Financial Liberalization and Bank Regulation in Developing Countries*

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Abstract

In this paper we study bank regulation in a simple dynamic model with moral hazard and imperfect competition in the market for deposits. Focus is on the optimal use of ex-ante audits and a capital requirement. Contrary to conventional wisdom, a rise in the number of banks may actually slacken a no-gambling condition. Moreover, the optimal capital requirement will increase following a rise in the number of banks, whereas ex-ante audits will always fall. A higher gambling yield has different effects on banks' risk-taking incentives. The optimal use of ex-ante audits will always increase, whereas the capital requirement may decrease. Our results suggest that domestic financial liberalization is less demanding than capital account liberalization in terms of prudential regulation.

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1 Introduction

Financial liberalization remains a core element of policy reform in developing countries. This is based in part on an overall belief in the virtues of free markets. In addition, there is a widespread perception in academia as well as policymaking circles that financial liberalization promotes financial development and economic growth (Levine, 1997).

Nevertheless, the actual experience with financial liberalizations has been somewhat disappointing. Recent research has established that financial liberalization is often a catalyst for banking crises (Demirgüc-Kunt and Detragiache, 1998), and the average cost of 59 banking crashes in developing countries during the period 1976-1996 was around 9 percent of GDP (Caprio and Honohan, 1999).

In order to lower the frequency of financial crises and reap the benefits from an improved allocation of resources, most developing countries have adopted what has come to be called the developed-country model of banking regulation. This framework basically consists of risk-weighted capital requirements along the lines of the Basel Capital Accord as well as prudential supervision based on the Basel Core Principles.[1]

Accordingly, banking supervision is based on a system of licensing, which allows bank regulators to identify the banks to be supervised and to control entry into the banking industry. In order to qualify for and retain a banking license, banks must meet certain prudential requirements. Under extreme circumstances, the regulator may have the authority to revoke the banking license.

The underlying rationale for bank regulation is to deal with the moral hazard problem in banking: a problem which derives from the fact that most countries have either explicit or implicit deposit insurance.[2] A capital requirement creates incentives for banks to invest prudently by increasing the loss for shareholders in case of default (Rochet, 1992). Prudential supervision mitigates banks' risk-taking by for instance making on-site inspections of banks (Cambell et al., 1992).

In this paper, we study the optimal use of capital requirements and ex-ante audits under financial liberalization in a developing-country context. Morrison and White (2002) also put forward a model in which a bank regulator performs ex-ante audits. However, their model is static. In order to

[1] See www.bis.org.

[2] Implicit deposit insurance refers to the situation where depositors expect the government will bail them out if a bank fails. Diaz-Alejandro (1985) provides a clear example (with reference to Chile) of just how difficult it is for the government to resist bailing out a large bank.

study the inherent dynamic nature of the relationship between ex-ante audits and franchise values (discounted future profits), we introduce ex-ante audits into a dynamic moral-hazard framework along the lines of Hellmann et al. (2000). We focus on the case where the supply of deposits is inelastic.[3] That is, we adopt Repullo's (2002) version of the Hellmann et al. model, where banks engage in spatial competition in the market for deposits along the lines of Salop (1979). Deposits are subsequently invested in either a prudent or a gambling asset. We depart from the Repullo setup by introducing a benevolent bank regulator which in addition to a capital requirement also has access to an ex-ante auditing technology. We thus incorporate that by auditing a bank ex ante, the bank regulator can seize the bank's franchise value in the event of noncompliance with prudent behavior. Moreover, we assume that financing the ex-ante auditing activity carries a distortionary cost.[4] The bank regulator maximizes the sum of banks' profits and the interest payments to depositors minus the cost of ex-ante audits, subject to a no-gambling condition.

The main results of the paper are the following: First, we show that counter to conventional wisdom, an increase in competition, often the direct result of domestic financial liberalization, will not per se tighten the no-gambling condition. This is in contrast to the result in Hellmann et al. (2000). They argue that an increase in competition always leads to higher gambling incentives since it erodes franchise values. However, by modelling monopolistic competition and an inelastic supply of deposits, the present paper captures another effect: an increase in competition also lowers the gain from gambling by reducing the scope for deposit mobilization. Depending on which of the two effects dominates, the no-gambling condition may slacken or tighten following an increase in competition. Conversely, an increase in the yield of the gambling asset, often a consequence of capital account liberalization, will always tighten the no-gambling condition. A higher gambling yield always increases the payoff from gambling, and this clearly raises gambling incentives.

Second, we show that when competition in the banking industry increases, i.e. when more banks enter the industry, it is always optimal to decrease ex-ante auditing. At a first glance, this is somewhat surprising. However, it

[3] There is little agreement as to whether a higher interest rate has any effect on savings in developing countries. If an effect exists at all it is relatively small (Fry, 1995). Moreover, none of our results relies on a completely inelastic supply of deposits.

[4] Government revenue collection in most developing countries tends to be distortionary. In fact, collecting any revenue at all can be very problematic. Ironically, financial repression was one way in which governments in developing countries raised revenue. With a liberalized financial sector this source of revenue is no longer present.

derives from the fact that an increase in competition erodes franchise values. An erosion of franchise values renders ex-ante auditing less effective since the threat of loosing the bank licence carries less bite. Capital requirements will increase, following the increase in the number of banks, if the no-gambling condition becomes tighter.

Finally, we show that when the yield of the gambling asset increases, the effectiveness of ex-ante auditing is unaffected, whereas capital requirements may become less effective. Hence, we obtain that ex-ante auditing should always increase, whereas capital requirements should sometimes be decreased. In equilibrium, the capital requirement is always effective. However, the marginal effectiveness of capital with respect to an increase in the gambling yield is positive if and only if an increase in the capital requirement lowers the size of a gambling bank. It may fail to do so since a higher capital requirement calls for more bank equity.

Overall, our analysis suggests that financial liberalization does not necessarily require more bank regulation. In addition, by emphasizing that the two regulatory instruments work in an asymmetrical manner, the analysis indicates that optimal regulation following financial liberalization depends on the extent to which liberalization brings about increased competition versus increased gambling opportunities.

The rest of the paper is organized as follows: Section 2 provides the basic set-up. In Section 3 we turn to the behavior of banks and derive the no-gambling condition, and in section 4 we address optimal regulation. Section 5 provides comparative statics, and in section 6 we consider a partial deposit insurance scheme. Finally, section 7 concludes.

2 Model

We are considering an economy which operates for an infinite number of periods. There are n risk neutral banks in the economy. Banks are indexed by $i = 1, 2, .., n$. Each period banks compete for depositors, where competition is assumed monopolistic along the lines of Salop (1979). That is, there is a continuum of overlapping depositors located uniformly around a circle. Depositors live for two periods; they are endowed with one unit of cash; and they only want to consume in the second period. Total length around the circle is normalized to one, and the n banks locate symmetrically around the circle. Depositors incur a transportation cost when travelling around the circle which is equal to μ times the distance between the bank and the depositor. In a symmetric equilibrium each bank offers the same deposit rate and mobilizes $1/n$ units of deposits in each period.

Banks invest the collected deposits in either a gambling asset or a prudent asset. The gambling asset pays γ per unit invested with probability θ and zero with probability $1-\theta$. The prudent asset pays α with certainty. We assume that $\gamma > \alpha > \theta\gamma$. This implies that the prudent asset has a higher expected value than the gambling asset, but when gambling succeeds the gambling asset has a higher payoff than the prudent asset.

We assume the existence of a government safety net. That is, all banks are covered by a deposit insurance scheme.[5] The existence of a deposit insurance scheme creates a potential desire for bank regulation on part of the deposit insurer. We consider optimal regulation from the perspective of a benevolent bank regulator. The regulator has two instruments at its disposal. It can set a capital requirement and it can audit banks. Capital requirements impose a cost on the banks since the opportunity cost of capital is $\rho > \alpha$.[6] When conducting an ex-ante audit, the regulator exerts an effort, $e \in (0,1)$, which allows it to detect a gambling bank with probability e. The cost of ex-ante audits is a function of effort and the number of banks, i.e. $c(e,n)$. The cost function is strictly convex in e and obey the Inada conditions: $c(0,n) = 0$, $\lim_{e\to 1} c(e,n) = \infty$, $c_e(0,n) = 0$, $\lim_{e\to 1} c_e(e,n) = \infty$. The cost function is also increasing in n, $c_n(e,n) > 0$. The cross derivative of the cost function is assumed to be nonnegative, i.e. $c_{en}(e,n) \geq 0$.[7]

Ex-ante auditing in our setup refers to the amount of auditing which is typically allocated to overseeing the amount of risk taking by banks. That is, the amount over and above what is needed to secure compliance with capital requirements. To be sure, in practice there exists a complementarity between ex-ante audits and the capital requirement. This is not captured in our specification. However, none of our results relies on this simplification.[8]

The regulator can seize the bank's license if the bank is caught gambling.[9]

[5] We demonstrate in section 6 that all our results carry over to a setting with only a partial deposit insurance scheme.

[6] We can think of the cost of capital as the dilution cost to the owners (see for instance Bolton and Freixas, 2000).

[7] We are thus assuming that it could become marginally more costly to monitor when more banks are entering the banking industry. The central bank in Thailand lost a significant amount of its most qualified staff to the private banking sector following the financial liberalization in the 1990s (Stiglitz, 2000). Private banks could, among other things, offer higher wages. Clearly, this would reduce the quality of the pool of prospective regulators and certainly contribute to a $c_{en}(e,n) > 0$.

[8] To see this, consider the following simple cost structure: Let E be the constant cost of ex-ante auditing of capital compliance. That is, it costs the bank regulator E to implement a capital requirement. The modified cost function is $C(e,E,n) = c(e,n) + 1_{[k>0]}E$, where $1_{[k>0]}$ is the indicator function. With this new cost structure the results in the paper would not change qualitatively.

[9] Cambell *et al.* (1992) and Morrison and White (2002) also assume that the regulator

We assume that there are no costs of closing an existing bank and setting up a new one. Hence, it is optimal for the regulator to remove the bank's license if it is caught gambling and allow a new bank to enter the market. Furthermore, at the end of the period the regulator observes if a bank is insolvent in which case the bank is also replaced by a new bank. Hence, at the beginning of any period the total number of banks is always n. Finally, all players discount the future according to $\delta \in (0,1)$.

The timing of the per-period stage game is as follows: First, the bank regulator chooses the amount of regulation; then banks choose both the deposit interest rate they will pay to depositors and in which assets to invest. Next, the regulator inspects the banks. Finally, returns are realized.

3 Bank Behavior

Consider an individual bank i offering a deposit rate equal to r_i, while the $n-1$ remaining banks offer r. The marginal depositor who is indifferent between going to i and $i+1$ will be located at distance x from bank i, where x is determined by $r_i - \mu x = r - \mu(1/n - x)$, and where $1/n - x$ is the distance between bank $i+1$ and the marginal depositor. Solving for x we obtain $x = (r_i - r)/2\mu + 1/2n$. The same reasoning applies for bank i and $i-1$. Since bank $i-1$ and $i+1$ are bank i's only effective competitors, we obtain

$$D(r_i, r) = 2x = \frac{r_i - r}{\mu} + \frac{1}{n}, \tag{1}$$

where $D(r_i, r)$ is the amount of deposits collected by bank i.

3.1 Prudent behavior

Given e and k an individual bank choosing the prudent asset will solve the following problem:

$$\max_{r_i} \left\{ (\alpha(1+k) - r_i - \rho k) \, D(r_i, r) + \delta V_P \right\}, \tag{2}$$

where V_P is the infinite stream of future profits from the prudent strategy. Note that a bank invests both the deposits it mobilizes and the imposed capital requirement share k of its own capital. The latter is expressed as

can close down a bank if monitoring has revealed that the bank is risky.

a percentage of the deposits mobilized. The total assets invested therefore becomes $(1+k)D(r_i, r)$.[10]

Solving (2) and using both (1) and the fact that $r_i = r$ in a symmetric Nash equilibrium, we obtain

$$r_P(k) = \alpha(1+k) - \rho k - \frac{\mu}{n}. \tag{3}$$

We can derive an expression for the franchise value by using both (3) and (1) in (2). We obtain

$$V_P = \frac{\mu}{(1-\delta)n^2}. \tag{4}$$

In Hellmann et al. (2000), an increase in capital decreases banks' franchise values. A lower franchise value increases banks' risk-taking incentives since it lowers the loss if a bank gambles and fails. They denote this the franchise-value effect of capital. In the present setup, banks pass the entire cost of capital on to depositors. Therefore, capital has no franchise-value effect. The reason can be seen upon inspecting (3). Banks simply lower equilibrium deposit rates proportionally to the cost of capital and, as can be seen from (1), this has no effect on deposits. In addition, we observe that ex-ante audits has no effect on the franchise value of a prudent bank. The bank regulator bears the full cost of ex-ante auditing.

3.2 Symmetric banking equilibrium

The n banks take e and k as given and play a stage game in which they choose an interest rate and either the prudent or the gambling investment. Since the per-period payoff functions are uniformly bounded, and since the overall payoffs are a discounted sum of per-period payoffs, we have by the one-stage deviation principle for infinite-horizon games that a strategy profile s is subgame perfect if and only if no player can gain by deviating in a single period and conforming to s thereafter.[11] In the present setup this translates into that if the $n-1$ remaining banks play the prudent strategy, no individual bank i will have an incentive to deviate if and only if the following one-stage deviation condition is satisfied:

$$\max_{r_i}(1-e)\left\{(\theta\left(\gamma(1+k) - r_i\right) - \rho k)\left(\frac{1}{n} + \frac{r_i - r_P(k)}{\mu}\right) + \theta\delta V_P\right\} \leq V_P. \tag{5}$$

[10] Since the opportunity cost of capital ρ is greater than the yield of the safe asset α, capital requirements impose a cost on the bank equal to $(\rho - \alpha)k$ per unit deposit.

[11] See Theorem 4.2 in Fudenberg and Tirole (1991).

That is, the expected payoff from a one-period gambling deviation while playing the prudent strategy thereafter (the LHS of (5)) must not exceed the value of playing the prudent strategy in all periods (the RHS).

Differentiating (5) with respect to r_i and setting equal to zero gives the optimal deviation interest rate, $\hat{r}_i$. Substitution of $\hat{r}_i$ back into (5) and using (3) and (4) yields

$$\widetilde{V} \equiv \left(\frac{(\gamma-\alpha-\Delta k)\,n+2\mu}{2\mu}\right)^2 - \frac{1-(1-e)\delta\theta}{(1-e)\,(1-\delta)\,\theta} \leq 0, \tag{6}$$

where $\Delta \equiv ((\theta\,(\alpha-\gamma)+(1-\theta)\,\rho)\,/\theta) > 0$.[12] Thus, whenever (6) is satisfied no single bank will have an incentive to deviate, and the prudent equilibrium is a subgame-perfect Nash equilibrium. Consequently, (6) is a *no-gambling condition.*[13] In addition, it follows from (6) that whenever

$$n > \frac{2\mu}{\gamma-\alpha}\left(\sqrt{(1-\delta\theta)\,/\,(1-\delta)\,\theta}-1\right), \tag{7}$$

some regulation is needed to implement the prudent equilibrium.[14] We assume that (7) is always satisfied.

Differentiating (6) with respect to k gives

$$\frac{\partial\widetilde{V}}{\partial k} = -\frac{\Delta n}{2\mu^2}\left((\gamma-\alpha-\Delta k)\,n+2\mu\right). \tag{8}$$

The capital requirement is effective if and only if $\partial\widetilde{V}/\partial k < 0$. The following lemma demonstrates that there always exists a non-empty interval where the capital requirement is effective:

Lemma 1 *For all ρ there exists a non-empty interval $\left[0,\overline{k}\right)$, where $\overline{k} = \left(\gamma-\alpha+2\frac{\mu}{n}\right)/\Delta > 0$, in which the capital requirement is effective.*

Proof. Since $\Delta > 0$, (8) is negative if and only if $(\gamma-\alpha-\Delta k)\,n+2\mu > 0$. Use the expression for Δ in $(\gamma-\alpha-\Delta k)\,n+2\mu > 0$ to get

$$\rho < \frac{\theta\left((\gamma-\alpha)\,(1+k)+2\frac{\mu}{n}\right)}{(1-\theta)\,k} \equiv \widetilde{\rho}(k). \tag{9}$$

[12] To show that $\Delta > 0$ we use that $\rho > \alpha > \theta\gamma$.

[13] The model has another equilibrium, which is an equilibrium where all banks gamble. However, since the prudent equilibrium is Pareto-dominating, we assume that banks play the prudent equilibrium.

[14] Specifically, (6) defines a quadratic equation in n with positive discriminant. However, since $\gamma-\alpha > 0$, the second root is always negative.

Whenever (9) is satisfied, $\partial \widetilde{V}/\partial k < 0$ for a given $k > 0$. Upon inspection of (9) it can be verified that $d\widetilde{\rho}(k)/dk < 0$, $\lim_{k\to 0}\widetilde{\rho}(k) = \infty$, and $\lim_{k\to\infty}\widetilde{\rho}(k) = \theta(\gamma-\alpha)/(1-\theta) < \alpha$. Since $\rho > \alpha$, there exists a $\overline{k} > 0$ such that $\widetilde{\rho}(\overline{k}) = \rho$. It follows that capital is effective in the non-empty interval $k \in \left[0, \overline{k}\right)$, where $\overline{k} = \left(\gamma - \alpha + 2\frac{\mu}{n}\right)/\Delta > 0$. ■

Thus, by the lemma the equilibrium level of the capital requirement will always belong to the interval $0 \leq k < \overline{k}$.

Turning to the other regulatory instrument, we have that differentiating (6) with respect to e gives

$$\frac{\partial \widetilde{V}}{\partial e} = -\frac{1}{(1-e)^2(1-\delta)\theta} < 0, \tag{10}$$

for all $e \in [0,1[$. Hence, ex-ante audits of banks always lowers incentives to gamble.

By differentiating (6) with respect to γ we get

$$\frac{\partial \widetilde{V}}{\partial \gamma} = \frac{(1+k)n}{2\mu^2}\left((\gamma-\alpha-\Delta k)n + 2\mu\right) > 0.$$

Thus, the higher the yield of the gambling asset, γ, the higher is the LHS of (6), and the more regulation is needed to sustain the prudent equilibrium. This is because an increase in γ increases the payoff from the one-period gambling deviation, and this in turn makes gambling more tempting.

By differentiating (6) with respect to n we get

$$\frac{\partial \widetilde{V}}{\partial n} = \frac{\left((\gamma-\alpha-\Delta k)n + 2\mu\right)}{2\mu^2}(\gamma-\alpha-\Delta k) \gtreqless 0.$$

An increase in the number of banks, n, will only lead to an increase in the LHS of (6) if $\gamma - \alpha - \Delta k > 0$. If $\gamma - \alpha - \Delta k < 0$ an increase in the number of banks will lead to a decrease in the LHS of (6), and less regulation is actually needed to sustain the prudent equilibrium.

The reason why an increase in n will not necessarily raise gambling incentives is that two opposite effects are at work. On the one hand, a higher number of banks erodes the franchise value from being a prudent bank. On the other hand, a higher n also lowers the payoff from the one-period gambling deviation. To see this more clearly, consider the effect on the one-stage deviation condition, given by (5), of an increase in n:

$$(1-e)\left[-\theta\frac{d\widehat{r}_i}{dn}D(\widehat{r}_i, r_p) + \left(\theta\left(\gamma(1+k) - \widehat{r}_i\right) - \rho k\right)\frac{dD(\widehat{r}_i, r_p)}{dn}\right] \lesseqgtr (1-(1-e)\theta\delta)\frac{dV_P}{dn},$$

where $d\widehat{r}_i/dn > 0$, $dD(\widehat{r}_i, r_p)/dn < 0$, and $dV_P/dn < 0$. The LHS is negative since a deviating bank has to pay a higher interest rate for a given amount of deposits and, at the same time, earns less for a given gambling margin since it mobilizes fewer deposits. The RHS is negative since market power, μ/n, and thus the franchise value, is falling. Whenever the LHS is numerically larger than the RHS, less regulation is needed following an increase in n.

We summarize the above discussion in the following proposition:

Proposition 2 *An increase in the yield of the gambling asset, γ, will always tighten the no-gambling condition. An increase in the number of banks, n, will slacken (resp. tighten) the no-gambling condition if and only if $k > (\gamma - \alpha)/\Delta$ (resp. $k < (\gamma - \alpha)/\Delta$).*

We therefore have the surprising result that an increase in the number of banks may actually slacken the no-gambling condition. This is in contrast to the result in Hellmann et al. (2000), where increased competition always leads to higher gambling incentives since franchise values are being eroded. The present paper captures another effect: an increase in competition also lowers the gain from gambling by reducing the scope for deposit mobilization. The net effect on banks' gambling incentives depends on which of the two effects dominates.

4 Optimal Regulation

The bank regulator maximizes the sum of banks' franchise values and the interest payments to depositors minus ex-ante auditing costs. There is a difference between the two instruments in that the cost of capital requirements are paid directly by banks, and, to the extent that higher capital requirements are translated on to depositors, also by depositors. In the present setup the costs of capital requirements are paid solely by depositors. Ex-ante auditing costs are financed by some distortionary mechanism. We express the net social cost as $\lambda > 0$.

A prudent equilibrium is only possible if (6) is satisfied, and we assume throughout the paper that the bank regulator wants to implement the prudent equilibrium. Together with the Inada conditions, this implies that e will be strictly positive in optimum. Therefore, the bank regulator solves the following program:

$$\max_{e>0,k\geq 0} \left(\frac{1}{1-\delta}\right)\left(\alpha(1+k) - \rho k - (1+\lambda)\, c(e,n)\right), \tag{11}$$

subject to the no-gambling condition (6).[15]

Turning to the solution, note that (6) will bind since the objective function is decreasing in the two arguments and (6) is more easily satisfied the higher the two instruments. The first-order conditions are

$$(1+\lambda)\, c_e(e,n) = \phi \frac{1}{(1-e)^2\theta}, \tag{12}$$

$$\frac{\rho-\alpha}{1-\delta} = \Delta n \phi \frac{(\gamma-\alpha-\Delta k)\, n + 2\mu}{2\mu^2} + \mu_k, \tag{13}$$

$$\left(\frac{(\gamma-\alpha-\Delta k)\, n + 2\mu}{2\mu}\right)^2 = \frac{1-(1-e)\delta\theta}{(1-e)\,(1-\delta)\,\theta}, \tag{14}$$

$$\mu_k \geq 0 \ (= 0 \text{ if } k > 0), \tag{15}$$

where ϕ is the multiplier associated with (6). The necessary second-order conditions are derived in Appendix A.1.[16] It follows from the first-order conditions that the lower the marginal cost of ex-ante audits, the higher is the optimum level of auditing, and the lower is the capital requirement.

Inspection of the first-order conditions shows that a necessary condition for $k > 0$ is that $c_e(e,n)$ is not too low. When $k > 0$, $\mu_k = 0$. Using this and dividing (12) and (13) gives

$$\frac{(1+\lambda)\, c_e(e,n)}{\rho-\alpha} = \frac{2\mu^2}{(1-e)^2(1-\delta)\theta\Delta n\left((\gamma-\alpha-\Delta k)\, n + 2\mu\right)}. \tag{16}$$

This is a standard optimality condition. The LHS is the ratio of the marginal cost of the two instruments, and the RHS side is the ratio of the marginal benefit of the two instruments in lowering the incentives to take risk.

[15] Written in full the objective function is

$$\sum_{t=0}^{\infty} \delta^t \left[n\left(\alpha(1+k) - r_P(k) - \rho k\right) \frac{1}{n} + r_P(k) - (1+\lambda)\, c(e,n) \right].$$

The first term inside the square bracket is the total net return to the banking system from investing in the prudent asset; $r_P(k)$ is the deposit rate paid to the unit mass of depositors; and $(1+\lambda)\, c(e,n)$ is the total social cost of ex-ante audits. As n and $r_P(k)$ cancels out we obtain (11).

[16] We require that the cost function is sufficiently curved.

5 Comparative Statics

In this section we turn to the comparative statics with respect to changes in the number of banks, n; changes in the yield of the gambling asset, γ; and changes in the net social cost of financing ex-ante audits, λ.

Turning first to a change in the number of banks we have the following result:

Proposition 3 $\partial e/\partial n < 0, \partial k/\partial n \begin{cases} > 0 & \text{if} \quad k < (\gamma - \alpha)/\Delta \\ \gtreqless 0 & \text{if} \quad k > (\gamma - \alpha)/\Delta \end{cases}$

Proof. See Appendix. ■

By Proposition 3, an increase in n always decreases the level of ex-ante audits. When more regulation is required following the increase in competition, i.e. when $k < (\gamma - \alpha)/\Delta$, the capital requirement should always increase. These are surprising results. What drives them are differences in how the two regulatory instruments work. Recall that by (4), an increase in n reduces the franchise value from pursuing the prudent strategy. At a given level of ex-ante audits, this renders the positive incentive effect of loosing the franchise value if caught gambling correspondingly smaller. That is, ex-ante audits becomes less effective as a regulatory instrument. In addition, the marginal cost of ex-ante audits is always increasing since $c_{ee}(e, n) > 0$, whereas the marginal cost of capital is constant. Consequently, an increase in the number of banks always leads to less ex-ante auditing, and it always leads to a higher capital requirement when more regulation is called for.[17]

Turning next to a change in the yield of the gambling asset we have the following result:

Proposition 4 $\partial e/\partial \gamma > 0, \partial k/\partial \gamma \gtreqless 0.$

Proof. See Appendix. ■

An increase in the gambling yield always results in an increase in ex-ante audits of banks, whereas capital requirements may go in either direction. To gain more insight into this result we consider the derivatives of (8) and (10) with respect to γ:

$$\frac{\partial^2 \widetilde{V}}{\partial e \partial \gamma} = 0,$$

[17] Many authors have argued that alongside measures of financial liberalization, regulators should be empowered so as to be able to enforce strict bank closure policies (Kane and Rice, 2000). However, Proposition 3 reveals that the benefits from such a policy is weakened by the negative franchise-value effect of increased competition.

and

$$\frac{\partial^2 \widetilde{V}}{\partial k \partial \gamma} = \frac{n}{2\mu^2}\left[\left(\gamma - \alpha - \Delta\left(1+2k\right)\right)n + 2\mu\right] \gtreqless 0. \tag{17}$$

Thus, following an increase in γ the effectiveness of ex-ante auditing remains constant, whereas the capital requirement may become more or less effective. In fact, there is a one-to-one correspondence between the effectiveness of the capital requirement following an increase in the gambling yield and the sign of

$$\frac{\partial\left(D(\widehat{r}_i(k), r_P(k))(1+k)\right)}{\partial k} = \frac{1}{n} + \frac{\gamma - \alpha - \Delta\left(1+2k\right)}{2\mu}, \tag{18}$$

where $D(\widehat{r}_i(k), r_P(k))(1+k)$ is the size of a gambling bank. It is straightforward to verify that a necessary and sufficient condition for (17) to be positive is that (18) is positive. Thus, capital becomes more effective following an increase in γ if and only if an increase in k lowers the size of a deviating bank.

Using the expression for Δ in (17), we have that $\partial^2\widetilde{V}/\partial k\partial\gamma < 0$ is equivalent to

$$\rho > \widehat{\rho}(k) \equiv \frac{2\theta\left(\left(\gamma-\alpha\right)\left(1+k\right)+\frac{\mu}{n}\right)}{\left(1+2k\right)\left(1-\theta\right)}. \tag{19}$$

It is easily verified that $d\widehat{\rho}(k)/dk < 0$, whence a necessary and sufficient condition for $\partial^2\widetilde{V}/\partial k\partial\gamma < 0$ for all $k \in \left[0, \overline{k}\right)$ is that

$$\rho > \widehat{p}_0 \equiv \frac{2\theta}{(1-\theta)}\left(\gamma + \frac{\mu}{n} - \alpha\right),$$

where $\widehat{p}_0 = \lim_{k\to 0}\widehat{p}(k) > \alpha$. Whenever $\rho > \widehat{p}_0$ capital always becomes more effective when γ increases and $\partial k/\partial\gamma > 0$ prevails.

From lemma 1 we know that $\partial\widetilde{V}/\partial k < 0$ for all $k \in \left[0, \overline{k}\right)$. That is, capital is always effective in equilibrium. But whenever $\partial^2\widetilde{V}/\partial k\partial\gamma > 0$ it becomes marginally less effective with respect to an increase in γ. Intuition would therefore suggest that if the marginal effectiveness of capital increases with γ, the use of the capital requirement should increase in optimum. This is confirmed by the following proposition, where we state necessary and sufficient conditions for the sign of $\partial k/\partial\gamma$ to be determinable:

Proposition 5 *There exists $\nu > 0$ such that $\partial k/\partial\gamma < 0$ if and only if $\partial^2\widetilde{V}/\partial k\partial\gamma > \nu$.*

Proof. See Appendix. ■

To understand why $\partial k/\partial \gamma$ may be negative two things should be noted. First, capital is always effective both before and after the increase in the gambling yield. However, when $\partial^2 \widetilde{V}/\partial k \partial \gamma > 0$ capital becomes marginally less effective. If the decrease in the effectiveness is sufficiently large it dominates the increase in the marginal cost of ex-ante audits. When this is the case the use of capital should decrease in optimum.

Finally, turning to an increase in the social costs of financing ex-ante audits, λ, we have that since this only affects the objective function of the bank regulator, $\partial e/\partial \lambda < 0$, $\partial k/\partial \lambda > 0$. Although this is very trivial analytically, we believe it to be worthwhile emphasizing. In a typical developing country there are significant costs of financing the ex-ante auditing activity. There are distortionary costs deriving from inefficient tax regimes. In addition, developing countries face high opportunity costs since governments have to spend scarce funds that could otherwise have been spend on public health, road construction, education, etc.[18]

6 Partial Deposit Insurance

Until now we have simply assumed the existence of a full deposit insurance scheme. In this section we investigate the sensitivity of our results to that assumption. In particular, we incorporate a parameter $\pi \in [0, 1]$ into the model, where π can be interpreted in two different ways. First, it may be interpreted as a partial deposit insurance scheme: viz., as the fraction of deposits covered in the case of bank default. But secondly, it may also be interpreted as the probability of a full depositor bailout.

We assume that depositors are risk-neutral.[19] Consider a gambling bank i offering a deposit interest rate equal to r_i while the $n-1$ remaining banks offer the prudent interest rate, $r_P(k)$. By similar arguments as in the derivation of (1), the gambling bank faces the following demand function for deposits: $D(r_i, r_P(k)) = ((\theta + \pi(1-\theta))r_i - r_P(k))/\mu + 1/n$. The modified one-stage

[18] Millions of aid dollars and technical assistance have been spend on developing the regulatory infrastructure in many developing countries (Cole and Slade, 1998)

[19] The assumption of risk neutrality simplifies the derivations substantially. However, if depositors are not "too" risk-averse, our results do not change qualitatively.

deviation condition becomes

$$\max_{r_i}(1-e)\left\{(\theta\left(\gamma(1+k)-r_i\right)-\rho k)\times\right.$$
$$\left.\left(\frac{((\theta+\pi(1-\theta))r_i-r_P(k))}{\mu}+\frac{1}{n}\right)+\theta\delta V_P\right\}\leq V_P \quad (20)$$

Upon solving (20) for the optimal deviation interest rate and substituting the expression back into (20), we obtain the no-gambling condition with partial deposit insurance

$$\widetilde{W}\equiv\frac{1}{\varphi}\left(\frac{(\varphi\gamma-\alpha-\bar{\Delta}k)n+2\mu}{2\mu}\right)^2-\frac{(1-(1-e)\theta\delta)}{(1-e)(1-\delta)\theta}\leq 0, \quad (21)$$

where $\varphi\equiv\theta+\pi(1-\theta)$ and $\bar{\Delta}\equiv\alpha-\varphi\gamma+\rho\left(\varphi-\theta\right)/\theta>0$.

Consider first the issue of whether any regulation at all is required in order to implement the prudent equilibrium with partial deposit insurance. Setting $e=k=0$ in (21), banks will have incentives to gamble when

$$\frac{1}{\varphi}\left(\frac{(\varphi\gamma-\alpha)n+2\mu}{2\mu}\right)^2-\frac{(1-\theta\delta)}{(1-\delta)\theta}>0. \quad (22)$$

(22) defines a quadratic equation in n whenever $\varphi\gamma\neq\alpha$. Since the determinant is always positive, there are two real roots. One root is always negative and one is always positive. Depending on whether $\varphi\gamma\lesseqgtr\alpha$ the positive root is given by

$$n=\begin{cases}\frac{2\mu}{\varphi\gamma-\alpha}\left(\sqrt{\varphi\left(1-\theta\delta\right)/\left(1-\delta\right)\theta}-1\right) & \text{if } \alpha<\varphi\gamma,\\ \\ \frac{2\mu}{\alpha-\varphi\gamma}\left(1+\sqrt{\varphi\left(1-\theta\delta\right)/\left(1-\delta\right)\theta}\right) & \text{if } \alpha>\varphi\gamma.\end{cases} \quad (23)$$

It is, however, possible to rule out the root where $\alpha>\varphi\gamma$.[20] To see this, note first that (22) can be rewritten as

$$\frac{\theta}{2}\left(\gamma-\frac{\alpha}{\varphi}+2\frac{\mu}{n\varphi}\right)\left(\frac{\gamma\varphi-\alpha}{2\mu}+\frac{1}{n}\right)-\frac{\mu\left(1-\theta\delta\right)}{\left(1-\delta\right)n^2}>0.$$

The term $\left(\left(\gamma\varphi-\alpha\right)/2\mu+1/n\right)$ is the amount of deposits mobilized by a deviating bank when there is no regulation. When $\alpha>\varphi\gamma$, the amount

[20] Note that full deposit insurance implies $\pi=1$ and hence $\varphi=1$, from which it immediately follows that condition (23) specializes to (7).

mobilized by the deviating bank is always strictly smaller than the amount mobilized by a prudent bank, $1/n$. The term $(\theta/2)(\gamma - \alpha/\varphi + 2\mu/n\varphi)$ is the gambling margin per unit deposit earned by a gambling bank. When $\alpha > \varphi\gamma$, this margin is always strictly smaller than μ/n, which is the margin earned by a prudent bank. Hence, deviation in this case can never by an optimal strategy. The reason why we obtain the root when $\alpha > \varphi\gamma$ is that a negative margin times a negative amount of deposits mobilized yields a positive one-period gambling deviation. Clearly, this case must be ruled out. Next, when $\alpha = \varphi\gamma$ regulation is never needed. This is easily verified upon substituting $\alpha - \varphi\gamma = 0$ into (22).

To sum, a necessary condition for regulation in equilibrium is that $\alpha < \varphi\gamma$, and this determines a range on π within which regulation is always needed. This range is given by $\pi \in \,](\alpha - \theta\gamma)/(\gamma - \theta\gamma), 1]$. Sufficiency requires, in addition, that the number of banks is larger than the corresponding root given by (23). We summarize this in the following proposition:

Proposition 6 *Whenever the partial deposit insurance scheme, π, is within the range $\pi \in \,](\alpha - \theta\gamma)/(\gamma - \theta\gamma), 1]$, and whenever the number of banks is sufficiently large, i.e. when (23) is satisfied, bank regulation is always required.*

Consider the case where the conditions in the above proposition are met. Differentiating (21) with respect to e gives the same as (10), so e is still an effective instrument. Differentiating with respect to k gives

$$\frac{\partial \widetilde{W}}{\partial k} = -\frac{1}{\varphi}\frac{\bar{\Delta}n}{2\mu^2}\left((\varphi\gamma - \alpha - \bar{\Delta}k)n + 2\mu\right).$$

Since $\bar{\Delta} > 0$ we require $(\varphi\gamma - \alpha - \bar{\Delta}k)n + 2\mu > 0$ in order to ensure that capital is an effective instrument, i.e. that $\partial\widetilde{W}/\partial k < 0$. By similar arguments as used in the proof of lemma 1, we have that capital is always effective in a non-empty interval.

Turning to an increase in the gambling yield we get

$$\frac{\partial \widetilde{W}}{\partial \gamma} = \frac{(1+k)n}{2\mu^2}\left(\left(\varphi\gamma - \alpha - \bar{\Delta}k\right)n + 2\mu\right) > 0.$$

As before, an increase in γ always raises gambling incentives.

The incentive effect of an increase in the number of banks is given by

$$\frac{\partial \widetilde{W}}{\partial n} = \frac{1}{2\varphi\mu^2}((\varphi\gamma - \alpha - \bar{\Delta}k)n + 2\mu)(\varphi\gamma - \alpha - \bar{\Delta}k) \lesseqgtr 0.$$

As before, an increase in the number of banks may slacken the no-gambling condition.

Since the derivatives of the modified no-gambling condition (21) with respect to e, k, n, and γ all have unchanged signs, and since the objective function of the bank regulator is also unchanged, it is routine to show that all our comparative statics results carry over to the setup with partial deposit insurance as long as the conditions in proposition 6 are met.[21]

7 Conclusions

Our analysis has shown that the optimal regulatory mix of ex-ante audits and capital requirements following financial liberalization is dependent upon the extent to which liberalization brings about increases in gambling-asset yields versus increases in competition. When there is a large increase in competition, e.g. through new entrants into the banking sector, regulation should rely more on capital requirements and less on on-site inspections. On the other hand, when there are increases in gambling yields, on-site inspections should always increase, whereas the capital requirement could increase or decrease.

Consequently, in a country such as China, where liberalization is only domestic and where new entry into the banking sector is widespread, the model therefore suggests a primary reliance on capital requirements. In Korea in the 1990s, capital account liberalization caused boom-bust cycles (Kim et al., 2003). Capital account liberalization led to an initial surge in capital, real exchange rate appreciation, domestic credit expansion, consumption and investment boom, and asset price bubbles. Similar patterns were observed in other East Asian countries (Furman and Stiglitz, 1998). Our model suggests that in such environments, on-site inspections should increase, whereas capital requirements should not necessarily increase. This is even more pertinent when consumption and investment lending is tightly rationed prior to capital account liberalization. Such preconditions are likely to intensify a boom-bust cycle (Kim et al., 2003).

Our results suggest that developing countries will find it less difficult to successfully implement domestic financial liberalization than capital account liberalization. Domestic financial liberalization does not necessarily require more regulation; and when it does, regulation should rely more on capital requirements and less on on-site inspections. This is good news in the sense that the former system is more based on "hard" information. That is, it is

[21] The derivations of these results are available from the authors upon request.

based on banks' financial statements, which are both supported by compulsory external audits and usually publicly available. This, in principle, leaves enforcement of capital requirements less open to regulatory forbearance.

Capital account liberalization always require more regulation, and regulation should rely more on on-site inspections and less on capital requirements. Information obtained by on-site inspections is both "soft" and to a high degree also private information to the regulator. This leaves on-site inspections more open to regulatory forbearance. In addition, the opaqueness of financial transactions increases as a result of complex financial instruments. This puts a lot of strain on the bank regulator. It certainly requires a highly skilled staff that has to obtain detailed and timely financial information. This is probably beyond what most regulatory authorities in developing countries can muster.

A Appendix

A.1 Concavity of the Lagrangian

Define $\pounds$ to be the Lagrangian of the program (11). $\pounds$ is concave in e, k if

$$\pounds_{ee} \leq 0, \pounds_{kk} \leq 0, \text{ and } \pounds_{ee}\pounds_{kk} - (\pounds_{ek})^2 \geq 0.$$

We have that

$$\begin{aligned}
\pounds_{ee} &= -(1+\lambda)\frac{c_{ee}}{1-\delta} + \frac{2\phi}{(1-e)^3(1-\delta)\theta} \lesseqgtr 0, \\
\pounds_{kk} &= -\frac{\phi(\Delta n)^2}{2\mu^2} < 0, \\
\pounds_{ke} &= \pounds_{ek} = 0.
\end{aligned}$$

Hence if $\pounds_{ee} \leq 0$ the Lagrangian is concave. This reduces to the requirement

$$\frac{2\phi}{(1-e)^3\theta(1+\lambda)} \leq c_{ee}(e,n). \tag{24}$$

A.2 Comparative statics

We assume an interior solution. The system of first-order conditions is:

$$\begin{aligned}
\pounds_{e} &= -(1+\lambda)\frac{c_e(e,n)}{1-\delta} + \frac{\phi}{(1-e)^2(1-\delta)\theta} = 0, \\
\pounds_{k} &= \frac{\alpha-\rho}{1-\delta} + \frac{\phi\Delta n}{2\mu^2}\left((\gamma-\alpha-\Delta k)n + 2\mu\right) = 0, \\
\pounds_{\phi} &= -\left(\left(\frac{[\gamma-\alpha-\Delta k]n + 2\mu}{2\mu}\right)^2 - \frac{1-(1-e)\delta\theta}{(1-e)(1-\delta)\theta}\right) = 0.
\end{aligned}$$

The determinant of the Jacobian, J, is given by

$$\begin{aligned}
|J| = \frac{\phi(\Delta n)^2}{2\mu^2(1-e)^4(1-\delta)^2\theta^2} - &\left[-(1+\lambda)\frac{c_{ee}(e,n)}{1-\delta} + \frac{2\phi}{(1-e)^3(1-\delta)\theta}\right] \\
&\times \left[\frac{\Delta n}{2\mu^2}\left((\gamma-\alpha-\Delta k)n + 2\mu\right)\right]^2.
\end{aligned}$$

By (24), $|J| > 0$.

A.2.1 Proof of Proposition 3

The determinant $|J_{en}|$ is given by

$$|J_{en}| = (1+\lambda)\frac{c_{en}(e,n)}{(1-\delta)}\left[\frac{\Delta n}{2\mu^2}\left(\left(\gamma-\alpha-\Delta k\right)n+2\mu\right)\right]^2 + \frac{\phi\Delta^2 n\left[\left(\left(\gamma-\alpha-\Delta k\right)n\right)^2+4\mu^2+4\mu\left(\gamma-\alpha-\Delta k\right)n\right]}{4\mu^4\left(1-e\right)^2\left(1-\delta\right)\theta} > 0,$$

where we have used that by lemma 1, $\left(\gamma-\alpha-\Delta k\right)n > -2\mu$. It follows that

$$\frac{\partial e}{\partial n} = -\frac{|J_{en}|}{|J|} < 0.$$

The determinant $|J_{kn}|$ is

$$|J_{kn}| = \left[-\left(1+\lambda\right)\frac{c_{ee}(e,n)}{1-\delta}+\frac{2\phi}{\left(1-e\right)^3\left(1-\delta\right)\theta}\right]\times \left[\frac{\left(\left(\gamma-\alpha-\Delta k\right)n+2\mu\right)^2\Delta n\left(\gamma-\alpha-\Delta k\right)}{4\mu^4}\right] - \left[\frac{\phi\Delta\left(2\left(\gamma-\alpha-\Delta k\right)n+2\mu\right)}{2\mu^2\left(\left(1-e\right)^2\left(1-\delta\right)\theta\right)^2} + \frac{\left(1+\lambda\right)c_{en}(e,n)\Delta n\left(\left(\gamma-\alpha-\Delta k\right)n+2\mu\right)}{2\mu^2\left(1-e\right)^2\left(1-\delta\right)^2\theta}\right].$$

The expression inside the last bracket is always positive. Using (24), the product of the first two brackets is negative if and only if $k < \left(\gamma-\alpha\right)/\Delta$. We thus have that

$$\frac{\partial k}{\partial n} = -\frac{|J_{kn}|}{|J|} > 0,$$

when $k < \left(\gamma-\alpha\right)/\Delta$. When $k > \left(\gamma-\alpha\right)/\Delta$, $\partial k/\partial n \lesseqgtr 0$.

A.2.2 Proof of Proposition 4

We have that

$$|J_{e\gamma}| = -\frac{\phi\Delta n^2\left[\left(\gamma-\alpha-\Delta k\right)n+2\mu\right]^2}{4\mu^4\left(1-e\right)^2\left(1-\delta\right)\theta} < 0,$$

and therefore that

$$\frac{\partial e}{\partial \gamma} = -\frac{|J_{e\gamma}|}{|J|} > 0.$$

The determinant of $|J_{k\gamma}|$ is

$$|J_{k\gamma}| = \frac{\phi n \left(\left(\gamma - \alpha - \Delta \left(1 + 2k \right) \right) n + 2\mu \right)}{2\mu^2 \left(\left(1 - e \right)^2 \left(1 - \delta \right) \theta \right)^2} + \left[- \left(1 + \lambda \right) \frac{c_{ee}(e,n)}{1-\delta} + \frac{2\phi}{\left(1 - e \right)^3 \left(1 - \delta \right) \theta} \right] \times \left[\frac{(1+k)\Delta n^2 \left(\left(\gamma - \alpha - \Delta k \right) n + 2\mu \right)^2}{4\mu^4} \right]. \quad (25)$$

By (24), the product of the terms in the square brackets is negative. The non-bracketed term may be either positive or negative, leaving the sign of $|J_{k\gamma}|$ indeterminate. Hence

$$\frac{\partial k}{\partial \gamma} = -\frac{|J_{k\gamma}|}{|J|} \gtreqless 0. \quad (26)$$

A.2.3 Proof of Proposition 5

Define ν to be the value of (17) that makes (25) equal to zero. From the proof of Proposition 4, we have that $\partial^2 \widetilde{V} / \partial k \partial \gamma > \nu$ if and only if $\partial k / \partial \gamma < 0$.

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