Is the International Convergence of Capital Adequacy Regulation Desirable?¹

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Abstract

We examine the merits of having international convergence of bank capital requirements in the presence of divergent closure policies of different central banks. In an optimal regulatory design, the level of bank capital requirement varies with forbearance in central bank’s closure policy. The lack of such variation leads to spillovers from more forbearing to less forbearing regimes, reducing the profits of banks in less forbearing regimes. In equilibrium, the central banks of these initially less forbearing regimes may adopt greater forbearance as well giving rise to a regression towards the worst closure policy.
1 Introduction

We study the joint design of two bank regulatory mechanisms: capital requirements, the ex-ante mechanism to prevent bank failures, and closure policy, the ex-post mechanism to manage bank failures. At the heart of our paper is a simple but fundamental point: ex-post policies distort ex-ante incentives, and hence, design of ex-ante mechanism must take account of any feedback from ex-post policies. We show that the optimal design of capital requirement should be 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, as proposed and implemented by the Basel Accord of 1988. We show that 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 regimes to less forbearing regimes. Banks of more forbearing regimes have greater risk-taking incentives, which in equilibrium reduces the profits of banks in the less forbearing regimes. Since these latter banks might be forced to “exit,” their central banks may adopt greater forbearance as well. The result is a “race to the bottom” where all central banks converge towards the worst level of forbearance. Intriguingly thus, convergence of capital requirements does tend to produce a level-playing field, however one with excessive forbearance. This outcome has a greater potential to destabilize the global economy compared to the one of no convergence on any regulatory mechanisms at all.

We develop an infinite-horizon single-economy banking model in general equilibrium. Banks are “special” in making loans but borrow competitively from depositors. Deposits take the form of a standard debt contract. The conflict of interest between bankowners (equityholders) and depositors gives rise to risk-shifting incentives where bankowners may choose a level of risk that is greater than the optimal risk for the bank as a whole (Proposition 1). If banks are closed when they do not meet the promised payments on their deposits, there is a loss of continuation value for both bankowners and depositors. 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 equity and deposits. The optimal design takes account of the risk-taking incentives of bankowners and the losses arising from bank failures.

The central bank can choose to close or bail out the failed banks, and also require that banks hold a minimum level of capital in the form of outside equity. On the one hand, bail outs induce moral hazard and accentuate the risk-shifting incentives. On the other hand, they increase the future continuation or “charter-value” of bankowners and induce risk-avoidance incentives. The inter-temporal tradeoff between the moral hazard and the preservation of continuation value, implies that, in general, it is ex-ante optimal for the central bank to adopt a mixed policy where it closes failed banks with a non-zero probability. This ex-ante
optimal policy however fails to be ex-post optimal: once a bank has failed, it is always optimal to bail it out. This time-inconsistency of central bank’s optimal closure policy creates room for regulatory forbearance (Proposition 2).

Requiring that banks hold a minimum amount of equity capital “buffers” them from failures, and at the same time, it being outside equity leads to dilution costs for the bankowners.\(^1\) Crucially, the optimal capital requirement is tied to the extent of forbearance practised by the regulator. At moderate to high levels of forbearance, optimal capital requirement increases with an increase in forbearance so as to mitigate risk-shifting incentives. However, at low levels of forbearance and with steep dilution cost of capital, it may be optimal to reduce capital with an increase in forbearance so as to enhance risk-avoidance incentives.\(^2\) This variation of optimal capital requirement with forbearance means that \textit{one size does not fit all} (Proposition 3), casting doubt over the desirability of uniform capital requirements for all nations even as their central banks adopt divergent closure policies.

To explore the implications of such a divergence, we employ a two-economy general equilibrium model of financial integration. Banks operate across borders in making loans and in taking deposits. They hold a uniform amount of capital, but enjoy the forbearance exercised by the central bank of their “home” country. We show that there is a spillover from more forbearing regime to the less forbearing one. In general equilibrium, financial integration gives rise to a common “world interest rate” that affects the cost of borrowing for both sets of banks. As banks of the more forbearing regime take greater risk, the world interest rate rises. This increases the cost of borrowing for banks of the less forbearing regime, squeezing their profits, and reducing their charter-values. Such spillovers increase in the heterogeneity amongst the regimes according to their (i) regulatory forbearance; (ii) size of banking sector measured as deposit base; and (iii) risk-taking incentives of bankowners (Proposition 4).

We argue that such heterogeneity in regulatory forbearance can arise due to a “regulatory capture,” the political economy aspect of regulation design. Central banks, in general, maximize a weighted average of the welfare of their “interest groups,” viz. bankowners and depositors. A greater weight on the welfare of bankowners leads a central bank to exercise excessive forbearance towards its banks, increasing the spillover to banks in other regimes. How would a central bank aligned less with its bankowners respond to this international spillover when it is constrained not to adjust capital requirements? We demonstrate that if heterogeneity in regulatory objectives of different central banks is high, the resulting spillover drives the banks of less forbearing regime to their reservation values. In order to avoid their

\(^1\)We assume that the private level of capital for bank’s equityholders is lower than the socially optimal level due to this dilution cost.

\(^2\)This non-monotone relationship between optimal capital requirement and central bank’s forbearance in a multi-period setting is counter to the standard intuition one obtains from a single-period setting where continuation value effects do not arise.
exit, the central bank of this regime also adopts greater forbearance in equilibrium. When this occurs, regulatory forbearances behave as strategic complements. The resulting equilibrium is one with a “regression towards the worst” forbearance (Proposition 5).

The essence of our argument is that with international banking operations, each regulator imposes an externality on the welfare of other regimes. In the absence of complete coordination amongst regulators, some of these externalities remain uninternalized. Importantly, coordination on some arms of regulation but not on others, eliminates an important weapon from the arsenal of regulators who wish to counteract the spillovers from worse regulated banks. Thus, reminiscent of theory of the second-best, a step towards complete coordination can be more harmful than no step at all. We conclude by discussing the relevance of our results for the current debate on creating a centralized lender-of-last-resort in the European Monetary Union.

Section 2 discusses related literature. Section 3 analyzes the single-economy model. Section 4 analyzes the multiple-economy model. Section 5 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.3

Theoretically, a few studies have underlined the importance of jointly designing different arms of bank regulation. 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 single-economy contexts. The calculation of deposit insurance premia and the monitoring of bank risk-taking vary widely across nations, whereas the capital adequacy regulation has moved uniformly towards a 8% or a value-at-risk type rule. This makes the focus of our paper particularly germane.

3 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).

Our result on regression to 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. There is a subtle difference however between our main result and theirs: our claim is that if regulators implement centralized solutions on some aspect, but fail to coordinate on others, then the final outcome may be worse than that under no coordination at all.\textsuperscript{4} The interplay of different regulatory arms is central to our paper.

Empirical evidence in support of international spillovers can be found in Peek and Rogengren (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 1988 to “level the playing field” by eliminating a funding-cost advantage of Japanese banks was not achieved. Japanese bank shareholders gained 31.63\% but the gains for shareholders of non-Japanese banks were insignificant. 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 builds upon the Allen and Gale (2000a) model of bubbles and crises, a two-date single-economy model of risk-shifting by investors who borrow money from lenders. 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 to study international spillovers.

3.1 Unregulated case

We first describe the model for the unregulated 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 equityholders), who have no wealth of their own.

\textsuperscript{4}Kane (2000), however, argues that technological improvements in off-shore financial regulation force the domestic regulations to discredit inefficient regulatory strategies. Our results are not inconsistent with such an outcome. Technological innovation in regulation is beneficial to the regulated but has no social cost. On the other hand, excessive regulatory forbearance in our theory entails the cost of greater instability. Competition in technological innovation and competition in regulatory forbearance thus produce different outcomes.
- There is a continuum of risk-neutral depositors with \( D \) units to invest in each period and no investment opportunities. Hence, they lend their goods to banks.

Bankowners and depositors have a common time-preference rate of \( \beta \in (0, 1) \). Deposits take the form of a simple debt contract with a promised deposit rate that 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.\(^5\) 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. Upon borrowing, bankowners solve a portfolio problem choosing the extent of investment in a *safe* asset and a *risky* asset.

**Safe asset:** The safe asset pays a fixed return \( r \), in each period to investors. We interpret the safe asset as capital goods leased to the corporate sector (or riskless corporate debt). Competition in market for capital goods ensures that the rate of return on the safe asset is the marginal product of capital. We assume a neo-classical diminishing-returns-to-scale production technology \( f(x), f'(x) > 0, f''(x) < 0, f'(0) = \infty, f'(\infty) = 0, \forall x > 0 \), and \( f(x) \) continuous. The equilibrium rate of return is given by \( r = f'(x) \), \( x \) being the total investment in the safe asset in current period.

**Risky asset:** The risky asset is to be interpreted as bank investments that have variable returns. These could be loans to manufacturers, retailers, home-owners, etc. Each bank has a *local* or a *spatial* monopoly over a set of entrepreneurs to whom it lends.\(^6\) 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.\(^7\) The risky asset gives a gross return \( R \) next period on a unit of investment this period. The return \( R \) is assumed to be random. In particular, \( R \sim h(\cdot) \) over \([0, R_{max}]\) with mean \( \bar{R} \). We assume that there is reward for bearing risk, i.e., \( \bar{R} > r \) in each period.

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

**Costs of risky investments:** Bankowners incur a non-pecuniary cost of investing in the risky asset. We want to introduce costs in a way that restricts the size of individual portfolios (a kind of effort-aversion) and at the same time ensures that banks make positive expected

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\(^5\)The lack of secondary trading in deposits also prevents deposit rates from being conditional upon 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).

\(^6\)Such monopolies can also be justified on the basis of information that banks obtain about borrowers by virtue of their being “inside lenders,” as in Rajan (1992) and Sharpe (1990).

\(^7\)That is to say, each bank is holding a well-diversified portfolio that bears only systematic risks.
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profits.\(^8\) Pecuniary costs can be dealt with some difficulty, but assuming non-pecuniary costs leads to a simple analysis and lets us illustrate our results in a succinct manner. The cost function \(c(x)\) satisfies the neo-classical assumptions: \(c(0) = 0\), \(c'(0) = 0\), \(c'(x) > 0\), \(c''(x) > 0\), \(\forall x > 0\), and \(c(x)\) continuous. These increasing costs generate diminishing-returns-to-scale for banks from risky investments as well.

**Investment choice of banks:** We assume that bank owners consume in each period all 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 examine each period of investment and consider its repetition in the infinite horizon, a simplification that keeps the problem tractable by reducing it to a stationary dynamic program.

As discussed before, exclusive contracts required to discriminate between banks, or between depositors, based on some observable characteristics are too costly to write. Hence, we consider the symmetric competitive equilibrium where all banks, assumed small and identical, choose the same portfolio, and all depositors charge the same rate of interest. Let \(X_S\) and \(X_R\) be the representative bank’s investments in the safe and the risky asset, respectively. Let \(r_D\) and \(r_S\) be the promised return on deposits and the return on safe asset, respectively. Then, the *equilibrium* is given by \((X_S, X_R, r_D, r_S)\) where (i) \((X_S, X_R)\) maximizes bank owners’ value given \(r_D\) and \(r_S\); (ii) aggregate budget constraint is satisfied: \(X_S + X_R = D\); (iii) short-sales constraint is not violated: \(X_S, X_R \geq 0\); and (iv) market for safe asset clears: \(r_S = f'(X_S)\).

To characterize the equilibrium, note that when the realized return on bank’s investments is lower than the promised return to its depositors, the bank is in default. The deposit claim being a “hard” claim cannot be renegotiated.\(^9\) A bank in default is closed and any returns on its investments are captured by the depositors. We consider bank bailouts later when we discuss regulation. Thus, there is default at the end of a period when \(r_S X_S + R X_R < r_D (X_S + X_R)\), i.e., when risky asset return is below a threshold return, \(R < R^c \equiv r_D + (r_D - r_S) \cdot \frac{X_S}{X_R}\).

As a result, for \(R < R^c\), the bank owners get nothing. Then, each period expected payoff of bank owners is given by

\[
v(X_S, X_R, r_D, r_S) = \int_{R^c}^{R_{max}} [(r_S - r_D) X_S + (R - r_D) X_R] h(R) dR - c(X_R). \tag{3.1}
\]

Denoting the continuation value of bank owners as \(V\), their portfolio problem is:

\[
\max_{X_S, X_R} v(X_S, X_R, r_D, r_S) + \beta V \int_{R^c}^{R_{max}} h(R) dR. \tag{3.2}
\]

\(^8\)These could be thought of as costs of loan initiation. Models that allow banks to choose the level of deposits often assume that the cost of deposits is increasing and convex in their level, e.g., Blum (1999).

\(^9\)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.
It follows that in any equilibrium, the contracted rate of interest on deposits, $r_D$, must be equal to the rate of return on the safe asset, $r_s$.\textsuperscript{10} We denote this common rate as simply $r$. Under this simplification, bankowners’ each period expected payoff is

$$v(r, X_R) = \int_r^{R_{max}} (R - r) X_R h(R) dR - c(X_R),$$

(3.3)

where the safe investment, $X_s$, has dropped out from the bankowners’ payoff and is determined from the aggregate budget constraint as residual investment, $X_s = D - X_R$.

Denoting the solution to bankowners’ portfolio problem in equation (3.2) as $X^*_R(r)$, the equilibrium is determined by the fixed-point $[r^*, X^*_s]$, where $X^*_R = X^*_R(r^*)$, and $r^* = f'(X_s) = f'(D - X^*_R)$. We assume that the deposit base is sufficiently large ($D$ is large), or that the net return on risky asset diminishes with scale sufficiently quickly ($c(\cdot)$ is convex enough), so as to ensure an interior choice of $X_R$, and in turn, a solution to this fixed-point problem.\textsuperscript{11}

Finally, the simple nature of deposit contract prevents bankowners from committing to inter-temporal investment decisions. Hence, the investment policy in each future period is sub-game perfect, so that in equilibrium

$$V = v(r, X_R) + \beta v(r, X_R) \int_r^{R_{max}} h(R) dR + \beta^2 v(r, X_R) \left[ \int_r^{R_{max}} h(R) dR \right]^2 + \ldots$$

$$= \frac{v(r, X_R)}{1 - \beta \int_r^{R_{max}} h(R) dR}, \text{ with } X_R = \hat{X}^*_R(r), \text{ as above.}$$

(3.4)

We wish to compare the bankowners’ investment choice with the investment choice that maximizes the value of the bank as a whole, i.e., the sum of the value of depositors’ claim

\textsuperscript{10} The argument is as follows: (i) If $r_D > r_s$, then bankowners lose with certainty $(r_D - r_s)$ on each unit of safe investment, and since $R^2$ increases in $X_s$, they fail often as well. Thus, it is optimal for bankowners to make no investment in the safe asset at all, i.e., $X_s = 0$. In equilibrium, however $r_s = f'(0) = \infty$, and banks must find it optimal to invest in the safe asset, a contradiction. (ii) On the other hand, if $r_D < r_s$, then bankowners have access to a free arbitrage technology and earn with certainty $(r_D - r_s)$ on each unit of safe investment. Thus, their demand response for safe investments is infinite. This must violate either the short-sales constraint ($X_R \geq 0$) or the aggregate budget constraint ($X_s + X_R = D$), and hence, cannot be an equilibrium. Thus, the only possibility in equilibrium is that $r_D = r_s$.

\textsuperscript{11} Note that with a positive level of risky investment, there is default in at least some states and hence, the expected rate of return on deposits is smaller than $r_D$, the promised rate of return. If the depositors could invest directly in the safe asset, they would charge a higher rate such that $r_s = r_D - Pr[R > r_D] + \int_0^{r_D} R h(R) dR$. The safe investments currently made by banks would be made by depositors instead. The details of this extension are available from the author upon request. What drives our results is the equityholder-bondholder conflict which arises in models with standard debt contract, as long as a pre-commitment of (the entire set of) investment policies of equityholders is not feasible.
and the value of bank’s equity. Denote the expected payoff for the whole bank in each period as \( w(r, X_R) \) and the expected continuation value as \( W \). Then,

\[
w(r, X_R) = rX_S + \hat{R}X_R - c(X_R) = rD + (\hat{R} - r)X_R - c(X_R), \tag{3.5}
\]

and for an investment policy \( X_R \),

\[
W = \frac{w(r, X_R)}{1 - \beta \int_r^{R_{\text{max}}} h(R)dR}.
\tag{3.6}
\]

Denoting the solution to bank-value maximization problem as \( \hat{X}_R^0(r) \), the equilibrium \( [r^*, X_R^0] \) is given by \( r^* = f'[D - X_R^0] \), where \( X_R^0 = \hat{X}_R^0(r) \).

### 3.2 Risk-shifting incentives of bankowners

This brings us 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).

**Proposition 1 (Risk-shifting)** The bankowners invest more in risky asset than is optimal for bank-value maximization, i.e., \( X_R^* > X_R^0 \). In equilibrium, the likelihood of bank’s default is greater than in the benchmark case of bank-value maximization, i.e., \( r^* > r^o \).

In the presence of a simple debt contract, bankowners do not bear the cost of a low return on their investments. This truncation of payoff leads to a preference for risk. Formally, the first order condition to bankowners’ maximization (3.2) is \( \int_r^{R_{\text{max}}} (R - r)h(R)dR - c'(X_R) = 0 \), which can be rewritten in a more convenient form as

\[
\hat{R} + \int_0^r (r - R)h(R)dR = r + c'(X_R). \tag{3.7}
\]

LHS represents the marginal benefit to bankowners from a unit of risky investment: the mean return, \( \hat{R} \), plus the “option” term, \( \int_0^r (r - R)h(R)dR \). RHS represents the marginal cost to bankowners of a unit of risky investment: the cost of borrowing plus the cost of making loans.

On the other hand, the firm-value maximization ignores the transfers between depositors and equityholders. The first order condition for the bank-value maximization problem is

\[
\hat{R} = r + c'(X_R), \tag{3.8}
\]

where the marginal benefit from a unit of investment is simply the mean return, \( \hat{R} \) without the additional “option” term present in equityholders’ maximization (equation 3.7) is absent.
Thus, it is the option term that leads bankowners to invest excessively in the risky asset. However, the greater likelihood of bank failure arises due to a general equilibrium effect. Greater investments in risky asset imply lower investments in safe asset, raising the equilibrium safe asset return, and in turn, increasing the cost of borrowing for banks. The greater likelihood of failure leads to greater expected loss of continuation value as well. Since depositors cannot write contracts to mitigate such agency costs, we introduce a central bank in the model that “represents” the bank as a whole and designs regulatory mechanisms.

3.3 Regulated case

The central bank’s objective is to maximize the value of the whole bank i.e., the profits of bankowners as well as returns to depositors. This is isomorphic to assuming that the central bank is equivalent to a central planner who weighs equally the welfare of bankowners and depositors. The ensuing analysis demonstrates that this economically appealing and relatively simple objective captures “the safety and soundness of the financial sector,” as regulation often claims. In Section 4.3, we allow the central bank to put different weights on the two claimants’ welfare. We ignore any deadweight costs of bank failures incorporating which does not affect the qualitative nature of our results.

The central bank employs two regulatory mechanisms that are interesting from a theoretical as well as an institutional perspective: (i) capital adequacy requirement, which is an ex-ante mechanism aimed at reducing the likelihood of bank failures; and (ii) closure or bail out policy, which is an 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.

**Capital requirement:** The wealth-constrained intermediaries who run the banks are required to hold $K$ units of capital in the form of outside equity. Raising such equity dilutes the claim of existing equityholders who are required to pay a higher than fair, expected rate

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12 The question as to why do we need a central bank is continually in debate. For a discussion, see Goodhart (1987). Meyer (1999) states, “Central banks have two core missions: the pursuit of monetary policy to achieve broad macroeconomic objectives and the maintenance of financial stability, including the management of financial crises. The latter mission is closely connected to regulation and supervision of the banking system, so I include this within the central banker’s perspective, as well as broader issues related to systemic risk in the financial sector.” While the issue of the exact role of a central bank remains open, we focus on the its role in the maintenance of financial stability.

13 This corresponds to Tier 1 capital required by the current regulation. For a description of what constitutes in practice as “regulatory capital,” see Basel Accords of 1988 and 1996, available at www.bis.org
of return on equity. Theoretical justifications\textsuperscript{14} and empirical evidence\textsuperscript{15} on 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 a bank’s owners to its new equityholders is $\theta(K)$, where $K$ is the amount of new equity issued, and $\theta(K)$ is increasing and convex: $\theta'(K) > 0$, $\theta''(K) > 0$. Note that such a dilution 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. We further assume that banks facing this private cost would (on their own) issue less outside equity than is socially optimal.

The budget-constraint is now given by $X_S + X_R = \hat{D} + K$, where $\hat{D}$ is the units of deposits available in each period in the presence of $K$ units of bank capital. Gorton and Winton (1999), and Diamond and Rajan (2000), consider general equilibrium and agency reasons, respectively, due to which $\hat{D} < D$, the latter being the level of deposits in the unregulated case. This is not so crucial to our analysis. Hence, for notational ease, we simply assume $\hat{D} = D$, i.e., deposit and equity markets are completely segmented in the economy. In the presence of capital, banks default whenever $rX_S + RX_R < rD$, i.e., whenever $R < R^e = r \cdot \left(1 - \frac{K}{X_R}\right)$. Note that $R^e < r$ for $K > 0$. The “buffer” role of capital, a “soft” claim that cannot be defaulted upon, is thus to reduce the threshold point below which banks default. Finally, market clearing for safe asset implies $r = f'(X_S) = f'(D + K - X_R)$.

**Closure policy:** 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. Complete forbearance towards bankowners may however be suboptimal due to the moral hazard it induces. Hence, 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 nationalizations, 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.

Note that neither the capital requirement nor the closure policy can be explicitly contin-

\textsuperscript{14} 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).

\textsuperscript{15} Lee et al. (1996) document that the indirect (underpricing) costs associated with raising new equity for US firms exceed 10% of market value of the issue for initial as well as seasoned public offerings.
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gent on the investment decision of the bank \( (X_R) \), 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 capital requirements by potentially levying sufficiently high penalties on any violators.\(^{16}\)

**Investment choice of banks:** Under these assumptions, the expected payoff to bank’s total equity in each period is

\[
v(r, X_R) = \int_{R^c}^{R_{max}} [rX_S + RX_R - rD] h(R)dR - c(X_R) \\
= \int_{R^c}^{R_{max}} (R - R^c)X_R h(R)dR - c(X_R),
\]

Thus, net of private issuance costs, the expected payoff to bankowners (old equityholders) is \( v(r, X_R) - \theta(K) \), and their continuation value for an investment policy \( X_R \) is given by

\[
V = \frac{v(r, X_R) - \theta(K)}{1 - \beta + \beta(1 - p) \int_0^{R^c} h(R)dR}.
\]

We shall refer to this continuation value of the bankowners as their *charter-value*. The first order condition of bankowners’ maximization problem

\[
\max_{X_R} \quad v(r, X_R) - \theta(K) + \beta \left[ V \int_{R^c}^{R_{max}} h(R)dR + p \cdot V \int_0^{R^c} h(R)dR \right]
\]

is thus

\[
\frac{\partial v(\cdot)}{\partial X_R} = \beta(1 - p) V \frac{\partial}{\partial X_R} \int_0^{R^c} h(R)dR.
\]

Note that in contrast to the unregulated case (equation 3.7), the threshold point of failure, \( R^c = r \cdot (1 - \frac{K}{X_R}) \), depends on the extent of risky investment, \( X_R \). In particular, \( R^c \) is increasing in \( X_R \). This induces amongst the bankowners a risk-avoidance incentive as they stand to lose their charter-value (RHS above) more often if they invest more in the risky asset.

\(^{16}\)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: central bank has a rule, and no discretion, for enforcement of capital requirements. This perhaps conforms to current practice, e.g., to the Prompt Corrective Action implemented by FDIC in the U.S. following the enactment of FDICIA (1991).
This risk-avoidance incentive is traded off against the risk-shifting incentive from convexity of each period’s option payoff (LHS above). This is an interesting characterization in itself: risk-neutral bankowners have both risk-shifting incentives (through truncated equity claim) and risk-avoidance incentives (through charter-value effect).\(^{17}\)

The expected payoff for the bank as a whole in each period can be shown to be

\[
w(r, X_R) = rD + (\bar{R} - R^e)X_R - c(X_R),
\]

and, the expected value in continuation for an investment policy \(X_R\) can be shown to be

\[
W = \frac{w(r, X_R)}{1 - \beta + \beta(1 - p) \int_0^{R^e} h(R)dR}.
\]

We shall denote the denominator as \(Z = 1 - \beta + \beta(1 - p) \int_0^{R^e} h(R)dR\).

The bank-value maximizing investment policy is thus given by the first order condition

\[
\frac{\partial w(\cdot)}{\partial X_R} = \beta(1 - p)W \frac{\partial}{\partial X_R} \int_0^{R^e} h(R)dR,
\]

which trades off the benefit to the entire bank from undertaking greater risk with the potential loss of continuation values in doing so.\(^{18}\)

### 3.4 Regulatory design problem

The central bank uses capital requirement and closure policy as mechanisms to give “instructions” to banks to mitigate the risk-shifting incentive. Thus, we view central bank as the principal and banks as the agent, where the principal solves the regulatory design problem subject to a constraint that agents are ensured a reservation value. This is formalized below:

\[
\max_{K, p} \ W(X_R \mid K, p)
\]

s.t. (IC: Incentive-Compatibility)

\[
X_R \in \arg \max_{X'_R} V(X'_R \mid K, p)
\]

\(^{17}\)The risk-avoidance effect is similar to that examined by Herring and Vankundre (1987), Keeley (1990), and, Cordella and Veyati (1999), in their analysis of banks’ growth opportunities, market power, and charter-values, respectively.

\(^{18}\)We would like to draw the reader’s attention to the fact that we have 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 depositories 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 (PC: Participation-Constraint)

$$V(X_R \mid K, \ p) \geq \bar{V}.$$ \hspace{1cm} (3.18)

We analyze this design problem in two steps: first, we consider the closure policy taking as given a capital requirement $K$, and next, the capital requirement for different closure policies.

**Design of closure policy:** Let $p^o$ be the optimal closure policy, the solution to above design problem for a capital requirement $K$. This policy will be called the *ex-ante* optimal closure policy since it is the probability of bail out that the central bank would like to pre-commit to at the beginning of each period, and crucially, *before* the bank is actually in default. We show below that this policy deviates, in general, from what is *ex-post* optimal. The latter is the likelihood $\bar{p}$ that the central bank will bail out once the bank is in default.

**Proposition 2 (Time-inconsistency of closure policy)** For a given capital requirement, the ex-ante optimal closure policy exhibits in general only partial forbearance, i.e., $p^o < 1$. On the other hand, the ex-post optimal closure policy exhibits complete forbearance, i.e., $\bar{p} \equiv 1$.

Intuitively, the central bank would like to commit to only partial forbearance towards banks. This is because exhibiting excessive forbearance towards banks in default induces a moral hazard on their ex-ante incentives, and leads them to take on greater risk. The optimal level of forbearance trades off this negative feedback effect with the positive benefit of preserving continuation values from bank bail outs. Ex-post, however, such a policy lacks commitment and is not credible from a sub-game perfection standpoint.

Formally, the analysis is a bit tricky and is detailed in the appendix. Consider the first order condition for risky investments by the regulated bank in equation (3.12). Complete forbearance by the central bank ($p = 1$) eliminates all risk-avoidance incentives of bankowners (RHS = 0). The bankowners anticipate that they will be bailed out always and undertake risk to maximize their option payoff from each period. On the other hand, exhibiting too little forbearance towards bankowners reduces their charter-value due to a greater frequency of closures expected in future periods. This can be seen by observing that the charter-value $V$ in equation (3.10) is increasing in $p$. Thus, the magnitude of risk-avoidance effect starts diminishing if the forbearance exercised by the central bank drops sufficiently. The optimal tradeoff between these two effects implies that in general the ex-ante optimal closure policy does not exhibit complete forbearance, i.e., $p^o < 1$. Figure 1 plots optimal closure policies in a numerical example for different capital levels to illustrate this point.

Consider now the ex-post outcome. If banks in default are closed, there will be no investments in the economy (at least until banks are allowed to re-enter). On the other hand, if banks are bailed out, investments in the economy remain uninterrupted. Given that it is
optimal to have some investments in the economy, i.e., banks are desirable in spite of agency issues, the central bank has no choice but to bail out the failed banks.\footnote{This lack of time-consistency in closure policy has also been examined by Mailath and Mester (1994).}

In practice, central banks have a “reputation” for being more or less forbearing. This reputation provides an inter-temporal commitment to a policy of partial forbearance and is often determined by political economy considerations considered in Section 4.3. Thus, one observes a wide dispersion in the forbearance exercised by different central banks. To capture this, we allow the central bank in our model to implement a (ex-ante) committed and (ex-post) exercised closure policy $p$ which is allowed to vary over the range $[0, 1]$. Thus, if $p$ is low, the central bank has reputation of being stringent or less forbearing, whereas if $p$ is high, it has reputation of being lax or more forbearing. Next, we examine capital requirements that are optimal for central banks with differing levels of forbearance.

**Design of optimal capital requirement:** Denote the optimal capital requirement for a closure policy $p$ as $K^o(p)$. At the outset, note that the participation-constraint (PC) in the design problem may bind at interior levels of capital if the dilution cost of capital is high. In other words, a capital requirement where all risky investments are funded by outside equity (in effect, producing a “narrow bank” w.r.t. deposits and their investments) may be infeasible, i.e., $K^o(p) < X_R$ in equilibrium. If $K^o(p) \geq X_R$ in equilibrium, banks never default and the design problem is rendered both uninteresting and unrealistic.

In fact, if the dilution cost of capital is steep enough, it turns out to be optimal for the central bank to implement an interior capital requirement. Intuitively, as capital requirements increase, $R^c = r \cdot \left(1 - \frac{K}{X_R}\right) \rightarrow r$, and the risk-shifting incentives are alleviated due to greater alignment of bankowners’ interests with firm-value maximization. However, the dilution cost of outside capital implies that the charter-value of bankowners, which is proportional to $[v(r, X_R) - \theta(K)]$, diminishes with increasing capital requirements due to equity issuances in future periods. Lowered charter-value, in turn, implies lower risk-avoidance incentive. The optimal capital requirement trades off the amelioration of risk-shifting incentive in each period with the negative feedback effect arising from poorer continuations for bankowners.\footnote{Formally, consider the first order condition of regulated bank’s maximization, equation (3.12). Then,

$$\frac{\partial (LHS)}{\partial K} = (r - R^c)h(R^c) \frac{\partial R^c}{\partial K} = -\frac{r^2 K}{X_R^2} h(R^c) < 0.$$}

Thus, increasing capital reduces risk-shifting incentive from each period’s convex payoff. Also,

$$\frac{\partial V}{\partial K} = \frac{1}{Z} \cdot \left[ \frac{\partial \psi}{\partial K} - \theta(K) \right] + \frac{1}{Z^2} \cdot \beta(1 - p) [v(r, X_R) - \theta(K)] \cdot \frac{r}{X_R} h(R^c),$$

$$= \frac{1}{Z} \cdot [r - \theta(K)] + \frac{1}{Z} \cdot \beta(1 - p) V \cdot \frac{r}{X_R} h(R^c).$$
This tradeoff becomes important in the analysis below. Should the capital requirement \( K^o(p) \) increase or decrease in \( p \)? *Ceteris paribus*, should a more forbearing central bank require greater capital for its banks? At first blush, it seems that capital requirements should get tighter with greater forbearance. This is the intuition one derives from a single-period model, and this is also the case in a multi-horizon setting when forbearance is at moderate to high levels. However, somewhat counterintuitively, this need not be when forbearance is quite low. The correct answer depends on whether the net effect of an increase in capital at a given closure policy is to ameliorate risk-shifting (through alignment of incentives discussed above) or to exacerbate risk-shifting (through feedback effect of lowered charter-values).

Let \( \hat{X}_R(r, K) \) denote the solution to bankowners’ maximization problem, the first order condition in equation (3.12), for a closure policy \( p \). Then,

**Proposition 3 (One size doesn’t fit all)** The optimal capital requirement is increasing in the extent of forbearance exercised by the central bank, i.e., \( K^o(p) \) is increasing at \( p \), whenever the extent of risky investment by the bank is decreasing in the capital requirement, i.e., \( \hat{X}_R(r, K) \) is decreasing in \( K \).

If the extent of risky investment by the bank is increasing in the capital requirement, i.e., \( \hat{X}_R(r, K) \) is increasing in \( K \), at a sufficiently steep rate, then the optimal capital requirement is decreasing in the extent of forbearance by the central bank, i.e., \( K^o(p) \) is decreasing at \( p \).

It is important to point out that as forbearance increases, bankowners’ charter-value increases, and thus, the participation-constraint (PC) becomes slacker. This implies that capital requirements can be increased, if required, to counteract the induced moral hazard. The proof in the appendix shows that if the central bank adopts moderate to high forbearance, i.e., \( p \) is high, then the first case of Proposition 3 arises: risk-shifting incentive in each period is mitigated by imposing a tighter capital requirement. In this case, increasing capital requirements and increasing forbearance act as *strategic complements*. On the other hand, if the central bank follows a stringent closure policy, i.e., \( p \) is low, and the dilution cost of capital is steep, i.e., \( \theta(K) \) rises sharply in \( K \), then the second case arises: risk-avoidance incentives are enhanced by in fact reducing the extent of capital required. In other words, increasing capital requirements and increasing forbearance may act as *strategic substitutes*. This non-monotone relationship between capital requirement and closure policy, and the overall regulatory design \( (K^o, p^o) \) is illustrated in Figure 1 for a numerical example.

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The first term is \( < 0 \) if marginal dilution cost of capital exceeds \( r \), the safe asset return. The second term is also small for \( K \) large. Thus, \( \frac{\partial \theta}{\partial K} \) is \( < 0 \) for \( K \) sufficiently large; increasing capital eventually reduces risk-avoidance incentive from continuation values, RHS in equation (3.12). This perverse effect of increasing capital requirements has also been pointed out by Blum (1999), and Hellmann, Murdock, and Stiglitz (2000).
What is crucial from our standpoint is that the optimal capital requirement is tied to the central bank’s forbearance. As a result, if different central banks exercise different levels of forbearance, then one size of capital requirement does not fit banking sectors of all economies.

**International convergence of capital adequacy standards:** Over the last two decades, increasing integration of global financial markets has led most large banks to have cross-border operations. The need for creating a “level-playing field” for banks across different countries has been suggested as the rationale behind a movement towards the uniformity of capital requirements. Following the Basel Accord of 1988, most countries have moved towards a uniform 8% capital adequacy requirement for banks against a suitable measure of their risk-adjusted assets. Closure policies adopted by central banks in different countries, however, remain highly divergent.\(^{21}\)

Our analysis suggests that *ceteris paribus*, financial sectors with differing forbearances sustain different levels of moral hazard and should adjust their capital requirements accordingly. The recent convergence in capital standards may thus be meritorious only if accompanied by a convergence of other institutions of banking regulation, in particular, the policies adopted to handle bank failures. Where such an accompanying convergence is infeasible, an appropriate divergence in capital requirements may be necessary.\(^{22}\) In the next section, we illustrate the ill-effects on the global economy from a coordination amongst different central banks on some but not all arms of regulation, and suggest possible remedies.

### 4 Multiple economy model

In this section, we examine the effect of having a uniform capital adequacy regulation amidst divergent closure policies on stability of the global economy.

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 to capture diversification benefit on the asset-side, and possibly, to also expand their deposit base. The access to assets in both regimes equilibrates the asset returns across the regimes, and hence, the cost of borrowing for all banks. These asset returns (and the cost of borrowing) are however determined by the risk-taking incentives of bankowners. A bank’s risk-taking incentives, in turn, are affected by the regulatory forbearance exercised in the regime where

\(^{21}\)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.

\(^{22}\)Differences in economic conditions and organizational structures across nations may also accentuate the need for such divergence.
it is chartered. 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 whose objective is to maximize the total value of his regime’s banking sector, as in the single economy model of Section 3. The size of deposit base in the two regimes in each period is $D_a$ and $D_b$, respectively. To start with, we assume that the regimes are identical in all respects otherwise. Banks face identical costs for making risky investments, and regulators in the two regimes enforce identical capital requirements and exercise identical forbearance towards the banks in their respective regimes. These assumptions will be relaxed soon to enrich the analysis.

4.1 Autarky

Under autarky, banks in a regime do not have access to assets or deposits of other regime. Denote the cost function that banks face as $c_u(\cdot)$, the subscript $u$ reflecting the fact that banks are not internationally diversified. Then, each regime is a replica of the single economy model. Given uniform regulations, viz. capital requirements $K$ and closure policy $p$, the market-clearing rates of borrowing in the two economies are given by

$$r_a = f[D_a + K - \hat{X}_{Ru}(r_a)], \quad \text{and} \quad r_b = f[D_b + K - \hat{Y}_{Ru}(r_b)],$$

where $\hat{X}_{Ru}(r)$ and $\hat{Y}_{Ru}(r)$ are given by equation (3.12) with $c_u'(\cdot)$ replacing $c'(\cdot)$.

4.2 Financial integration

Under financial integration, banks are allowed cross-border asset investments as well as deposit collection through foreign “branches.” Since depositors cannot write contracts that can differentiate across banks, all banks are charged the same rate of interest. Further, as in the single-economy model, this promised rate of interest must equal the safe asset return in equilibrium. Finally, the safe asset returns in the two regimes must be identical, since otherwise banks would make no investments in safe technology in one of the regimes driving the marginal product of capital in that regime to infinity. This however cannot be an equilibrium outcome. We denote the common rate of interest on deposits and the return on safe assets in both regimes as the “world interest rate” $r_w$.

In order to capture the diversification benefit to banks from making international asset investments, we assume that banks face a cost structure $c(X_R)$ that is proportionally lower than its undiversified counterpart. In other words, $c(X_R) = \alpha \cdot c_u(X_R), \ \forall X_R, \ \alpha \in (0,1)$. 

Thus, the return on a dollar of risky investment net of costs is higher when banks hold an internationally diversified portfolio compared to a domestically diversified one. This makes risky investments more attractive for banks and generates greater profits, justifying financial integration of the regimes as a possibly desirable outcome.  

Finally, banks are regulated on an internationally consolidated basis. To be precise, each bank is required to hold $K$ units of capital against its sum total risky investment, $X_R$, which is the sum of its domestic and foreign risky investments. Similarly, upon a bail out of a bank by the central bank of its regime, both domestic and international 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 central bank $i$. We argue in Section 4.4 that this makes the model most applicable to international banks in the United States prior to 1991, and to the recent surge in cross-border banking in the European Monetary Union.

Denote as $(X_{Sa}, X_{Sb}, X_R)$ the safe investments of representative bank $A$ in regimes $A$ and $B$, and its total risky investment, respectively. Similarly, denote as $(Y_{Ra}, Y_{Rb}, Y_R)$ the investments of representative bank $B$. Then, in equilibrium, the following conditions hold:

- No-arbitrage implies $r_{Sa} = f'(X_{Sa} + Y_{Sa}) = r_{Sb} = f'(X_{Sb} + Y_{Sb}).$
- Budget constraint implies $X_{Sa} + X_{Sb} + Y_{Sa} + Y_{Sb} = D_a + D_b + 2K - X_R - Y_R.$

These conditions can be simplified to yield

$$X_{Sa} + Y_{Sa} = X_{Sb} + Y_{Sb} = \frac{1}{2}(D_a + D_b + 2K - X_R - Y_R). \tag{4.2}$$

Note that $X_R = \hat{X}_R(r)$ (and similarly, $Y_R = \hat{Y}_R(r)$) satisfies the first order condition in equation (3.12). Thus, the world interest rate is given by

$$r_w = f' \left[ \frac{1}{2} \left( D_a + D_b + 2K - \hat{X}_R(r_w) - \hat{Y}_R(r_w) \right) \right]. \tag{4.3}$$

What happens to the cost of borrowing for (say) banks in regime $B$ upon integration, $r_w$, compared to its autarky level, $r_b$? Do banks in regime $B$ get hurt due to a competition from banks in regime $A$ for deposits? How do the risk-taking incentives of banks in regime $A$ affect the outcome? To answer these questions, we define as spillover the difference between these costs, i.e., spillover is $\Delta r = r_w - r_b$. From the standpoint of examining the merits of “level-playing field” argument, the following is particularly relevant: how does the spillover behavie when the two regimes have identical capital adequacy requirements but they diverge.

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23 We discuss other possible ways of capturing diversification benefits in Section 4.5 of the unabridged version of the paper, available from the author upon request.
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in (i) their regulatory forbearances \((p_a \neq p_b)\), (ii) the size of their banking sectors measured in terms of deposits \((D_a \neq D_B)\), and (iii) the size of their banks measured in terms of risky investments \((\hat{X}_R(\cdot) \neq \hat{Y}_R(\cdot))\) arising due to the fact that \(c'_a(\cdot) \neq c'_b(\cdot)\).

The following proposition characterizes when the spillover will be positive and how its magnitude changes as these differences become larger.

**Proposition 4 (International spillovers)** If the risky investments of banks decrease in their cost of borrowing, i.e., \(\forall r, \hat{X}_R(r) \text{ and } \hat{Y}_R(r)\) are decreasing in \(r\), then the spillover from regime A banks to regime B banks, measured as \(\Delta r = r_w - r_b\), is

(i) increasing in \(p_a\), the forbearance exercised by the central bank of regime A;
(ii) decreasing in \(D_a\), the size of deposit base of regime A; and
(iii) increasing in \(\hat{X}_R(r)\), the size of risky investments of banks in regime A.

Further, if international diversification makes risky investments more attractive, i.e., \(\forall r, \hat{Y}_R(r) > \hat{Y}_{Ra}(r)\), then the spillover \(\Delta r\) is positive when ceteris paribus

(i) \(p_a > p_b\); (ii) \(D_a < D_b\); or (iii) \(\hat{X}_R(r) > \hat{Y}_R(r)\).\(^{24}\)

Finally, the charter-value of regime B banks decreases with an increase in the spillover \(\Delta r\).

We discuss each of these effects in detail below.\(^{25}\)

**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 impose vastly different closure policies. As the forbearance of regime A increases, banks chartered in regime A find risky investments more attractive (Lemma 2 in the appendix). These banks substitute some of their safe investments with risky investments, in turn, raising the level of world interest rate, \(r_w\). Thus, there is an international spillover: the world interest rate is the equilibrium promised rate on deposits for regime B banks as well. This endogenous general equilibrium effect implies that relaxing regulation in regime A increases the cost of borrowing for regime B banks, reduces their charter-value, and may in fact increase their likelihood of failure. The greater the forbearance exercised by regime A regulator, the greater the magnitude of this spillover.

\(^{24}\)Note that these conditions are only sufficient and not necessary to have \(\Delta r > 0\). If \(\hat{Y}_R(r) < \hat{Y}_{Ra}(r)\), as might occur if international diversification raises charter-value of banks high enough to reduce their risk-taking propensity, then we need \((p_a - p_b), (D_b - D_a), \text{ and } (\hat{X}_R(r) - \hat{Y}_R(r))\), to be sufficiently high to obtain \(\Delta r > 0\). The spirit of the result thus remains the same.

\(^{25}\)The condition that \(\hat{X}_R(r)\) and \(\hat{Y}_R(r)\) decrease in \(r\) is not very restrictive. It can be verified that \(\text{sign}(\Delta X_r) = \text{sign}(\frac{\partial V}{\partial X_r})\) which is < 0 for \(V\) sufficiently high. Intuitively, as the bank’s cost of borrowing rises, their profit from incremental investment in risky assets falls. Moreover, if \(V\) is high then they counteract increase in \(R^c = r(1 - \frac{K}{X_R})\), the likelihood of failure, due to an increase in \(r\) by reducing \(X_R\).
The increased forbearance of regime $A$ is thus not just destabilizing for its own banks (who take greater risk), but is destabilizing for global financial system as a whole. Two points are in order. First, in a world where capital requirements are uniform, regime $B$ 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 $B$ through the world interest rate. Given that each regime’s regulator is concerned only about maximizing the value of its own banking sector, this externality may not be internalized in the absence of coordination. Thus, the situation where each regime increases its forbearance producing welfare costs for other regimes may in fact be an equilibrium outcome. We explore this possibility in Section 4.3.

Size of deposit base of regime $A$: Consider regime $A$ being “smaller” than regime $B$ in terms of deposit base, i.e., $D_a < D_b$, but their banks being otherwise identical, i.e., $\hat{X}_R(r) \equiv \hat{Y}_R(r)$. Under autarky, the safe investments in two regimes are $D_a - \hat{X}_{Ra}(r)$ and $D_b - \hat{Y}_{Ra}(r)$, respectively, which are not identical if $D_a \neq D_b$. However, under financial integration, to equilibrate the safe asset returns across the two regimes, the level of safe investments in both regimes must be identical. Thus, if $D_a < D_b$ then there must be a flow of deposits from regime $B$ into safe investments in regime $A$, as evidenced by equation (4.2). This however must occur at the cost of giving up some safe investments in regime $B$. The net effect of these cross-border flows is to raise the world interest rate, and possibly above the level of regime $B$ interest rate in autarky.

Thus, on the one hand, integration with regime $A$ may benefit regime $B$ banks on asset-side through diversification ($c_b(x) < c_a(x)$). On the other hand, it hurts them on the liability-side due to competition in the deposit market with regime $A$ banks ($r_b > r_a$). The smaller the deposit base of regime $A$, greater is the cross-border flow of funds out of regime $B$, and, greater is this liability-side spillover.\textsuperscript{26}

Size of risky investments of regime $A$ banks: This effect is analogous to the effect of deposit base. As seen from equation (4.2), as the risky investment demand of regime $A$ banks, $\hat{X}_R(r)$, increases, the aggregate level of safe investments across the two regimes falls. In equilibrium, this raises the world rate of interest producing a spillover on the cost of borrowing for regime $B$ banks.\textsuperscript{27}

\textsuperscript{26}Note that if banks could raise loan rates in response to an increase in borrowing cost, then the resulting spillover would get passed through to the real sector of the less forbearing regime. An increase in loan rates may however ration some of the borrowers and perhaps induce a “credit crunch.” The spillover would then still affect the joint welfare of real and financial sectors.

\textsuperscript{27}Note that the risky investment demand, $\hat{X}_R(r)$, may rise or fall with the diversification benefit, viz. reduction in $c_a(x)$, depending upon the relevant tradeoff between risk-taking and risk-avoiding. If diversification benefit is substantial, i.e., $c_a(x) << c_a(x)$, then regime $A$ banks undergo a substantial increase in charter-
The proposition thus suggests that there are two important channels through which international spillovers could arise upon integration of economies: (i) differences in regulation, and (ii) heterogeneity of banking sectors. Further, the spillover is likely to affect adversely the economy that integrates with another economy when the latter has a more forbearing regulatory stance, a smaller banking sector (either due to geographical size or due to low levels of current economic activity), or banks that are more aggressive in risk-taking. In fact, such heterogeneity across banking sectors, or, a difference in weights on bankowners’ and depositors’ welfare in the central bank objective, may precisely be the determinant of why one regulator may prefer a low level of forbearance compared to the other. We next study how the other regulator responds to the international spillover that is entailed upon such excessive forbearance from one of the regulators.\footnote{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.}

### 4.3 Regression to the worst regulation

In this section, we address the question of how does a central bank respond to the spillover arising from the forbearance exercised by other central banks? If central banks 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 in equilibrium, there may be a regression to 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 first need to model why different central banks might adopt different levels of forbearance. We claim that this arises in part due to heterogeneity of central bank objectives. Central banks and supervisors may not be perfectly aligned with overall bank value maximization. Instead, they may be 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. To model this, we consider generalizing central bank’s objective to one that maximizes a weighted average of bankowners’ and depositors’ welfare. Thus,

\[
W(\lambda, r, X_R) = \lambda \cdot V(r, X_R) + (1 - \lambda) \cdot U(r, X_R), \tag{4.4}
\]

value that may mitigate their risk-taking behavior. However, if such benefit is not substantial then they may undertake greater risk because (diversified) risky assets are now more attractive. The details are similar to the proof of Proposition 3 in the appendix and not presented here.
where $V(r, X_R)$ is the charter-value given by equation (3.10), and $U(r, X_R)$ is depositors’ welfare (equal to bank value minus charter-value). Note that $\lambda = \frac{1}{2}$ corresponds to bank value maximization studied until now; $\lambda > \frac{1}{2}$ reflects a greater weight on bankowners’ interest, i.e., the political economy consideration of a regulatory capture; and $\lambda < \frac{1}{2}$ represents a conservative regulator more aligned with depositors’ interests.

We assume that two regimes are identical in their economic characteristics, i.e., $D_a = D_b = D$, and $c_a(\cdot) = c_b(\cdot) = c(\cdot)$. The only difference between the two regimes arises due to a difference in their regulatory weights, $\lambda_a$ and $\lambda_b$, respectively. We treat $\lambda_b$ as fixed and allow $\lambda_a$ to vary as we study the effect of heterogeneity in regulatory objectives. Further, there is an international convergence of capital requirements at a level $K$. As a benchmark, let $K$ be optimal when two regimes have identical weights, $\lambda_a = \lambda_b$, the case of no spillover across the regimes. Then, each central bank solves a design problem that is a modification of the one specified in equations (3.16)-(3.18). Thus, central bank $A$’s problem is

$$\max_{p_a} \quad W(\lambda_a, X_R \mid K)$$

s.t. (IC: Incentive-Compatibility)

$$X_R \in \arg \max_{X'_R} V(X'_R \mid K, p_b)$$

and (PC: Participation-Constraint)

$$V(X_R \mid K, p_a) \geq \bar{V}$$

Central bank $B$’s problem is specified similarly. The interaction of these two design problems arises through the equilibrium market-clearing condition that determines the world interest rate. Denote the forbearances of the two central banks as $p_a(r, \lambda_a)$ and $p_b(r, \lambda_b)$, respectively, where the equilibrium world interest rate $r$ satisfies:

$$r \equiv r_w = f' \left[ D + K - \frac{1}{2} \hat{X}_R[r_w, p_a(r_w, \lambda_a)] - \frac{1}{2} \hat{Y}_R[r_w, p_b(r_w, \lambda_b)] \right],$$

which emphasizes the dependence of risk-taking by banks on the respective forbearances. In the benchmark case, let $\lambda_a = \lambda_b$. Denote the benchmark equilibrium as $(r, p_a, p_b) = (\hat{r}, \hat{p}, \hat{p})$ where $p_a = p_b = \hat{p}$, and $\hat{r}$ is given by equation (4.8) above.

First, we show that as $\lambda_a$ increases, $p_a$ increases as well. The following lemma shows that a greater alignment of objective with bankowners makes forbearance more attractive.

**Lemma 1** For a given world interest rate, the forbearance of central bank $A$ increases in its alignment with its bankowners, i.e., $p_a(r, \lambda_a)$ is increasing in $\lambda_a$. 

Thus as $\lambda_a$ increases, the corresponding increase in $p_a$ leads to greater risk-taking by regime $A$ banks. This raises the world interest rate producing a spillover on regime $B$ banks. If the spillover is large enough, the charter-value of regime $B$ banks falls below their reservation value, and in equilibrium, the central bank of regime $B$ is forced to adopt greater forbearance as well. Proposition 5 formalizes that this happens precisely when the regulatory capture of regime $A$ central bank, $\lambda_a$, is high enough that the induced spillover is sufficient to cause regime $B$ banks to exit unless greater forbearance is exercised by their central bank.

**Proposition 5 (Regression to the worst)** In equilibrium, central bank $B$ increases its forbearance upon an increase in the regulatory capture of central bank $A$, i.e., both forbearances $p_a$ and $p_b$ increase in $\lambda_a$, if

(i) increase in $p_a$, the forbearance of central bank $A$, increases the spillover $\Delta r$ on regime $B$ (under conditions stated in Proposition 4), and

(ii) central bank $A$ is sufficiently captured by its bankowners, i.e., $\lambda_a > \lambda^*(\lambda_b)$.

We show in the proof that if $\lambda_a$ and $\lambda_b$ are sufficiently low, then (PC) will bind for both central banks, and locally, an increase in $\lambda_a$ does not shift the equilibrium. If $\lambda_b$ is low so that (PC) binds for central bank $B$ and $\lambda_a$ is high such that (PC) does not bind for central bank $A$, then an increase in $\lambda_a$ increases the world interest rate driving regime $B$ banks’ charter-value below their exit point. Thus, in equilibrium, central bank $B$ increases its forbearance as well to counteract the spillover. In other words, regulatory forbearances act as strategic complements. Finally, if both $\lambda_a$ and $\lambda_b$ are such that (PC) does not bind for either banks, then an increase in $\lambda_a$ may initially lead central bank $B$ to counteract the resulting spillover by reducing its forbearance, i.e., regulatory forbearances may behave as strategic substitutes initially. However, if $\lambda_a$ increases sufficiently, then an additional decrease in forbearance drives the regime $B$ banks to their exit point. Thus, for all $\lambda_a$ above a critical level $\lambda_a^* (\lambda_b)$, regulatory forbearances again behave as strategic complements.

We call this perverse phenomenon as a “regression to 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 their economic characteristics. We conjecture thus that a lack of coordination in regulation will be most destabilizing for those financial integrations where (i) the member nations are very different in their economic characteristics, and (ii) the regulators in these member nations deviate in the extent of their alignment with their domestic banks. The first requirement 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.\textsuperscript{29}

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 capital requirement front. In other words, central banks exhibiting greater forbearance could be required to impose different capital requirements on their banks. Then, the capital requirements would be designed in conjunction with the closure policy, i.e., \((K_a, \alpha)\) for regime \(A\) banks and \((K_b, \alpha)\) for regime \(B\) banks. From Proposition 3, for moderate to high forbearance levels, the optimal capital requirements increase with an increase in forbearance so that \(K_a > K_b\) if \(\alpha_a > \alpha_b\). 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 to regime \(A\)'s forbearance. Thus it is plausible that no convergence in regulatory policies may be better than a convergence of capital adequacy regulation amidst divergent closure policies!

\section{Proposals for regulation of international banks}

With the growing integration of financial markets around the world, the likelihood of international spillovers has gone up substantially. To report an early statistic, Japanese banks owned over twenty-five percent of California bank assets at the end of the 1980s. Peek and Rosengren (1997, 2000) report that the massive pulling back by these Japanese banks following the asset bubble burst of 1990 had a significant effect on the economies where these banks operated, including the U.S. economy. Such spillovers are at the heart of this paper.

We propose three possible remedies to prevent the spillovers with relevant examples.

\textbf{Complete coordination of regulation:} This solution perhaps seems the most apt for the European Monetary Union (EMU). A central issue that has arisen following the formation of the EMU is to what extent the policies of different member nations should be harmonized. The Single Market Act has allowed both branches and subsidiaries to be opened by every bank in each country, the bank is subject to the regulations of its home country.\textsuperscript{30} While the 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 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 may facilitate a complete regulatory alignment.

\textsuperscript{29}Dell’Ariccia and Marquez (2000) make a singular point in their analysis of competition amongst regulators.

\textsuperscript{30}This is the so-called “home country control” rule in the EU directives, documented, e.g., in Iakova (2000).
Non-uniform capital adequacy regulation: Taking cognizance of the implicit and the discretionary nature of most lender-of-last-resort policies, a feasible regulatory option is to let member nations of Basel Accord to set capital ratios higher than the international minimum. There is some evidence that Basel regulators are moving towards institutionalizing such greater-than-minimum country-specific capital requirements.31

“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 of New York. 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: the domestic or “host” country regulation of foreign subsidiaries and branches supersedes any regulatory apparatus of their parent or “home” country regimes.32

5 Conclusion

In this paper, we have illustrated an application to bank regulation of a simple but a fundamental point: ex-post policies may distort 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

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31 Argentina, Hong Kong, and U.K. implement greater than 8% capital requirements for individual banks based on their supervisory reports. Several other countries such as Bahrain, Brazil, Estonia, Latvia, India, Kazakhstan, Korea, Kuwait, Mongolia, Russia, Thailand, Uganda, and Ukraine, require higher capital requirements for all banks.

32 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.”
the need for a link between the effectiveness of bank supervision (enforcement) and capital requirements. An alternative interpretation of our paper can be derived from its emphasis on the joint design of different arms of regulation. 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. All these are fruitful avenues for further research.

Finally, there is no satisfactory theory of financial architecture and regulation of international financial institutions. Countries and their regulators face difficult to answer 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 this relatively untapped, but apparently promising, line of enquiry.

A Proofs

**Proposition 1:** From the first order conditions (3.7) and (3.8), it follows that \( \hat{X}_R^*(r) > X_R^0(r), \forall r \). It can be verified by differentiating equation (3.7) w.r.t. \( r \), that \( \hat{X}_R^*(r) \) is non-increasing in \( r \). Suppose now to the contrary that \( r^* < r^o \). Then, \( X_R^* = \hat{X}_R^*(r^*) \geq \hat{X}_R^*(r^o) > X_R^0(r^o) = X_R^*, \) in turn implying \( r^* = f'[D - X_R^*] > f'[D - X_R^0] = r^o \), a contradiction. □

**Proposition 2:** Consider first the incentive-compatibility condition (IC) in the central bank’s design problem in equations (3.16)-(3.18). The bankowners’ first order condition is given by equation (3.12) where \( \frac{\partial q_r}{\partial X_R} = \hat{R} + \int_0^{R^c} (r - R) h(R) dR - r - c'(X_R) \). Denoting the solution to the first order condition as \( \hat{X}_R^*(r) \), we have

**Lemma 2** The risky investment of bankowners increases with an increase in forbearance, i.e., \( \frac{\partial \hat{X}_R^*(r)}{\partial p} > 0, \forall p \in [0, 1] \).

Differentiating the first order condition w.r.t. \( p \), we get

\[
(r - R^c) h(R^c) \frac{d R^c}{dp} = c''(X_R) \frac{d X_R}{dp} + \beta \frac{d}{dp} \left[ (1 - p) V \frac{\partial}{\partial X_R} \int_0^{R^c} h(R) dR \right].
\] (A.1)

For ease of notation, we have used \( X_R \) instead of \( \hat{X}_R^*(r) \). Since \( R^c = r(1 - \frac{K}{X_R}) \), and the charter-value \( V \) given by equation (3.10) depends on \( p \), we can use chain-rule to obtain

\[
\left[ c''(X_R) + \beta (1 - p) V \frac{\partial^2}{\partial X_R^2} \int_0^{R^c} h(R) dR - (r - R^c) h(R^c) \frac{\partial R^c}{\partial X_R} \right] \frac{d X_R}{dp} = \beta \frac{d}{dp} \left[ -(1 - p) V \cdot \frac{\partial}{\partial X_R} \int_0^{R^c} h(R) dR \right].
\] (A.2)
This is the standard condition that \( \frac{\partial^2 V}{\partial X_R^2} \cdot \frac{dX_R}{dp} + \frac{\partial^2 V}{\partial X_R \partial \phi} = 0. \) Thus, the term inside [\( \cdot \)] in LHS is \( > 0 \) from second order condition for bankowners’ maximization. Further, using the lemma below, \( \frac{d}{dp}[-(1-p)V] > 0. \) Finally, \( \frac{\partial}{\partial X_R} \int_0^{R^c} h(R) \, dR = \frac{rK}{X_R} \cdot h(R^c) > 0. \) These results together imply that \( \frac{dX_R^*(r)}{dp} > 0. \) \( \Box \)

**Lemma 3**  \( \frac{d}{dp}[-(1-p)V] > 0. \)

\[
   \frac{d}{dp}[-(1-p)V] = V - (1-p) \frac{dV}{dp}, \text{ where } \frac{dV}{dp} = \frac{\partial V}{\partial p} + \frac{\partial V}{\partial X_R} \frac{dX_R}{dp} = \frac{\partial V}{\partial p}, \text{ since } \frac{\partial V}{\partial X_R} = 0. \text{ From equation (3.10), } \frac{\partial V}{\partial p} = \frac{1}{2} \cdot \beta \cdot V \int_0^{R^c} h(R) \, dR. \text{ Then, } \frac{d}{dp}[-(1-p)V] = \frac{1}{2} \cdot (1-\beta)(1-p)V \int_0^{R^c} h(R) \, dR > 0. \) \( \Box \)

Consider now the design problem of the central bank. Its objective function \( W(X_R | K, p) \) is given by equation (3.14), where \( X_R = \hat{X}_R^*(p) \) (suppressing the dependence on \( r \) and emphasizing the dependence on \( p \)). Then, some algebra reveals that

\[
   \frac{dW}{dp} = \mathcal{L}(\hat{X}_R^*(p)) \cdot \frac{d\hat{X}_R^*}{dp} + \beta \cdot W(\hat{X}_R^*(p)) \int_0^{R^c} h(R) \, dR, \quad \text{(A.3)}
\]

\[
   \mathcal{L}(X_R) = \frac{\partial w(\cdot)}{\partial X_R} - \beta(1-p)W \frac{\partial}{\partial X_R} \int_0^{R^c} h(R) \, dR \quad \text{(A.4)}
\]

is the first order derivative of central bank’s objective function w.r.t. \( X_R. \) Since \( \hat{X}_R^*(p) \) satisfies equation (3.12), it can be shown that

\[
   \mathcal{L}(\hat{X}_R^*(p)) = -\int_0^{R^c} (r - R)h(R) \, dR - \beta(1-p)(W - V) \frac{\partial}{\partial X_R} \int_0^{R^c} h(R) \, dR, \quad \text{(A.5)}
\]

which is \( < 0. \) This is simply the result that bankowners choose a level of risk that is greater than socially optimal. Thus, the first term on RHS of equation (A.3) is negative: increasing \( p \) increases the moral hazard through the risk-shifting incentive. However, the second term on RHS of equation (A.3) is positive: increasing \( p \) increases future social welfare since continuation losses are avoided. Note that if \( \beta = 0, \) then the second term is zero and it is optimal to set \( p^o = 0. \) However, if \( \beta > 0, \) then the tradeoff becomes relevant.

It can be checked from equation (A.2) and equation (A.3) that if \( p \) is very small \( (p \approx 0), \) then \( \frac{dX_R^*}{dp} \) is small so that \( \frac{dW}{dp} > 0: \) increasing forbearance is socially beneficial. However, if \( p \) is very large \( (p \approx 1), \) then \( \frac{dX_R^*}{dp} \) is large and \( \frac{dW}{dp} < 0: \) decreasing forbearance becomes desirable. The optimal tradeoff thus implies that the ex-ante optimal policy, \( p^o, \) in general, does not equal complete forbearance, i.e., \( p^o < 1. \) Note that it is possible however for specific parameters to obtain \( p^o = 1. \) If the (PC) is not met at the unconstrained optimum, \( p^o, \) then the optimal policy is \( p \) s.t. \( V(p) = \bar{V}. \) This is unique since \( \frac{dW}{dp} > 0, \forall p \) as shown below in the proof of Proposition 3, part (i).
The proof that the ex-post optimal policy, \( \hat{p} \equiv 1 \), follows from the discussion in the text that once banks are in default, there is social value to their making investments in the economy compared to closing them down. In other words, \( W(\hat{X}_R^*(\hat{p})) > \frac{D}{1-\beta}, \forall \hat{p} \), the latter corresponding to the outcome that depositors simply consume their goods in future. \( \square \)

**Proposition 3:** Consider any \( p \in (0,1) \), and define \( p' = p + \delta, \delta > 0 \). Let the optimal capital requirement at \( p \) be \( K \).

(i) Denote the set of capital requirements feasible at \( p \), i.e., ones that satisfy (PC) in equation (3.18), as \( \mathcal{K}(p) \). Then, the claim is that \( K \in \mathcal{K}(p') \). In other words, the optimal capital requirement at \( p \) is feasible at \( p' \). To see this, note that

\[
\frac{dV}{dp} = \frac{\partial V}{\partial X_R} \cdot \frac{dX_R}{dp} + \frac{\partial V}{\partial p} = \frac{1}{Z} \cdot \beta V \int_0^{R^c} h(R)dR > 0, \quad (A.6)
\]

since \( \frac{dV}{\partial X_R} = 0 \) at \( X_R = \hat{X}_R^*(r, K) \). Thus, (PC) at \( (K, p') \) is slacker than it is at \( (K, p) \).

(ii) Consider how central bank’s objective changes value as capital requirements are increased, i.e., examine \( \frac{dW}{dK} \) for a given \( p \). Applying chain-rule to equation (3.14),

\[
\frac{dW}{dK} = r + \frac{1}{Z} \int \left( \beta \left( \frac{r}{X_R} - d(X_R) - (1 - p)W \frac{\partial}{\partial X_R} \int_0^{R^c} h(R)dR \right) \cdot \frac{dX_R}{dK} \right) + \frac{1}{Z} \beta (1 - p)W \frac{r}{X_R} h(R^c), \quad \text{where} \quad X_R = \hat{X}_R^*(r, K)
\]

\[
= \frac{1}{Z} \left( r + \beta (1 - p)W \frac{r}{X_R} h(R^c) + \mathcal{L}(\hat{X}_R^*) \frac{d\hat{X}_R^*}{dK} \right), \quad (A.7)
\]

where \( \mathcal{L}(\hat{X}_R^*) < 0 \) as shown in equation (A.4). Since first two terms inside \( [\cdot] \) are positive, the sign of \( \frac{dW}{dK} \) depends on the sign of \( \frac{d\hat{X}_R^*}{dK} \). If \( \frac{d\hat{X}_R^*}{dK} \) is is \( \leq 0 \), then \( \frac{dW}{dK} > 0 \), whereas if \( \frac{d\hat{X}_R^*}{dK} \) is \( > 0 \) by a sufficient amount, then \( \frac{dW}{dK} < 0 \). In the first (second) case, we can pick some \( \epsilon > 0 \) such that \( K' = K + (\pm) \epsilon \), is feasible at \( p' \), and in fact, is better than \( K \). This proves Proposition 3 that the optimal capital requirement, \( K^*(p) \), varies with \( p \) as described above.\( ^{33} \) \( \square \)

\( ^{33} \)To understand this result better, differentiate first order condition (3.12) w.r.t. \( K \). We get \( \frac{\partial V}{\partial K} \cdot \frac{dX_R}{dK} + \frac{\partial^2 V}{\partial K \partial X_R} = 0 \). Since \( \frac{\partial V}{\partial K} < 0 \) from the second order condition for bankowners’ maximization, the sign of \( \frac{d\hat{X}_R^*}{dK} \) is the same as the sign of \( \frac{\partial V}{\partial K \partial X_R} \), which in turn, is the same as sign of

\[
\frac{\partial v(\cdot)}{\partial K} \frac{\partial X_R}{\partial K} = \beta (1 - p) \frac{\partial}{\partial K} \left( V \frac{\partial}{\partial X_R} \int_0^{R^c} h(R)dR \right) \quad (A.8)
\]

The first term on RHS equals \( (r - R^c) h(R^c) \frac{dK}{dK} \frac{dX_R}{dK} = -\frac{\partial \hat{K}}{\partial K} h(R^c) < 0 \). Applying chain-rule, the second term on RHS equals \( \frac{\partial \hat{K}}{\partial K} h(R^c) \frac{dV}{dK} + V \frac{\partial^2 V}{\partial K \partial X_R} \int_0^{R^c} h(R)dR \). Using the expression for \( \frac{\partial V}{\partial K} \) from footnote (20), and
Proposition 4: (i) Differentiating equation (4.3) for \( r_w \) w.r.t. \( p_a \), we get

\[
\frac{dr}{dp_a} = f''(\cdot) \left[ - \frac{\partial \hat{X}_R}{\partial p_a} - \frac{\partial \hat{Y}_R}{\partial p_a} \frac{dr}{dp_a} - \frac{\partial \hat{Y}_R}{\partial r} \frac{dr}{dp_a} \right],
\]

(A.9)

which implies that

\[
\left[ 1 + f''(\cdot) \frac{\partial \hat{X}_R}{\partial r} + f''(\cdot) \frac{\partial \hat{Y}_R}{\partial r} \right] \frac{dr}{dp_a} = - f''(\cdot) \frac{\partial \hat{X}_R}{\partial p_a}.
\]

(A.10)

Since \( f''(\cdot) < 0 \) and \( \frac{\partial \hat{X}_R}{\partial p_a} > 0 \) (Lemma 2), it follows that \( \frac{dr}{dp_a} > 0 \) if \( \frac{\partial \hat{X}_R}{\partial r} < 0 \), and, \( \frac{\partial \hat{Y}_R}{\partial r} < 0 \).

(ii) Similarly by differentiating equation (4.3) for \( r_w \) w.r.t. \( D_a \) and rearranging, we get

\[
\left[ 1 + f''(\cdot) \frac{\partial \hat{X}_R}{\partial r} + f''(\cdot) \frac{\partial \hat{Y}_R}{\partial r} \right] \frac{dr}{dD_a} = f''(\cdot).
\]

(A.11)

Again, \( f''(\cdot) < 0 \) implies that if \( \frac{\partial \hat{X}_R}{\partial r} < 0 \), and, \( \frac{\partial \hat{Y}_R}{\partial r} < 0 \), then \( \frac{dr}{dD_a} < 0 \).

(iii) Finally, differentiating equation (4.3) w.r.t. \( \alpha \) where \( c_a(\cdot) = \alpha \cdot c_u(\cdot) \), we get

\[
\left[ 1 + f''(\cdot) \frac{\partial \hat{X}_R}{\partial r} + f''(\cdot) \frac{\partial \hat{Y}_R}{\partial r} \right] \frac{dr}{d\alpha} = - f''(\cdot) \frac{\partial \hat{X}_R}{\partial \alpha}.
\]

(A.12)

Thus, if \( \frac{\partial \hat{X}_R}{\partial r} < 0 \), and \( \frac{\partial \hat{Y}_R}{\partial r} < 0 \), then \( \frac{dr}{d\alpha} \sim (\cdot) \) depending upon \( \frac{\partial \hat{X}_R}{\alpha} \sim (\cdot) \). Footnote 27 discusses the two possibilities in some detail.

We prove the result for \( \Delta r > 0 \) for case (i) where \( p_a > p_b \), \( D_a = D_b \), and \( c_a'(\cdot) \equiv c_b'(\cdot) = \alpha \cdot c_u'(\cdot) \). The proof follows along identical lines for cases (ii) and (iii).

Recall that \( r_w = f''[D_b + \frac{1}{2}(\hat{X}_R(r_w) + \hat{Y}_R(r_w))] \), and \( r_b = f''[D_b + K - \hat{Y}_Ru(r_b)] \), where \( \hat{X}_R(r) \) and \( \hat{Y}_R(r) \) are given by first order condition (3.12) under forbearance parameters \( p_a \) and \( p_b \) respectively, and \( \hat{Y}_Ru(r) \) is given by the same equation but with \( c'(\cdot) \) replaced by \( c_u'(\cdot) \). Assume that \( \hat{Y}_R(r) > \hat{Y}_Ru(r) \), \( \forall r \). By Lemma 2, \( p_a > p_b \) implies that \( \hat{X}_R(r) > \hat{Y}_R(r) \), \( \forall r \), thus \( \hat{X}_R(r) > \hat{Y}_Ru(r) \). Suppose now to the contrary that \( \Delta r \leq 0 \), i.e., \( r_w \leq r_b \). Then, \( \hat{X}_R(r_w) + \hat{Y}_R(r_w) \leq 2 \hat{Y}_Ru(r_b) \). Further, \( \hat{X}_R(r) \) and \( \hat{Y}_R(r) \) are decreasing in \( r \) so that \( \hat{X}_R(r_w) + \hat{Y}_R(r_w) \leq \hat{X}_R(r_b) + \hat{Y}_R(r_b) \), implying that \( \hat{X}_R(r_b) + \hat{Y}_R(r_b) \leq 2 \hat{Y}_Ru(r_b) \). This contradicts the facts that \( \hat{Y}_R(r) > \hat{Y}_Ru(r) \), and \( \hat{X}_R(r) > \hat{Y}_Ru(r) \), \( \forall r \).

Thus, the overall sign of \( \frac{dX^*_R}{dK} \) is determined by the magnitude of forbearance parameter \( p \) and the dilution cost of capital \( \theta(K) \).

concluding some tedious algebra reveals that for \( p \approx 1 \), the overall sign is negative and thus \( \frac{dX^*_R}{dK} < 0 \) as well.

However, if \( p \) is small and \( \theta(K) \) is large, then it is possible to obtain \( \frac{dX^*_R}{dK} > 0 \). Thus, the overall sign of \( \frac{dX^*_R}{dK} \) is determined by the magnitude of forbearance parameter \( p \) and the dilution cost of capital \( \theta(K) \).
The proof that the charter-value of regime $B$ banks, $V_b$, decreases with an increase in the spillover $\Delta r$ is common for all the cases. Consider $V_b$ given by equation (3.10). Then,

$$\frac{dV}{dr} = \frac{\partial V}{\partial r} + \frac{\partial V}{\partial Y_R} \cdot \frac{dY_R}{dr} = \frac{\partial V}{\partial r},$$

(A.13)

since $\frac{\partial V}{\partial Y_R} = 0$ by bankowners’ maximization. Note that for simplicity, we have denoted $V_b$ as $V$, $r_w$ as $r$, and $\hat{Y}_R(r)$ as $Y_R$. Then, $\frac{dV}{dr} < 0$, since

$$\frac{\partial V}{\partial r} = \frac{1}{Z} \left[ \frac{\partial v(\cdot)}{\partial r} - \beta(1 - p_b) V \frac{\partial}{\partial r} \int_{0}^{R_b} h(R) dR \right]$$

(A.14)

$$= \frac{1}{Z} \left[ (K - Y_R) - \beta(1 - p_b) V \frac{\partial}{\partial r} \int_{0}^{R_b} h(R) dR \right] < 0, \text{ since}$$

(A.15)

(i) $\frac{\partial v(\cdot)}{\partial r} = \frac{\partial}{\partial r} \left[ (\hat{R} - r) Y_R + rK - \int_{0}^{R_b} (R - R_b^c) h(R) dR - c(Y_R) \right]$ (A.16)

$$= (K - Y_R) - \frac{\partial}{\partial r} \int_{0}^{R_b} (R - R_b^c) h(R) dR = (K - Y_R) < 0 \quad (A.17)$$

under our maintained assumption that $K < Y_R$, and

(ii) $\frac{\partial}{\partial r} \int_{0}^{R_b} h(R) dR = (1 - \frac{K}{Y_R}) h(R_b^c) > 0$. □

**Lemma 1:** Consider the design problem in equations (4.5)–(4.7). Since $r$ is constant, we simplify notation by suppressing it. We show first that the unconstrained maximum $p^{\text{uc}}_a(\lambda_a)$ is increasing in $\lambda_a$. By the first order condition,

$$\frac{\partial W}{\partial p_a} = \lambda \cdot \frac{\partial V}{\partial p_a} + (1 - \lambda) \cdot \frac{\partial U}{\partial p_a} = 0,$$

(A.18)

where $\frac{\partial V}{\partial p_a}$ and $\frac{\partial U}{\partial p_a}$ are written as partial derivatives to separate the effect of $\lambda_a$ below. These derivatives include the effect of $p_a$ on $X_R$ and of $p_b$ on $Y_R$. Then, $\frac{\partial U}{\partial p_a} = -\frac{1}{1 - \lambda} \cdot \frac{\partial V}{\partial p_a} < 0$, since from equation (A.6), $\frac{\partial V}{\partial p_a} > 0$. Taking the partial derivative of first order condition w.r.t. $\lambda_a$,

$$\frac{\partial^2 W}{\partial p_a^2} \cdot \frac{dp_a}{d\lambda_a} + \frac{\partial^2 W}{\partial \lambda \partial p_a} = 0.$$

(A.19)

By second order condition for maximization, $\frac{\partial^2 W}{\partial p_a^2} < 0$. Further, $\frac{\partial^2 W}{\partial \lambda \partial p_a} = \frac{\partial V}{\partial p_a} - \frac{\partial U}{\partial p_a} > 0$, since $\frac{\partial V}{\partial p_a} > 0$ and $\frac{\partial U}{\partial p_a} < 0$. It follows that $\frac{dp_a}{d\lambda_a} > 0$.

Suppose (PC) does not bind at the benchmark case when $\lambda_a = \lambda_b$. Then, it will not bind at $\lambda_a > \lambda_b$ since $p^{\text{uc}}_a$ is increasing in $\lambda_a$ and $\frac{\partial V}{\partial p_a} > 0$. On the other hand, if (PC) binds at
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\[ \lambda_a = \lambda_b, \text{ then let } p_a^\epsilon \text{ be such that } V(r, p_a^\epsilon) = \bar{V}. \text{ Then, } p_a = \max[p_b, p_a^\epsilon(\lambda_a)] \text{ is the optimal design, and } p_a \text{ is non-decreasing in } \lambda_a. \quad \square \]

**Proposition 5:** First, we show an intermediate result that if (PC) binds, then \( p(r, \lambda) \) is increasing in \( r \). Since \( V(r, p(r, \lambda)) = \bar{V}, \frac{\partial V}{\partial r} + \frac{\partial V}{\partial p} \frac{dp}{dr} = 0 \). From equation (A.15), \( \frac{\partial V}{\partial r} < 0 \), and from equation (A.6), \( \frac{\partial V}{\partial p} > 0 \). Hence, \( \frac{dp}{dr} > 0 \).

In proving the proposition, we will assume the conditions for a spillover stated in Proposition 4 that \( \hat{X}_R(r) \) and \( \hat{Y}_R(r) \) are decreasing in \( r \). The following three cases arise:

(i) (PC) binds at both \( \lambda_a \) and \( \lambda_b \). In this case, \( p_a = p_b = p \) s.t. \( V(r, p) = \bar{V} \), where \( r \) is determined by fixed-point (4.8). Then, the equilibrium is locally unaffected as \( \lambda_a \) changes.

(ii) (PC) binds at \( \lambda_a \) but not at \( \lambda_b \). Let the equilibrium be denoted as \( (r, p_a, p_b) \) where \( p_a = p_b(r, \lambda_a) \) is the unconstrained optimum for central bank A, \( p_b = p_b(r, \lambda_b) \) s.t. \( V(r, p_b) = \bar{V} \), and again, \( r \) is given by fixed-point (4.8). Then, as \( \lambda_a \) increases and \( p_b \) stays the same, then (PC) is violated for central bank B’s design problem. To see this, note that differentiating equation (4.8) w.r.t. \( \lambda_a \), we get

\[
\frac{dr}{d\lambda_a} = f''(\cdot) \left[ -\frac{1}{2} \left( \frac{\partial \hat{X}_R}{\partial r} \frac{dr}{d\lambda_a} + \frac{\partial \hat{X}_R}{\partial p_a} \frac{dp_a}{d\lambda_a} \right) \right],
\]

which can be rearranged to yield

\[
\left[ 1 + \frac{1}{2} f''(\cdot) \frac{\partial \hat{X}_R}{\partial r} \right] \frac{dr}{d\lambda_a} = -\frac{1}{2} f''(\cdot) \frac{\partial \hat{X}_R}{\partial p_a} \frac{dp_a}{d\lambda_a}.
\]

From Lemma 1, \( \frac{dp_a}{d\lambda_a} > 0 \). From Lemma 2, \( \frac{\partial \hat{X}_R}{\partial p_a} > 0 \). Since \( f''(\cdot) < 0 \) and \( \frac{\partial \hat{X}_R}{\partial r} < 0 \) by the spillover assumption, it follows that \( \frac{dr}{d\lambda_a} > 0 \). Thus, if we consider \( \lambda_a' > \lambda_a \), then \( r' > r \).

However, \( V(r', p_b') < V(r, p_b) = \bar{V}, \forall p_b' \leq p_b \) since \( \frac{\partial V}{\partial r} < 0 \) and \( \frac{\partial V}{\partial p} < 0 \). Hence, in equilibrium, \( p_b \) must increase in \( \lambda_a \), or in other words, \( (r', p_a', p_b') > (r, p_a, p_b) \) point-wise.

(iii) (PC) does not bind at \( \lambda_a \) and \( \lambda_b \). The same argument as in (ii) establishes that \( \frac{dp_b}{d\lambda_a} > 0 \). However, since (PC) does not bind at \( \lambda_b \), \( p_b(r, \lambda_b) \) need not increase in \( r \).\footnote{It can be shown that \( \frac{dp_b}{d\lambda_b} \) may be decreasing in \( r \). When (PC) does not bind, \( p_b(r, \lambda_b) \) satisfies \( \frac{\partial V(\lambda_b)}{\partial p_b} = 0 \). Then, \( \text{sign} \left( \frac{dp_b}{d\lambda_b} \right) = \text{sign} \left( \frac{\partial V}{\partial r} \right) \) for \( \lambda_b \) sufficiently high. From equation (A.15), we obtain that

\[
\frac{\partial^2 V}{\partial r \partial p_b} = \frac{1}{Z^2} \beta(K - Y_R) \int_0^{R^c} h(R) dR 
+ \frac{1}{Z^2} \frac{rK}{Y_R^2} \beta Y_R h(R^c) \cdot \left[ \frac{dY_R}{dr} \frac{dY_R}{dr} + \frac{Y_R(Y_R - K)}{rK} \left( 1 - \beta \right) \left( 1 - \beta \right) \frac{\partial V}{\partial r} \right],
\]

which is < 0 for \( \beta \approx 1 \).}
case that $p_b(r, \lambda_b)$ increases in $r$, then it follows that for $\lambda'_a > \lambda_b \lambda_a$, $(r', p'_a, p'_b) > (r, p_a, p_b)$ point-wise as in (ii). However, if $p_b(r, \lambda_b)$ decreases in $r$, then consider the sequence of equilibria $(r, p_a, p_b)$ as $\lambda_a$ is increased, where $p_b$ is decreasing in $\lambda_a$. If $V(r^*, p^*_b) = \nabla$ for equilibrium corresponding to $\lambda_a = \lambda^*_a$, then $\forall \lambda_a > \lambda^*_a$, (PC) binds for central bank $B$ and $p_b$ increases in $\lambda_a$ as in case (ii). □

References


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