Branch or Subsidiary? Capital Regulation of Multinational Banks*

Thomas Harr
University of Copenhagen

Thomas Rønde
University of Copenhagen, CEBR, CEPR

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Abstract

We study capital regulation of multinational banks (MBs). The MBs can set up either as one legal unit facing limited liability jointly (branch structure) or as separate units, each subject to limited liability (subsidiary structure). MBs have private information about the risk that stems from their asset choices (moral hazard) and the inherent risk of their assets (adverse selection). The branch structure is shown to be more prudent, but when problems arise it is also more fragile. There exists an optimal screening mechanism where safe MBs choose a branch structure and receive a capital requirement discount whereas riskier MBs choose a subsidiary structure. Finally, capital requirements may increase when MBs are subject to two regulators.

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1 Introduction

One of the great challenges to contemporary financial regulation is cross-border banking. Multinational banks (MBs) have activities that reach across regulatory jurisdiction and they often have opaque ownership structures. Therefore, national regulators face both problems of cooperation and informational constraints when supervising MBs, which the scandal surrounding the bankruptcy of Bank of Credit and Commerce International illustrated with clarity.[1] Financial regulators worldwide have invested considerable efforts in developing a sound regulatory framework for MBs, but many questions remain open and deserve careful analysis (BIS, 1983 and 1992).

In this paper we will look at incentive problems that arise within a MB. Among the regulatory concerns are: a) losses and gains may be shifted between the entities within the MB to reduce tax payments or avoid regulatory scrutiny, b) capital requirements may be boosted artificially through stock purchase loans, and c) risks may "spill over" from one entity to another entity (BIS, 2003).

We analyze capital regulation of multinational banks with focus on the problem of risk spillovers. For most parts of the analysis we will abstract from problems related to opportunistic behavior by national regulators and instead restrict attention to study optimal regulation from the perspective of a single regulator.[2] We consider a setup where a MB consists of two offices that have common ownership. The MB is subject to two types of risk: exogenous and endogenous risk. The exogenous risk is the probability that some of its investments will fail for reasons outside the control of the management. We will refer to the exogenous risk as the MB's "type". The endogenous risk stems from the asset choices of the MB, which are unobservable to outsiders. Each office collects deposits and invests them in either a prudent asset yielding the highest expected return or a gambling asset that yields high private return for the bank if the gamble succeeds but imposes costs on the deposit insurer if it fails. The MB can choose to set up either as one legal unit with two branches (a

[1] The liquidation of Bank of Credit and Commerce International has been running for more than 11 years and the costs have passed \$1.2bn (*The Guardian,* May 15, 2003).

[2] Calzolari and Loranth (2003) and Holthausen and Rønde (2003), for example, analyze how opportunistic behavior by national supervisors can lead to inefficient closure decisions.

branch-MB) or as two separate legal units (a subsidiary-MB). The important difference is that the offices are jointly liable for deposits in the branch structure but not in the subsidiary structure.[3]

We show that the two structures have different advantages from the point of view of regulation. A branch structure is less prone to risk-taking in “normal times”, because the downside of a gamble is carried by both offices. On the other hand, in “bad times” when one of the offices is in troubles, the other office has a stronger incentive to gamble in a branch-MB than in a subsidiary-MB. Put differently, risk spillovers occur only inside the branch structure. The incentive to gamble in the branch structure in bad times is very similar to the debt-overhang problem analyzed in the corporate finance literature (Myers, 1977; Green, 1984) and to the gambling for resurrection behavior studied in the banking literature (see e.g. Kane, 1989).

We analyze optimal capital regulation of branch- and subsidiary-MBs. In our model capital requirements have the standard feature that they reduce the incentive for banks to gamble by increasing the loss of shareholders in case of default (Rochet, 1992 and Hellman et al., 2000). Due to the effects explained above, a lower capital requirement is needed to ensure overall prudent investment in a branch structure in normal times. However, in order to stop gambling also in bad times, a branch-MB must face a higher capital requirement than a subsidiary-MB.

First, we consider a situation where a benevolent regulator observes the MB’s type and chooses both capital requirements and the MB’s legal structure optimally. In this case the regulator sets capital requirements to deal with the bank’s moral hazard problem with respect to its asset choices. Comparing the two legal structures, we show that the regulator may prefer that banks with an intermediate level of exogenous risk choose a subsidiary structure. Still, the branch structure tends to dominate, from a welfare point of view, because it economizes on private funds in the form of bank capital for low risk types and on public funds for deposit insurance for high risk types.

In the second part of the paper we look at the situation where the regulator cannot observe the exogenous risk of MBs. Hence, the regulator faces both a problem of moral

[3] For simplicity, we will sometimes refer to the MB as a ’bank’ even if it can legally be two separate banks.

hazard and adverse selection. The regulator then announces two capital requirements, one for the branch and another for the subsidiary structure, after which the MB chooses how to set up the bank. We argue that it is optimal from a welfare point of view to sort banks such that safe types choose a branch and riskier types a subsidiary structure. The subsidiary structure has the advantage for the banks that there is "double limited liability". That is, a loss in one office is not carried by the other office. It is therefore necessary to give branch-MBs a capital requirement discount compared to subsidiary-MBs to avoid that all types choose the subsidiary structure. Since double limited liability is more valuable to higher risk types, the banks self-select in the desired way: safe types choose the branch and riskier types the subsidiary structure. We show that screening is costly because the capital requirement for the branch structure has to be increased to induce the risky types to choose the subsidiary structure. Therefore, it may sometimes be welfare enhancing to set the capital requirement for the branch structure so low that all types choose this structure.

Our analysis has several implications with respect to capital adequacy rules. The Basel capital rules do not take into account multinational banks' liability structure. Our model suggests they should. Specifically, our analysis proposes that capital requirements for branch structures should be more sensitive to the overall health of the bank than for subsidiary structures. Moreover, to make it sufficiently attractive for banks to set up as branch structures, branch-MBs should in general face lower capital requirements than subsidiary-MBs.

In the last part of the paper we present an example that considers opportunistic behavior by national regulators. It is shown that regulators have incentives to increase capital requirements for subsidiary-MBs, because the cost of capital is shared with the other country. As a result, it may be necessary also to increase the capital requirement for branch-MBs to avoid that risky banks choose a branch structure. This is in contrast to Acharya (2003) and Dell 'Ariccia and Marquez (2003) who show that decentralized regulation tends to create a "race to the bottom" phenomenon as regulators attempt to further the competitive position of their domestic banks.

Besides the already mentioned, our analysis is related to a few other papers. In parallel work, Loranth and Morrison (2003) also study capital regulation of multinational banks. They show that capital requirements for international banks should depend on the banks' incentives to underinvest and argue that optimal capital requirements should always be lower for branch than for subsidiary structures. We argue that this should depend on the underlying risk of the bank. Moreover, Loranth and Morrison do not consider the interplay between regulation and banks' choice of legal structure. This paper presents to the best of our knowledge the first analysis that endogenizes both these dimensions.

Also, Kahn and Winton (2003) consider the optimal legal structure in a quite general framework. They show among other things that the subsidiary structure may be optimal due to the risk spillovers that arise in a branch structure. However, Kahn and Winton do not consider the application to banking regulation. Therefore, they do not look at capital requirements. Nor do they study the screening of types according to risk, which plays an important role in our analysis.

The rest of the paper is organized as follows: Section 2 outlines the model. Section 3 analyzes optimal capital regulation when the benevolent regulator observes the MB's exogenous risks, but not its asset choices (moral hazard). Section 4 contains the analysis where the regulator neither observes the exogenous risks nor the asset choices (adverse selection and moral hazard). In Section 5 we study capital regulation when the MBs are subject to two regulators, and Section 6 concludes.

2 The Model

2.1 The Multinational Bank

We consider a multinational bank that consists of two offices with common owners.[4] Each office has access to one unit of deposits that is invested into projects. The gross deposit rate is normalized to 1. The asset choices are made so as to maximize the profits of the MB and are unobservable to outsiders.

Endogenous and Exogenous Risk The MB is exposed to two types of risk, endogenous and exogenous risk. The endogenous risk stems from the asset choices of the two offices. The exogenous risk is due to events outside the control of the MB such as, for example, a shock

[4] From now we will refer to the owners as simply the MB.

to the local economy or to specific industries where the MB operates. First, we describe the asset opportunities of the MB. Thereafter, we explain the exogenous risk that the MB faces.

Each office can invest in two different assets: a gambling asset and a prudent asset. Suppose that the MB is not hit by an exogenous shock. Then, the gambling asset pays R per unit invested with probability p and 0 with probability $1-p$. The prudent asset pays α per unit invested with certainty. All returns are realized at the end of the game. We make the following assumptions concerning the two assets:

Assumption 1. *i)* $\alpha > pR$, *ii)* $p(R-1) > \alpha - 1$.

Assumption 1 *i)* and *ii)* are the standard assumptions in banking models that introduce a risk-shifting problem.

The exogenous risk is modelled in the following manner: With probability $\widetilde{\theta}$, there is no shock and the MB is only exposed to the endogenous risk. With probability $1-\widetilde{\theta}$, one of the two offices is subject to an exogenous shock and loses all its investment return which is either $0, \alpha$ or R. We assume that $\widetilde{\theta} \epsilon [\eta, 1]$, $\eta < 1$ and that $\widetilde{\theta}$ is drawn from a distribution function $F(\widetilde{\theta})$ with a continuous density function $f(\widetilde{\theta})$. The MB observes the realization of $\widetilde{\theta}$, θ. One interpretation is that the MB's day-to-day interactions with borrowers provides it with information about its exogenous risk. We refer to θ as the MB's type.

Risk Spillovers An important ingredient of our model is the possibility of risk spillovers between the offices of a MB. For such spillovers to occur, we need that an office, at least sometimes, has the possibility to gamble if the other office has a low return. We model this in the simplest possible way by assuming that the investment opportunities of the two offices arrive sequentially. Specifically, we assume that the two offices are equally likely to invest first, and we denote the first office to invest by 'office-1' and the second by 'office-2'. It is assumed that the MB receives a perfect but private signal about the return in office-1 before investing again in office-2. Moreover, we assume that if the MB is subject to the exogenous shock it will always hit office-1. That the shock can hit office-1 creates the possibility of risk spillovers but our results would not change qualitatively if both offices could be hit by a shock.

Legal Structure We consider the issue of whether the MB will set up as a branch-MB or as a subsidiary-MB. The crucial difference between these two legal structures is the liability structure. If the MB sets up as a subsidiary-MB, each office functions as a separate legal entity with limited liability.[5] Hence, if one office becomes insolvent, the other office is not liable. If the MB sets up as a branch-MB, the two offices are jointly liable for the deposits.

2.2 The Regulatory Environment

The depositors of the MB are protected by a full deposit insurance scheme. The deposit insurance scheme is financed by public funds. The social cost of one unit of public funds is $1 + \lambda$, $\lambda > 0$. This cost reflects the social losses that occur when distortionary taxes are imposed to finance the deposit insurance scheme.

We study prudential regulation from the perspective of a single benevolent regulator that maximizes social welfare. To curb risk-taking incentives, the regulator requires that banks hold a certain amount of capital per unit of deposits. To simplify expressions, it is assumed that the capital cannot be invested. The capital requirement imposes a cost on the MB since the opportunity cost of capital is ρ per unit, $\lambda \geq \rho > 0$.[6] The regulator sets a capital requirement for the branch-MB as a whole whereas it sets a capital requirement for each of the offices in the subsidiary-MB. We assume that the regulator does not monitor the MB so closely that it observes which of the two offices that invest first and whether office-1 was hit by a shock. Therefore, capital requirements cannot be made contingent upon these events. We denote by k_B the capital requirement for the branch-MB and by k_S the total capital requirement for the subsidiary-MB.

[5] We are therefore considering parallel-owned MBs. Parallel-owned banks are defined as banks licensed in different jurisdictions that, while not being part of the same financial group for regulatory consolidation purposes, have the same beneficial owner(s) and consequently, often share common management and inter-linked businesses. Parallel-owned banks do not include structures in which one depository institution is a subsidiary of the other (BIS, 2003 and FDIC, 2002).

[6] We can think of the private costs of bank capital as the dilution cost to the owners (see e.g. Bolton and Freixas, 2000). Moreover, we will assume that the social costs of bank capital equalize the private costs. Gorton and Winton (2000) provide a justification for the assumption that bank capital is socially costly, based on illiquidity costs of bank equity.

We consider two scenarios concerning the information of the regulator. In Section 3 the regulator observes the MB's type and determines both capital requirements and the MB's legal structure. In Section 4 the regulator does not observe the realized type. Therefore, the regulator announces capital requirements for branch-MBs and for subsidiary-MBs and let the MBs select their structure.

2.3 The Rest of the Game

Except for the asset choices, the sequence of investment opportunities, the return in office-1, and the type (in Section 4) that are private information to the MB, all other aspects of the game are common knowledge.

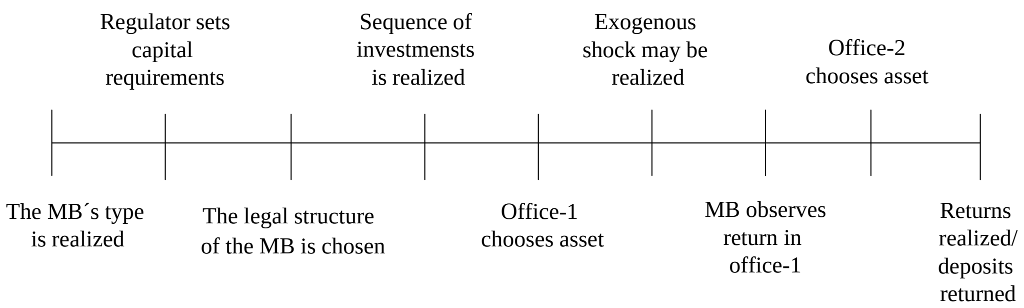

Figure 1: Timing of the game

Figure 1 describes the timing of the game. First, the MB's type is realized. Then, the regulator chooses the capital requirements. Thereafter, the legal structure of the MB is chosen either by the regulator (Section 3) or the MB itself (Section 4). Next, the sequence of the investment opportunities is realized, and the MB invests in office-1. Then, the exogenous shock may hit office-1. The MB observes the future return on the asset in office-1 after which the investment in office-2 is made. At the end of the game returns are realized and deposits are paid back.

3 Optimal Regulation Under Moral Hazard

In this section we study the optimal regulation when the regulator observes the MB's type. We start by determining the capital requirements that secure prudent investment in the branch-MB and subsidiary-MB. Afterwards, we compare the two legal structures in terms of welfare for different types of the MB.

3.1 Capital Requirement of the Branch-MB

Consider the subgame where the MB has set up as a branch-MB. Before continuing, we make the following assumption.

Assumption 2. $R > 2$.

Assumption 2 secures that when one office will fail the branch-MB will survive if the other office invests in the risky asset and succeeds. The assumption therefore creates an incentive to gamble for resurrection in a branch-MB. It can be shown that most of our results hold qualitatively without Assumption 2.

Figure 2 illustrates the game tree for the branch-MB.

[Figure 2 here]

The game is solved by backwards induction, so we start by looking at the investment in office-2. There are three types of situations to consider depending on the asset choice in office-1 and on the realization of the shock.

First, we look at the subgame where office-1 has invested prudently and no exogenous shock has occurred. We obtain that the branch-MB invests prudently in office-2 given that

$$2\alpha + k_B - 2 \geq p(R + \alpha + k_B - 2) + (1-p)\max(0, \alpha + k_B - 2). \tag{1}$$

Notice that if $\alpha + k_B - 2 > 0$, (1) is always satisfied. We denote by k_B^g the minimal capital requirement that secures that (1) is satisfied,

$$k_B^g = \max\left(\frac{p(R+\alpha-2) - 2(\alpha-1)}{1-p}, 0\right). \tag{2}$$

Since $R > 2$, we obtain that the branch-MB will always invest prudently in office-2 given that it gambled in office-1 and the return on the investment will be R. Finally, consider the subgames where an exogenous shock has occurred and/or the branch-MB gambled in office-1 and will fail. Let k_B^b be the capital requirement such that office-2 invests prudently:

$$k_B^b = \frac{p(R-2) - (\alpha - 2)}{1-p}. \tag{3}$$

Assumption 1 *ii*) secures that k_B^b is strictly positive.

Consider now the asset choice of office-1. The capital requirement k_B^0 that ensures prudent investment in office-1 is given by:

$$k_B^0 = 2 - (\alpha - Rp)\frac{(2-p)}{(1-p)^2}. \tag{4}$$

To reduce the number of cases that we need to consider, but without loss of insight, it is assumed that k_B^0 is positive:

Assumption 3. $\dfrac{2(1-p)^2}{2-p} > \alpha - pR.$

Notice that $k_B^g < k_B^0 < k_B^b$. A branch-MB faced with a capital requirement of k_B^0 will therefore gamble in office-2 if and only if an exogenous shock has occurred.

3.2 Capital Requirement of the Subsidiary-MB

Consider now the risk-taking incentive of a subsidiary-MB. Each of the two offices is subject to limited liability and faces a separate capital requirement. Since the two offices are equally likely to invest first and the capital requirements can neither be made contingent upon the timing of the two offices' investment decisions nor on whether office-1 was hit by a shock, the regulator sets the same capital requirement for the two offices. Let k_S denote the total capital requirement for the subsidiary-MB. Each of the offices will then invest prudently if

$$\alpha + k_S/2 - 1 \geq p(R + k_S/2 - 1).$$

Let k_S^0 be the minimal total capital requirement that ensures prudent investment by both offices:

$$k_S^0 = \frac{2p(R-1) - 2(\alpha - 1)}{1-p}. \tag{5}$$

Assumption 1 $ii)$ secures that k_S^0 is strictly positive.

3.3 Capital Requirements of the Branch- and Subsidiary-MB

We are now ready to compare the branch and the subsidiary structure. First, we look at the investment decision of the MB when investing in office-2. The following result follows from the analysis above.

Lemma 1 *We have that* $k_B^g < k_S^0 < k_B^b$.

Proof. Follows directly from comparing (2), (3), and (5). ■

The intuition behind Lemma 1 is that a branch-MB considers the net return in office-1 like additional equity when investing in office-2. Hence, if the net return in office-1 is positive, the branch-MB has little incentive to gamble and put the return in office-1 at risk. The capital requirement in the branch structure (k_B^g) can thus be set lower than in the subsidiary structure (k_S^0). A negative net return, on the other hand, provides a strong incentive to take risk, because the deposit insurer carries most of the gamble's downside.[7] This is the problem of risk spillovers discussed in the introduction, and it is the reason for the fact that $k_S^0 < k_B^b$.

With respect to the asset choice in office-1, we obtain:

Lemma 2 *We have that* $k_B^0 < k_S^0$.

Proof. Follows directly from comparing (4) and (5). ■

Lemma 2 shows that the branch-MB has less incentive to gamble in office-1 than the subsidiary-MB, which is explained by the different liability structure of a branch-MB and a subsidiary-MB. It is only within a branch-MB that a failed gamble in office-1 is a liability for office-2. A branch-MB is therefore less inclined to take risk in office-1, and a lower capital requirement is needed to ensure prudent investment.

Taken together, Lemma 1 and 2 illustrate the basic trade-off between the two banking structures. A branch-MB is more prudent than a subsidiary-MB in normal times. However,

[7] This effect is known as the "debt-overhang problem" in the corporate finance literature (Myers, 1977; Green, 1984) and the "gambling for resurrection" in the banking literature (see e.g. Kane, 1989).

when problems arise in one office of a branch-MB it may trigger gambling by the other office. The branch structure is at the same time more prudent and more fragile than the subsidiary structure.

3.4 Optimal Regulation

We now turn to the regulator's preferred capital requirements and legal structure. The regulator maximizes welfare, which consists of the MB's profit plus payments to depositors minus the total cost of the deposit insurance scheme. Let $W_i(k_i, \theta)$ denote the regulator's payoff when the capital requirement is k_i and the type is θ. Subscript i indicates the legal structure, $i \in \{B(ranch), S(ubsidiary)\}$.

We obtain

$$\begin{aligned} W_B(k_B, \theta) &= \theta(2\alpha + k_B - 2) + (1-\theta)p(R + k_B - 2) - \\ &\quad (1-\theta)(1-p)(2-k_B)(1+\lambda) - (1+\rho)k_B \text{ for } k_B^b > k_B \geq k_B^0, \end{aligned} \tag{6}$$

since when $k_B < k_B^b$ the branch-MB gambles in office-2 if a shock occurs. With probability $1-p$ the gamble fails, and depositors are bailed out by the deposit insurance scheme. Similarly, we get

$$W_B(k_B, \theta) = \theta(2\alpha + k_B - 2) + (1-\theta)(\alpha + k_B - 2) - (1+\rho)k_B \text{ for } k_B \geq k_B^b, \tag{7}$$

because the branch-MB always invests prudently when the capital requirement is at least k_B^b. Finally, the welfare if the bank chooses a subsidiary-MB is

$$\begin{aligned} W_S(k_S, \theta) &= \theta(\alpha + k_S/2 - 1) + (\alpha + k_S/2 - 1) - \\ &\quad (1-\theta)(1-k_S/2)(1+\lambda) - (1+\rho)(k_S) \text{ for } k_S \geq k_S^0. \end{aligned} \tag{8}$$

We make an additional assumption that allows us to focus on the minimum capital requirements derived above:

Assumption 4. $(1-\eta)Max(1/2, 1-p) \leq \dfrac{\rho}{\lambda} \leq (1-p)^2$.

In Appendix A it is shown that assumption 4 implies that the optimal capital requirements when the type is known are k_S^0 for a subsidiary-MB and either k_B^0 or k_B^b for a branch-MB. Assumption 4 reflects that capital is costly but not excessively so. It is therefore not optimal to increase capital requirements unless it changes the risk-taking behavior of the MB. However, it is always optimal to induce prudent investment in office-1. Notice also that Assumption 4 implicitly assumes that $p < \eta$. That is, the endogenous risk is assumed to be higher than the exogenous risk for all types.

The next remark that compares the use of public funds is helpful to interpret our later results.

Remark 1 *Suppose that the capital requirements of a branch-MB and subsidiary-MB are respectively k_B^0 and k_S^0. Then, for a given type θ the expected use of public funds for the deposit insurance scheme is higher for the branch-MB than for the subsidiary-MB. If a branch-MB is subject to a capital requirement of k_B^b it will never be insolvent in equilibrium, and hence use no public funds.*

Proof. First, compare a subsidiary-MB and a branch-MB with a capital requirement of k_B^0 and k_S^0, respectively. The expected use of public funds is $(1-\theta)(1-p)(2-k_B^0)$ for the branch-MB and $(1-\theta)(1-k_S^0/2)$ for the subsidiary-MB. We have that $(1-\theta)(1-p)(2-k_B^0)-(1-\theta)(1-k_S^0/2)=(1-\theta)(\alpha-pR)>0$. The second part of the remark follows from the fact that $\alpha+k_B^b>2$. ■

In the following we study the regulator's preferred legal structure and capital requirements as a function of the MB's exogenous risk. By substituting (3), (4) and (5) into (6), (7), and (8) we obtain:

$$\begin{aligned} W_B(k_B^0,\theta) &\geq W_B(k_B^b,\theta) \Leftrightarrow \theta \geq 1-\frac{\rho}{(1-p)\left[(1-p)+(2-p)\lambda\right]} \equiv A, \\ W_S(k_S^0,\theta) &\geq W_B(k_B^0,\theta) \Leftrightarrow B \equiv 1-\frac{\rho p}{(1+\lambda)(1-p)^2} \geq \theta, \\ W_S(k_S^0,\theta) &\geq W_B(k_B^b,\theta) \Leftrightarrow \theta \geq 1-\frac{\rho}{\lambda} \equiv C. \end{aligned} \tag{9}$$

From the comparison of $W_B(k_B^0,\theta)$ and $W_B(k_B^b,\theta)$, we obtain the following remark.

Remark 2 *For $\eta < A$ the optimal capital requirement for a branch-MB is increasing in the exogenous risk whereas the capital requirement for a subsidiary-MB is independent of the risk.*

Remark 2 is easy to understand from the discussion above. Risk spillovers arise only in a branch-MB. Therefore, capital requirements should be increasing in the exogenous risk for a branch-MB but not for a subsidiary-MB. The thresholds derived above compare in the following way:

$$B > A > C \Leftrightarrow \frac{\lambda}{1+\lambda} < \frac{(1-p)^2}{p}, \tag{10}$$

$$C > A > B \Leftrightarrow \frac{\lambda}{1+\lambda} > \frac{(1-p)^2}{p}. \tag{11}$$

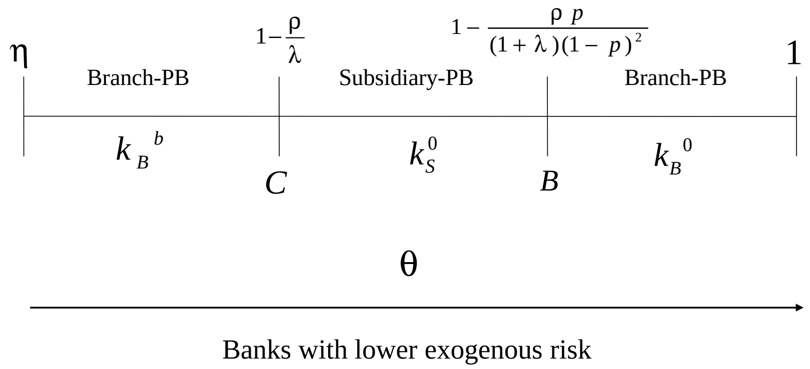

Figure 3: The welfare maximizing legal structure and capital requirement as a function of θ for $\lambda/(1+\lambda) < (1-p)^2/p$.

Hence, there are two cases. Consider first the case where $B > A > C$. Figure 3 illustrates the regulator's preferred legal structure and capital requirement as a function of the type θ.[8] Bank capital imposes a cost on the shareholders of the MB with certainty but reduces

[8] In the discussion we assume that $\eta < C$. If $\eta \geq C$ or $\eta \geq B$ not all the solutions illustrated in Figure 3 are relevant.

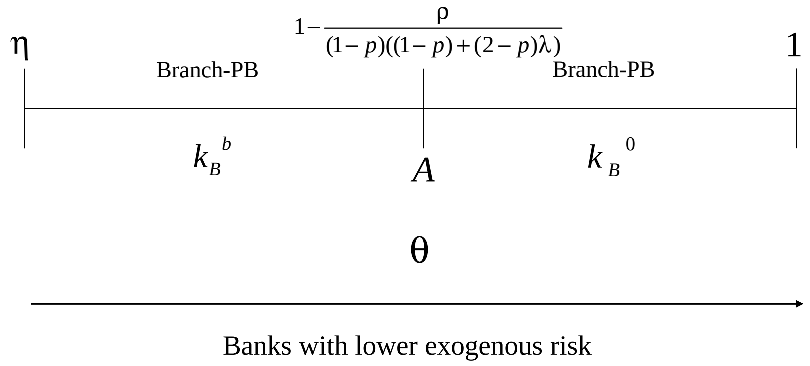

Figure 4: The welfare maximizing legal structure and capital requirement as a function of θ for $\lambda/(1+\lambda) > (1-p)^2/p$.

the cost of deposit insurance only if an exogenous shock occurs. For this reason, the optimal regulation involves more use of private and less use of (more expensive) public funds as the exogenous risk of the MB increases. First, if the MB faces low exogenous risk (θ high), a branch-MB and a capital requirement of k_B^0 is the optimal regulation. Since the probability of a negative shock is low, the regulator accepts that gambling may occur to reduce the capital requirement. For intermediate risk types, gambling becomes too expensive. Instead, the regulator prefers a subsidiary-MB with a capital requirement of k_S^0. This is the intermediate solution both in terms of the amount of public and private funds used (see Lemma 1, Lemma 2, and Remark 1). Finally, risky types (θ low) should set up as a branch-MB with a capital requirement of k_B^b to prevent the use of public funds altogether.

The case where $C > A > B$ shows the same overall picture: more risk involves less use of public and more use of private funds. Figure 4 illustrates the optimal regulation in this case.[9] The main difference to the previous case is that a subsidiary-MB is never optimal, but is dominated by a branch-MB either with a low or a high capital requirement. The intuition for this difference is twofold. First, in the case where $C > A > B$ the costs of public funds

[9] In Figure 4 we assume that $A > \eta$. If $A \leq \eta$ the regulator prefers that all types choose a branch structure facing a low capital requirement.

are relatively high compared to the case where $B > A > C$. This makes a subsidiary-MB less attractive in proportion to a branch-MB with a high capital requirement. Second, since $k_S^0 - k_B^0 = (\alpha - pR)\frac{p}{(1-p)^2}$, the difference between k_S^0 and k_B^0 is relatively high compared to the first case, which makes a branch-MB with a low capital requirement relatively more attractive compared to a subsidiary-MB.

The following proposition summarizes the analysis in this section.

Proposition 1 ***(Optimal regulation under moral hazard)*** *The regulator chooses that safe types set up as a branch-MB ($\theta \geq \max\{B, A\}$). The capital requirement is such that there is no gambling in office-1, but there is gambling in office-2 if the MB is hit by an exogenous shock ($k_B = k_B^0$). Risky types also have to set up as a branch-MB ($\theta < \min\{A, C\}$). The capital requirement is so high that the MB never gambles and never becomes insolvent ($k_B = k_B^b$). Finally, for some parameter values ($\lambda/(1+\lambda) < (1-p)^2/p$), intermediate risk types have to set up as a subsidiary-MB ($C \leq \theta < B$). The capital requirement is between those for risky and safe types and induces prudent investment ($k_S = k_S^0$).*

4 Optimal Regulation Under Moral Hazard and Adverse Selection

In this section we study the optimal regulation when the regulator neither observes the asset choices of the MBs nor their type. From the analysis above, we obtain that the profit functions of MBs as a function of their capital requirements, structures, and types are given by:

$$\begin{aligned}&\Pi_B(k_B, \theta) \\ = &\begin{cases} \theta(2\alpha + k_B - 2) + (1-\theta)p(R + k_B - 2) - (1+\rho)k_B \text{ for } k_B^b > k_B \geq k_B^0, \\ \theta(2\alpha + k_B - 2) + (1-\theta)(\alpha + k_B - 2) - (1+\rho)k_B \text{ for } k_B \geq k_B^b, \end{cases}\end{aligned} \quad (12)$$

$$\Pi_S(k_S, \theta) = (1+\theta)(\alpha + k_S/2 - 1) - (1+\rho)k_S \text{ for } k_S \geq k_S^0. \quad (13)$$

The analysis in Section 3 shows that the regulator would like to screen MBs in such a way that safe (risky) types set up as a branch-MB and face a low (high) capital requirement. Depending on the parameters, it may be optimal that intermediate types set up as a subsidiary-MB. The capital requirements found in the previous section cannot induce this allocation when the MBs' types are unknown to the regulator. To see this, suppose that the regulator would offer a menu of capital requirements (first entry) and legal structures (second entry): (k_B^0, branch), (k_B^b, branch), or (k_S^0, subsidiary). We have that

$$\Pi_B(k_B^0, \theta) - \Pi_S(k_S^0, \theta) = \rho \frac{p}{(1-p)^2}(\alpha - pR) > 0, \tag{14}$$

$$\Pi_S(k_S^0, \theta) - \Pi_B(k_B^b, \theta) = (\rho + 1 - \theta)\frac{\alpha - pR}{1-p} > 0. \tag{15}$$

Therefore, faced with this menu of choices, the MBs would for all θ choose to set up as branch-MBs subject to the low capital requirement, k_B^0.

Below, we show that it is possible to screen the MBs according to their types by choosing the capital requirements appropriately. For a given legal structure, the MBs always prefer the lowest possible capital requirement. Hence, we can restrict attention to a menu with only one capital requirement for each structure.

In the following we assume that it does not pay off for the regulator to let the MBs gamble in office-1. That is, we assume that it is never optimal for the regulator to choose $k_S < k_S^0$.[10] It then follows from (14) and Assumption 4 that it is never optimal for the regulator to choose $k_B < k_B^0$. We will start by analyzing the case where $k_B^0 \leq k_B < k_B^b$ and $k_S^0 \leq k_S$. Afterwards, we will consider the case where $k_B \geq k_B^b$.

Solving the equation $\Pi_B(k_B, \theta) = \Pi_S(k_S, \theta)$ for θ, we find:

$$\widehat{\theta} = 1 - \frac{(k_S - k_B)\rho}{(\alpha - 1) - p(R-2) + k_B(1-p) - k_S/2}. \tag{16}$$

We will say that there is *screening* when $\widehat{\theta} \in (\eta, 1)$ so that not all types choose the same legal structure.

The following lemma characterizes the screening mechanism.

[10] When the agent can take two actions it is a standard assumption in mixed adverse selection - moral hazard models that the principal finds it valuable to induce the agent to take the correct action, i.e. in our framework to make the prudent investment (see Laffont and Martimort, 2002).

Lemma 3 *A necessary condition for screening is that* $k_S > k_B$ *and*

$$(\alpha - 1) - p(R-2) + k_B(1-p) - k_S/2 > 0. \qquad \text{(Single Crossing)}$$

Proof. From (16) we want to exclude screening for combinations of k_B and k_S such that

$$\begin{aligned} k_S &< k_B, \\ (\alpha - 1) - p(R-2) + k_B(1-p) - k_S/2 &< 0. \end{aligned} \qquad (17)$$

First, consider $p < 1/2$. We have that necessary conditions for (17) to be satisfied are $(\alpha - 1) < p(R-2)$ and $k_S < 2(p(R-2) - (\alpha - 1))/(1-2p)$. However, since $2(p(R-2) - (\alpha - 1))/(1-2p) < k_S^0$, this is outside the range considered. Consider instead $p \geq 1/2$. A necessary condition for (17) to be satisfied is that $k_B > 2(\alpha - 1 - p(R-2))/(2p-1) > k_B^b$. Again, this is outside the range considered. ■

The single crossing condition in Lemma 3 ensures that $\partial(\Pi(k_B, \theta) - \Pi(k_S, \theta))/\partial\theta > 0$. Hence, if $\Pi_B(k_B, \theta) = \Pi_S(k_S, \theta)$ for some $\widehat{\theta} \in (\eta, 1)$, types above $\widehat{\theta}$ will set up as a branch-MB whereas types below $\widehat{\theta}$ will set up as a subsidiary-MB. Equation (16) shows that if the capital requirements do not depend on the legal structure (i.e. $k_S = k_B$) all types will set up as a subsidiary-MB.

Next, we obtain the following lemma.

Lemma 4 *The optimal capital requirement for the subsidiary-MB is* k_S^0*.*

Proof. For any marginal type, $\hat{\theta} \in [\eta, 1]$, there exists a mechanism $(\hat{k}_B, k_S^0)$ that satisfies (16). Consider any other mechanism $(\tilde{k}_B, \tilde{k}_S)$ that induces $\hat{\theta}$. Given the range considered we have that $\tilde{k}_S > k_S^0$. From (16) we obtain that $\tilde{k}_B > \hat{k}_B$. Assumption 4 then gives that the regulator prefers the mechanism $(\hat{k}_B, k_S^0)$. ■

The intuition behind this result is that the higher is k_S, the higher must k_B also be to induce risky types to set up as subsidiary-MBs. In equilibrium it is optimal to set k_S as low as possible to minimize the use of capital. We will from now on suppress k_S^0 in the notation such that $W_S(\theta) \equiv W_S(k_S^0, \theta)$.

Solving equation (16) for k_B and inserting $k_S = k_S^0$, we obtain:

$$k_B(\hat{\theta}) = k_B^0 + \frac{p(\alpha - pR)\rho}{(1-p)^2((1-p)(1-\hat{\theta}) + \rho)}. \qquad (18)$$

$k_B(\hat{\theta})$ denotes the capital requirement of a branch-MB such that all types higher (lower) than θ choose a branch structure (subsidiary structure).We have that $\frac{\partial k_B(\hat{\theta})}{\partial \hat{\theta}} > 0$. Hence, if the regulator wants lower types to set up as a subsidiary-MB, the capital requirement for a branch-MB must be increased. Notice that

$$\begin{aligned} k_B(1) &= k_S^0, \\ k_B(\eta) &= k_B^0 + \frac{p(\alpha - pR)}{(1-p)^2((1-p)(1-\eta)+\rho)} > k_B^0, \end{aligned}$$

so $k_B(\hat{\theta}) \in (k_B^0, k_S^0]$ for all $\hat{\theta} \in [\eta, 1]$.

We now turn to the problem of choosing the optimal capital requirement for a branch-MB. The expected welfare as a function of $\hat{\theta}$ is given by:

$$W(k_B) \equiv E\left[W(k_B, \tilde{\theta})\right] = \left[\int_{\eta}^{\hat{\theta}} W_S(\tilde{\theta}) f(\tilde{\theta}) d\tilde{\theta} + \int_{\hat{\theta}}^{1} W_B(k_B, \tilde{\theta}) f(\tilde{\theta}) d\tilde{\theta}\right]. \tag{19}$$

One candidate solution for the regulator is to pick a $k_B \in [k_B(\eta), k_S^0]$ that maximizes $W(k_B)$. Using Leibniz' formula, the FOC amounts to:

$$\frac{\partial W(k_B)}{\partial k_B} = \left[W_S(\hat{\theta}) - W_B(k_B, \hat{\theta})\right] f(\hat{\theta}) \frac{\partial \hat{\theta}}{\partial k_B} + \int_{\hat{\theta}}^{1} \frac{\partial W_B(k_B, \tilde{\theta})}{\partial k_B} f(\tilde{\theta}) d\tilde{\theta} = 0. \tag{20}$$

The first term is the marginal benefit from having a MB of type $\hat{\theta}$ choosing to set up as a subsidiary-MB rather than as a branch-MB. The second term reflects the fact that if the regulator raises the capital requirement for the branch-MB to induce the $\hat{\theta}$-type to set up as a subsidiary-MB, it has a cost in terms of a higher capital requirement for all the types higher than $\hat{\theta}$ which still choose to set up as a branch-MB. This is the infra-marginal cost of screening. We note that since the second term in (20) is negative by Assumption 4, the first term is positive whenever (20) is satisfied. The regulator must therefore obtain a higher payoff when the marginal type sets up as a subsidiary-MB than as a branch-MB.

From (20) we immediately obtain the following two results.

Lemma 5 *The regulator screens the MBs in equilibrium only if* $\partial(W_B(k_B, \theta) - W_S(k_S^0, \theta))/\partial\theta > 0$.

Proof. In an equilibrium with screening we have that $W_B(k_B, 1) > W_S(k_S^0, 1)$ since $k_B < k_S$. Since $W_S(\hat{\theta}) - W_B(k_B, \hat{\theta}) > 0$, because (20) is satisfied we must have that $\partial(W_B(k_B, \theta) - W_S(k_S^0, \theta))/\partial\theta > 0$. ■

Lemma 5 simply states that the regulator will induce screening only if MBs self-select in the desired way from the point of view of welfare. Put differently, the benefit of having the MB choosing to set up as a branch-MB instead of as a subsidiary-MB has to be increasing in the type.

Remark 3 *Suppose that we are at an interior solution to the problem of maximizing (19), i.e.* $k_B(\hat{\theta}) \in]k_B(\eta), k_S^0[$, $\hat{\theta} \in]\eta, 1[$. *Then, we obtain that an increase in the cost of public funds, an increase in* λ, *will lead to an increase in* $k_B(\hat{\theta})$, *and i.e. an increase in* $\hat{\theta}$, *if and only if* $(1-p)(2-k_B(\hat{\theta})) > 1 - k_S^0/2$.

Proof. By differentiating (20) with respect to λ we obtain that $\frac{\partial^2 W(k_B)}{\partial k_B \partial \lambda} \mid_{k_B(\hat{\theta})} > 0 \Leftrightarrow (1-p)(2-k_B(\hat{\theta})) > 1 - k_S^0/2$. Hence, given that $k_B(\hat{\theta})$ is an interior solution we obtain the statement in the remark. ■

The condition in Remark 3 compares the expected use of public funds in the branch-MB and the subsidiary-MB in a screening equilibrium (see the proof of Remark 1). Hence, Remark 3 states that if and only if the expected use of public funds is higher in a branch-MB than in a subsidiary-MB will an increase in the cost of public funds lead to a higher capital requirement for branch-MBs. In this case, more banks will choose a subsidiary structure in equilibrium. Notice that if $p \leq 1/2$ an increase in λ will always lead to a higher capital requirement for branch-MBs.

Consider now the solution to the regulator's problem of finding a k_B that maximizes (19) where $k_B^0 \leq k_B < k_B^b$. It is not possible to determine the sign of the *SOC* in general. To find the solution to the regulator's problem, it is thus necessary to check the solutions to (20) as well as the corner solutions $k_B(\eta)$ and $k_B(1)$. In the following we will characterize the optimal solution. We will denote the optimal solution by k_B^*, θ^*.

The first thing to notice is that because $k_B(\hat{\theta}) > k_B^0$ for all $\hat{\theta} \in [\eta, 1]$ it is costly to start to screen the MBs, as the capital requirement of a branch-MB has to be increased discretely. It is therefore a candidate solution to set $k_B = k_B^0$. Furthermore, we obtain that it is never a solution to screen the MBs in such a way that only a few, very risky types choose to set up as a subsidiary-MB (i.e. θ^* close to η). Here, the additional cost of capital that is imposed on all types above θ^*, which choose a branch-MB, outweighs the benefit of having the very risky types set up as subsidiary-MBs. The next lemma makes this intuition precise.

Lemma 6 *There exists a* $\underline{\theta} > \eta$ *such that* $\theta^* \notin (\eta, \underline{\theta})$.

Proof. Assumption 1 and Assumption 4 give that $\int_\eta^1 W_B(k_B^0, \widetilde{\theta}) f(\widetilde{\theta}) d\widetilde{\theta} - W(k_B(\eta)) = \frac{(\alpha - pR)(\rho - (1-p)(1-E(\theta))\lambda)\rho}{(1-p)^2(1+\rho-p(1-\eta)-\eta)} > 0$ where $E(\theta) \equiv \int_\eta^1 \widetilde{\theta} f(\widetilde{\theta}) d\widetilde{\theta}$. It follows from continuity of $W(k_B(\eta))$ that there exists a region $(\eta, \underline{\theta})$ such that $\int_\eta^1 W_B(k_B^0, \widetilde{\theta}) f(\widetilde{\theta}) d\widetilde{\theta} > W(k_B(\theta))$ for $\theta \in (\eta, \underline{\theta})$. ■

The next lemma shows that unless the risky asset has a very low probability of success, it is not optimal to induce all types to choose a subsidiary-MB by setting $k_B \geq k_S^0$.

Lemma 7 *For* $p > \frac{1+\lambda}{3+2\lambda}$ *it is not optimal to let all types choose a subsidiary-MB, i.e.* $\theta^* \neq 1$.

Proof. From *FOC* we have that $\frac{\partial W(k_B)}{\partial k_B} |_{k_B(1)} = 0$. Consider *SOC*. We obtain that $\frac{\partial^2 W(k_B)}{\partial (k_B)^2} |_{k_B(1)} \geq 0 \Leftrightarrow p \geq (1+\lambda)/(3+2\lambda)$. Hence, if $p > (1+\lambda)/(3+2\lambda)$, it follows from continuity of $\frac{\partial W(k_B)}{\partial k_B}$ and $\frac{\partial^2 W(k_B)}{\partial (k_B)^2}$ that there exists a region $(\overline{\theta}, 1)$ such that $\frac{\partial W(k_B)}{\partial k_B} < 0$ for all θ in $(\overline{\theta}, 1)$. Therefore, $W(\overline{\theta}) > W(1)$. ■

Finally, consider the case where $k_B \geq k_B^b$. We have the following lemma.

Lemma 8 *A candidate solution is* $k_B = k_B^b$ *and* $k_S > k_B$ *such that all types set up as a branch-MB.*

Proof. Assume that $k_B \geq k_B^b$. As in Lemma 3, we have that screening requires $k_S > k_B$. Analog to Lemma 4, it follows that to reduce the use of private funds the optimal capital requirement for a branch-MB is k_B^b . Comparing the two structures, we have that $W_B(k_B^b, \theta) > W_S(k_S, \theta)$ since the branch structure involves less use of both public and private funds. Hence, screening is not optimal and k_S should be chosen such that all the types set up as a branch-MB subject to a high capital requirement. ■

From the discussion above, we have that there are three candidate solutions with no screening. Either the MBs set up as a branch structure with a capital requirement of k_B^0

or k_B^b or they set up as a subsidiary structure with a capital requirement of k_S^0. Since the welfare functions are linear in θ, we can use the analysis in Section 3 to compare the candidate solutions without screening using the MBs' expected type, $E(\theta)$.

We summarize our analysis in the following proposition.

Proposition 2 ***(Optimal regulation under moral hazard and adverse selection)*** *There are two kinds of candidate solutions to the regulator's problem. In a solution with screening, subsidiary-MBs should face the minimal capital requirement that prevents gambling ($k_S = k_S^0$). Branch-MBs should be offered a capital requirement discount compared to subsidiary-MBs, but the capital requirement is still higher than necessary to stop them from gambling in office-1 ($k_B^0 < k_B = k_B^* < k_S^0$). The optimal k_B is an interior solution to equation (20).*
There is for all $E(\theta)$ maximally one candidate solution with no screening:
i) If MBs face a low expected risk ($E(\theta) \geq \max\{A, B\}$), MBs are induced to set up as a branch structure and face a low capital requirement ($k_B = k_B^0$).
ii) If MBs face a high expected risk ($E(\theta) < \min\{A, C\}$), MBs are induced to set up as a branch structure but face a high capital requirement ($k_B = k_B^b$).
iii) If MBs face an intermediate expected risk ($Min\{A, C\} \leq E(\theta) < Max\{A, B\}$) and the condition in Lemma 7 is not satisfied, MBs are induced to set up as a subsidiary structure and gambling is prevented ($k_S = k_S^0$).

Proof. Follows from Proposition 1, Lemma 4, and Lemma 6 - 8. ■

The perhaps greatest obstacle that regulators face when dealing with multinational banking groups is to determine, which banks are part of such a group (BIS, 2003). Owners have rich possibilities to hide their true identity behind ownership pyramids, 'straw men', or off-shore locations with little regulatory control.

In the analysis above we have implicitly assumed that the regulator can identify entities within a multinational banking group. Suppose instead that this is not possible so offices of subsidiary-MBs have to be treated as local stand-alone banks. Furthermore, suppose that the number of local banks is large relative to the number of MBs. In this case, it is not optimal to increase the capital requirement for locally registered banks above k_S^0 only to regulate MBs more efficiently. Hence, the candidate solution with no screening where $k_S > k_B^b$ is not relevant.

An attractive feature of the rest of the solution in Proposition 2 is that it can be implemented also in a scenario where the regulator cannot identify the entities within MBs. If a MB chooses to set up as a subsidiary-MB, the two offices are treated like any other local bank ($k_S = k_S^0$). In an equilibrium with screening, branch-MBs receive a capital requirement discount compared to other banks. Therefore, safe types among the MBs have an incentive to set up a branch-MB and reveal themselves as part of a banking group. In the same way, all MBs will set up as a branch-MB when $k_B = k_B^0$. Hence, as long as MBs do not have a high expected risk, optimal capital regulation does not require the regulator to actively identity banks within multinational banking groups.[11]

Our analysis may also provide an explanation for MBs' choice of legal structure given the capital regulation currently in place. As pointed out by Dermine (2002), somewhat surprisingly, cross-border banking within the European Union often take place through subsidiaries even though the EU's single banking licence rule makes it much easier for multinational banks to expand through branches.[12] One explanation for this fact may be that the Basel capital adequacy rules are not dependent upon the legal structure of MBs. Our model suggests that in this situation MBs should indeed prefer the subsidiary structure due to double limited liability.

4.1 Numerical Example

To illustrate the results obtained, we derive the optimal regulation for a specific example where the types are uniformly distributed on the interval $[0.8, 1]$. There are several candidate solutions to the regulator's problem as specified in Proposition 2.

Figure 5 illustrates the equilibrium outcome as a function of (λ, p). The parameter restrictions of the model are satisfied between the two lines indicated by A.3 and A.4, which

[11]It may, of course, be desirable to have this information for reasons outside our model. The regulator needs, for example, this information to monitor the bank's dealings with other banks.

[12]The single banking license allows any EU bank to expand abroad as long as the bank operate through branches (Second Banking Co-ordination Directive, 1993). On the contrary, if banks want to operate through subsidiaries they need special licenses.

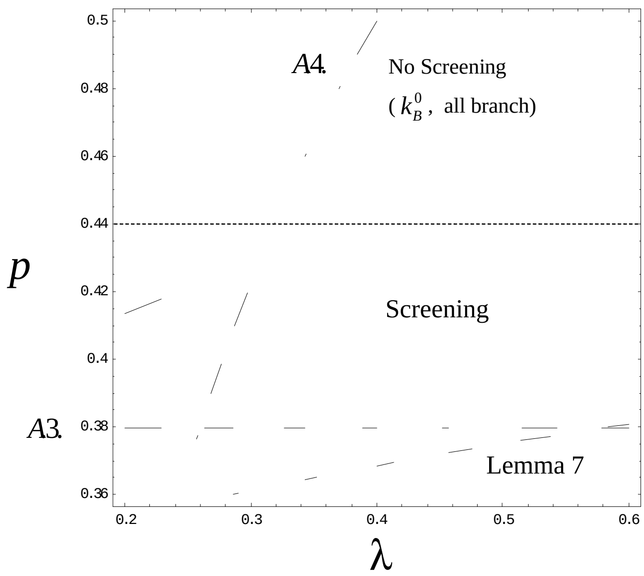

Figure 5: The optimal regulation as a function of p and λ when $\theta \sim U[0.8, 1]$, $R = 2.7$, $\alpha = 1.5$, and $\rho = 0.1$. Assumptions 1-4 are satisfied between the two lines indicated by A.3 and A.4. Above the solid line, the regulator sets the capital requirement of a branch-MB to k_B^0, and all types choose this structure. Below the solid line, the regulator sets the capital requirement for the branch structure to $k_B(\theta^*)$. Safe MBs ($\theta > \theta^*$) choose a branch and risky MBs ($\theta \leq \theta^*$) a subsidiary structure.

refer to Assumption 3 and Assumption 4, respectively. That is, the parameter restrictions of the model are satisfied above the line indicated by A.3 and to the right of the line indicated by A.4. (The parameter restrictions that are not shown in Figure 5 do not bind).

Above the solid line in Figure 5 the expected value of a risky project is close to that of a safe one. Therefore, a branch-MB and subsidiary-MB involve almost the same expected amount of public funds (see the proof of Remark 1). Thus, the regulator chooses optimally not to screen the MBs to economize on private capital costs. For the given parameter values, the optimal solution with no screening is to set k_B^0, and induce all types to set up a branch-MB. Below the solid line, banks are screened even if it implies a higher capital cost for the safe types that choose a branch-MB. Since more public funds are spend on deposit insurance

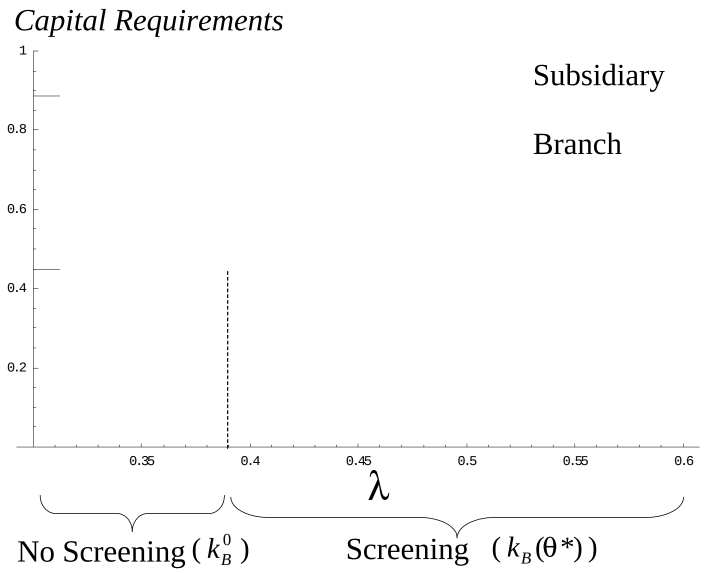

Figure 6: The capital requirements for the branch and subsidiary-MB as a function of λ when $\theta \sim U\,[0.8, 1]\,,\, p = 0.44,\ R = 2.7,\ \alpha = 1.5$, and $\rho = 0.1$ The capital requirement of a branch-MB increases discretely for $\lambda \simeq 0.39$ where the regulator starts to screen the types and increases continuously thereafter.

when types are not screened, the size of the region with no screening is decreasing in the cost of public funds, λ. The upward sloping dashed line is the condition in Lemma 7. Above this line the regulator will never induce all types to choose the subsidiary structure. There exists a small region for λ close to 0.6 where Assumption 1-4 are satisfied and the condition in Lemma 7 does not hold. Here, $k_B = k_B(1)$ is a local maximum, but it is not a global maximum for the parameters considered. That is, it is not optimal to induce all banks to set up as subsidiary-MBs. Finally, in this example it is never optimal to induce all types to set up as branch-MBs facing a high capital requirement.

Figure 6 considers the same example as Figure 5, but illustrates the capital requirements as a function of λ for $p = 0.44$. That is, the figure illustrates the capital requirements as we move along the thin, dotted line in Figure 5. There are several things to notice from the figure. First, the capital requirement is always lower for a branch-MB than for a subsidiary-

MB. Second, there is a discrete increase in the capital requirement for the branch structure, as λ becomes so high that the regulator finds it optimal to start to screen the MBs. In Figure 6 this happens for $\lambda \simeq 0.39$. Finally, the capital requirement of the branch-MB is increasing in λ in the region with screening. This is due to the fact that a higher capital requirement for branches reduces the use of public funds in the screening equilibrium (Remark 3).

5 Capital Regulation with Two Regulators

Until now we have considered the optimal capital regulation from the perspective of a single benevolent regulator. In this section we will extend our previous analysis to a situation where MBs are subject to two national regulators that set capital requirements strategically.

We take a political economy approach to regulation and assume that the national banking regulators maximize local welfare, disregarding the welfare of the other country. The regulators thus set capital requirements strategically, which complicates the analysis considerably. It is hard to characterize the equilibrium for general distributions of types, and the analysis of this case is outside the scope of this paper. Instead, we consider a simplified version of the general model with only two types and develop a numerical example that illustrates how results may change importantly compared to the single-regulator case.[13]

5.1 The Setup

We consider the following variation of the model: MBs have two offices in different countries, country X and Y, and choose between a branch and a subsidiary structure. A branch-MB obtains its banking license in country X (the home country), and has a branch in country Y (the host country). A subsidiary-MB consists of two legal entities and needs a licence in each country.[14] We assume that the regulator in the home country, regulator X, determines the capital requirement of the entire branch-MB, k_B. A subsidiary-MB, on the other hand, faces

[13] The qualitative effects we point at in this section would also be present in the setup with continuos types.

[14] Notice that this is consistent with the EU's single market and principle of 'one single license' regulation (see footnote 12).

a separate capital requirement in each country.[15] We denote by k_S^i the capital requirement for the subsidiary-office in country i, $i = X, Y$.

We assume that MBs can be of two types. A MB is a safe type ($\theta = \theta_S$) with probability δ and a risky type ($\theta = \theta_R$) with probability $1-\delta$, $\theta_S > \theta_R$. For simplicity, it is assumed that $\theta_S = 1$, so safe types are never hit by an exogenous shock. We assume that overall welfare is maximized when the types are screened such that safe types set up a branch-MB and risky types a subsidiary-MB. Furthermore, Assumption 4 continues to hold with θ_R replacing η. Taken together, this implies that the optimal regulation from the perspective of a single benevolent regulator is $k_S = k_S^0$ and $k_B = k_B(\theta_R)$ where $k_B(\theta_R)$ is given by (18).

The regulators maximize local welfare and set capital requirements strategically. It turns out that the regulators may have incentives to increase capital requirements without limit. Therefore, we specify upper limits on the capital requirements that the regulators can set, $k_S^X, k_S^Y \in [k_S^0/2, \overline{k}_S]$ and $k_B \in [k_B^0, \overline{k}_B]$, where we for simplicity with respect to the numerical example assume that $\overline{k}_B < k_B^b$. The upper limits on the capital requirements can be interpreted as the degree of discretion of the national regulators.[16]

To highlight the strategic effects that come into play when there are two regulators, we keep the objective functions of the national regulators as close as possible to the one of the single benevolent regulator. In particular, we assume that half of the shareholders are located in each country, so profits are split 50:50. Moreover, when a MB has set up as a branch-MB, the two regulators share the costs of the deposit insurance scheme equally.[17] The office of a subsidiary-MB is legally a domestic bank, and all costs of deposit insurance are paid by the country where the office is registered. Let $W_B^i(k_B, \theta)$ and $W_S^i(k_S^X, k_S^Y, \theta)$ denote regulator i's

[15] This is also in accordance with current regulation within the EU. The principle of home country supervision dictates that it is the regulator in the country where the bank is licensed that performs the consolidated supervision.

[16] The Basel capital rules and the idea of the "level playing field" have mainly imposed constraints on regulators' discretion to set lower capital requirements. However, as our analysis illustrates, with multinational banks the discretion to require higher capital requirements becomes important.

[17] This is the practice in the US where depositors in foreign branches are covered by the FDIC. In Europe, on the other hand, depositors in host countries are typically insured by the home country deposit insurance scheme (exceptions arise when the coverage differs in home and host country). However, the point of this section does not depend on the assumption that the regulators share the cost of deposit insurance equally.

payoff when a MB of type θ sets up as a branch-MB and as a subsidiary-MB, respectively. We have

$$\begin{aligned} W_B^i(k_B, \theta) &= \frac{1}{2}\left(\Pi_B(k_B, \theta) - (1-\theta)(1-p)(2-k_B)(1+\lambda)\right), \; i = X, Y, \\ W_S^i(k_S^X, k_S^Y, \theta) &= \frac{1}{2}\Pi_S(k_S^X + k_S^Y, \theta) - \frac{(1-\theta)}{2}(1-k_S^i)(1+\lambda), \; i = X, Y. \end{aligned} \tag{21}$$

where $\Pi_B(\cdot)$ and $\Pi_S(\cdot)$ are given by (12) for $k_B^0 < k_B < k_B^b$ and (13), respectively. Notice that our symmetry assumptions imply that $W_B^i(k_B, \theta) = W_B(k_B, \theta)/2$ and $W_S^i(k_S^X, k_S^Y, \theta) = W_S(k_S^X + k_S^Y, \theta)/2$ for $k_S^X = k_S^Y$.

5.2 A Race to the Top

We now turn to the regulators' choices of capital requirements. Assumption 4 implies that a benevolent regulator would always set the capital requirement of subsidiary-MBs as low as possible as long as it induces prudent investment. That is,

$$\partial W_S(k_S, \theta_R)/\partial k_S \leq 0 \Leftrightarrow 1/2(1-\theta_R)\lambda - \rho < 0.$$

However, this assumption is not enough to ensure that the national regulators set $k_S^X = k_S^Y = k_S^0/2$. From (21) we obtain that

$$\frac{\partial W_S^i(k_S^X, k_S^Y, \theta_R)}{\partial k_S^i} = 1/2\left((1-\theta_R)(\lambda + 1/2) - \rho\right) \lesseqgtr 0.$$

Although $\partial W_S(k_S, \theta)/\partial k_S$ is negative, $\partial W_S^i(k_S^X, k_S^Y, \theta)/\partial k_S^i$ may be positive due to the fact that the regulators do not internalize the cost that a higher capital requirement imposes on the other country's shareholders.

Suppose that $\partial W_S^i(k_S^X, k_S^Y, \theta)/\partial k_S^i > 0$. The regulators may then have an incentive to increase the capital requirements for subsidiary-MBs. Still, they might not wish to set the capital requirements so high that risky MBs choose the branch instead of the subsidiary structure. Lemma 9 in appendix B provides a necessary and sufficient condition for the first best capital requirements, $k_S^X = k_S^Y = k_S^0/2$ and $k_B = k_B(\theta_R)$, to be sustainable as an equilibrium outcome.

Assume for the remainder that the first best capital requirements are not sustainable. In this case, we develop in Appendix B a numerical example where all equilibria are such that $k_S^Y + k_S^X > k_S^0$ and $k_B > k_B(\theta_R)$. The capital requirements for both branch-MBs and subsidiary-MBs are thus above the optimal levels. We term this equilibrium phenomenon a "race to the top". The intuition behind this outcome is twofold. First, due to the fact that the regulators do not take into account the other country's shareholders, the regulators have incentives to increase the capital requirements for subsidiary offices above the social optimum. Second, the home country regulator then has to increase k_B to avoid that risky MBs choose a branch structure.

As mentioned in the introduction, this race to the top phenomenon is in contrasts to the results by Acharya (2003) and Dell'Ariccia and Marquez (2003). They argue that decentralized regulation tends to create a "race to the bottom" in capital requirements as national regulators attempt to further the competitive position of their domestic banks. Our analysis suggests that the opposite may occur when one considers MBs and endogenizes their choice of legal structure.

6 Concluding Remarks

In this paper we have studied capital regulation of multinational banks. We have shown that in normal times MBs with a branch structure should face a lower capital requirement than banks with a subsidiary structure. However, in order to stop gambling also in times of financial distress branch structures must be subject to higher capital requirements.

We have analyzed capital regulation and the choice of legal structure both when a regulator has information about the MBs' underlying risk and when this is private information to the MBs. We argued that when the regulator knows the underlying risk of the MBs, the branch structure tends to dominate from a welfare perspective. However, if the MBs have private information about their risk, the regulator may choose to screen the MBs such that risky MBs choose a subsidiary structure and safe MBs a branch structure. To induce safe MBs to set up as a branch structure, they must receive a capital requirement discount relatively to subsidiary structures. Finally, we present an example where MBs are subject to multiple national regulators. We show that capital requirements may increase when they are set strategically by the regulators, which provides an interesting contrast to the race to the bottom phenomenon previously found in the literature.

We will argue that our analysis has broader applications than just for multinational banks. Indeed, our results are related to the debate concerning the regulation of stand-alone financial firms versus firms within a financial conglomerate (see, e.g., EU Directive on Supervision of Financial Conglomerates, 2002).[18] Our analysis suggests that firms within a financial conglomerate in general behave more prudently, because losses are carried by all firms in the conglomerate, and therefore should face a lower capital requirement than stand-alone firms. Of course, a proper analysis of capital regulation of financial conglomerates should take into account the differences between banks and firms in other financial sectors with respect to, for example, market discipline and the riskiness of their assets. This is left for future research.

[18] Financial conglomerates are defined as any group of companies under common control whose exclusive or predominant activities consist of providing significant services in at least two different financial sectors (banking, securities, insurance) (see e.g. Joint Forum, 2001).

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A Derivation of Assumption 4

First, we derive the condition, which secures that the regulator sets the minimum capital requirements necessary to induce a certain behavior. We get that

$$\frac{\partial W_B(k_B,\theta)}{\partial k_B} \mid_{k_B \geq k_B^b} < 0,$$

$$\frac{\partial W_B(k_B,\theta)}{\partial k_B} \mid_{k_B \geq k_B^0} < 0 \Leftrightarrow \frac{\rho}{\lambda} > (1-p)(1-\theta), \tag{22}$$

$$\frac{\partial W_S(k_S,\theta)}{\partial k_S} \mid_{k_S \geq k_S^0} < 0 \Leftrightarrow \frac{\rho}{\lambda} > \frac{1}{2}(1-\theta), \tag{23}$$

We have that (22) and (23) are satisfied if $\frac{\rho}{\lambda} > (1-\theta)Max(1/2, 1-p)$.

Consider now the regulator's payoff from setting the capital requirements below k_B^0 and k_S^0. We get that

$$\frac{\partial W_B(k_B,\theta)}{\partial k_B} \mid_{k_B < k_B^0} > 0 \Leftrightarrow \frac{\rho}{\lambda} < (1-p)(1-\theta p), \tag{24}$$

$$\frac{\partial W_S(k_S,\theta)}{\partial k_S} \mid_{k_S < k_S^0} > 0 \Leftrightarrow \frac{\rho}{\lambda} < \frac{1}{2}\left[(1-p)+(1-\theta p)\right]. \tag{25}$$

Since $(1-p)(1-\theta p) < \frac{1}{2}\left[(1-p)+(1-\theta p)\right]$ we obtain that (24) and (25) are satisfied if $\frac{\rho}{\lambda} < (1-p)(1-\theta p)$. In this case the best alternatives to k_B^0 and k_S^0 are $k_B^0 - \varepsilon$ and $k_S^0 - \varepsilon$. Since $W_B(k_B^0,\theta) > W_B(k_B^0 - \varepsilon,\theta)$ and $W_S(k_S^0,\theta) > W_S(k_S^0 - \varepsilon,\theta)$, the regulator never sets capital requirements below k_B^0 and k_S^0.

Finally, $(1-\theta)Max(1/2, 1-p) \leq \frac{\rho}{\lambda} \leq (1-p)(1-\theta p)$, $\forall\ \theta\ \epsilon\ [\eta, 1]$ is fulfilled if and only if $(1-\eta)Max(1/2, 1-p) \leq \frac{\rho}{\lambda} \leq (1-p)^2$.

B Capital Regulation with Two Regulators

In this appendix, we analyze capital regulation when the two offices are located in different countries and when the national regulators maximize local welfare. First, we determine the conditions under which the optimal screening equilibrium, $k_S = k_S^0$ and $k_B = k_B(\theta_R)$, is an equilibrium outcome in the setup with two regulators. We need to introduce some additional notation. Consider equation (16) with $\hat{\theta}$ replaced by θ_R and k_S by $k_S^X + k_S^Y$. Equation (16) gives combinations of k_B, k_S^X and k_S^Y such that the risky type is indifferent between setting up a branch-MB or a subsidiary-MB. We define $\widetilde{k}_B(k_S^X, k_S^Y)$ as the capital requirement for the branch-MB, as a function of k_S^X, k_S^Y, such that the risky type is indifferent between the two structures. The two other capital requirements $\widetilde{k}_S^X(k_B, k_S^Y)$ and $\widetilde{k}_S^Y(k_B, k_S^X)$ are defined in a similar manner.

We obtain the following lemma.

Lemma 9 *A necessary and sufficient condition for* $k_S^X = k_S^Y = k_S^0/2$ *and* $k_B = k_B(\theta_R)$ *to be an equilibrium is that*

$$\frac{\partial(\delta W_B^1(\widetilde{k}_B(k_S^X, k_S^Y), 1) + (1-\delta)W_S^1(k_S^X, k_S^Y, \theta_R))}{\partial k_S^X} \leq 0. \tag{26}$$

Proof. First, suppose that (26) does not hold. Then, since $\widetilde{k}_B(k_S^0/2, k_S^0/2) = k_B(\theta_R)$, regulator X would benefit from choosing $k_S^X > k_S^0/2$ and increasing k_B to $\widetilde{k}_B(k_S^X, k_S^Y)$. Equation (26) is thus a necessary condition.

To show that it is also a sufficient condition assume that (26) holds. For regulator Y the only possible deviation is to increase k_S^Y, which would induce both types to choose a branch structure. Since screening is optimal in the single regulator case, we have that $W_S^i(k_S^0/2, k_S^0/2, \theta_R) - W_B^i(k_B(\theta_R), \theta_R) = 1/2(W_S(k_S^0, \theta_R) - W_B(k_B(\theta_R), \theta_R)) > 0$. Therefore, $k_S^Y > k_S^0/2$ is not a profitable deviation.

Consider now regulator X. Equation (26) gives that it is never optimal to increase both k_S^X and k_B in such a way that the two types are still screened. Instead, regulator X could lower k_B to induce both types to set up branch-MBs. Since screening is optimal in the single-regulator case, we have:

$$\begin{aligned} \delta W_B^X(k_B(\theta_R), 1) + (1-\delta)W_S^X(k_S^0/2, k_S^0/2, \theta_R) &= \frac{1}{2}\left(\delta W_B(k_B(\theta_R), 1) + (1-\delta)W_S(k_S^0, \theta_R)\right) \geq \\ \frac{1}{2}\left(\delta W_B(k_B, 1) + (1-\delta)W_B(k_B, \theta_R)\right) &= \delta W_B^X(k_B, 1) + (1-\delta)W_B^X(k_B, \theta_R), \end{aligned}$$

for all $k_B^0 \leq k_B \leq k_B(\theta_R)$. Hence, $k_B < k_B(\theta_R)$ is not a profitable deviation. Finally, increasing k_B in order to induce the safe types to set up subsidiary-MBs is not a profitable deviation, because it decreases profits without reducing the costs of deposit insurance. ■

It is important to notice that even if (26) is satisfied, $k_S^X = k_S^Y = k_S^0/2$ and $k_B = k_B(\theta_R)$ may not be the unique equilibrium. We assume in the sequel that condition (26) is violated.

In this case, the opportunistic behavior by the regulators is certain to have a welfare cost. In the following we analyze the reaction correspondences of the two regulators and find the set of candidate best responses. Afterwards, we derive reaction correspondences and equilibria in a numerical example that illustrates the point made in Section 5.2.

B.1 Reaction Correspondence of Regulator X

The first thing to notice is that it is never optimal for the regulator in country X to induce both types to set up as a subsidiary-MB. To see this, consider k_S^X and k_B such that both types prefer the subsidiary structure. The regulator can instead choose a lower value of k_B such that the safe types set up as a branch-MB. Notice that this is always feasible without inducing gambling in office-1 by the safe types, because $k_B^0 < k_S^0$. Screening the types in this way is welfare improving for two reasons: i) profits increase, since the safe types face a lower capital requirement; ii) the cost of deposit insurance remains unchanged, because the safes types never fail.

Lemma 10 *Regulator X always sets the capital requirements such that safe types choose to set up as a branch-MB.*

Consider now an equilibrium with screening. From $\partial W_B^X(k_B, 1)/\partial k_B < 0$ it follows that it is optimal to reduce k_B until the risky types are indifferent between the branch and the subsidiary structure. Since (26) is violated, we obtain the following lemma.

Lemma 11 *A candidate best response to k_S^Y is either $(k_B, k_S^X) = (\overline{k}_B, \widetilde{k}_S^X(\overline{k}_B, k_S^Y))$ or $(k_B, k_S^X) = (\widetilde{k}_B(\overline{k}_S, k_S^Y), \overline{k}_S)$.*

Finally, regulator X may choose to set k_B so low that both types prefer the branch structure. Since $W_B^X(k_B, \theta) = W_B(k_B, \theta)/2$, it follows from Assumption 4 that the optimal capital requirement is $k_B = k_B^0$.

Lemma 12 *A candidate best response to k_S^Y is (k_B^0, k_S^X) where $k_S^X \in [k_S^0/2, \overline{k}_S]$.*

B.2 Reaction Correspondence of Regulator Y

Since (26) is violated, we have that $\partial W_S^Y(k_S^X, k_S^Y, \theta_R)/\partial k_S^Y > 0$. In a screening equilibrium, the regulator in country Y thus wishes to set the capital requirement as close to $\widetilde{k}_S^Y(k_B, k_S^X)$ as possible.

Lemma 13 *A candidate best response is:*

$$k_S^Y = \begin{cases} k_S^Y \in [k_S^0/2, \overline{k_S}] & \textit{for} \quad \widetilde{k}_S^Y(k_B, k_S^X) < k_S^0/2 \\ \widetilde{k}_S^Y(k_B, k_S^X) & \textit{for} \quad k_S^0/2 \leq \widetilde{k}_S^Y(k_B, k_S^X) < \overline{k}_S \\ \overline{k}_S & \textit{otherwise} \end{cases} .$$

Notice that the choice of k_S^Y does not affect welfare if $\widetilde{k}_S^Y(k_B, k_S^X) < k_S^0/2$, because both types set up branch-MBs.

Another candidate best response is to set k_S^Y such that the risky types set up as a branch-MB. This is never a best response if $k_S^X = k_S^0/2$ and $k_B = k_B(\theta_R)$ (see the proof of Lemma 9), but it may be optimal if $k_B > k_B(\theta_R)$.

Lemma 14 *For $\overline{k}_S > \widetilde{k}_S^Y(k_B, k_S^X) \geq k_S^0/2$, a candidate best response is $k_S^Y \in (\widetilde{k}_S^Y(k_B, k_S^X), \overline{k}_S]$.*

The last candidate best response is, if possible, to set k_S^Y so low that both types prefer the subsidiary structure, $k_S^Y < k_B - k_S^X$. Whether the regulator in this case wishes to set k_S^Y to $k_S^0/2$ or to $k_B - k_S^X - \varepsilon$ depends on the sign of $\partial(\delta W_S^Y(k_S^X, k_S^Y, 1) + (1-\delta) W_S^Y(k_S^X, k_S^Y, \theta_R))/\partial k_S^Y$.

Lemma 15 *For $k_B - k_S^X > k_S^0/2$ a candidate best response is $k_S^0/2$ ($k_B - k_S^X - \varepsilon$) for $\partial(\delta W_S^Y(k_S^X, k_S^Y, 1) + (1-\delta) W_S^Y(k_S^X, k_S^Y, \theta_R))/\partial k_S^Y < (\geq) 0$.*

B.3 Numerical Example

In this section we derive the equilibrium for the following parameter values: $p = 0.42$, $R = 2.7$, $\alpha = 1.5$, $\rho = 0.1$, $\lambda = 0.3$, $\delta = 0.5$, $\theta_R = 0.6$, $\overline{k}_S = 0.5$ and $\overline{k}_B = 1$. It can be verified that for these values the capital requirements chosen by a single, benevolent regulator are $(k_B, k_S) = (k_B(\theta_R), k_S^0)$. We have that $k_S^0/2 = 0.37$ and $k_B^0 = 0.28$.

We start by deriving the reaction correspondences of the regulators. Afterwards, we find the equilibria of the game.

The Reaction Correspondence of Regulator X We have that $\widetilde{k}_S^X(1, k_S^Y) > \overline{k}_S = 0.5$, so Lemma 11 - 12 imply that the candidate best responses are $(k_B, k_S^X) = (\widetilde{k}_B(1/2, k_S^Y), 1/2)$ and $(k_B, k_S^X) = (k_B^0, k_S^X)$ for some $k_S^X \in [k_S^0/2, 1/2]$. It can be verified that for the parameter values considered:

$$\delta W_B^X(\widetilde{k}_B(k_S^Y, 1/2), 1) + (1-\delta) W_S^X(1/2, k_S^Y, \theta_R) > \delta W_B^X(k_B^0, 1) + (1-\delta) W_B^X(k_B^0, \theta_R)$$

for all $k_S^Y \in [k_S^0/2, 1/2]$. Hence, it follows:

$$R^X(k_S^Y) = \begin{cases} k_S^X = 1/2 \\ k_B = \widetilde{k}_B(1/2, k_S^Y) \end{cases}.$$

The Reaction Correspondence of Regulator Y For the given parameter values we obtain that $\partial(\delta W_S^Y(k_S^X, k_S^Y, 1) + (1-\delta) W_S^Y(k_S^X, k_S^Y, \theta_R))/\partial k_S^Y > 0$. From Lemma 13 - 15 it follows that the candidate best responses are: $k_S^Y \in [k_S^0/2, 1/2]$, $\widetilde{k}_S^Y(k_B, k_S^X)$, $\overline{k}_S$, $k_S^Y \in (\widetilde{k}_S^Y(k_B, k_S^X), 1/2]$ and $k_B - k_S^X - \varepsilon$. As a shortcut, we impose $k_S^X = 1/2$, which has to hold in equilibrium. Straightforward calculations show that for all $k_B \in [k_B^0, 1]$:

$$\delta W_B^Y(k_B, 1) + (1-\delta) W_S^Y(1/2, \widetilde{k}_S^Y(k_B, 1/2), \theta_R) >$$
$$\delta W_S^Y(1/2, k_B - k_S^X - \varepsilon, 1) + (1-\delta) W_S^Y(1/2, k_B - k_S^X - \varepsilon, \theta_R),$$

and

$$\delta W_B^Y(k_B, 1) + (1-\delta) W_S^Y(1/2, \widetilde{k}_S^Y(k_B, 1/2), \theta_R) > \delta W_B^Y(k_B, 1) + (1-\delta) W_B^Y(k_B, \theta_R).$$

The best response is therefore given by Lemma 13. Suppressing $k_S^X = 1/2$ in the notation, we can then write the reaction function of country Y as:

$$R^Y(k_B) = \begin{cases} k_S^Y \in [k_S^0/2, 1/2] & \text{for} \quad \widetilde{k}_S^Y(k_B, 1/2) < k_S^0/2 \Leftrightarrow k_B < 0.53 \\ \widetilde{k}_S^Y(k_B, 1/2) & \text{for} \quad k_S^0/2 \leq \widetilde{k}_S^Y(k_B, 1/2) < 1/2 \Leftrightarrow 0.53 \leq k_B < 0.65 \\ \overline{k}_S = 1/2 & \text{otherwise} \end{cases}.$$

The Equilibrium Capital Requirements Figure 7 illustrates the reaction correspondences and the equilibrium in (k_B, k_S^Y)-space. The figure shows that $R^X(k_S^Y)$ and $R^Y(k_B)$ coincide for $k_B \in [\widetilde{k}_B(1/2, k_S^0/2), \widetilde{k}_B(1/2, 1/2)]$, because $R^X(\cdot) = (R^Y)^{-1}(\cdot)$. Hence, there

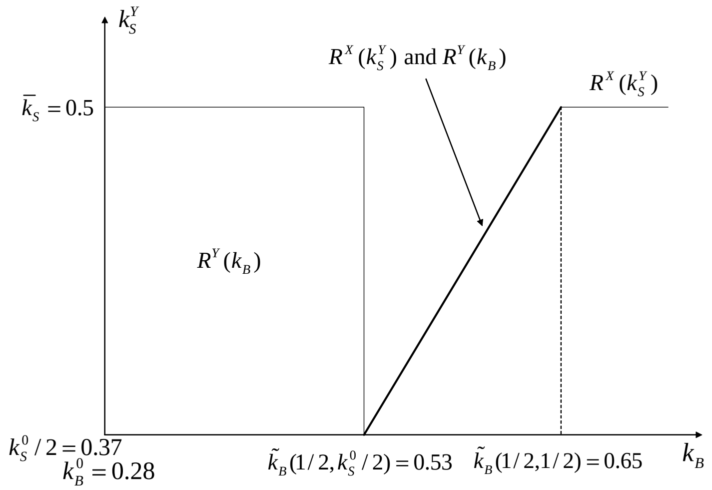

Figure 7: The reaction correspondences of the regulators in the two countries in the numerical example. The correspondences are drawn using the optimal response $k_S^X = 1/2$. The set of equilibria is indicated with the thick line.

is a continuum of equilibria described by $(k_B, k_S^X, k_S^Y) = (k_B, 1/2, \widetilde{k}_S^Y(k_B, 1/2))$ for $k_B \in [\widetilde{k}_B(1/2, k_S^0/2), \widetilde{k}_B(1/2, 1/2)]$. The equilibrium capital requirements of both the safe and the risky types are increasing in k_B. In Figure 7 the equilibria are indicated with a thick line.

A benevolent regulator would in the example set $k_S^X = k_S^Y = k_S^0/2 = 0.37$ and $k_B(\theta_R) = 0.43$, so both types face a higher capital requirement than in the optimal screening equilibrium. Hence, the welfare maximizing equilibrium is the one that minimizes capital requirements, namely $(k_B, k_S^X, k_S^Y) = (\widetilde{k}_B(1/2, k_S^0/2), 1/2, k_S^0/2)$.

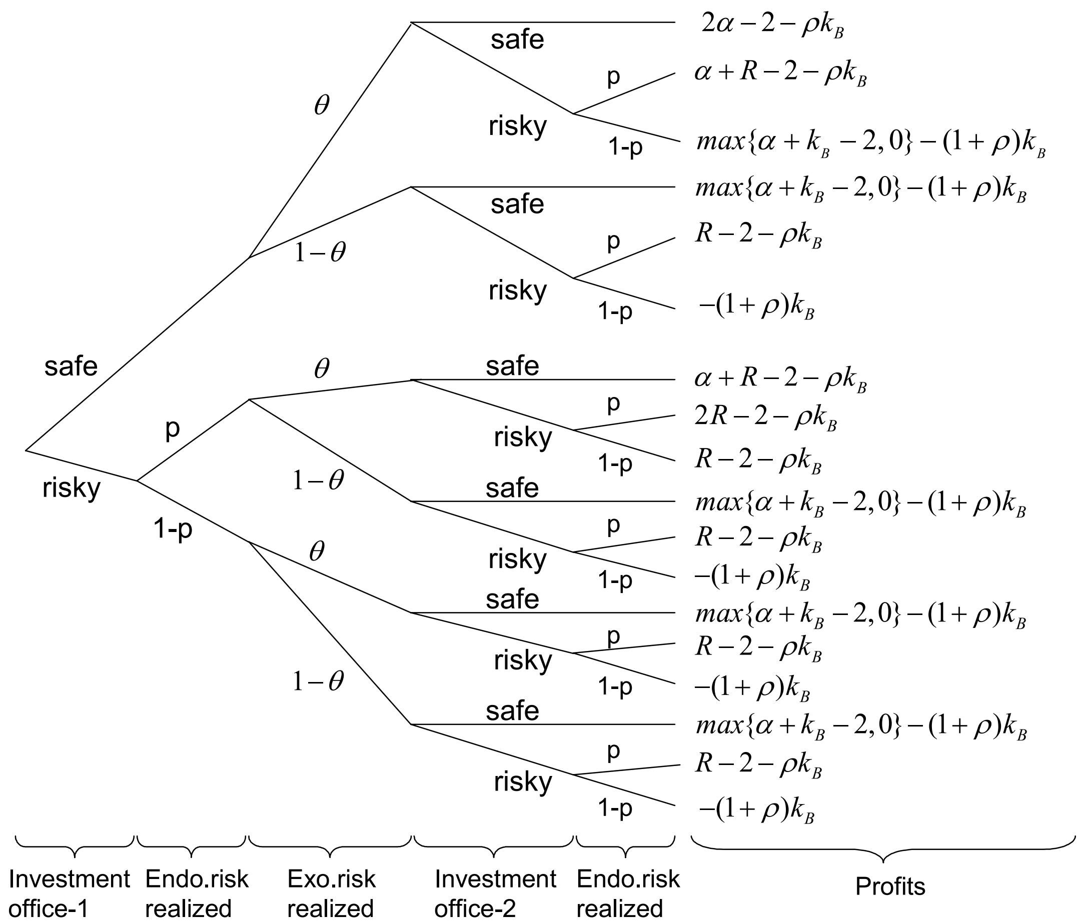

Figure 2: *The game tree in the subgame where the bank has set up as a branch-MB.*