates an important weapon from the arsenal of regulators who wish to counteract spillovers from poorly regulated banks abroad. Thus, reminiscent of theory of the second–best, a step towards complete coordination can be more harmful than no step at all.

Section 2 discusses related literature. Section 3 analyzes the single–economy model. Section 4 characterizes the privately optimal and the socially optimal bank capital levels. Section 5 analyzes the multiple–economy model. Section 6 discusses the robustness of the results. Section 7 concludes. All proofs are contained in the appendix.

2 Related literature

We study the joint design of capital requirements and closure policy for banks in a single economy, later extending the analysis to multiple economies. To our knowledge, this is the first attempt to combine all these features in a unified framework.[2]

Acharya and Dreyfus (1989) advocate a linkage between the design of closure policies and the deposit insurance premium scheme, and Davies and McManus (1991) suggest that the extent of monitoring of a bank should be tied to the level of strictness of its closure policy. These papers however do not consider capital requirements and are developed in a single-economy context. Our result on regression towards the worst regulation is closest in spirit to Dell'Ariccia and Marquez (2000) who focus exclusively on competition among regulators in setting capital requirements. They show that Nash competition reduces regulatory standards relative to a centralized solution. They do not consider regulators implementing centralized solutions on some aspect, but failing to coordinate on others. The interplay of different regulatory arms is however central to our paper.

Empirical evidence in support of international spillovers can be found in Peek and Rosengren (1997, 2000) who document that loan supply shocks emanating from Japan had real spillover effects on economic activity in the U.S. through the Japanese bank penetration of the U.S. markets. Wagster (1988) finds that the ostensible purpose of the Basel Accord of

[2]We abstract from the micro-motives for banking such as delegated monitoring of Diamond (1984), and liquidity provision of Diamond and Dybvig (1983). A summary of the seminal papers in regulation based on micro-theory of banks can be found in Dewatripont and Tirole (1993), and Freixas and Rochet (1997).

In some recent work, Gorton and Winton (1999) delineate what are the private and the 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 banks' collection of loans. An alternative approach to bank regulation exploits the owner/manager conflict as in John, Senbet, and Saunders (2000).

1988 to "level the playing field" by eliminating a funding–cost advantage of Japanese banks was not achieved. Scott and Iwahara (1994) reinforce this finding attributing it to differences between the U.S. and Japan in safety net policies.

3 Single economy model

Our model studies the privately optimal bank capital level, the socially optimal bank capital level, their relative levels, and their relationship with regulatory forbearance. The model is inspired by the Allen and Gale (2000) model of bubbles and crises, a two–date single–economy model of risk–shifting by investors who borrow money from lenders. We extend the model to incorporate (i) infinite horizon with repeated one-period investments; (ii) closure policy and capital requirement as regulatory mechanisms; and (iii) multiple economies. We first describe the model for the single economy case.

Banks and depositors: The economy consists of a single banking sector with a single consumption good at each date $t = 0, 1, \ldots, \infty$.

- There is a continuum of homogeneous banks, owned by risk–neutral intermediaries (referred to as bankowners or inside equityholders), who have no wealth of their own. Banks have access to investments in a safe asset and in a risky asset.
- There is a continuum of risk-neutral investors with D units of the good to invest in each period. Depositors can invest in the safe asset, lend their goods to banks in form of deposits, or invest in bank capital (bank equity).

Bankowners and depositors have a common time–preference rate of $\beta \in (0, 1)$.

Safe asset: 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.

Risky asset: The risky asset in the economy is to be interpreted as bank investments that have variable returns. These could be loans to manufacturers, retailers, home-owners, etc. The entrepreneurs holding the risky asset (a claim to their business profits) supply it to the bank in exchange for good. For simplicity, the risky investments of different banks are perfectly correlated.[3] The risky asset technology is also constant returns to scale. It yields a return R next period on a unit of investment this period, $R \sim h(\cdot)$ over $[0, R_{max}]$ with mean $\bar{R}$. We assume that there is reward for bearing this risk, i.e., $\bar{R} > r_S$.

[3] That is to say, each bank is holding a well-diversified portfolio that bears only systematic risks.

Note that both safe and risky assets are "loans" and any short-sales are ruled out.

Costs of risky investments: Bankowners incur non–pecuniary costs of investing in the risky asset. First, banks compete in the market for making risky loans. As a result, the cost incurred is increasing in the extent of aggregate investment in the risky asset. Second, the cost incurred is increasing in the size of bank's own investment, and increases at an increasing rate. To capture this, we model the cost function as $f(\bar{x}) \cdot c(x)$ 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 neo–classical assumptions: $c(0) = 0$, $c'(0) = 0$, $c'(x) > 0$, $c''(x) > 0$, $\forall x > 0$, $c(x)$ continuous, and exactly identical behavior of $f(\bar{x})$ as a function of $\bar{x}$. These costs generate diminishing returns to scale for banks from risky investments, and in turn, bound the size of their portfolios. While pecuniary costs can be dealt with some difficulty, non–pecuniary costs (akin to effort aversion in principal–agent setups) lead to a simple analysis and let us illustrate our results in a succinct manner.

Bank deposits: Deposits take the form of a simple debt contract with a promised deposit rate r_{Dt} and maturity of one period. The rate r_{Dt} is not contingent on the size of deposit or on asset returns. Costly state verification as in Townsend (1979) or Gale and Hellwig (1985) justifies such a simple debt contract.[4] Since deposits cannot be conditioned on their size, they are inelastic and banks can borrow as much as they like at going rate of interest. However, since depositors have access to the safe asset as well, the going rate of interest must be such that it is individually rational for the depositors to lend to banks. Further, the deposit claim is a "hard" claim and cannot be renegotiated.[5] Hence, a bank that fails to repay the promised payment to its depositors is in "default."

Bank capital: In addition to raising deposits, the wealth–constrained intermediaries who own the banks can raise capital by issuing outside equity. However, raising such equity dilutes the value of bank's inside equity since bankowners are required to pay a higher than fair, expected rate of return on equity. Theoretical justifications[6] and empirical evidence[7] on

[4]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 bank-notes (e.g. subordinated debt), has been noted by Gorton (1985) and Gorton and Mullineaux (1987).

[5]Diamond and Rajan (2000), for example, justify this on the basis of a collective action or a coordination problem between dispersed depositors in the presence of a sequential service constraint in the deposit contract.

[6]Rock (1986) suggests that the dilution cost must be borne by the issuer to ensure that uninformed investors purchase the issue even in the presence of informed investors. A lemon's dilution cost arises in the presence of asymmetric information, as in Leland and Pyle (1977), and Myers and Majluf (1984). Gorton and Winton (1999), and Bolton and Freixas (2000) employ this dilution approach to study equilibrium models of banks and their regulation. An alternative explanation based on the agency between the manager-entrepreneur and the external financiers is employed by Froot, Scharfstein and Stein (1993).

[7]Lee et al. (1996) document that the indirect (underpricing) costs associated with raising new equity for

such dilution costs is plenty. For simplicity, we do not model the process of equity issuance, and instead assume directly that the total value transferred from bankowners to its new equityholders is $\theta(K)$, where K is the amount of new equity issued, $\theta(K)$ is increasing and convex, i.e., $\theta'(K) > 0$, $\theta''(K) > 0$, $\theta(0) = 0$, $\theta'(0) = 0$, $\theta(K)$ continuous, and $\theta(K) \geq r_S K$, the last assumption ensuring that it is individually rational for depositors to invest in bank capital. Note that the dilution of bank's inside equity constitutes a private cost of bank capital but, in itself, it does not constitute a social cost of bank capital: it is a pure transfer from the existing equityholders to the new equityholders.

For simplicity, we assume that the set of investors who lend deposits and the set of investors who invest in bank capital are segmented. This assumption allows us to ignore the optimal investment problem of investors (as would be important in a general equilibrium setting), and instead enables us to focus exclusively on the investment problem of banks.

Regulator: Bank capital structure and investment choices maximize the value of bankowners, i.e., the value of bank's inside equity. Thus, in general, the economy above entails agency costs due to the conflict of interest between bankowners and investors. To mitigate such costs, there is a bank "regulator" (e.g., the Central Bank) in the economy who designs regulatory mechanisms. The regulator's objective is to maximize the value of the bank as a whole, i.e., the value of bank's inside equity as well as the value to investors from their bank deposit or (outside) equity claims. The regulator weighs equally the welfare of all claimants.[8]

The regulator employs two mechanisms that are interesting from a theoretical as well as an institutional perspective: (i) minimum capital requirement, which is the *ex-ante* mechanism aimed at reducing the likelihood of bank failures; and (ii) closure or bail out policy, which is the *ex-post* mechanism to reduce continuation value losses arising from bank failures. In our multi-period setting, the ex-ante mechanism is employed in each period, and hence, also 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, i.e., the central bank designs regulation in an environment of incomplete contractability. This renders the design problem non-trivial and realistic. However, central banks can verify the level of bank capital, and, enforce a minimum capital requirement by levying sufficiently high penalties on any violators.[9]

US firms exceed 10% of market value of the issue for initial as well as seasoned public offerings.

[8]Note that we have ignored any deadweight costs of bank failures in the regulator's weflare. Incorporating such costs does not affect the qualitative nature of our results.

[9]Since banks are socially valuable, the enforcement of capital requirements may also lack credibility, as pointed out by Gorton and Winton (1999). We abstract from this consideration. In our model, the central bank has a *rule* but no *discretion* regarding the enforcement of capital requirements.

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. This corresponds to Tier 1 capital required by the current regulation.[10]

Closure policy: The model assumes that if a bank fails, its continuation value is dissipated unless it is rescued. In addition, it assumes that upon rescue, this loss of value can be avoided only if bank continues to operate under the existing bankowners. While both these are strong assumptions on the uniqueness of each bank and the specificity of bankowners to their respective bank, relaxing these assumptions entails several issues that are beyond the scope of the current paper. On the one hand, the possibility of bank value transfers to surviving banks alters the industrial organization of banking sector through time unless bank entry is modeled in a way that ensures its stationarity. On the other hand, the possibility of replacing bank ownership requires modeling a labor market equilibrium of financial intermediaries.

Hence, we simply assume that in order to reduce continuation value losses from bank closures, it may be optimal for the central bank to bail out the depositors of the failed banks and allow the bankowners to continue their lending activities. We model the closure policy as $p \in [0, 1]$, the probability that a bank in default will be bailed out by the central bank and allowed to continue its operations. Such mixed strategies have often been referred to as "constructive ambiguity," e.g., in Freixas (1999). In practice, central banks adopt a very wide variety of mechanisms such as nationalization, bank sales, firing of managers, etc., upon bank failures. Our choice of closure policy is supposed to represent the extent of forbearance exercised by the central bank, a higher value of p representing a more forbearing policy.

4 Private and social levels of bank capital

In this section, we treat the forbearance p of the regulator as given to study the behavior of the privately optimal and the socially optimal levels of bank capital as the regulator's forbearance is varied. Later, in Section 5.1, we endogenize the choice of p. To this end, we first consider the investment choice of banks for a given capital structure K.

[10]For a description of what constitutes in practice as "regulatory capital," see Basel Accords of 1988 and 1996 at www.bis.org. In practice, regulators impose minimum capital requirement not on the absolute level of bank capital but on the level of bank capital as a fraction of its "risk–adjusted" assets. Since level of bank investments are not contractible in our setup, our choice of modeling minimum capital requirement on the absolute level is natural. A more detailed discussion of this point is contained in Section 6.

4.1 Investment choice of banks

We consider the *symmetric competitive equilibrium* where all banks take borrowing rate and aggregate investment as given, choose the same capital structure, the same portfolio of safe and risky investments, and all depositors are promised the same rate of interest. We assume that bank's equityholders (bankowners as well as outside investors) consume in each period the profits generated in that period (if any), and similarly, depositors consume in each period any return on their deposits in that period (if any). This lets us reduce the infinite horizon repetition of each period of investment to a stationary dynamic program.[11]

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 capital structure is formed, i.e., deposits borrowed and capital raised, bankowners solve a portfolio problem choosing the extent of investment in the safe asset and the risky asset denoted as 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 has enabled us to suppress the time subscripts. Then, for a given capital structure K, the *equilibrium* is given by (X_S, X_R, r_D) where (i) (X_S, X_R) maximizes bankowners' value given r_D and r_S; (ii) short-sales constraint is not violated: $X_S, X_R \geq 0$; and (iii) 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 $r_S X_S + R X_R < r_D(X_S + X_R - K)$, i.e., whenever $R < R^c$, the threshold return on risky investment below which default occurs:

$$R^c(X_S, X_R, K) = (r_D - r_S) \cdot \frac{X_S}{X_R} + r_D \cdot \left(1 + \frac{X_S}{X_R} - \frac{K}{X_R}\right) \tag{4.1}$$

Note that capital being a "soft" claim that cannot be defaulted upon "buffers" a bank by reducing the threshold point below which it defaults. When default occurs, independent of whether the bank is bailed our or not, the equityholders get no return for that period. Hence, the expected payoff to bank's total equity in each period is

$$v(X_S, X_R, K) = \int_{R^c}^{R_{max}} \left[r_S X_S + R X_R - r_D(X_S + X_R - K)\right] h(R) dR - f(\bar{X}_R) \cdot c(X_R) \tag{4.2}$$

where R^c is as above in equation (4.1) and $\bar{X}_R$ is the aggregate investment in risky asset.

Thus, net of private issuance costs, the expected payoff to bankowners (old or inside equityholders) is $v(\cdot) - \theta(K)$. Since bankowners cannot commit to dynamic investment strategies,

[11]Relaxing this assumption affects the tractability of the model significantly. Dynamic management of wealth by banks and investors is however an important consideration and its implications are discussed in some detail in Section 6.

they must treat their continuation value V as a lump-sum constant in solving for their current period investments. Given that upon default, the bank is bailed out with probability p and closed with probability $1-p$, bankowners' portfolio problem in each period can be stated as:

$$\max_{X_S, X_R \geq 0} \; v(X_S, X_R, K) - \theta(K) + \beta \left[V \int_{R^c}^{R_{max}} h(R)dR + p \cdot V \int_0^{R^c} h(R)dR \right] \tag{4.3}$$

In equilibrium, symmetry across all banks implies that the aggregate investment $\bar{X}_R$ in equation (4.2) above must equal X_R, the risky investment of the representative bank. Further, stationarity of the investment problem implies that the sub-game perfect investment policy must be identical in all periods. Hence, the value of the lump-sum constant V must equal the continuation value of bankowners for an investment policy (X_S, X_R) in each period and is given by

$$\begin{aligned} V &= [v(\cdot) - \theta(K)] + \beta \cdot [v(\cdot) - \theta(K)] \cdot \left[\int_{R^c}^{R_{max}} h(R)dR + p \cdot \int_0^{R^c} h(R)dR \right] + \ldots \\ &= \frac{v(\cdot) - \theta(K)}{1 - \beta + \beta(1-p) \int_0^{R^c} h(R)dR} . \end{aligned} \tag{4.4}$$

We shall denote the denominator as $Z = 1 - \beta + \beta(1-p) \int_0^{R^c} h(R)dR$ and refer to this continuation value of the bankowners, 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 of r_S from safe investments:

$$\begin{aligned} r_S &= r_D \int_{R^c}^{R_{max}} h(R)dR \\ &+ r_D \cdot p \int_0^{R^c} h(R)dR \;+\; (1-p) \int_0^{R^c} \left(\frac{r_S X_S + R X_R}{X_S + X_R - K} \right) h(R)dR \end{aligned} \tag{4.5}$$

since the depositors are insured with probability p, and 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:

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

- Given that $r_D \geq r_S$, $R^c(\cdot)$ is increasing in X_S, and hence, bankowners do not find it optimal to invest any raised funds into the safe asset: $X_S = 0$. This implies that banks make only risky investments, $X = X_R$. Further, banks raise $X_R - K$ units of deposits, K units of capital, and the remaining goods, $D - X_R$, are invested in the safe asset by investors.

- Deposit insurance induces moral hazard among banks: they have an incentive to undertake "excessive" risky investment to maximize the value of their option to default and get bailed out (with probability p).[12] Charter-value of banks however induces a counteracting risk-avoidance incentive: banks stand to lose their continuation value more often if they undertake greater risky investment.[13] Thus, banks trade off the benefits of risky investments, viz., the expected return including the option provided by deposit insurance, against the costs of making risky investments, viz., the direct non-pecuniary costs and the expected loss of charter-value. This is summarized in the first-order condition:

$$\frac{\partial v(\cdot)}{\partial X_R} = \beta(1-p)V \, \frac{\partial}{\partial X_R} \int_0^{R^c} h(R)dR, \text{ where} \tag{4.6}$$

$$R^c(X_R, K) = r_D \cdot \left(1 - \frac{K}{X_R}\right), \tag{4.7}$$

$$v(X_R, K) = \int_{R^c}^{R_{max}} \left[RX_R - r_D(X_R - K)\right] h(R)dR - f(\bar{X}_R) \cdot c(X_R), \text{ and} \tag{4.8}$$

$$\frac{\partial v(\cdot)}{\partial X_R} = \bar{R} + \int_0^{R^c} (r_D - R)h(R)dR - r_D - f(X_R) \cdot c'(X_R). \tag{4.9}$$

Note that we have substituted the equilibrium condition $\bar{X}_R = X_R$ in $\frac{\partial v(\cdot)}{\partial X_R}$ above and the charter-value V is given by equation (4.4).

4.2 Capital structure choice of banks

Denote the equilibrium choice of risky investment of the banks characterized above for a given capital structure K as $\hat{X}_R(K, p)$ where we have emphasized the dependence on the capital structure K and the regulatory forbearance p. The capital structure choice that banks face subject to the minimum capital requirement can be stated as follows:

$$\max_{K \leq \hat{X}_R(\cdot),\; K \geq K_{min}} \; v(\hat{X}_R, K) - \theta(K) + \beta V - \beta(1-p)V \int_0^{R^c} h(R)dR \tag{4.10}$$

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 which in equilibrium is given by equation (4.4).

[12] This is akin to the classic problem of "risk-shifting" or "asset-substitution" by equityholders, studied in corporate finance by Jensen and Meckling (1976), Green (1984), John and John (1993), etc., and in credit-rationing by Stiglitz and Weiss (1981).

[13] This risk-avoidance effect is similar to that examined by Herring and Vankundre (1987), and Keeley (1990), in their analysis of banks' growth opportunities and market power, respectively.

Further, banks are price–takers with respect to the deposit rate r_D which in equilibrium is given by equation (4.5).[14] We shall denote the maximand above as simply $\hat{V}(K,p)$.

To understand the choice of the optimal capital structure, we need to first analyze the unconstrained problem, i.e., the problem above without the minimum capital requirement $K \geq K_{min}$. Denote the optimal capital structure under this unconstrained problem for a given forbearance parameter as $K(p)$. We shall call this the *privately optimal* level of bank capital. Then, the optimal capital structure under the constrained problem is simply $\hat{K}(p) = \max(K(p), K_{min}(p))$ where $K_{min}(p)$, the regulatory capital requirement may also be a function of regulatory forbearance p.

The next proposition establishes that if the dilution cost of bank capital is "sufficiently steep," then bank's privately optimal capital level is interior, i.e., $K < \hat{X}_R(K,\cdot)$. Further, as regulatory forbearance increases, bank's privately optimal capital level falls, whereby the private level of bank capital and regulatory forbearance act as *strategic substitutes*.

Proposition 4.1 (Privately Optimal Bank Capital Level) *If the dilution cost of capital is sufficiently high, then bank's privately optimal capital level $K(p)$ is smaller than its total risky investment, i.e., $K(p) < \hat{X}_R(K(p),p)$. The privately optimal capital level and regulatory forbearance behave as strategic substitutes, i.e., $K(p)$ is decreasing in p.*

The proof in Appendix B characterizes the precise condition on the dilution cost $\theta(K)$ to be sufficiently high.[15] The condition essentially ensures that designing an all–equity bank is not in the interests of bankowners due to high dilution cost of outside equity. On the other hand, an all–deposit bank is not optimal either since having *some* equity capital in the bank structure enhances bankowners' value. Bank capital acts as a "buffer" which reduces the likelihood of default and, in turn, the loss of bankowners' continuation value. The privately optimal bank capital level trades off this benefit with the (private) dilution cost of capital.

Design of minimum capital requirement: Next, we wish to identify conditions under which this privately optimal bank capital level, $K(p)$, is lower than the regulatory optimum, $K_{min}(p)$, so that the minimum capital requirement binds. To this end, we first need to

[14] This assumption is reasonable in our setting since there is a continuum of banks and the deposit market is competitive. It can also be justified if the sequence of capital structure formation is that deposits are issued first and capital level is chosen next.

[15] The condition is that $\theta'(X_R^*) > \bar{R} - f(X_R^*) \cdot c'(X_R^*)$ where X_R^* is the risky investment choice of an all equity bank. In particular, X_R^* satisfies the first order condition (4.6) above with $R^c = 0$ since an all–equity bank never faces default, so that $r_D = r_S$:

$$\bar{R} - r_S - f(X_R) \cdot c'(X_R) = \beta(1-p)V \cdot h(0)\frac{r_S}{X_R} \ .$$

characterize the optimal minimum capital requirement or the socially optimal bank capital level $K_{min}(p)$. Recall that the regulator "represents" all the claimants of the bank, and hence, maximizes the sum of the values of all bank claims: deposits, bank capital, and inside equity of the bank. Since minimum capital requirement is imposed as a regulatory constraint on bankowners, it could potentially be privately costly to the bankowners. To ensure that bankowners continue to perform the intermediation activities, we assume a participation constraint that bankowners must be guaranteed a reservation value of $\overline{V}$.

The sum of the expected payoff of all bank claims in each period is

$$w(X_R) \quad = \quad (\bar{R} - r_S)X_R - f(X_R) \cdot c(X_R) \ . \tag{4.11}$$

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

$$W(X_R, K) \quad = \quad \frac{w(X_R)}{1 - \beta + \beta(1-p)\int_0^{R^c} h(R)dR} \ . \tag{4.12}$$

Note that the sub–game perfect investment policy that maximizes this objective is given by

$$\frac{\partial w(\cdot)}{\partial X_R} \quad = \quad \beta(1-p)W \, \frac{\partial}{\partial X_R} \int_0^{R^c} h(R)dR, \tag{4.13}$$

which trades off the benefit to the economy from undertaking greater risk with the potential loss of economy's continuation value in doing so.[16] However, the regulator cannot contract on the investment policies of the bank. In other words, the regulator can be viewed as a "principal" and bankowners as an "agent," where the principal designs minimum capital requirement $K_{min}(p)$ under the knowledge that investment policy X_R is the choice of the banks and subject to the constraint that banks earn at least their reservation value $\overline{V}$. This regulatory design problem is formalized below:

$$\max{}_{K_{min}} \qquad W(\hat{X}_R,\ K \mid p) \tag{4.14}$$

s.t. (IC: Incentive-Compatibility)

$$\hat{X}_R \quad \in \quad \arg\max{}_{X_R} \ v(X_R, K) - \theta(K) - \beta(1-p)V \int_0^{R^c(X_R)} h(R)dR \tag{4.15}$$

[16]We draw the reader's attention to the fact that we have throughout taken the costs of conducting depositor bail outs to be zero. We can either consider a mechanism where funds for bail outs are obtained from depositors themselves through taxes, and hence, represent inter-temporal transfers in their welfare, or introduce deposit insurance premium in the model. This complicates the analysis and takes us away from our main goal which is to study the design of capital requirements and closure policy.

and (MCR: Minimum Capital Requirement)

$$\max_{K \leq \hat{X}_R(\cdot),\ K \geq K_{min}} \quad v(\hat{X}_R, K) - \theta(K) - \beta(1-p)V \int_0^{R^c(\hat{X}_R)} h(R)dR \tag{4.16}$$

and (PC: Participation-Constraint)

$$V(\hat{X}_R,\ K) \ \geq \ \overline{V} \tag{4.17}$$

and (IR: Individual Rationality of Depositors)

$$r_S \ = \ r_D \int_{R^c}^{R_{max}} h(R)dR + r_D \cdot p \int_0^{R^c} h(R)dR \ + \ (1-p) \int_0^{R^c} \frac{RX_R}{X_R - K} h(R)dR \tag{4.18}$$

Note that $v(\cdot)$, $V(\cdot)$, and $W(\cdot)$ are given by the equations (4.8), (4.4), and (4.12), respectively.

Then, we obtain the following lemma which characterizes when the minimum capital requirement binds.

Lemma 4.2 *If $\hat{X}_R(K)$ is the risky investment at privately optimal capital level K, then*

- *the minimum capital requirement, K_{min}, exceeds the privately optimal capital level, K, whenever $\hat{X}_R(K)$ is decreasing in K, but*
- *the minimum capital requirement, K_{min}, may be lower than the privately optimal capital level, K, if $\hat{X}_R(K)$ is increasing in K.*

The intuition for the result is as follows. Capital requirement is employed by the regulator as a device to curb excessive risky investment by bankowners. If the level of risky investment is decreasing in capital at bank's privately optimal capital level, then incremental capital is beneficial to the bank as a whole. This corresponds to the first case above. However, if incremental capital induces greater risk–taking, then the bank as a whole benefits from in fact reducing capital below the private optimum. Since risky investment $\hat{X}_R(K)$ is itself an endogenous consequence, we characterize its behavior as a function of capital K in Lemma B.3 in Appendix B. The lemma shows that a crucial determinant of whether risky investment decreases or increases with capital is whether the sign of the cross–partial derivative $\frac{\partial^2}{\partial K \partial X_R} \int_0^{R^c} h(R)dR$ is positive or negative. If this derivative is positive (negative), then the probability of bank failure increases with risky investment at an increasing (decreasing) rate as the level of bank capital rises.

If we assume that the return distribution of bank's risky loans is unimodal, then whenever the critical point of failure of the bank, R^c, lies to the right of the distribution's central tendency, we have $h'(R^c) < 0$, the cross–partial derivative above is positive, and the level of risky investment decreases as capital rises.[17] Adding capital to these banks ameliorates the risk–shifting problem. Intuitively, these banks are relatively risky and the disciplining effect of their low continuation values is not sufficient for them to internalize the costs of bank default to the economy. Hence, they remain under–capitalized compared to the socially optimal capitalization levels.

On the other hand, if the critical point of failure of the bank, R^c, lies to the left of the distribution's central tendency and the bank's likelihood of failure is very low, i.e., we have $h'(R^c) > 0$ and $h(R^c)$ small, then the cross–partial derivative above is negative and the level of risky investment increases as capital rises. Adding capital to these banks enables them to undertake more risky investments. Intuitively, these banks are relatively safe and the disciplining effect of their large continuation values is sufficient for them to internalize the costs of bank default to the economy. In fact, they behave more "risk–averse" than is socially desirable and remain over–capitalized.[18]

This predicted behavior in fact seems to conform well with the empirically observed levels of bank capital. When banks are healthy and in boom states of the economy when bank failure probabilities are low, banks tend to hold capital well above the regulatory minimums. However, when bank health deteriorates and during economic recessions, bank failure probabilities are high and minimum capital requirements bind: banks do not hold more capital than regulation requires them to hold (e.g., see Keeley, 1990, and, Saunders and Wilson, 2001). This discussion is summarized in the following proposition.

Proposition 4.3 (Private vs. Socially Optimal Bank Capital Levels) *If the distribution of risky asset return, $h(R)$, is assumed to be unimodal over $[0, R_{max}]$, then*

- *the minimum capital requirement, K_{min}, exceeds the privately optimal capital level, K, whenever bank's critical point of default, $R^c(K)$, lies to the right of the central tendency of the distribution $h(R)$, and*
- *the minimum capital requirement, K_{min}, may be lower than the privately optimal capital level, K, if bank's critical point of default, $R^c(K)$, lies to the left of the central tendency of the distribution $h(R)$.*

[17] As an illustration, assume that the risky asset return is the standard log–normal distribution (Figure 1), i.e., $\ln(R) \sim N(0,1)$, then the central tendency of the distribution is around 0.4. For, $R^c > 0.4$, we have $h'(R^c) < 0$ as evidenced by the downward sloping density function for values greater than 0.4. On the other hand, for $R^c < 0.4$, we have $h'(R^c) > 0$.

[18] It is of some analytical interest that this classification of banks based on whether their point of default lies to the left or to the right of the central tendency of their portfolio return plays an important role also in studying the effect of focus and diversification on the endogenous monitoring incentives of banks. Winton (1999) formalizes this result.

Finally, we come to the question of primary importance to this paper: how does $K_{min}(p)$ behave as a function of p? *Ceteris paribus,* should a more forbearing regulator require greater capital for its banks? The following proposition shows that level of minimum capital requirement and regulatory forbearance are *strategic complements* in the regulatory design problem.

Proposition 4.4 (One Size Doesn't Fit All) *The optimal minimum capital requirement and the regulatory forbearance are strategic complements, i.e., $K_{min}(p)$ is increasing in p.*

The result is intuitive. We showed in Proposition 4.3 that the minimum capital requirement binds when banks are "risky" and, in this case, their risky investment decreases as the level of bank capital increases. Let us first assume that the participation constraint in equation (4.17) does not bind in the regulatory design problem. In this case, as forbearance increases, bankowners of risky banks undertake greater risk and this is counteracted by requiring greater bank capital. On the other hand, if the participation constraint binds, then an increase in regulatory forbearance increases the charter-value of banks. Thus, the participation constraint becomes slack and the minimum capital requirement can be increased to counteract the increase in moral hazard. In either case, level of capital requirement complements the level of regulatory forbearance.

In other words, the ex–ante regulatory mechanism, viz., the minimum capital requirement, should be designed to take account of the negative feedback on incentives arising from discretion in the ex–post mechanism, viz., the regulator's bank closure policy. This is to be contrasted with the result of Proposition 4.1 which showed that bank's privately optimal capital level and regulatory forbearance are *strategic substitutes*. It suggests thus that the lack of such complementary variation is likely to result in suboptimal bank capital structures in situations wherein the minimum capital requirement binds, i.e., for banks which are risky, during recessionary periods when private bank capital levels fall, and, when the anticipated and exercised regulatory forbearance is high.[19]

Note that the closure policies adopted by central banks in different countries are highly divergent.[20] The results above caution us that the convergence in capital standards following the Basel Accord of 1988 may lack theoretical merit. Such convergence is likely to be meritorious only if accompanied by a convergence of other aspects of bank regulation such

[19] Note that it is possible to derive an alternate characterization of when privately optimal capital level is lower than socially optimal level. An immediate corollary of Proposition 4.1 (K and p are strategic substitutes) and Proposition 4.4 (K_{min} and p are strategic complements) is that if minimum capital requirement binds at a level of forbearance p', it binds for all greater forbearance levels $p > p'$ as well.

[20] For example, Dewatripont and Tirole (1993) document that while U.S. and Nordic countries have stringent bank closures, Japan and most emerging economies have fairly lax closure practices. State-owned banks in most emerging economies enjoy an almost 100% (implicit) safety-net. The degree of such safety-nets is dispersed even amongst developed nations and members of the Basel Committee.

as closure policies. Where such accompanying convergence is infeasible, an appropriate divergence in capital requirements may be necessary. Differences in economic conditions and organizational structures across nations may also accentuate the need for such divergence. In the next section, we investigate this issue further by illustrating the potential ill–effects on the global economy from a convergence amongst countries on capital requirements even as they practise divergent closure policies towards their banks.

5 Multiple economy model

To study potential spillovers from one economy's regulation to other economies (and their regulation), we build a simple model with two *regimes*. Banks operate across regimes and have common access to deposit borrowing and lending opportunities. The extent of competition that banks face in lending and hence the costs they incur are affected by the aggregate level of risky investments. However, unlike in the single economy case, this aggregate level comprises of risky investments of banks in *both* regimes. A bank's risk-taking incentives, in turn, are affected by the regulatory forbearance exercised in the regime where it is chartered. Thus, the equilibrium value of each regime's banks depends also on the forbearance of the other regime. Financial integration of the regimes through international operations of their banks thus generates a potential for spillover arising due to their 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 depositors, and a regulator (as in the single–economy model of Section 3). The regulators in the two regimes are constrained to enforce identical minimum capital requirement. We assume that banks are regulated on an internationally consolidated basis. To be precise, each bank is required to hold a minimum of K_{min} units of capital against its total risky investment, i.e., the sum of its domestic and foreign risky investments.

Similarly, upon a bail out of a bank by the regulator of its regime, both domestic and foreign depositors of the bank are bailed out. Further, and this is crucial in the ensuing analysis, the closure or the bail out of a bank in regime i is governed *only* by the policy of regulator i.[21] The central banks may however adopt closure policies with different levels of forbearance towards banks chartered in their respective regimes. We denote these forbearances as p_a and p_b, respectively.

The investor endowment in the two regimes in each period is D, there is a common return on safe asset r_S, and a common return on risky asset denoted as $R \sim h(\cdot)$ over $[0, R_{max}]$ as before. The profit margins from risky lending may however be heterogeneous across regimes.

[21] The discussion in Section 5.2 on "home" country vs. "host" country regulation presents the implications of relaxing this assumption.

The cost structure facing a representative regime A bank is $f(\bar{X}_{Ra} + \bar{X}_{Rb}) \cdot c(X_{Ra})$ 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 $f(\cdot)$ and $c(\cdot)$ are the increasing and convex neoclassical cost functions as before.

On the other hand, the cost structure faced by a representative regime B bank is given as $\alpha f(\bar{X}_{Ra} + \bar{X}_{Rb}) \cdot \beta c(X_{Rb})$. For $\alpha > 1$, regime B banks are more adversely affected by competition than regime A banks. This could arise for example if a greater proportion of risky assets are constituted by regime A firms (borrowers from banks) and regime A banks have superior relationships with these local firms. Similarly, for $\beta > 1$, regime B banks' individual cost efficiency in loan initiation, administration, and collection, is lower than that of regime A banks. Thus, in a simple reduced–form manner, both α and β capture the relative difference between regime A and regime B banks' profit margins from lending.

What is the effect of forbearance exercised towards regime A banks on the value of regime B banks? We show that the size of regime B banks measured by their charter–value, $V_b(p_a, p_b)$, is decreasing in the forbearance p_a. We call this effect the *spillover* of regime A's regulation on regime B banks. Further, the magnitude of this decrease increases as the size of regime B banks shrinks. This happens when (i) regime A becomes more forbearing, and (ii) regime B banks face greater competition or run less efficiently.

Proposition 5.1 (International Spillover) *The charter–value of regime B banks, $V_b(p_a, p_b)$, is decreasing in p_a, the forbearance exercised by regime A regulator. The magnitude of this spillover, i.e., the magnitude of the rate of decrease in $V_b(p_a, p_b)$ as a function of p_a, is increasing in α, the competition faced by regime B banks, and in β, the inefficiency of regime B banks.*

We discuss these effects below.

Forbearance of regime A: Allowing for a difference in the forbearance between the two regimes ($p_a \neq p_b$) helps us capture the institutional reality that most central banks adopt vastly different closure policies. As the forbearance of regime A increases, banks chartered in regime A find risky investments more attractive (Lemma B.4 in the appendix). These banks increase their risky investments, in turn, raising the competition in lending markets. In equilibrium, this lowers the profit margin of regime B banks net of the costs of lending activity. Since the risk–adjusted cost of borrowing for all banks is identical (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 regime A regulator, the greater is the spillover.

The increased forbearance of regime A is thus not just destabilizing for its own banks (who take greater risk), but is potentially destabilizing for banks in other regimes as well.

Two points are in order. First, in a world where capital requirements are uniform, regime B regulator cannot impose differential capital requirements on regime A banks to curb their risk–taking incentives. This lack of flexibility is crucial in generating the spillover. Second, the regulation adopted by regime A has an externality on regime B banks through the effect of aggregate level of lending on costs of lending activity. If each regime's regulator is concerned only about maximizing the value of its own banking sector, this externality will in general not be internalized in absence of coordination. Thus, the situation where each regime increases its forbearance producing welfare costs for other regimes has the potential of being an equilibrium outcome. We formalize this intuition precisely in Section 5.1.

Competition faced by regime B banks: As discussed above, the spillover operates through an increase in the cost of lending activity of regime B banks when regime A banks increase their risk–taking. As α increases beyond its benchmark value of one, regime B banks face greater competition in the lending market and their profit margins get eroded more quickly for a given increase in forbearance towards regime A banks. The overall effect is thus to shrink the banks more and increase the magnitude of the spillover.

Efficiency of regime B banks: This effect is analogous to that of competition faced by regime B banks. As regime B banks' lending activities get more inefficient, their profit margins fall more sharply for a given increase in forbearance towards regime A banks.

The proposition thus suggests that the magnitude of regulatory spillover depends on the differences in regulation and also on the heterogeneity of banking sectors. Further, the spillover is likely to adversely affect an economy when it has a less forbearing regulatory stance and its banks have low profit margins. In fact, such heterogeneity across banking sectors or a difference in the regulatory objectives may explain why one regulator prefers a lower level of forbearance than the other. Next, we allow for such a difference in regulatory objectives and study how a regulator responds to the international spillover entailed upon excessive forbearance by the other regulator.[22]

5.1 Regression towards the worst regulation

If regulators adopt their closure policies in an uncoordinated fashion but coordinate on capital requirements, what equilibrium results? Is coordination on one but not all regulatory policies a desirable step for integrated regimes? We show below that if regulatory objectives are sufficiently divergent across regimes then in equilibrium, there may be a "regression towards

[22] The following section has evolved in response to the referee's suggestion of examining the political economy effect of forbearance in one regime on forbearance in other regimes.

the worst regulation": a central bank aligned more with the interests of its own bankowners exercises greater forbearance and other central banks respond by behaving similarly. The answer to the last question above may thus be in the negative: a "race to the bottom" that results could be worse than no coordination on any policies at all.

To this end, we model why different regulators adopt different levels of forbearance by appealing to the fact that they are aligned to different degrees with the normative objective of overall bank value maximization. Put differently, some of the regulators are more aligned with one of the "interest groups," viz. bankowners. Laffont and Tirole (1991) provide a theoretical analysis of such "regulatory capture," and Kane (1990) documents empirical evidence of the same during S&L crisis in the U.S. We generalize the regulator's objective to one that maximizes a weighted average of the welfare of bankowners and the welfare of outside claimants of its domestic banks. Thus,

$$W_\lambda \;\; = \;\; \lambda \cdot V + (1-\lambda) \cdot (W - V) \tag{5.1}$$

where V is the value of bank's "inside" equity owned by bankowners (equation 4.4), and W is the total value of the bank inclusive of all its claims (equation 4.12). Thus, $W - V$ represents the sum of values of claims held by depositors and outside equityholders. Note that if $\lambda = \frac{1}{2}$ then $W_\lambda = \frac{1}{2}W$ which corresponds to bank value maximization studied until now; $\lambda > \frac{1}{2}$ reflects a greater weight on bankowners' interest; $\lambda < \frac{1}{2}$ represents a conservative regulator aligned more with the interests of bank's outside claimants.

To start with, we assume that the two regimes are identical in their banking sector characteristics, i.e., $\alpha = 1$ and $\beta = 1$. The only difference between the two regimes arises due to a difference in their regulatory weights, λ_a and λ_b, respectively. We treat λ_b as fixed and allow λ_a to increase in order to study the effect of heterogeneity in regulatory objectives. As before, there is an international convergence of minimum capital requirement at a level K_{min}. Then, each regulator solves a design problem that is a variant of the one specified in equations (4.14)–(4.17). Regulator A's problem is

$$\max_{\,p_a} \qquad W_{\lambda_a}(\hat{X}_R \mid K_{min}, p_a) \tag{5.2}$$

s.t. (IC: Incentive-Compatibility)

$$\hat{X}_R \;\in\; \arg\max_{\,X_R}\, v(X_R, K) - \theta(K) - \beta(1-p_a)V \int_0^{R^c(X_R)} h(R)dR \tag{5.3}$$

and (MCR: Minimum Capital Requirement)

$$\max_{\,K \le \hat{X}_R(\cdot),\; K \ge K_{min}} \qquad v_a(\hat{X}_R, K) - \theta(K) - \beta(1-p_a)V \int_0^{R^c(\hat{X}_R)} h(R)dR \tag{5.4}$$

and (PC: Participation-Constraint)

$$V(\hat{X}_R,\ K)\ \geq\ \overline{V} \tag{5.5}$$

and (IR: Individual Rationality of Depositors)

$$r_S\ =\ r_D\int_{R^c}^{R_{max}} h(R)dR + r_D\cdot p_a\int_0^{R^c} h(R)dR\ +\ (1-p_a)\int_0^{R^c}\frac{RX_R}{X_R-K}h(R)dR \tag{5.6}$$

where for simplicity we have suppressed the subscript a on all terms other than p_a and λ_a. Regulator B's problem is specified similarly. The interaction of these two design problems arises through the equilibrium cost of making loans faced by banks, $f(\bar{X}_{Ra}+\bar{X}_{Rb})\cdot c(X_{Ri})$, which is increasing in the aggregate level of lending activity, $\bar{X}_{Ra}+\bar{X}_{Rb}$. Denote the forbearances of the two regulators as $p_a(\lambda_a)$ and $p_b(\lambda_b)$, respectively.

First, we show that as λ_a increases, p_a increases as well, i.e., a greater alignment of regulator's objective with its bankowners makes forbearance more attractive.

Lemma 5.2 *Ceteris paribus, the forbearance of central bank A increases in its alignment with its bankowners, i.e., $p_a(\lambda_a)$ is increasing in λ_a.*

Thus, an increase in λ_a leads to a corresponding increase in p_a but the capital requirement K_{min} stays the same. This gives rise to greater risk–taking by regime A banks, in turn, producing a spillover on regime B banks. The spillover, if large enough, forces the charter–value of regime B banks to fall below their reservation value, and in equilibrium, the regulator of regime B is forced to adopt greater forbearance as well. When this happens, regulatory forbearances start behaving as *strategic complements*. Proposition 5.3 formalizes that this happens precisely when the regulatory capture of central bank A is sufficiently high to cause regime B banks to exit unless greater forbearance is exercised by central bank B.

Proposition 5.3 (Regression Towards the Worst) *In equilibrium, the regulator of regime B increases forbearance towards its banks upon an increase in the capture of regulator of regime A, i.e., both forbearances p_a and p_b increase in λ_a, if*

(i) the regulator of regime B is also "captured" by its bankonwers, i.e., $\lambda_a > \lambda_b > \frac{1}{2}$, or

(ii) if the regulator of regime A is sufficiently captured by its bankowners compared to regulator of regime B, i.e., $\lambda_a - \lambda_b$ is greater than a critical threshold $\Delta\lambda \geq 0$.

We show in the proof that if both λ_a and λ_b are sufficiently low such that (PC) binds for design problems of both regulators, then locally, a small increase in λ_a does not shift the equilibrium. On the other hand if λ_b is low relative to λ_a so that (PC) binds for regime B

banks but does not bind for regime A banks, then an increase in λ_a induces a spillover driving regime B banks' charter–values below their exit point unless compensated through greater forbearance by their regulator. Thus, regulator of regime B is forced to behave as though its "effective" alignment with bankowners is greater than λ_b and somewhat more like λ_a: regulatory capture in one of the regimes induces the other regime regulator to be captured as well by the interests of its bankowners.

Finally, if λ_a and λ_b are such that (PC) does not bind for both regime banks, then it can be shown that if regime B regulator is more aligned with bankowners than with other bank claimants, i.e., $\lambda_b > \frac{1}{2}$, then it always responds to the induced spillover by increasing its forbearance. On the other hand, if regime B regulator is more conservative, i.e., $\lambda_b \leq \frac{1}{2}$, then it responds initially by lowering its forbearance. However, the combined effect of decrease in p_b and increase in p_a is to eventually drive the regime B banks's charter–values below their exit point. A sufficient heterogeneity in the regulatory objectives thus forces the conservative regulator of regime B to start exhibiting greater forbearance towards its shrinking banks.

We call this perverse phenomenon as a "regression towards the worst" or a "race to the bottom." A regulator by exercising lower forbearance can enable other regulators to exercise lower forbearance as well. This externality is however not taken into account by regulators when they take uncoordinated actions. The fact that the spillover from regime A's regulation reduces regime B banks' charter–value is the driving force behind these results. Recall that the spillover is also likely to be severe when integrating economies are heterogeneous in some of their banking sector characteristics. We conjecture thus that a lack of coordination in closure policies will be most destabilizing for those banking sector integrations where (i) the sectors are different in the profitability of their banks, and (ii) the regulators of these sectors differ substantially in the extent of alignment with their domestic banks. The first condition implies that the externality of one regime's policies on other regimes is likely to be high, and, the second suggests that these externalities are likely to remain uninternalized.[23]

In principle, a central authority in financial integration (if there is one, e.g., the European Central Bank in EMU) could deviate from "one size fits all" on minimum capital requirement front. Regulators exhibiting greater forbearance could be required to impose appropriately adjusted capital requirements on their banks. Then, 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_b, p_b) for regime B banks. From Proposition 4.4, the optimal capital requirement increases with an increase in forbearance so that $K_a > K_b$ if $p_a > p_b$. This would counteract the excessive risk–taking by regime A banks, reduce the spillover to regime B, and in turn, reduce central bank B's incentives to converge towards regime A's forbearance.

[23] Dell'Ariccia and Marquez (2000) make a similar point in their analysis of competition amongst regulators.

5.2 Proposals for regulation of international banks

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

Complete coordination of regulation: This solution seems the most apt for the European Monetary Union (EMU). A central issue following the formation of the EMU has been to what extent the policies of member nations should 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.[24] While banks are required to meet the 8% Basel capital requirement, there are no explicit rules as to who should do a bail out for a failed bank. EMU is still debating about the question: should there be a central lender-of-last-resort in Europe? Our analysis suggests that the answer is YES. Given that these banks are all subject to same Basel capital requirements, national regulators may favor their own country banks by exercising high levels of regulatory forbearance and low levels of regulatory supervision. The slow movement towards an alignment of political agendas across different member countries should however facilitate a complete regulatory alignment as well.

"Host" country regulation: This solution has been adopted by the United States. The International Banking Act of 1978 (IBA) sought to give national treatment in the U.S. to foreign banks by treating them as domestic banks. However, poor foreign supervisory standards led to a series of undesirable outcomes: 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. This led to the passage of the Foreign Bank Supervision Enhancement Act (FBSEA) of 1991. We view the steps taken by the FBSEA, viz. the enhanced powers of the federal regulators on entry, closure, examination, deposit taking, and activity powers of foreign banks as a step towards complete regulatory insulation of U.S. banking sector from foreign regulation.

In particular, FBSEA requires that a foreign bank entering the U.S. banking sector activities *must be* subject to comprehensive supervision on a *consolidated basis* by a home regulator. Further, 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 if its home country supervision is inadequate, it it has violated U.S. laws, or if it engaged in unsound and unsafe banking practices.[25] 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.

[24] This is the so-called "home country control" rule in the EU directives, documented, e.g., in Iakova (2000).

[25] In an account of a recent U.S. investigation against Credit Lyonnais, *Economist*, January 13th, 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."

Note that it would be virtually impossible for "host" country regulator to dictate *all* regulations that govern foreign banks' activities. It can nevertheless induce appropriate incentives for risk–taking in these banks if it exercises supervision and a credible threat of closure of local activities of these banks.[26] In our model, we have not allowed for this possibility. However, it is a plausible way of counteracting any regulatory spillover from abroad.

6 Robustness of the model and results

Absolute level of bank capital vs. capital ratio: In practice, capital requirement is not imposed as a required absolute level of bank capital but as a required ratio of bank capital to (suitably) risk–adjusted assets. Can the implications of our model be then applied directly to existing regulation? Our claim is that there is a mapping between these settings.

In our 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 requirement against non–traded risks divides all risky assets into "coarse" risk buckets. Banks thus have incentives to over–invest in the riskier assets within each bucket. The role played by the level of risky investment in our model will thus be played by these riskier assets. The regulatory spillover in our model arises due to an increase in risky lending by banks of more forbearing regime and the fact that they are not required to hold more capital against this increased risk. In the setting with "coarse" risk buckets, banks of more forbearing regime can increase their investments in the riskier assets within each risk bucket. This would result in these banks having a competitive edge in increasing the size of such investments and eroding profits from similar investments by banks of less forbearing regime. Thus, through a subtle but qualitatively similar channel, we believe that the intuition of our model also applies to the capital ratio setting as long as there is incompleteness of contracting on some dimension of risk.

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 "peking order." Note however that whether capital should be issued in single or multiple issuances depends crucially on the issuance cost structure: convex issuance costs will

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

lead to smaller size but 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 and size of capital issuance. Nevertheless, how does relaxing our myopic assumption affect the qualitative nature of our results?

Our first conjecture is that this would drive even a bigger wedge between safe and risky banks in terms of their capitalization levels. Over time, safer banks can build up their capital levels. Their enhanced charter–values would then give them even further incentive to build up more capital. On the other hand, riskier banks will see their capital cushion wiped out more often and be forced to incur greater dilution costs in future. The lowered charter–value would in turn further reduce their incentive to invest in capital today. Our second conjecture is that if costs of equity issuance are counter–cyclical, then banks will raise more capital in "good" times and "transfer" it to "bad" times when capital issuance is more costly. The result that minimum capital requirement increases with regulatory forbearance should hold even though the optimal level of capital required may be counter–cyclical.

7 Conclusion

In this paper, we have illustrated an application to bank regulation of a simple but a fundamental point: ex-post policies affect the optimality of ex-ante incentives, and thus an ex-ante optimal design must take account of this feedback effect. Such a result is likely to apply in many other corporate finance settings: (i) relationship between managerial compensation and retention/severance policies; (ii) effect of bankruptcy codes (debtor-friendly as in the U.S. vs. creditor-friendly as in the U.K.) on the risk-taking incentives, and thus, on the cost of borrowing for firms; and (iii) feedback of poor enforcement or legal underdevelopment in a financial system on the design of ex-ante contracts between parties.

Our analysis can be extended to many other arms of banking regulation such as the effect of competition on continuation values, and hence, on risk-taking incentives of banks; and the need for a link between the effectiveness of bank supervision (enforcement) and capital requirements. While most studies of regulation, including this one, have focused on the role of stabilizing the financial sector, this role may have interesting interactions with the monetary policy of the central bank in pursuit of its real sector objectives. Further, there is no satisfactory theory of organizational structure and regulation of international financial institutions. Countries and their regulators face the task of answering difficult design questions given the growing trend towards international harmonization. We hope that our model 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 enquiry.

Finally, there is a parallel between the results in this paper and the literature on winners and losers from regional integration (Venables, 2000) and on the need for including protection of intellectual property rights (IPRs) in multilateral trade agreements (Goh and Olivier, 2000). The first literature has spillover results between countries and the second literature is concerned with the interaction between trade policies and protection of IPRs as strategic substitutes. It is our conjecture that such parallels will arise in many situations with multiple policy instruments and harmonization amongst heterogeneous economies. Some recent examples include (i) talks regarding harmonization of bankruptcy codes within European Union following bail outs by governments of their domestic airlines after September 11, 2001, and (ii) concern in the U.S. over the erosion of competitive edge of some American corporations due to stricter pollution and environment control policies in the U.S. compared to those faced by their peer firms in many other countries.

A Existence of equilibrium

We characterize the conditions under which the symmetric competitive equilibrium discussed in Section 4.1 exists and has interior investment choices.

Proposition A.1 *A symmetric competitive equilibrium of the economy where banks hold capital K exists whenever*

(i) there is reward for bearing some risk, i.e., $\bar{R} > r_S$, and

(ii) the costs of making risky investments are sufficiently steep, in particular, whenever $f(D) \cdot c'(D) > \int_{r_S}^{R_{max}} (R - r_S) h(R) dR$.

In equilibrium: (i) $r_D \geq r_S$, (ii) $X_S = 0$, and (iii) $X_R < D$.

Proof: From individual rationality of depositors in equation (4.5), it follows that

$$\frac{r_S}{r_D} = \int_{R^c}^{R_{max}} h(R)dR + p\int_0^{R^c} h(R)dR \ + \ (1-p)\int_0^{R^c} \frac{r_S X_S + R X_R}{r_D \cdot (X_S + X_R - K)} h(R)dR.$$

From the definition of R^c in equation (4.1), it follows that whenever $R < R^c$, the last integrand, viz., $\frac{r_S X_S + R X_R}{r_D \cdot (X_S + X_R - K)}$ is less than 1. Thus, the RHS of the equation above is always less than or equal to 1. It follows that $r_S \leq r_D$ always.

Next, whenever $r_D \geq r_S$, it can be readily verified from equations (4.1) and (4.2) that $\frac{\partial R^c}{\partial X_S} > 0$, $\frac{\partial v}{\partial X_S} < 0$, $\frac{\partial v}{\partial R^c} < 0$, and hence, $\frac{dv}{dX_S} = \frac{\partial v}{\partial X_S} + \frac{\partial v}{\partial R^c} \cdot \frac{\partial R^c}{\partial X_S} < 0$. Further, since V is a lump sum constant for bankowners' maximization, it also follows that

$$\frac{\partial}{\partial X_S}[\ \beta(1-p)V\int_0^{R^c} h(R)dR\ ] = \beta(1-p)V\frac{\partial}{\partial X_S}\int_0^{R^c} h(R)dR = \beta(1-p)Vh(R^c)\frac{\partial R^c}{\partial X_S} > 0.$$

Since bankowners' maximization in equation (4.3) can be restated as

$$\max_{X_S, X_R \geq 0} \; v(r_S, r_D, X_S, X_R, K) - \theta(K) + \beta V - \beta(1-p)V \int_0^{R^c} h(R)dR, \tag{A.1}$$

we infer that the first order derivative of the maximand 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.

Substituting $X_S = 0$ and optimizing the reduced problem w.r.t. X_R, the first order condition is obtained as:

$$\frac{\partial v(\cdot)}{\partial X_R} = \beta(1-p)V \frac{\partial}{\partial X_R} \int_0^{R^c} h(R)dR, \text{ where} \tag{A.2}$$

$$R^c(X_R, K) = r_D \cdot \left(1 - \frac{K}{X_R}\right), \tag{A.3}$$

$$v(X_R, K) = \int_{R^c}^{R_{max}} [RX_R - r_D(X_R - K)]\, h(R)dR - f(\bar{X}_R) \cdot c(X_R), \text{ and} \tag{A.4}$$

$$\frac{\partial v(\cdot)}{\partial X_R} = \bar{R} + \int_0^{R^c} (r_D - R)h(R)dR - r_D - f(\bar{X}_R) \cdot c'(X_R). \tag{A.5}$$

Note that in the symmetric equilibrium $\bar{X}_R = X_R$ in $\frac{\partial v(\cdot)}{\partial X_R}$ above, and by stationarity, the charter-value V is given by equation (4.4).

The first order condition can thus be written in the simplified form:

$$\int_{R^c}^{R_{max}} (R - r_D)h(R)dR = f(X_R) \cdot c'(X_R) + \beta(1-p)Vh(R^c)\frac{\partial R^c}{\partial X_R}. \tag{A.6}$$

It is clear from the first order condition that if $X_R = 0$ which in turn 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 $\bar{R} > r_S$, i.e., as long as there is reward for bearing at least "some" risk.

Next, we wish to identify conditions under which the choice of X_R is interior, i.e., $X_R < D$. Since $\frac{\partial R^c}{\partial X_R} = \frac{r_D K}{X_R^2} > 0$, a sufficient condition to obtain $X_R < D$ is that

$$\int_{r_D(1-\frac{K}{D})}^{R_{max}} (R - r_D)h(R)dR < f(D) \cdot c'(D). \tag{A.7}$$

Since $\int_{r_D(1-\frac{K}{D})}^{r_D} (R - r_D)h(R)dR \leq 0$, the sufficient condition can be weakened to have

$$\int_{r_D}^{R_{max}} (R - r_D)h(R)dR < f(D) \cdot c'(D). \tag{A.8}$$

The LHS in this condition is decreasing as a function of r_D and sine $r_D \geq r_S$ 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 $f(D) \cdot c'(D) > \int_{r_S}^{R_{max}} (R - r_S)h(R)dR$, i.e., the cost functions for making risky investments are "sufficiently steep." □

B Proofs

We next prove two intermediate results to be used in proofs that follow.

Lemma B.1 *Bank charter–value increases with regulatory forbearance.*

From equation (4.4),

$$\frac{dV}{dp} = \frac{\partial V}{\partial X_R} \cdot \frac{dX_R}{dp} + \frac{\partial V}{\partial p} = \frac{\partial V}{\partial p} = \frac{1}{Z} \cdot \beta V \int_0^{R^c} h(R)dR > 0, \tag{B.1}$$

since $\frac{\partial V}{\partial X_R} = 0$ at $X_R = \hat{X}_R(K,p)$ given by equation (4.6). □

Lemma B.2 $\frac{d}{dp}[(1-p)V] < 0$.

Note that $\frac{d}{dp}[(1-p)V] = -V + (1-p)\frac{dV}{dp}$, where $\frac{dV}{dp} = \frac{1}{Z} \cdot \beta\ V \int_0^{R^c} h(R)dR$ from equation (B.1). Then, $\frac{d}{dp}[(1-p)V] = -\frac{1}{Z} \cdot (1-\beta)V \int_0^{R^c} h(R)dR < 0$. □

Proposition 4.1: Note that if we denote the maximand in bank's maximization problem in equation (4.10) as $\hat{V}$, then the first order condition w.r.t. capital K is:

$$\frac{\partial \hat{V}}{\partial K} + \frac{\partial \hat{V}}{\partial X_R} \cdot \frac{dX_R}{dK} = 0 \tag{B.2}$$

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

$$\begin{aligned} \frac{\partial \hat{V}}{\partial K} &= \frac{\partial v}{\partial K} - \theta'(K) - \beta(1-p)V\frac{\partial}{\partial K}\int_0^{R^c} h(R)dR \\ &= r_D \int_{R^c}^{R_{max}} h(R)dR - \theta'(K) + \beta(1-p)Vh(R^c) \cdot \frac{r_D}{X_R} = 0. \end{aligned} \tag{B.3}$$

First, note that if $K = 0$ then $\frac{\partial \hat{V}}{\partial K} > 0$. Second, we show that if K is such that $K = X_R^* \equiv \hat{X}_R(K,p)$, then $\frac{\partial \hat{V}}{\partial K} < 0$ provided that $\theta'(K) > \bar{R} - f(X_R^*) \cdot c'(X_R^*)$. To see this, observe that if $K = \hat{X}_R(\cdot)$, then $R^c = 0$ and $r_D = r_S$, so that

$$\frac{\partial \hat{V}}{\partial K} = r_S + \beta(1-p)Vh(0) \cdot \frac{r_D}{X_R} - \theta'(K). \tag{B.4}$$

However, the first order condition (4.6) at $K = X_R$ implies that

$$\bar{R} - r_S = f(X_R) \cdot c'(X_R) + \beta(1-p)Vh(0) \cdot \frac{r_D}{X_R} \tag{B.5}$$

Substituting this in the expression for $\frac{\partial \hat{V}}{\partial K}$, we obtain

$$\frac{\partial \hat{V}}{\partial K} = \bar{R} - f(X_R) \cdot c'(X_R) - \theta'(K) < 0 \text{ if } \theta'(K) > \bar{R} - f(X_R^*) \cdot c'(X_R^*) \tag{B.6}$$

where X_R^* is given by the first order condition for an all–equity bank, i.e., equation (B.5) above. It follows now that under this condition, the privately optimal capital level of the bank, $K(p)$ is such that $K(p) < \hat{X}_R(K(p), p)$.

Next, we prove that $K(p)$ is decreasing in p using the standard strategic substitution argument. Since $K(p)$ maximizes $\hat{V}$, it follows that $\frac{\partial^2 \hat{V}}{\partial K^2} < 0$. Further, $\frac{\partial \hat{V}}{\partial K} = 0$ implies

$$\frac{\partial^2 \hat{V}}{\partial K^2} \cdot \frac{dK}{dp} + \frac{\partial^2 \hat{V}}{\partial K \partial p} = 0. \tag{B.7}$$

Combining these results and equation (B.3), we obtain the strategic interaction condition:

$$\begin{aligned} \text{sign}\left(\frac{dK}{dp}\right) &= \text{sign}\left(\frac{\partial^2 \hat{V}}{\partial K \partial p}\right) \\ &= \text{sign}\left[\beta h(R^c) \frac{r_D}{X_R} \cdot \frac{\partial}{\partial p}((1-p)V)\right] < 0, \end{aligned} \tag{B.8}$$

where the last inequality follows from Lemma B.2 (recognizing that the partial derivative w.r.t. forbearance p above is employed to separate out its effect on capital K). It follows that K and p behave as strategic substitutes for bankowners. □

Lemma 4.2: Consider the design problem faced by the regulator specified in equations (4.14)–(4.18). It is clear that the design of minimum capital requirement K_{min} affects equilibrium outcomes only when the requirement binds. Hence, to determine the level of K_{min} we assume this to be the case, i.e., $K = K_{min}$. To start, we also assume that the participation constraint (PC) is slack.

Then, the first order derivative for regulatory design problem is

$$\begin{aligned} \frac{dW}{dK} &= \frac{\partial W}{\partial K} + \frac{\partial W}{\partial r_D} \cdot \frac{dr_D}{dK} + \frac{\partial W}{\partial X_R} \cdot \frac{dX_R}{dK} \\ &= \frac{\partial W}{\partial K} + \frac{\partial W}{\partial r_D} \cdot \frac{\partial r_D}{\partial K} + \left(\frac{\partial W}{\partial X_R} + \frac{\partial W}{\partial r_D} \cdot \frac{\partial r_D}{\partial X_R}\right) \frac{dX_R}{dK} \end{aligned} \tag{B.9}$$

where W is given by equation (4.12) and $X_R = \hat{X}_R(K, p)$ is given by equation (4.6). Note that unlike an individual bank's owners, the regulator takes account of the effect of bank capital on equilibrium cost of borrowing for banks and also the effect on induced aggregate investment. Both these are taken as given by individual banks who act as price–takers.

Using the individual rationality of depositors stated formally in equation (4.18), it is straightforward to show that $\frac{\partial r_D}{\partial K} < 0$ and $\frac{\partial r_D}{\partial X_R} > 0$, i.e., ceteris paribus, an increase in capital reduces borrowing cost whereas an increase in risk increases borrowing cost. The other terms can be obtained using equations (4.6) and (4.12) to yield

$$\frac{\partial W}{\partial K} = \frac{1}{Z} \cdot \beta(1-p)Wh(R^c) \cdot \frac{r_D}{X_R} > 0, \tag{B.10}$$

$$\frac{\partial W}{\partial r_D} = -\frac{1}{Z} \cdot \beta(1-p)Wh(R^c) \cdot \left(1 - \frac{K}{X_R}\right) < 0, \text{ and} \tag{B.11}$$

$$\begin{aligned}
\frac{\partial W}{\partial X_R} &= \frac{1}{Z} \cdot \left[\bar{R} - r_S - f(X_R) \cdot c'(X_R) - f'(X_R) \cdot c(X_R) - \beta(1-p)Wh(R^c) \cdot \frac{r_D K}{X_R^2}\right] \\
&< \frac{1}{Z}\left[\bar{R} - r_S - f(X_R) \cdot c'(X_R) - \beta(1-p)Vh(R^c) \cdot \frac{r_D K}{X_R^2}\right] \\
&= \frac{1}{Z}\left[(1-p)\int_0^{R^c}\left(r_D - \frac{RX_R}{X_R - K}\right)h(R)dR - \int_0^{R^c}(r_D - R)h(R)dR\right] \\
&< 0 \text{ where we have employed } X_R = \hat{X}_R(K,p).
\end{aligned} \tag{B.12}$$

These are simply the results that *ceteris paribus*, an increase in capital increases the value of the bank as a whole and an increase in cost of deposits reduces the value of the bank as a whole (due to greater default). Finally, bankowners have risk–shifting incentives due to moral hazard arising from deposit insurance and hence invest more in risky asset than is optimal for the bank as a whole. In particular, the analysis above holds if K is chosen to be the privately optimal capital level of the bank in absence of any minimum capital requirement, $K(p)$.

Combining these facts, we conclude that if $\frac{dX_R}{dK} < 0$ at $K(p)$, then $\frac{dW}{dK} > 0$ so that $K_{min}(p) > K(p)$, i.e., the minimum capital requirement binds. However, if $\frac{dX_R}{dK} > 0$ at $K(p)$, then it cannot be guaranteed that $\frac{dW}{dK} > 0$ and minimum capital requirement may not bind. Thus, capital requirement can be guaranteed to have some "bite" only when it can be employed to curb the risk–taking incentives of bankowners. We characterize below the behavior of $\frac{dX_R}{dK}$ to enrich the content of this lemma as presented in Proposition 4.3. □

Lemma B.3 *If the distribution of returns on bank's investments, $h(R)$, is assumed to be unimodal over its support $[0, R_{max}]$, then*

- *the risky investment of bank, X_R, decreases in level of capital, K, at its privately optimal capital level, $K(p)$, whenever bank's critical point of default, $R^c(K)$, lies to the right of the central tendency of the distribution $h(R)$, and*
- *the risky investment of bank, X_R, may increase in level of capital, K, at its privately optimal capital level, $K(p)$, if bank's critical point of default, $R^c(K)$, lies to the left of the central tendency of the distribution $h(R)$.*

Using analysis similar to that employed in the proof of Proposition 4.1, we obtain the strategic interaction condition:

$$\text{sign}\left(\frac{dX_R}{dK}\right) = \text{sign}\left(\frac{\partial^2 \hat{V}}{\partial K \partial X_R}\right) \tag{B.13}$$

where from equation (4.6), we obtain that

$$\frac{\partial \hat{V}}{\partial X_R} = \int_{R^c}^{R_{max}} (R - r_D)h(R)dR - f(X_R)\cdot c'(X_R) - \beta(1-p)V\cdot\frac{\partial}{\partial X_R}\int_0^{R^c} h(R)dR.$$

Thus, taking the partial derivative w.r.t. K, we get

$$\begin{aligned}\frac{\partial^2 \hat{V}}{\partial K \partial X_R} &= (r_D - R^c)\frac{\partial R^c}{\partial K} - \beta(1-p)V\cdot\frac{\partial^2}{\partial K \partial X_R}\int_0^{R^c} h(R)dR \\ &= -\frac{r_D^2 K}{X_R^2} - \beta(1-p)V\cdot\frac{r_D}{X_R^2}\left[h(R^c) - \frac{r_D K}{X_R}h'(R^c)\right].\end{aligned} \tag{B.14}$$

It follows that if $h'(R^c) < 0$, then $\frac{\partial^2 \hat{V}}{\partial K \partial X_R} < 0$, and in turn, $\frac{dX_R}{dK} < 0$, proving the first part of the lemma. This case arises when R^c lies to the right of the central tendency of unimodal distribution $h(R)$ (see Figure 1 for an illustration with log–normal distribution). On the other hand, if $h'(R^c) > 0$ this need not hold. In other words, a necessary condition to obtain $\frac{dX_R}{dK} > 0$ is to have $h'(R^c) > 0$, i.e., R^c lies to the left of the central tendency of $h(R)$. □

Note that Proposition 4.3 is a direct consequence of Lemma 4.2 and Lemma B.3 proved above.

The following lemma is employed to prove that the minimum capital requirement and regulatory forbearance are strategic complements (from the viewpoint of the regulator).

Lemma B.4 *The risky investment of bankowners increases with regulatory forbearance.*

As before, we employ the strategic interaction condition:

$$\text{sign}\left(\frac{dX_R}{dp}\right) = \text{sign}\left(\frac{\partial^2 \hat{V}}{\partial p\, \partial X_R}\right) \tag{B.15}$$

where taking the partial derivative of $\frac{\partial \hat{V}}{\partial X_R}$ (from the proof above) w.r.t. p, we get

$$\frac{\partial^2 \hat{V}}{\partial p\, \partial X_R} = -\beta h(R^c) \cdot \frac{r_D K}{X_R^2} \cdot \frac{\partial}{\partial p}((1-p)V) > 0. \tag{B.16}$$

The last inequality follows from Lemma B.2 (recognizing that the partial derivative w.r.t. forbearance p above is employed to separate out its effect on capital K). □

Proposition 4.4: To study the behavior of optimal minimum capital requirement, $K_{min}(p)$, as a function of regulatory forbearance p, it suffices to examine the case where the constraint binds. For this, we focus on the first case of Lemma 4.2 where $\frac{\partial X_R}{\partial K} < 0$. Again, we have employed the partial derivative to separate the effect of p on X_R.

(i) If (PC) does not bind, then the analysis of Lemma 4.2 shows that $\frac{dW}{dK} > 0$ 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 differentiating which w.r.t. p yields

$$\frac{dK_{min}}{dp} = \frac{\partial X_R}{\partial K} \cdot \frac{dK_{min}}{dp} + \frac{\partial X_R}{\partial p} \tag{B.17}$$

so that

$$\frac{dK_{min}}{dp}\left[1 - \frac{\partial X_R}{\partial K}\right] = \frac{\partial X_R}{\partial p}\ . \tag{B.18}$$

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

(ii) On the other hand, if (PC) binds then we must have $V(K_{min}(p), p) = \overline{V}$, where we have stressed the dependence on forbearance p as well. Then, differentiating w.r.t. p and using the envelope condition $\frac{\partial V}{\partial X_R} = 0$,[27] gives

$$\frac{\partial V}{\partial p} + \frac{\partial V}{\partial K} \cdot \frac{dK_{min}}{dp} = 0. \tag{B.19}$$

[27] Though bankowners take future continuation value as given and optimize $\hat{V}(\cdot)$ w.r.t. X_R where $\hat{V}$ is as defined in equation (4.10), the stationarity of the problem nevertheless implies the result: $\frac{\partial V}{\partial X_R} = 0$.

From Lemma B.1, $\frac{\partial V}{\partial p} > 0\ \forall p$. Further, $\frac{\partial V}{\partial K} < 0$ since the minimum capital requirement binds. It follows that $\frac{dK_{min}}{dp} > 0$.

Thus, the optimal minimum capital requirement, K_{min}, and regulatory forbearance, p, act as strategic complements from the regulator's viewpoint. □

Proposition 5.1: Note that in order to analyze the spillover, we need to consider the effect of aggregate investment $\bar{X}_{Rb}(p_a)$ on V_b where V_b is given by equation (4.4) suitably modified for the multiple economy case. Since $\bar{X}_{Rb}(p_a) \equiv X_{Rb}(p_a)$ in our symmetric equilibrium, we simply use this latter notation. Then, using the envelope condition that $\frac{\partial V_b}{\partial X_{Rb}} = 0$,

$$\frac{\partial V_b}{\partial p_a} \;=\; \frac{\partial V_b}{\partial X_{Ra}} \cdot \frac{dX_{Ra}}{dp_a} \;<\; 0, \tag{B.20}$$

since $\frac{dX_{Ra}}{dp_a} > 0$ by Lemma B.4, and

$$\frac{\partial V_b}{\partial X_{Ra}} \;=\; \frac{1}{Z} \cdot \frac{\partial v_b}{\partial X_{Ra}} \;=\; -\frac{1}{Z} \cdot \alpha f'(X_{Ra} + X_{Rb}) \cdot \beta c(X_{Rb}) \;<\; 0. \tag{B.21}$$

Further, differentiating w.r.t. α, we obtain

$$\frac{\partial^2 V_b}{\partial \alpha\, \partial p_a} \;=\; \frac{\partial^2 V_b}{\partial \alpha\, \partial X_{Ra}} \cdot \frac{dX_{Ra}}{dp_a} \;=\; -\frac{1}{Z} \cdot f'(X_{Ra} + X_{Rb}) \cdot \beta c(X_{Rb}) \;<\; 0. \tag{B.22}$$

In other words, as α increases, the rate of decrease of V_b as a function of p_a becomes more negative or greater in magnitude. The effect w.r.t. β follows along identical steps. □

Lemma 5.2: Consider regulator A's design problem in equations (5.2)–(5.5). Since p_b is constant for this design problem, we suppress it in the notation below. We show first that the unconstrained optimum $p_a^{uc}(\lambda_a)$ is strictly increasing in λ_a. By the first order condition,

$$\frac{\partial W_\lambda}{\partial p_a} \;=\; (2\lambda_a - 1) \cdot \frac{\partial V}{\partial p_a} + (1 - \lambda_a) \cdot \frac{\partial W}{\partial p_a} \;=\; 0, \tag{B.23}$$

where $\frac{\partial V}{\partial p_a}$ and $\frac{\partial W}{\partial p_a}$ are written as partial derivatives to separate the effect of λ_a below. These derivatives include the effect of p_a on X_R. Then, $\frac{\partial W}{\partial p_a} = \frac{1-2\lambda_a}{1-\lambda_a} \cdot \frac{\partial V}{\partial p_a}$. Taking the partial derivative of first order condition w.r.t. λ_a, we obtain the strategic interaction condition:

$$\frac{\partial^2 W_\lambda}{\partial p_a^2} \cdot \frac{dp_a}{d\lambda_a} + \frac{\partial^2 W_\lambda}{\partial \lambda_a\, \partial p_a} \;=\; 0. \tag{B.24}$$

By second order condition for p_a to be optimal, $\frac{\partial^2 W_\lambda}{\partial p_a^2} < 0$. Further, $\frac{\partial^2 W_\lambda}{\partial \lambda_a \partial p_a} = 2 \cdot \frac{\partial V}{\partial p_a} - \frac{\partial W}{\partial p_a} = \frac{1}{1-\lambda_a} \frac{\partial V}{\partial p_a} > 0$. The last equality follows from the fact that $\frac{\partial W}{\partial p_a} = \frac{1-2\lambda_a}{1-\lambda_a} \cdot \frac{\partial V}{\partial p_a}$ and the last inequality is due to $\frac{\partial V}{\partial p_a} > 0$ from Lemma B.1. It follows that $\frac{dp_a}{d\lambda_a} > 0$ if $p_a = p_a^{uc}(\lambda_a)$.

Suppose that the participation–constraint (PC) in equation (5.5) does not bind at a specific value of λ_a. Then, it will not bind at $\lambda'_a > \lambda_a$ since $p_a^{uc}(\lambda_a)$ is strictly increasing in λ_a and $\frac{\partial V}{\partial p_a} > 0$. On the other hand, if (PC) binds at λ_a, then let p_a^c be such that $V(p_a^c) = \overline{V}$. Then, $p_a = \max\left[p_a^c, p_a^{uc}(\lambda_a)\right]$ is the optimal design. Since p_a^c is independent of λ_a, we obtain that p_a is (weakly) increasing in λ_a. □

Proposition 5.3: The following cases are possible as λ_a is increased beyond λ_b:

(i) (PC) binds for both regimes at (λ_a, λ_b): In this case, $p_a = p_b = p$ s.t. $V(p,p) = \overline{V}$. Then, equilibrium is locally unaffected as λ_a changes.[28]

(ii) (PC) binds for regime B banks but not for regime A banks at (λ_a, λ_b): Denote the equilibrium as (p_a, p_b) where $p_a \equiv p_a(\lambda_a)$ is the unconstrained optimum for regulator A, and $p_b \equiv p_b(\lambda_b)$ s.t. $V_b(p_a, p_b) = \overline{V}$. Then, differentiating w.r.t. λ_a, we obtain that

$$\left[\frac{\partial V_b}{\partial p_b} \cdot \frac{\partial p_b}{\partial \lambda_a} + \frac{\partial V_b}{\partial p_a}\right] \frac{dp_a}{d\lambda_a} \quad = \quad 0. \tag{B.25}$$

Since $\frac{\partial V_b}{\partial p_b} > 0$ by Lemma B.1 and $\frac{\partial V_b}{\partial p_a} < 0$ by the spillover result of Proposition 5.1, it follows that $\frac{\partial p_b}{\partial \lambda_a} > 0$. In other words, 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 (λ_a, λ_b): In this case, both p_a and p_b are unconstrained and we need to examine the strategic interaction condition

$$\text{sign}\left(\frac{dp_b}{d\lambda_a}\right) \quad = \quad \text{sign}\left(\frac{\partial^2 W_{\lambda_b}}{\partial p_a\, \partial p_b} \cdot \frac{dp_a}{d\lambda_a}\right) \tag{B.26}$$

where from Lemma 5.2 and Lemma B.1, it can be shown that $\frac{dp_a}{d\lambda_a} > 0$ and

$$\frac{\partial^2 W_{\lambda_b}}{\partial p_a\, \partial p_b} \quad = \quad \frac{1 - 2\,\lambda_b}{1 - \lambda_b} \cdot \frac{\partial^2 V_b}{\partial p_a \partial p_b} \tag{B.27}$$

$$= \quad \frac{1 - 2\,\lambda_b}{1 - \lambda_b} \cdot \frac{\partial}{\partial p_a}\left[\frac{1}{Z} \cdot \beta V_b \int_0^{R_b^c} h(R)dR\right] \tag{B.28}$$

$$= \quad \frac{1 - 2\,\lambda_b}{1 - \lambda_b} \cdot \frac{\beta}{Z}\left[\frac{\partial V_b}{\partial p_a} + \frac{1}{Z} \cdot \frac{1 - \beta}{\left(\int_0^{R_b^c} h(R)dR\right)^2} \cdot \frac{\partial}{\partial p_a} \int_0^{R_b^c} h(R)dR\right] \tag{B.29}$$

$$= \quad \frac{1 - 2\,\lambda_b}{1 - \lambda_b} \cdot \frac{\beta}{Z}\left[\frac{\partial V_b}{\partial p_a} + \frac{1}{Z} \cdot \frac{1 - \beta}{\left(\int_0^{R_b^c} h(R)dR\right)^2} \cdot h(R_b^c)\frac{\partial R_b^c}{\partial X_{Rb}} \cdot \frac{\partial X_{Rb}}{\partial p_a}\right] \tag{B.30}$$

[28] Strictly speaking, we require that (PC) binds for regulator A's problem at $\lambda_a + \epsilon$, $\forall \epsilon$, $0 < \epsilon < \bar{\epsilon}$, where $\bar{\epsilon}$ can be arbitrarily small.

$$> \quad 0 \text{ iff } \lambda_b > \frac{1}{2} \tag{B.31}$$

since $\frac{\partial V_b}{\partial p_a} < 0$ by Proposition 5.1, $\frac{\partial R_b^c}{\partial X_{Rb}} = r_{Db} \cdot \frac{K_{min}}{X_{Rb}^2} > 0$, and $\frac{\partial X_{Rb}}{\partial p_a} < 0$. The last inequality follows from the observation that $\frac{\partial X_{Rb}}{\partial p_a} = \frac{\partial X_{Rb}}{\partial X_{Ra}} \cdot \frac{\partial X_{Ra}}{\partial p_a} < 0$ since $\text{sign}(\frac{\partial X_{Rb}}{\partial X_{Ra}}) = \text{sign}(\frac{\partial^2 V_b}{\partial X_{Ra} \partial X_{Rb}})$ which is negative and $\frac{\partial X_{Ra}}{\partial p_a} > 0$ by Lemma B.4.

Thus, if $\lambda_b > \frac{1}{2}$, p_b is increasing in λ_a since regulator A is captured and increases forbearance to compensate its banks from induced spillover. However, if $\lambda_b \leq \frac{1}{2}$, the regulator of regime B responds to the induced spillover by first reducing its forbearance p_b. However, as p_b decreases and p_a increases, V_b decreases (again follows from Lemma B.1 and Proposition 5.1). Thus for λ_b sufficiently below $\frac{1}{2}$ and λ_a sufficiently high, p_b would be low enough and p_a would be high enough so as to obtain $V_b = \overline{V}$. When this occurs, the analysis reverts to Case (ii) above and we obtain that p_b must be raised to prevent exit of regime B banks. □

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Figure 1: Lognormal Density function h(x) = d/dx [N(ln x)].