Multinational Bank Capital Regulation with Deposit Insurance and Diversification Effects*

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Abstract

We analyse a model in which bank deposits are insured and there is an exogenous cost of bank capital. The former effect results in bank overinvestment and the latter in underinvestment. Regulatory capital requirements introduce investment distortions which are a constrained optimal response to these market imperfections. We show that capital requirements which are constrained optimal for national banks result in underinvestment by multinational banks. The extent of underinvestment depends upon the home bank's riskiness, the extent of international diversification, and the liability structure (branch or subsidiary) of the multinational. Capital requirements for international banks should therefore reflect these effects. We relate our findings to observed features of multinational banks and we discuss the possible existence of a multinational bank channel for financial contagion.
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1. Introduction

In this paper we examine capital adequacy requirements and their effects upon lending policy in diversified multinational banks. Our work is motivated by a number of observations of the current regulatory framework and its apparent consequences for banker behaviour.

Firstly, it has been widely observed that current, risk-insensitive, international capital adequacy standards have resulted in a reduction in lending to low risk projects and an increase in riskier lending (Furfine et al, 1999). The practitioner community appears to attribute this to the costs of meeting differences between their own assessments of capital requirements, or "economic" capital, and those of the regulators.[1]

Secondly, the effects of capital regulation on mulinational banks (MNBs) are attracting an increasing degree of attention from the academic and regulatory communities. MNBs consist of a home bank and a number of foreign banks. At present foreign banks are run either as subsidiaries of the home bank, or as branches. One can think of branches as extensions of the home bank: the two institutions share joint liability for the failure of their assets and they call upon the same deposit insurance fund. Subsidiary banks are themselves assets of the home bank and are therefore closer to independent insitutions. While the subsidiary and home banks share liability for the home bank's assets, the home bank has no liability for subsidiary bank failure.

Branch and subsidiary banks are further distinguished by their regulation. Branches, as an extension of the home bank, are regulated by the home regulator; subsidiaries, as quasi-foreign banks, are regulated by the foreign regulator. Deposits in the foreign branch and subsidiary banks are similarly insured by the respective home or the foreign regulators. Thus, although all MNBs are subject to consolidated supervision by the home regulator, the foreign regulator's influence is extremely important in the case of subsidiaries.

European regulators have instigated a "single passport" scheme (EEC, 1989) which allows any home E.U. bank to establish branches elsewhere in the E.U. This is intended to demolish protective barriers to entry errected by foreign regulators and hence to facilitate banking competition in the European Union. Notwithstanding this legislation, many home banks have nevertheless elected to expand within the European Union via the creation of foreign subsidiaries (Dermine, 2002). This suggests that there is a material difference between the operation of branch and subsidiary banks.

MNB structure in both Latin America and Eastern Europe provides further evidence that bankers differentiate between branch and subsidiary structures. In both regions bankers have a free choice between subsidiary and branch structures and yet in both cases the subsidiary bank predominates (BIS, 2001).

Thirdly, there is ongoing discussion concerning the appropriate regulatory response to portfolio diversification in banks. Practioners argue[2] that, because diversification reduces the risk of bank failure, the regulator should respond to to it by reducing capital requirements. In response regulators have argued that this would be inappropriate because diversification benefits are hard to measure. This debate is of clear importance when considering the systemic consequences of

[1] See J.P. Morgan (1997) for a discussion of economic capital, and Altman, Bharath and Saunders (2002) for evidence concerning the relative levels of economic and regulatory capital.

[2] See for example J.P. Morgan (1997).

cross-border diversification by a MNB.

In this paper we present a simple model in which depositors are protected by a deposit insurance net and bankers are subject to an exogenous cost of capital; this reflects the practitioner beliefs which we highlight above and can be formally explained in terms of pecking order effects (Myers and Majluf, 1984; Froot, Scharfstein and Stein, 1993; Froot and Stein, 1998; and Bolton and Freixas, 2000). These two phenomena drive our results. The insured depositors are risk-insensitive and the banker therefore has an incentive to overinvest in risky projects. Because capital is costly the banker is unwilling to invest in marginal projects and underinvestment will therefore ensue. We model a surplus-maximising regulator who responds to these stimuli by setting a minimum capital requirement. The optimal capital requirement for a standalone bank trades off the under-investment caused by high capital requirements against the over-investment resulting from low capital requirements and an insured depositor base.

We are therefore able to provide a simple formal explanation for the first of our above observations. We then extend our reasoning to examine cross border expansion. We assume that foreign banks are established after home banks and that the investment policy of the foreign bank is therefore predicated upon the portfolio of the home bank. We are able to show that a capital requirement which is optimal for a national bank results in underinvestment when applied to a multinational bank. Our results are a consequence of cross-border diversification effects. When a home bank opens a branch in another country, diversification effects across the two portfolios reduce the value to both banks' shareholders of the deposit insurance net subsidy. As a result the branch bank sets a higher hurdle rate than a standalone bank faced with the same investment opportunity set. A similar effect obtains for subsidiary banks, but is less pronounced because the home bank can in that case walk away from a failing foreign bank so that the subsidiary bank extracts the full standalone value of the deposit insurance safety net.

The inefficiency which we identify in the above paragraph arises because cross-border diversification effects force the internalisation of some of the negative effects of over-investment. Because this reduces the burden placed upon the deposit insurance fund, standard arguments suggest that this increases welfare.[3] In our model this is not the case. Capital requirements for standalone banks introduce some deliberate underinvestment which optimally counters the over-investment induced by deposit insurance. Diversification reduces the over-investment problem and it follows that retaining the same capital requirement results in an inefficiently low level of investment.

This reasoning allows us to explain the predominance when bankers have a choice of subsidiary over branch bank structures. Although E.U. law encourages the creation of branch networks, bankers choose optimally to establish subsidiaries so as to avoid as far as possible the underinvestment problems which we have identified above. Similarly, the preference for subsidiary structures in Latin America and in the transition economies may be a consequence of the underinvestment induced by branch banks, rather than the fear of cross-subsidisation by home regulators which has previously been identified with a policy of "ring-fencing" (Basle Committee on Banking Supervision, 1992).

Our model also allows us to discuss the optimal regulatory response to diversification. As diver-

[3] See for example Merton (1977), Freixas and Rochet (1997, chapter 9.4.1) and references therein.

sification reduces deposit insurance-induced overinvestment incentives, the appropriate response in our set-up is clearly to reduce the counterbalancing underinvestment effect of capital requirements. In other words, our work suggests that diversified insitutions should have lower capital requirements. Note that although our recommendations are in accordance with the received wisdom of practitioners, our reasons are different. Capital requirements in our model deliberately introduce one imperfection in response to the existence of another; the practitioner argument appears largely to rest upon the economic benefits of a reduced probability of bankruptcy.

Our work extends a substantial literature on bank capital and bank regulation. Several papers study the role of capital requirements in correcting moral hazard problems. Dewatripont and Tirole (1993a, 1993b) determine the capital structure which implements the optimal intervention policy of a regulator acting to correct moral hazard problems in an incomplete contracting environment. Deposit insurance has no role in their work and, in contrast to our model, their regulator is concerned with *ex post* levels of depositor welfare rather than with *ex ante* social surplus. Bhattacharya (1982), Rochet (1992) and Morrison and White (2002) also study moral hazard problems; Milne (2002) does so in an environment in which capital has an exogenous cost. Other papers have examined the role of capital adequacy requirements in combatting bank runs (Diamond and Dybvig, 1983; Diamond and Rajan, 2000, 2001), and in maintaining bank rents (Hellman, Murdock and Stiglitz, 2000). As far as we are aware, ours is the first paper explicitly to model the relationship between deposit insurance and capital rationing.

There is a growing literature on multinational banks. Repullo (2001) addresses the problem of limited supervisory information on a MNB's foreign activities and draws conclusions on cross-border takeovers. Holthausen and Rønde (2002) examine informational problems in international bank regulation and show that, if national interests are not aligned, the first-best closure rule in branch MNBs cannot be implemented if the home regulator has to rely on information from the foreign regulator. Kahn and Winton (2001) examine the impact of organisational structure on risk-taking and project selection. They argue that separating low from high risk assets in a subsidiary structure may reduce incentives for risk-shifting. In contrast to their paper, we consider the effect of regulatory tools on project selection under different MNB organisational structures. Acharya (2002) studies the interaction between regulatory capital requirements and closure policy. He demonstrates that a lack of cross-border capital harmonisation can result in closure policy spillovers from more to less forbearing regimes. In an analysis of the effects of the representation form of a multinational bank upon its regulation, Calzolari and Lóránth (2002) compare regulators' responsiveness to information when taking prudential actions. However, their paper is mainly concered with closure policies and they do not examine the impact of regulation on project selection. Finally, Bebchuk and Guzman (1999) focus on the effects of the legal regime ("territoriality" versus "universality") governing transnational bankruptcies. As well as affecting the the distribution of assets in bankruptcy, they show that the legal regime has *ex ante* consequences for the allocation of investment. They argue that universality, by treating all creditors equally, avoids distortions in investment patterns.

The remainder of the paper is organised as follows. In section 2 we describe the basic set-up of our model and we derive the optimal capital requirement for a standalone bank with insured depositors which faces an exogenous cost of capital. In sections 3 and 4 we show how investment behaviour in a foreign bank faced with a standalone bank's capital requirements is distorted by diversification effects. Section 5 contains some concluding remarks about systemic effects. Several of the proofs are relegated to an appendix.

2. Standalone Bank Regulation

2.1. The Model

In this section we introduce our modelling approach and we use it to discuss capital requirements for a standalone bank regulated by a single regulator: in later sections we extend our analysis to multinational banks. The bank is a risk-neutral profit maximiser which collects deposits from insured depositors and selects investments on their behalf. The regulator provides deposit insurance and sets capital adequacy requirements for the bank so as to maximise *ex ante* expected social surplus.

We are concerned in this paper with the allocative distortions caused by deposit insurance and we ignore payments which the banker might make into a deposit insurance scheme. We return to this point in the conclusion, where we argue that, as the banker is charged for the average rather than the marginal cost of his risk-shifting, these payments cannot resolve the allocative problems which we identify below.

The bank operates in the following manner.

At time t_0, nature presents the bank with an investment project (B, R). Investment opportunities require a time t_1 investment of 1 and at time t_2 they return $R + B$ if successful and $R - B$ if unsuccessful; the probability of success and of failure is 0.5. We assume that (B, R) is uniformally distrubuted over $\mathcal{A} \equiv \left\{(B, R) \in \Re^2 : R_l \leq R \leq R_h, 0 \leq B \leq R\right\}$, and we write $A \equiv \frac{1}{2}(R_h - R_l)(R_h + R_l)$ for the area of $\mathcal{A}$.

At time t_1 the bank decides whether or not to invest in the project. If it elects to invest then it raises $(1 - C)$ from depositors and C as equity capital; C is dictated by the regulator. We assume that there is an exogenous dead weight cost κ per unit of equity capital which the bank deploys. As we discuss in the introduction, this assumption is intended to capture the *de facto* capital rationing which appears to exist in financial intermediaries. We identify in the introduction a number of papers which have exaplained this rationing by appealing to information asymmetries which result in adverse selection problems between the banker and the capital markets.

If the bank invests in the project then its returns are realised at time t_2 and are distributed to the various providers of funds.

Our goal is to model the impact which capital requirements and deposit insurance have upon the agency problem which exists between the regulator, as administrator of the deposit insurance fund, and the bank, as the agent which deploys capital. We therefore ignore in this paper the role of banks in providing liquidity insurance (see for example Diamond and Dybvig, 1983).

2.2. Banker Investment Decisions

The first best investment decision for the banker would be to invest in any project with positive NPV: in other words, for which $R \geq 1$. In practice, the banker will deviate from this strategy for two reasons: because depositors are protected by deposit insurance, and because the bank faces an exogenous cost κ of raising fresh capital. In this section, we determine the banker's response to a capital requirement of C; in the following one we use this analysis to determine the optimal level for C.

As noted in the introduction, the effects of deposit insurance are well understood. If the bank experiences a loss in excess of its equity capital base, the losses will be borne by the deposit insurance fund and not by the depositors. Such a loss is possible in our model for a project (R, B) whenever $R - B + C < 1$: in other words, when combining the returns from project failure with the bank's capital base is insufficient to repay the depositors. In the presence of deposit insurance, the depositors will not price this loss. The bank's shareholders will therefore experience a profit of

$$\mathcal{D} \equiv \frac{1}{2}\left[(1 - C) - (R - B)\right] \tag{1}$$

without paying for the corresponding loss. This effect generates excessive risk-taking.

We define $\mathcal{S} \equiv \{(B, R) \in \mathcal{A} : \mathcal{D} > 0\}$ to be the set of **speculative** projects and $\mathcal{P} \equiv \mathcal{A} \backslash \mathcal{S}$ to be the set of **prudent** projects. We say that a bank with project (B, R) is speculative or prudent according to whether (B, R) is speculative or prudent. Shareholders in speculative banks receive a wealth transfer with expected value $\mathcal{D}$ from the deposit insurance fund; those in prudent banks experience the whole of any losses experienced by their projects.

The bank's objective is to maximise the value of its shares. Investing in project (B, R) generates shareholder value

$$\frac{1}{2}\left\{(R + B - (1 - C)) + \max\left(R - B - (1 - C), 0\right)\right\} - C\left(1 + \kappa\right).$$

The expected shareholder payoff from prudent investments is $R - 1 - C\kappa$ and from speculative investments is $\frac{1}{2}(R + B - 1 - C) - C\kappa = \frac{1}{2}(R - [1 - B + C(1 + 2\kappa)])$. The banker will invest in any project which yields a positive NPV. This yields hurdle rates for prudent and speculative projects of $H^P(B)$ and $H^S(B)$ respectively, where

$$H^P(B) \equiv 1 + C\kappa; \tag{2}$$

$$H^S(B) \equiv 1 - B + C(1 + 2\kappa). \tag{3}$$

Note that at the boundary between the speculative and the prudent regions, $H^P(B) = H^S(B)$.[4]

The intutition for these hurdle rates is simple. With a capital requirement of C the cost of investing in project (B, R) is $1 + C\kappa$. The bank's shareholders experience all of the profits and losses associated with prudent projects and therefore price them correctly: this yields the hurdle rate H^P. When they invest in speculative projects, the bank's shareholders receive a wealth transfer $\mathcal{D}$ from the deposit insurance fund: as a consequence, they will invest in any project for which

$$R \geq 1 + C\kappa - \mathcal{D}. \tag{4}$$

[4] To see this, observe that at the boundary the hurdle rate H^P is equal to $B + 1 - C$. Setting this equal to $1 + C\kappa$ yields $B = C(1 + \kappa)$, at which point $H^S(B) = 1 + C\kappa$ as required.

Rearranging equation 4 yields $R \geq H^S(B)$, as required.

2.3. Optimal Capital Adequacy Requirement

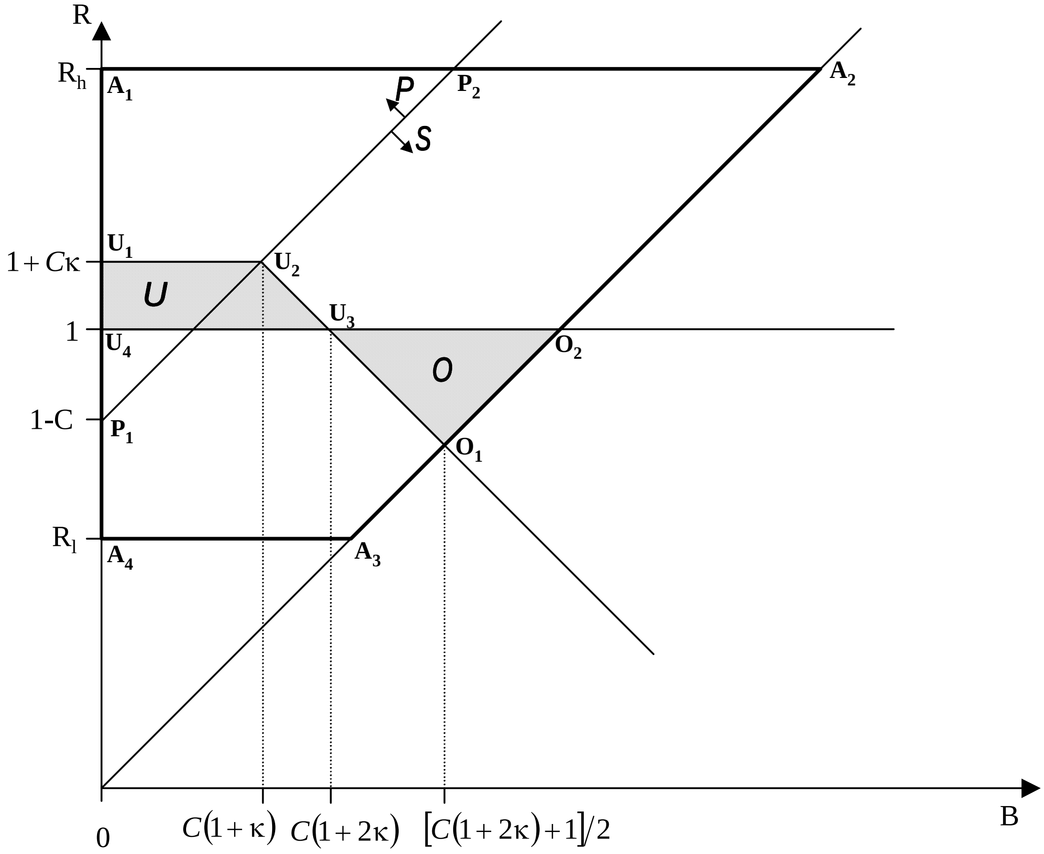

Figure 1: Investment decisions in response to a capital requirement C. The banker will invest in projects bordered by $A_1A_2O_1U_2U_1A_1$. This compares to the socially first best region $A_1A_2O_2U_4A_1$: the regions $\mathcal{U}$ and $\mathcal{O}$ respectively represent under- and over- investment.

The discussion thus far is illustrated in figure 1. The region $\mathcal{A}$ from which nature selects the banker's investment opportunities is bordered by the bold line $A_1A_2A_3A_4A_1$. The line P_1P_2 is the locus of points for which $\mathcal{D} = 0$: prudent investments lie above this line and speculative investments below it. The hurdle rate is given by line U_1U_2 (equal to H^P) in the prudent region and by line $U_2U_3O_1$ (equal to H^S) in the speculative region. It follows that the banker will accept any project (B, R) in the region bordered by $A_1A_2O_1U_2U_1A_1$. This is in contrast to the socially first best investment strategy: as noted above, this is to accept any projects with $R \geq 1$. It is clear from the figure that the banker will refuse some profitable projects and that he will accept some unprofitable ones. These are indicated on the figure by the shaded areas $\mathcal{U}$ and $\mathcal{O}$, representing respectively the under- and over- investment induced by the capital requirement C.

In other words, the flat capital requirement C induces the banker to turn away some safe profitable investment opportunities (region $\mathcal{U}$), and to accept some unprofitable risky ones (region

$\mathcal{O}$). This is precisely the behaviour observed in response to the first Basle Accord on bank capital (Furfine et al, 1999). Note that region $\mathcal{U}$ in figure 1 exists because of the non zero deadweight cost κ of capital; region $\mathcal{O}$ exists because the uninsured bank depositors are risk-insensitive and the banker can therefore shift some of the costs of his risk-taking onto the deposit insurance fund. Without these effects both regions would be empty and the banker's investment decision would be capital-invariant, as predicted by the Modigliani and Miller (1958) propositions.

Note that when C assumes its minimum value of 0, $\mathcal{U}$ shrinks to zero and $\mathcal{O}$ expands to fill the region between the line $R = 1$ and the downward sloping 45° line from $(B = 0, R = 1)$. When C assumes its maximum value of 1, $\mathcal{O}$ vanishes and $\mathcal{U}$ expands all the way to the line $R = B$. By varying C the regulator can therefore trade off the risk-shifting costs associated with deposit insurance (region $\mathcal{O}$) with the inefficiencies induced by the dead weight costs κ of capital (region $\mathcal{U}$).

The risk-shifting cost of deposit insurance is given by

$$\omega(C) \equiv \frac{1}{A}\int\int_{\mathcal{O}} (1 - R)\, dBdR,$$

and the underinvestment cost of the capital adequacy requirement C is given by

$$\upsilon(C) \equiv \frac{1}{A}\int\int_{\mathcal{U}} (R - 1)\, dBdR.$$

The sum of these expressions gives the total total allocative inefficiency induced by deposit insurance and the capital adequacy requirement C. The regulator therefore selects C^* in order to minimise $\omega(C^*) + \upsilon(C^*)$. Proposition 1, which is proved in the appendix, guarantees that $0 < C^* < 1$.

Proposition 1 The optimal capital requirement for a standalone bank lies strictly between 0 and 1.

3. Regulating A Multinational Bank with A Branch

We now extend the analysis of section 2.1 to discuss the regulation of a simple multinational bank consisting of a home bank and one foreign bank. In this section we consider a branch banking structure; in the following we consider a subsidiary structure.

Foreign branches are legally integral parts of the MNB . This has several implications. The most important ones from our point of view are firstly, that assets and liabilities can be freely shifted between the branch and the parent division and among the branches themselves (Benston, 1994);[5] and secondly, that in case of bank failure or closure, the multinational bank is wound up as one legal entity and branches are treated only as offices of the larger corporate entity.

[5] As branch's own capital is not clearly defined (Benston, 1994), lending limits imposed by host countries on local branches of foreign banks are generally based on the banks' worldwide capital and not on some capital measure imputed from an individual branch's own balance sheet (Houpt, 1999).

3.1. The Model

As noted in the introduction, we assume that foreign banks are opened after home banks have selected their investments and hence that the investment policy of the foreign bank depends upon the portfolio of the home bank. To understand the formation of foreign bank investment policy we consider the following extension of the model of section 2.1.

At time t_0, nature presents the home bank with an investment opportunity (B_H, R_H), drawn from the set $\mathcal{A}$ as in section 2.1.

At time t_1 the bank decides whether to invest in the project, and if it elects to invest it raises $(1 - C_H)$ from depositors and C_H as equity capital. C_H is determined by the regulator. At time t_2, and conditional upon the time t_1 investment decision, the home bank transmits an investment policy to the subsidiary: this takes the form of an investment hurdle rate $I_B(B)$ which is a function of the investment opportunity's riskiness B.[6]

At time t_3, nature presents the branch bank with an investment opportunity (B_B, R_B), drawn from $\mathcal{A}$ according to a distribution which is identical to but independent of that from which (B_H, R_H) is drawn. The returns of the home bank and subsidiary bank's projects are independent.

At time t_4 the subsidiary's manager invests in the project (B_B, R_B) if and only if $R_B \geq I_B(B_B)$. If investment occurs the subsidiary raises $(1 - C_B)$ from depositors and C_B in equity capital. C_B is determined by the regulator.

At time t_5 the returns from both projects are realised and are distributed amongst the various providers of finance.

We examine in subsequent sections the investment decision of the home bank, and the investment policies which will be selected in the wake of no investment by the home bank, a speculative investment, and a prudent invesment.

3.2. Home Bank Investment Decision

The investment sets of the home and the branch banks are independent and the time t_1 investment decisions of the home bank are therefore determined in precisely the same way as those of the standalone bank which we studied in section 2. The home bank will accept any investment (B_H, R_H) which lies in region $\mathsf{A}_1\mathsf{A}_2\mathsf{O}_1\mathsf{U}_2\mathsf{U}_1\mathsf{A}_1$ of figure 1.

3.3. Investment Policy: No Investment by the Home Bank

If the home bank does not make a time t_1 investment then the branch's investment returns cannot affect the performance of the home bank. In this case, the branch's investment policy will be the same as that derived in section 2 for a standalone bank.

3.4. Investment Policy: Speculative Home Bank

Suppose that the home bank has accepted a speculative project B_H, R_H, so that $R_H - B_H + C_H < 1$.

[6] The most general investment policy is a subset of projects in $\mathcal{A}$ which the subsidiary should accept. We demonstrate below that the optimal such policy is described by a hurdle rate of this form.

Conditional upon the branch bank investing in a project (B_B, R_B), there are four possible time t_4 outcomes, corresponding to the success or failure (S or F) of each of the two projects. Denoting outcomes by ordered pairs in which the home bank's result appears first, the payoff (gross of costs) to the shareholders from each outcome is as follows, where the superscript b appears because the MNB has branch structure:

$$V_{SS}^b \equiv R_H + B_H - (1 - C_H) + R_B + B_B - (1 - C_B)\,; \tag{5}$$
$$V_{SF}^b \equiv \max\left[R_H + B_H - 1 + C_H + R_B - B_B - 1 + C_B, 0\right]; \tag{6}$$
$$V_{FS}^b \equiv \max\left[R_H - B_H - 1 + C_H - R_B + B_B - 1 + C_B, 0\right]; \tag{7}$$
$$V_{FF}^b \equiv \max\left[R_H - B_H - 1 + C_H - R_B - B_B - 1 + C_B, 0\right]. \tag{8}$$

The limited liability of the combined multinational bank is reflected in these expressions by the square bracketted $\max[.]$ terms.

The projects of the home and subsidiary banks are by assumption independent. The net expected shareholder return from investing in both projects is therefore

$$V^s \equiv \frac{1}{4}\left[V_{SS}^b + V_{SF}^b + V_{FS}^b + V_{FF}^b\right] - (C_H + C_B)(1 + \kappa)\,. \tag{9}$$

To facilitate our analysis, we make the following defintions by analogy to equation 1:

$$\begin{aligned} \mathcal{D}_H &\equiv \frac{1}{2}\left[(1 - C_H) - (R_H - B_H)\right]; \\ \mathcal{D}_S &\equiv \frac{1}{2}\left[(1 - C_S) - (R_S - B_S)\right]. \end{aligned}$$

$\mathcal{D}_H$ and $\mathcal{D}_S$ are respectively the value of the deposit insurance net for a standalone home bank and a standalone subsidiary bank. Define similarly the hurdle rate H_S for the standalone subsidiary bank. We use these definitions to rewrite equations 6, 7 and 8 as

$$\begin{aligned} V_{SF}^b &\equiv 2\max\left[-(\mathcal{D}_H + \mathcal{D}_B) + B_H, 0\right]; \\ V_{FS}^b &\equiv 2\max\left[-(\mathcal{D}_H + \mathcal{D}_B) + B_B, 0\right]; \\ V_{FF}^b &\equiv 2\max\left[-(\mathcal{D}_H + \mathcal{D}_B), 0\right]. \end{aligned}$$

We proceed by examination of the respective cases where $-(\mathcal{D}_H + \mathcal{D}_B) + B_H$, $-(\mathcal{D}_H + \mathcal{D}_B) + B_B$ and $-(\mathcal{D}_H + \mathcal{D}_B)$ are greater than and less than zero. These cases divide the region $\mathcal{A}$ into five regions, as illustrated in figure 2.

The five regions for branch bank projects in figure 2 are named according to the solvency properties of the associated multinational bank.[7] We refer to a branch structure multinational bank as safe, diversified, and so on according to the region within which its branch bank project (B_B, R_B) lies. As illustrated in figure 3, irrespective of the performances of their respective divisions, safe banks are always *ex post* solvent. In diversified banks, the success of one division is always sufficient to ensure MNB solvency in the wake of failure by the other division, although failure of

[7] For branch bank MNBs, the cost of insolvency is met entirely from the deposit insurance fund of the home country.

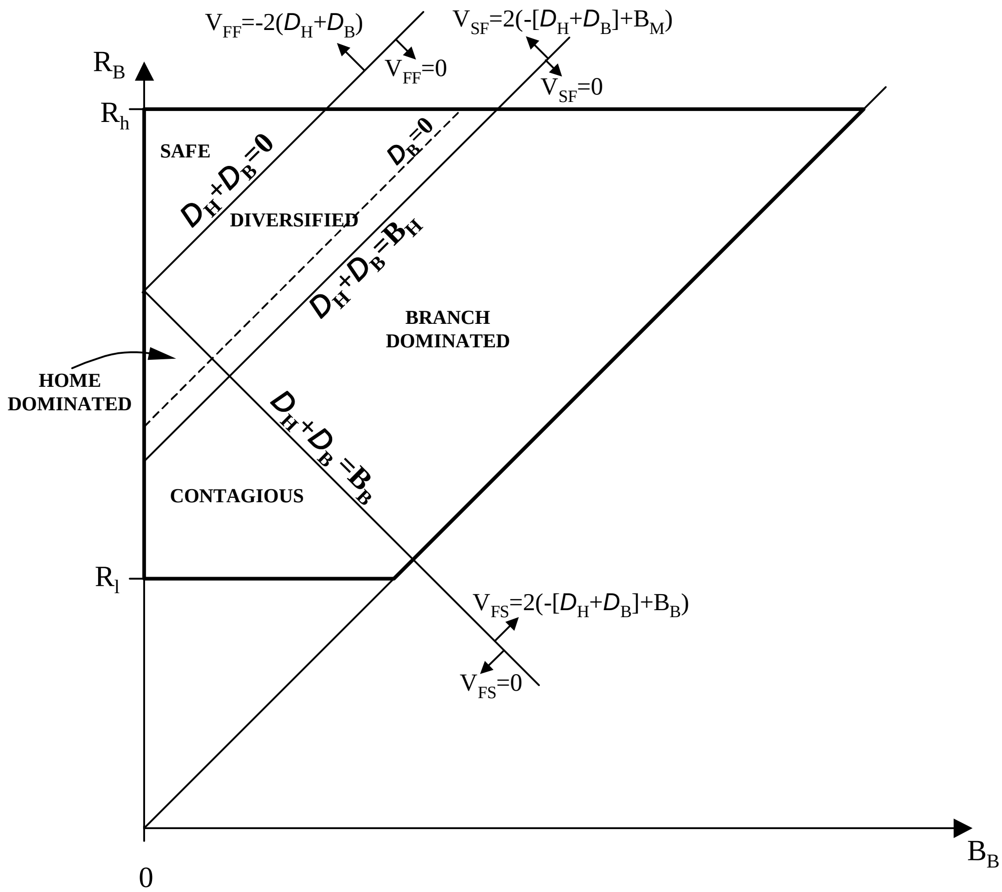

Figure 2: Branch bank projects, speculative home bank.

both divisions results in MNB insolvency. Branch dominated multinational banks have solvency properties which mirror those of their branch division; similarly, home dominant banks reflect the solvency properties of their home division. Finally, in contagious MNBs the failure of one division always results in the insolvency of the entire institution.

For a given project (B_B, R_B), the subsidiary will invest if and only if R_B is sufficiently high. The appropriate hurdle for R will depend upon the values of V_{SS}, V_{SF}, V_{FS} and V_{FF} and hence will depend upon the MNB's type: safe, diversified and so on. Proposition 2 establishes the type-contingent hurdle rates for the subsidiary.

Proposition 2 The speculative home bank requires the branch bank to invest in a project (B_B, R_B) precisely when the following type-contingent condition is satisfied:

1. Safe MNBs: $R_B \geq R^s_{B,Sf} \equiv H^P_B(B_B) + \mathcal{D}_H$;
2. Diversified MNBs: $R_B \geq R^s_{B,Dv} \equiv H^P_B(B_B) + \frac{1}{2}(\mathcal{D}_H - \mathcal{D}_B)$;
3. Branch Dominated MNBs: $R_B \geq R^s_{B,Br} \equiv H^S_B(B_B) + B_H$;
4. Home Dominated MNBs: $R_B \geq R^s_{B,Hm} \equiv H^P_B(B_B) + \left(-\mathcal{D}_B + \frac{1}{2}B_B\right)$;
5. Contagious MNBs: $R_B \geq R^s_{B,Ct} \equiv H^S_B(B_B) - (\mathcal{D}_H + \mathcal{D}_B) + (B_H + B_B)$.

SAFE

		Home Bank: Succeed	Home Bank: Fail
Branch Bank	Succeed	Solvent	Solvent
	Fail	Solvent	Solvent

DIVERSIFIED

		Home Bank: Succeed	Home Bank: Fail
Branch Bank	Succeed	Solvent	Solvent
	Fail	Solvent	Insolvent

BRANCH DOMINATED

		Home Bank: Succeed	Home Bank: Fail
Branch Bank	Succeed	Solvent	Solvent
	Fail	Insolvent	Insolvent

HOME DOMINATED

		Home Bank: Succeed	Home Bank: Fail
Branch Bank	Succeed	Solvent	Insolvent
	Fail	Solvent	Insolvent

CONTAGIOUS

		Home Bank: Succeed	Home Bank: Fail
Branch Bank	Succeed	Solvent	Insolvent
	Fail	Insolvent	Insolvent

Figure 3: Branch MNB Solvency. The tables show the effect which the results of the home and the branch bank have upon the solvency of the multinational bank.

Proof. In the appendix. 2

The superscript s on the R terms in this proposition reflects the fact that the home bank is speculative.

(i) Discussion of Proposition 2

Precise expressions for the hurdle rates in terms of the primitive variables B_B, R_B, B_H, C_H and C_B appear in the proof of proposition 2 in the appendix. The expressions in the statement of the proposition are presented in a form for which it is easy to provide intutition by comparing the value of the project (B_B, R_B) to a standalone bank with its value to the branch: we do so below.

Safe MNBs are always solvent and hence never call upon the deposit insurance fund. In accepting a project in the safe region the MNB therefore gives up the value $\mathcal{D}_H$ of the deposit insurance safety net which the speculative standalone home bank would otherwise receive. The profits $R_B - H_B^P$ of the branch bank must therefore be sufficient to cover this loss: this yields the expression for $R^s_{B,Sf}$.

As illustrated in figure 3, diversified banks will receive a payment from the deposit insurance fund only when both of their divisions fail. Diversified MNBs therefore lose half of the expected deposit insurance payment $\mathcal{D}_H$ which the home bank would otherwise receive. Prudent branch banks would on a standalone basis have a value $-2\mathcal{D}_B$ in the wake of failure: with probability $\frac{1}{4}$ this is given up in a diversified MNB. The profits $R_B - H_B^P$ of such a branch must therefore exceed $\frac{1}{2}(\mathcal{D}_H - \mathcal{D}_B)$, which yields $R^s_{B,Dv}$. The value to a speculative branch bank of the deposit insurance safety net is $\mathcal{D}_B$: half of this is lost when the branch is incorporated into a diversified MNB. In this case the profits $\frac{1}{2}\left[R_B - H_B^S(B_B)\right]$ of the branch bank must exceed the combined deposit insurance fund loss $\frac{1}{2}(\mathcal{D}_H + \mathcal{D}_B)$: manipulation of this requirement again yields $R^s_{B,Dv}$.

When a branch dominated MNB's home bank fails the value $2\mathcal{D}_H$ of its deposit insurance bail out is lost if the branch bank succeeds. Similarly, in the event that the branch fails and the home bank succeeds, the deposit insurance payment is reduced by the residual value $2(-\mathcal{D}_H + B_H)$ of the home bank. Both of these events occur with probability $\frac{1}{4}$. Since branch banks in this region are speculative, their standalone value is $\frac{1}{2}\left[R_B - H_B^S(B_B)\right]$: investment will only occur if this exceeds the total expected loss $\frac{1}{2}B_H$: equivalently, when $R_B \geq R_{B,Br}^s$.

The branch bank of a home bank dominated MNB may be either prudent or speculative. The argument for a speculative branch is similar to that for branch dominated MNBs: the deposit insurance payment $2\mathcal{D}_B$ from branch bank failure is again lost with probabilty $\frac{1}{4}$ and the deposit insurance payment in the wake of home bank failure is reduced by $2(-\mathcal{D}_B + B_B)$ if the branch bank succeeds: requiring the standalone profit $\frac{1}{2}\left[R_B - H_B^S(B_B)\right]$ to exceed the expected total loss yields $R \geq R_{B,Hm}^s$. A prudent branch is subject only to the second of these effects: requiring its standalone profit $R_B - H_B^P(B_B)$ to exceed its expected value again yields the expression for $R_{B,Hm}^s$.

Finally, note that contagious banks lose the value of a successful division in the event that the other succeeds: the total expected value of these effects is $\frac{1}{2}(-\mathcal{D}_B + B_B) + \frac{1}{2}(-\mathcal{D}_H + B_H)$. Investment in the branch bank's project will therefore occur precisely when its standalone profit $\frac{1}{2}\left[R_B - H_B^S(B_B)\right]$ exceeds this figure, which happens precisely when $R \geq R_{B,Ct}^s$.

(ii) Investment Policy

For a given riskiness B_B, only one of the hurdle rates identified in proposition 2 for the various regions which lie above B_B on figure 2 can lie inside the region to which it applies.[8] This rate is therefore equal to the investment policy $I_B^s(B_B)$ defined in section 3.1. We have already argued that the investment policy is determined by the effects of cross-border diversification upon expected receipts from the deposit insurance fund and in addition to B_B, I_B^s will therefore depend upon the value $\mathcal{D}_H$ of the deposit insurance net to the home bank. A precise characterisation of I_B^s appears in the appendix as proposition 10 and is illustrated in figure 4, which shows the branch bank's hurdle rate I_B^s and also the hurdle rate H for a standalone project with the same capital requirements.

Note that with common capital requirements for branches and standalone banks, the branch will invest in strictly fewer projects. To understand this, recall that the liability structure of the combined banking group forces the home and the branch banks to bail one another out. This reduces the value to the banking group of the home and branch bank's deposit insurance net and hence acts as a disincentive to branch bank investment. If the capital requirement is set constrained optimally set for standalone banks it therefore follows that branches invest in an inefficiently low number of projects.

3.5. Investment Policy: Prudent Home Bank

Suppose that the home bank has accepted a prudent project B_H, R_H, so that $R_H - B_H + C_H > 1$.

Equations 5 to 8 again give the shareholder returns in the terminal states of nature and the project space is again partitioned as in figure 2. Note though that when the home bank is prudent, the line $\mathcal{D}_B = 0$ lies strictly above the line $\mathcal{D}_H + \mathcal{D}_B = 0$, so that the safe MNB region includes a

[8] To see this, suppose that $R_a < R_b$ were two such hurdle rates, corresponding to regions a and b. Then for small enough ε, the branch would invest in projects with return $R_a + \varepsilon$ but not in projects with return $R_b - \varepsilon > R_a + \varepsilon$. Since both projects have the same riskiness this is a contradiction.

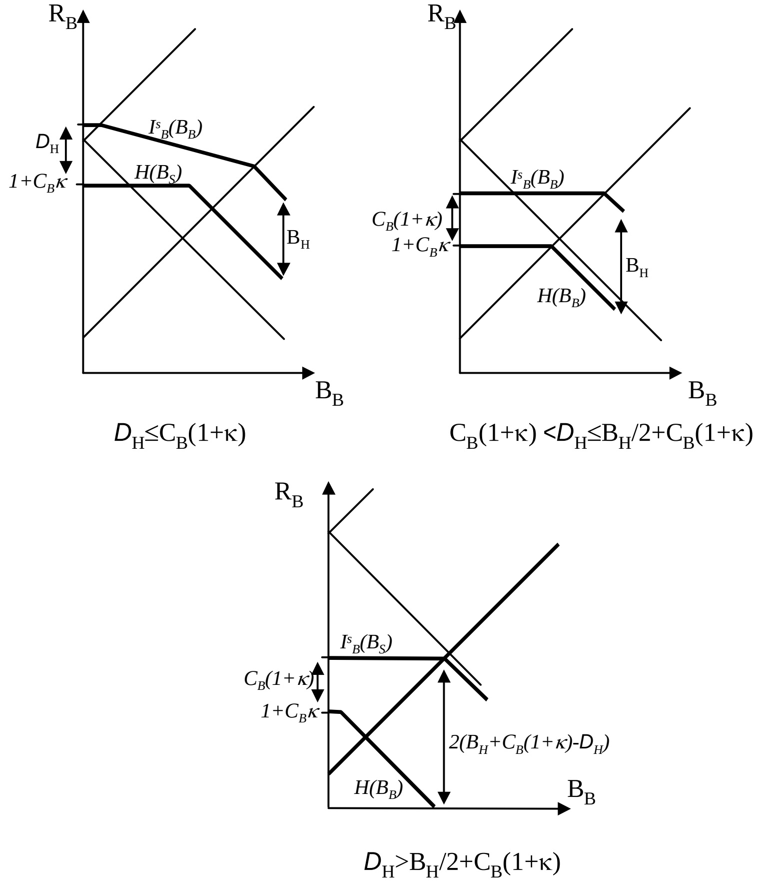

Figure 4: Investment policy for a branch bank with a speculative home bank as a function of $\mathcal{D}_H$.

strip of speculative projects. The reason for this is obvious: a combination of a mildly speculative branch bank with a prudent home bank will never draw upon the deposit insurance fund and hence will be safe.

The proof of proposition 3 is entirely analogous to that of proposition 2 and hence is omitted. The superscript p in the proposition refers to the fact that the home bank is prudent.

Proposition 3 The hurdle rate for a prudent bank's branch depends upon the MNB type associated with the prospective project (B_B, R_B) in the following way:

1. Safe MNBs: $R_B \geq R^p_{B,Sf} \equiv H^P_B(B_B)$;
2. Diversified MNBs: $R_B \geq R^p_{B,Dv} \equiv H^S_B(B_B) + \mathcal{D}_B - \mathcal{D}_H$;
3. Branch Dominated MNBs: $R_B \geq R^p_{B,Br} \equiv H^S_B(B_B) + B_H - 2\mathcal{D}_H$;

The intutition for proposition 3 is similar to that for proposition 2. With prudent home banks, neither safe MNBs nor the standalone institutions of which they are comprised receive deposit insurance payments; the branch bank's hurdle rate will in this case therefore equal that of a standalone institution. In diversified MNBs, the losses from a failing branch bank will be met from the profits of a successful home bank; diversification effects do not reduce expected deposit insurance payouts in the wake of a prudent home bank's failure. Finally, the deposit insurance payment in the wake of branch bank failure will be reduced in a branch-dominated bank by $-2\mathcal{D}_H$ or $2(-\mathcal{D}_H + B_H)$, according to the failure or success of the home bank.

The expressions for the home dominated and contagious MNB hurdle rates are ommited from proposition 3 because it is possible to prove (see the appendix) that when the home bank is prudent, the investment policy $I_B^p(B_B)$ of the branch bank always yields a safe, diversified or a branch dominated MNB. A precise characterisation of I_B^p appears in the appendix as proposition 12: we illustrate our findings in figure 5.

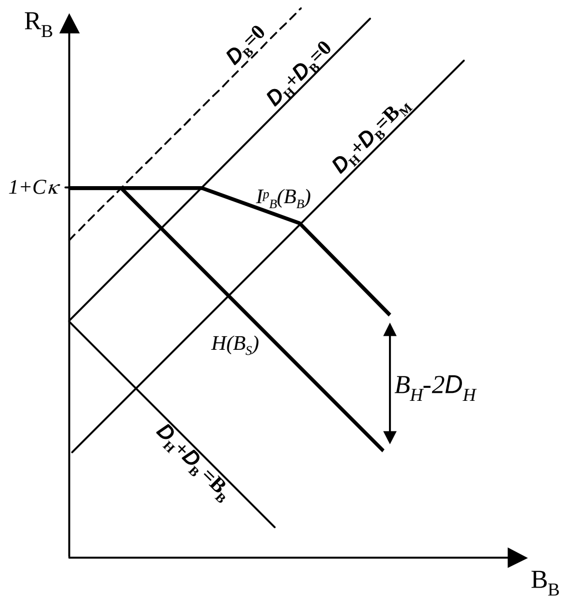

Figure 5: Investment policy for a branch of a prudent mother bank.

The lower bold line in figure 5 shows the hurdle rate for a standalone bank. Note that, for a given capital adequacy requirement, the branch bank performs less investment than the standalone bank. As for with speculative home banks, this because the prudent home bank is required to bail out the branch in the event that it fails and this reduces the value to the branch bank of the deposit insurance net.

For both prudent and speculative home banks, the branch bank performs less investment than the corresponding standalone bank. This is because the value to the shareholders of the deposit insurance safety net is reduced by the cross-subsidisation which occurs. This suggests the following result, which we prove in the appendix.

Proposition 4 The extent of branch bank underinvestment is an increasing function of the value $\mathcal{D}_H$ of the home bank's deposit insurance safety net.

The following corollary follows immediately from this proposition, and is implicit in our discussion so far:

Corollary 5 Optimal capital requirements for branch bank MNBs are lower than those for standalone banks, and they are dropping in the value $\mathcal{D}_H$ of the home bank's deposit insurance safety net.

4. Regulating A Multinational Bank with A Subsidiary

In this section we analyse the investment policy of a multinational bank consisting of a home bank with a subsidiary. Foreign subsidiaries are separately incorporated and capitalized units of an MNB. Thus they generally operate more like independent foreign banks. Even if they are formally independent from the parent (home) bank, all subsidiaries are at least majority owned and controlled by the parent, which takes all of the relevant decisions for the controlled subsidiaries. Subsidiaries can fail separately from the home bank. However, it is not possible for the home bank to fail without the subsidiary also failing.

We again wish to characterise the relationship between the home bank's portfolio and the investment policy $I_S(B)$ which it transmits to the subsidiary bank. The model which we employ is therefore identical to that used in section 3.1 to analyse branch banks. At times t_0, t_1 and t_2 the home bank makes its own investments and then transmits an investment policy $I_S(B)$ to the subsidiary. At times t_3 and t_4 the subsidiary is presented with an investment policy (B_S, R_S) and decides whether to invest in it, and at time t_5 project returns are apportioned.

Note firstly that the time t_1 investment decisions of the home bank will again be identical to those of a standalone bank, for the reasons discussed in section 3.2. Similarly, the subsidiary bank's investment policy in the absence of home bank investment will again be the same as a standalone bank's.

In the remainder of this section we establish the investment policy transmitted by speculative and prudent home banks.

4.1. Investment Policy: Speculative Home Bank

Suppose that the home bank has accepted a speculative project (B_H, R_H), so that $R_H - B_H + C_H < 1$.

We follow section 3.4: denoting outcomes by ordered pairs in which the home bank's result appears first, the payoff to the shareholders conditional upon investing in a subsidiary bank project (B_S, R_S) is as follows, where the superscript s appears because the MNB has subsidiary structure:

$$\begin{aligned}
V^s_{SS} &\equiv (R_H + B_H) - (1 - C_H) + (R_S + B_S) - (1 - C_S)\,; && (10)\\
V^s_{SF} &\equiv (R_H + B_H) - (1 - C_H) + \max\left[(R_S - B_S) - (1 - C_S), 0\right] \\
&= 2\left\{-\mathcal{D}_H + B_H + \max\left[-\mathcal{D}_S, 0\right]\right\}; && (11)\\
V^s_{FS} &\equiv \max\left\{(R_H - B_H) - (1 - C_H) + (R_S + B_S) - (1 - C_S), 0\right\} \\
&= 2\max\left\{-\left(\mathcal{D}_H + \mathcal{D}_S\right) + B_S, 0\right\}; && (12)\\
V^s_{FF} &\equiv \max\left\{(R_H - B_H) - (1 - C_H) + \max\left[(R_S - B_S) - (1 - C_S), 0\right], 0\right\} \\
&= 2\max\left\{-\left(\mathcal{D}_H + \mathcal{D}_S\right), 0\right\}. && (13)
\end{aligned}$$

These expressions reflect the liability structure of the multinational bank. The subsidiary bank has limited liability, which is reflected in the square bracketed max [.] terms in V^s_{SF} and V^s_{FF}. The combined institution has limited liability, reflected in the curly bracketed max $\{.\}$ terms in V^s_{FS} and V^s_{FF}.

Equations 10 to 13 partition the project space in an analogous way to equations 5 to 8 in section 3.4: figure 6 illustrates the partition.

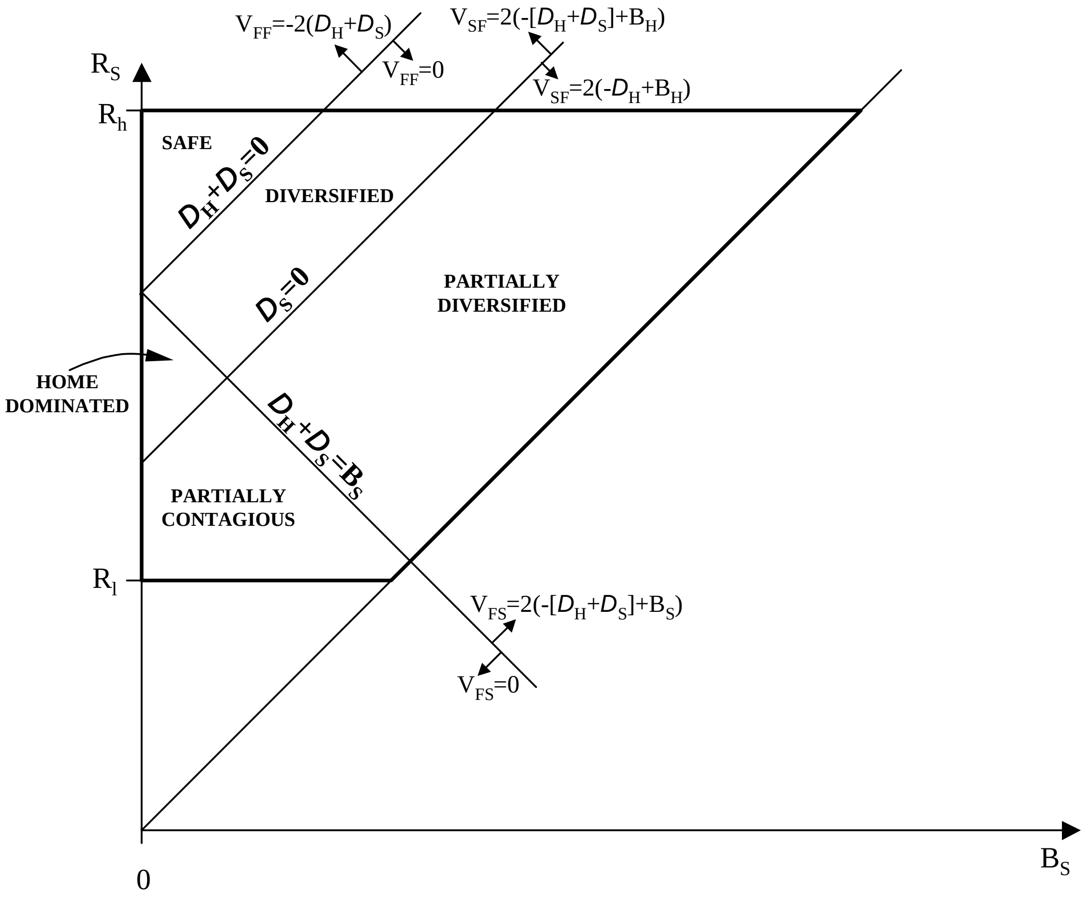

Figure 6: Subsidiary bank projects, speculative home bank.

The five regions for subsidiary bank projects in figure 6 are again named according to the solvency properties of the associated multinational bank. As we discuss in detail below, the situation in this section is slightly more complex than for branch banks because the home bank can walk away from an insolvent subsidiary.[9] As in section 3.4, we refer to a subsidiary structure multinational bank as safe, diversified, and so on according to the region within which its subsidiary bank project (B_S, R_S) lies. The dependency of the MNB's solvency upon the performance of its divisions is illustrated in figure 7. As in the subsidiary bank case, safe MNBs are always ex post solvent and diversified MNBs are solvent provided at least one division succeeds. Since the home bank is not

[9]In this case note that the cost of subsidiary bank insolvency is met by the foreign country deposit insurance fund. As we are concerned only with the incentive effects of deposit insurance for bankers this institutional detail is not germane to our discussion.

liable for the losses of the subsidiary, this can only occur when a failed subsidiary is solvent: in other words, when it is prudent. It is for this reason that the diversified region for subsidiary banks is strictly smaller than it is for branch banks. In partially diversified MNBs a failing mother bank is always bailed out by a successful subsidiary; failing subsidiaries are allowed to fail and to leave behind a solvent home bank.[10] Since it is impossible for the subsidiary to abandon a failed home bank, home bank dominated MNBs again reflect the solvency properties of the home division. Finally, in partially contagious MNBs failure of the home bank causes MNB insolvency even when the subsidiary succeeds; limited liability of the home bank prevents contagion occuring from the subsidiary to the home bank.

SAFE

Branch Bank		Home Bank: Succeed	Home Bank: Fail
	Succeed	Solvent	Solvent
	Fail	Solvent	Solvent

DIVERSIFIED

Branch Bank		Home Bank: Succeed	Home Bank: Fail
	Succeed	Solvent	Solvent
	Fail	Solvent	Insolvent

PARTIALLY DIVERSIFIED

Branch Bank		Home Bank: Succeed	Home Bank: Fail
	Succeed	Solvent	Solvent
	Fail	Home Solvent	Insolvent

HOME DOMINATED

Branch Bank		Home Bank: Succeed	Home Bank: Fail
	Succeed	Solvent	Insolvent
	Fail	Solvent	Insolvent

PARTIALLY CONTAGIOUS

Branch Bank		Home Bank: Succeed	Home Bank: Fail
	Succeed	Solvent	Insolvent
	Fail	Home Solvent	Insolvent

Figure 7: Subsidiary MNB Solvency. The tables show the effect which the results of the home and the subsidiary bank have upon the solvency of the multinational bank.

As in section 3.4, project hurdle rates will depend upon the characteristics of the corresponding MNB. Proposition 6 is analogous to propositions 2 and 3. The superscript s in the proposition refers to the fact that the home bank is speculative:

Proposition 6 The hurdle rate for a speculative bank's subsidiary depends upon the MNB type associated with the prospective project (B_B, R_B) in the following way:

Safe MNBs: $R_S \geq R^s_{S,Sf} \equiv H^P_S(B_S) + \mathcal{D}_H$;

Diversified MNBs: $R_S \geq R^s_{S,Dv} \equiv H^P_S(B_S) + \frac{1}{2}(\mathcal{D}_H - \mathcal{D}_S)$;

Partially Diversified MNBs: $R_S \geq R^s_{S,Pd} \equiv H^S_S(B_S) + \mathcal{D}_H$;

Home Dominated MNBs: $R_S \geq R^s_{S,Hm} \equiv H^P_S(B_S) + \left(-\mathcal{D}_S + \frac{1}{2}B_S\right)$;

Partially Contagious MNBs: $R_S \geq R^s_{S,Pc} \equiv H^S_S(B_S) - \mathcal{D}_S + B_S$.

Proof. In the appendix. 2

[10] Note that the partially diversified region for subsidiary banks corresponds to the branch dominated region for branch banks. The differing liability of the home bank towards the foreign bank accounts for the differences between the two.

(i) Discussion of Proposition 6

We can understand the hurdle rates of proposition 6 by comparing the liability of the deposit insurance fund for a standalone bank to its liability for a subsidiary. Observe from figure 6 that safe, diversified and home dominated banks all have prudent subsidiaries: the intuition for the corresponding subsidiary hurdle rates carries over unchanged from section 3.4.

The standalone subsidiary in partially diversified banks is speculative and earns $\frac{1}{2}\left[R_S - H_S^S\left(B_S\right)\right]$. It is clear from figure 7 that within an MNB this must exceed the loss of one half of the value $\mathcal{D}_H$ of the home bank's deposit insurance net, which immediately yields the expression for $R_{S,Pd}^s$.

Finally, the standalone value $\frac{1}{2}\left[R_S - H_S^S\left(B_S\right)\right]$ of the subsidiary bank in a partially contagious MNB must exceed the expected cost $\frac{1}{2}\left(-\mathcal{D}_S + B_S\right)$ of the transfer from a successful subsidiary to a failed home bank.

(ii) Investment Policy

Analogously to section 3.4.ii, for a given subsidiary bank investment opportunity (B_B, R_B), the subsidiary bank's investment policy $I_S^s\left(B_B\right)$ is equal to the single hurdle rate $R_S^s\left(B_S\right)$ of those established in proposition 6 which lies inside the region to which it refers. A precise characterisation of I_S^s appears in the appendix as proposition 13 and is illustrated in figure 8, which shows the dependence of the hurdle rate $I_S^s\left(B_S\right)$ for subsidiary projects upon $\mathcal{D}_H$, and the corresponding hurdle rate $H\left(B_S\right)$ for a standalone project with the same capital requirements.[11]

The dashed lines in figure 8 indicate the investment policy for the corresponding branch-organised MNB. Figure 8 therefore implies that, with common capital requirements for all banks, subsidiary banks will invest in fewer projects than standalone banks, and more than branch banks. The latter observation holds because the home bank can walk away from a failing subsidiary but not from a failing branch bank. The subsidiary bank therefore has a lower impact upon expected receipts from the deposit insurance fund than the branch bank and hence will accept more projects.

Underinvestment occurs because the subsidiary bank reduces the value of the home bank's deposit insurance net, which is in turn increasing in $\mathcal{D}_H$. This suggests the following result, which is proved in the appendix:

Proposition 7 The extent of the subsidiary's underinvestment is an increasing function of the value $\mathcal{D}_H$ of the home bank's deposit insurance net.

The following corollary is immediate:

Corollary 8 Optimal capital requirements for subsidiary bank MNBs are lower than those for standalone banks, and higher than those for branch bank MNBs, and they are dropping in the value $\mathcal{D}_H$ of the home bank's deposit insurance safety net.

[11] The first graph illustrates the case where $C_S(1+\kappa) > \mathcal{D}_M > \frac{1}{2}C_S(1+\kappa)$; when $\mathcal{D}_M < \frac{1}{2}C_S(1+\kappa)$, the standalone hurdle rate H intersects the y-axis above $\mathcal{D}_M + \mathcal{D}_S = 0$.

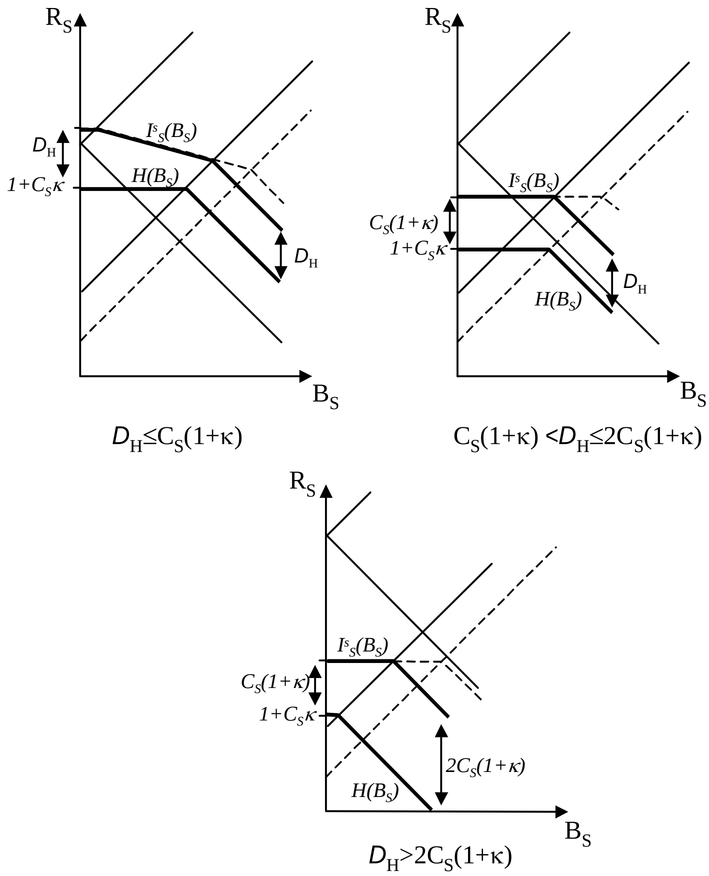

Figure 8: Subsidiary investment policy as a function of $\mathcal{D}_H$.

4.2. Investment Policy: Prudent home Bank

The deposit insurance net has no value to shareholders in a prudent bank and the disincentive to subsidiary investment identified in section 4.1 will therefore not exist. Conversely, since the home bank's shareholders can walk away from failing subsidiaries, they will be able to extract the full value of the subsidiary's deposit insurance net. Subsidiary investment policy will therefore be the same as standalone bank investment policy.

5. Conclusion

We demonstrate in this paper how capital requirements may be justified in an environment where deposits are insured and bank capital is rationed. These minimal assumptions are sufficient to derive the capital-shifting from safe to risky projects which is an observed feature of the banking sector. We show that capital adequacy requirements can be viewed as a constrained optimal response to these problems which force bankers to select socially optimal investments in the presence of these imperfections.

The constrained optimum which we derive for a standalone bank in section 2 trades off the costs of the overinvestment induced by deposit insurance against the costs of underinvestment induced by capital rationing. We show in sections 3 and 4 that the same capital requirement will result in underinvestment relative to the achievable second best of section 2. This follows because multinational diversification lowers the value of the deposit insurance net and hence reduces the appropriate level of underpricing which the regulator should induce. This effect is stronger for branches, in which the extent of diversification is greater, than it is for subsidiaries. In other words, we demonstrate that foreign banks in multinational banking organisations should be subject to lower capital requirements than the local standalone banks.

Bankers in our model do not pay deposit insurance premia. Could such premia eliminate these project selection distortions? We argue that, for two reasons, they could not. Firstly, observed deposit insurance premia are flat. Secondly, they are generally set to reflect the average riskiness of the bank's portfolio, and not the risk of its marginal project.[12]

As we discuss in the introduction, our formal results explain observed liability structures in multinational banks. Furthermore, we can explain other phenomena associated with multinational banks. Scher and Weller (1999) report that foreign banks are guilty of "cherry-picking" : in other words, that they accept only the highest quality projects in their host country. We have demonstrated that this behaviour is a rational response by insured foreign banks to their liability structure.

In addition, we believe that our model may generate some insights into the causes of systemic risk and of financial contagion. A standard argument in the literature on MNBs is that the diversification associated with branch banks reduces systemic risk because the home bank is required to bail out a failing subsidiary. In our model branch banks are less likely to fail than standalone national banks because of the *ex ante* effect of the MNB's liability structure upon the investment decisions of the branch. This may reduce systemic risk, but the reason relates to investment policy, and not to bailouts *per se*.

Our simple framework also suggests a possible financial contagion channel. Suppose that the home bank experiences an exogenous and local shock which increases the volatility of returns of its portfolio. This immediately increases the value which its shareholders derive from the deposit insurance safety net and hence raises the above cost of diversification. The inevitable consequence of this is an increase in the hurdle rate applied to projects in foreign banks. In other words, problems in the home country could result in a credit crunch in the foreign country.

Finally, our model provides a counter argument to the statement (Basle Committee on Banking Supervision, 1997) that common capital standards across home and foreign banks are necessary to ensure an international "level playing field" for commercial banks. On the contrary, we have demonstrated that, with common capital requirements, diversification effects are sufficient to tilt the playing field between national and multinational banks.

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[12] See Freixas and Rochet (1998) for a discussion of some related issues.

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Appendix

Proof of Proposition 1

We firstly characterise the total allocative inefficiency induced by a capital requirement C coupled with deposit insurance:

Lemma 9

$$\omega(C) + \upsilon(C) = \frac{C^3\kappa^2}{6A}(4\kappa+3) + \frac{1}{24A}\left[1 - C(1+2\kappa)\right]^3. \tag{14}$$

Proof. There are two cases to consider, according to whether $C(1+2\kappa)$ is less than or greater than 1. The former case is ; in the latter, which is illustrated in figure , region $\mathcal{O}$ vanishes.

Case 1: $C(1+2\kappa) \leq 1$. This is the case which is illustrated in figure 1. $\mathcal{U}$ is comprised of a rectangular area and a right angled triangle bounded below by $R = 1$ and above by $R = C(1+2\kappa) + 1 - B$:

$$\begin{aligned}
\upsilon(C) &= \frac{1}{A}\int_0^{C(1+\kappa)}\int_0^{C\kappa} RdRdB + \frac{1}{A}\int_{C(1+\kappa)}^{C(1+2\kappa)}\int_0^{C(1+2\kappa)-B} RdRdB \\
&= \frac{C^3\kappa^2}{2A}(1+\kappa) + \frac{1}{6A}\left[\{C(1+2\kappa) - B\}^3\right]_{C(1+2\kappa)}^{C(1+\kappa)} = \frac{C^3\kappa^2}{6A}(4\kappa+3).
\end{aligned}$$

It is convenient to think of O as comprising two identical right angled triangles:

$$\begin{aligned}
\omega(C) &= \frac{2}{A}\int_{\frac{C(1+2\kappa)+1}{2}}^{1}\int_B^1 (1-R)\,dRdB \\
&= \frac{1}{A}\int_{\frac{C(1+2\kappa)+1}{2}}^{1}(1-B)^2\,dB = \frac{1}{3A}\left[(1-B)^3\right]_1^{\frac{C(1+2\kappa)+1}{2}} = \frac{1}{24A}\left(1 - C(1+2\kappa)\right)^3.
\end{aligned}$$

Adding these expressions yields equation 14.

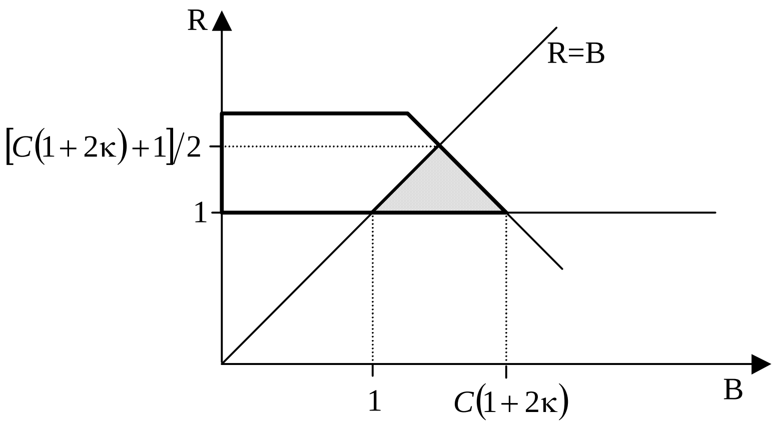

Figure 9: Region $\mathcal{U}$ when $C(1+2\kappa) > 1$.

Case 2: $C(1+2\kappa) > 1$. This case is illustrated in figure 9. In this case region $\mathcal{O}$ vanishes and region U is the region with the bold outline, with the shaded area removed. $\alpha(C)$ can therefore be obtained by subtracting the welfare which could be attained by investing in shaded area projects from that attained by investing in all projects in the bold outline. The welfare from projects in the bold outline is given by $\upsilon(C)$ above; that from projects in the shaded area is

$$\frac{2}{A}\int_1^{\frac{C(1+2\kappa)+1}{2}}\int_0^{B-1} RdRdB = \frac{1}{24A}\left(1-C(1+2\kappa)\right)^3,$$

from which the required result follows immediately. 2

The proposition follows immediately from lemma 9 and the following observation:

$$\begin{aligned}\omega'(0)+\upsilon'(0) &= -\frac{(1+2\kappa)}{24A}<0;\\ \omega'(1)+\upsilon'(1) &= \frac{\kappa^2}{A}(1+\kappa).\end{aligned}$$

Proof of Proposition 2

The subsidiary should invest in a project (B_S, R_S) precisely when its incremental present value is positive: in other words, when

$$V-\frac{1}{2}\left(R_H+B_H-(1-C_H)\right)+C_H(1+\kappa)\geq 0, \tag{15}$$

where the shareholder value V of the banking group is defined in equation 9. The values of the constituent parts of V are defined in equations 5 to 8 and can be read from figure 2. Inserting these into equation 15 and performing straightforward manipulations yields the following necessary and sufficient conditions for investment in safe, diversified, home and branch dominated, and contagious multinational banks:

$$\begin{aligned}R_B &\geq 1+C_S\kappa+\frac{1}{2}\left[1-C_H-(R_H-B_H)\right]; && \text{(InvSafe)}\\ R_B &\geq \frac{1}{3}(1-C_H-R_H+B_H)+1-\frac{1}{3}B_S+\frac{1}{3}(C_S+4\kappa); && \text{(InvDiv)}\\ R_B &\geq 1-B_B+C_B(1+2\kappa); && \text{InvBranch}\\ R_B &\geq 1+C_S(1+2\kappa); && \text{(InvHome)}\\ R_B &\geq C_B(3+4\kappa)-B_B+(R_H+B_H+C_H). && \text{(InvCont)}\end{aligned}$$

Using the definitions of H_B, $\mathcal{D}_H$ and $\mathcal{D}_S$ and performing further straightforward manipulation of equations InvSafe to InvCont yields the expressions in proposition 2.

Investment Policy $I_B^s(B_S)$ for a Speculative Home Bank's Branch

Proposition 10 The investment policy I_B^s depends upon the hurdle rates established in proposition 2 and upon $\mathcal{D}_H$ as follows:

1. If $\mathcal{D}_H \leq C_B(1+\kappa)$ then

$$I_B^s(B_B)=\begin{cases} R^s_{B,Sf}, & \text{if } B_B\leq C_B(1+\kappa)-\mathcal{D}_H\\ R^s_{B,Dv}, & \text{if } C_B(1+\kappa)-\mathcal{D}_H<B_B\leq C_B(1+\kappa)+\frac{3}{2}(B_H-\mathcal{D}_H)+\frac{1}{2}\mathcal{D}_H\\ R^s_{B,Br}, & \text{if } B_B>C_B(1+\kappa)+\frac{3}{2}(B_H-\mathcal{D}_H)+\frac{1}{2}\mathcal{D}_H\end{cases}$$

2. If $C_B(1+\kappa) < \mathcal{D}_H \leq \frac{1}{2}B_H + C_B(1+\kappa)$ then

$$I_B^s(B_B) = \begin{cases} R_{B,Hm}^s, & \text{if } B_B \leq 2[\mathcal{D}_H - C_B(1+\kappa)] \\ R_{B,Dv}^s, & \text{if } 2[\mathcal{D}_H - C_S(1+\kappa)] < B_B \leq C_B(1+\kappa) + \frac{3}{2}(B_H - \mathcal{D}_H) + \frac{1}{2}\mathcal{D}_H \\ R_{B,Br}^s, & \text{if } B_B > C_B(1+\kappa) + \frac{3}{2}(B_H - \mathcal{D}_H) + \frac{1}{2}\mathcal{D}_H \end{cases}$$

3. If $\mathcal{D}_H > \frac{1}{2}B_H + C_B(1+\kappa)$ then

$$I_B^s(B_B) = \begin{cases} R_{B,Hm}^s, & \text{if } B_B \leq 2[\mathcal{D}_H - C_B(1+\kappa)] \\ R_{B,Ct}^s, & \text{if } B_B > 2[\mathcal{D}_H - C_B(1+\kappa)] \end{cases}$$

Proof. As we note in section 3.4.ii, for a given B_B, at most one of the regions above B_B can contain the hurdle rate identified in proposition 2. The corresponding hurdle rate is the value of $I_B^s(.)$ at B_B. Proof of proposition 10 is therefore a simple matter of determining the conditions which must obtain for each region to contain its hurdle rate.

The following lemma is obtained by straightforward manipulation of the relevant expressions:

Lemma 11

1. $R_{B,Sf}^s$ and $R_{B,Dv}^s$ both intersect the line $\mathcal{D}_H + \mathcal{D}_B = 0$ where $B_B = C_B(1+\kappa) - \mathcal{D}_H$;
2. $R_{B,Dv}^s$ and $R_{B,Br}^s$ both intersect the line $\mathcal{D}_H + \mathcal{D}_B = B_H$ where $B_B = C_B(1+\kappa) + \frac{3}{2}B_H - \mathcal{D}_H$;
3. $R_{B,Dv}^s$ and $R_{B,Hm}^s$ both intersect the line $\mathcal{D}_H + \mathcal{D}_B = B_B$ where $B_B = 2[\mathcal{D}_H - C_B(1+\kappa)]$;
4. $R_{B,Hm}^s$ and $R_{B,Ct}^s$ both intersect the line $\mathcal{D}_H + \mathcal{D}_B = B_H$ where $B_B = 2[B_H - \mathcal{D}_H + C_B(1+\kappa)]$.

It follows immediately that I_B^s must be continuous and that its path through the regions of figure 2 is completely determined by its value when $B_B = 0$.

Part 1 of the lemma implies that $I_B^s(0) = R_{B,Sf}^s$ precisely when $C_B(1+\kappa) \geq \mathcal{D}_H$ and that it continues to assume this value until $B_B = C_B(1+\kappa) - \mathcal{D}_H$, at which point it assumes value $R_{B,Dv}^s$. Since $R_{B,Dv}^s(B_B)$ has slope $-\frac{1}{3}$ (equation InvDiv) and $\mathcal{D}_H + \mathcal{D}_B = B_B$ has slope -1 it is immediate from figure 2 and part 2 of the lemma that $I_B^s(B_B)$ has value $R_{B,Dv}^s$ until $B_B = C_B(1+\kappa) + \frac{3}{2}B_H - \mathcal{D}_H$, after which it takes value $R_{B,Br}^s(B_B)$ and, since $R_{B,Br}^s(B_B)$ has slope -1, it continues to do so for higher values of B_B.

Note from part 4 of the lemma that $B_B > 0$ when $R_{B,Hm}^s$ and $R_{B,Ct}^s$ intersect and hence that when $C_B(1+\kappa) < \mathcal{D}_H$ we must have $I_B^s(0) = R_{B,Hm}^s$. The intersection of $R_{B,Hm}^s$ and $\mathcal{D}_H + \mathcal{D}_B = B_B$ lies on the border with the diversified region precisely when it occurs at a lower B_B value than the intersection of $R_{B,Hm}^s$ and $\mathcal{D}_H + \mathcal{D}_B = B_H$. It follows from parts 3 and 4 of the lemma that this occurs if and only if $\mathcal{D}_H \leq \frac{1}{2}B_H + C_B(1+\kappa)$. In this case part 3 of the lemma implies that $I_B^s = R_{B,Hm}^s$ for $B_B \leq 2[\mathcal{D}_H - C_B(1+\kappa)]$. For higher values of B_B, reasoning about the slope of $R_{B,II}^s$ as in the above paragraph implies that $I_B^s = R_{S,Dv}$ until $C_B(1+\kappa) + \frac{3}{2}(B_H - \mathcal{D}_H) + \frac{1}{2}\mathcal{D}_H$, after which it takes value $R_{B,Br}^s$.

For $\frac{1}{2}B_H + C_B(1+\kappa) \geq \mathcal{D}_H$ part 4 of the lemma implies that $I_B^s = R_{B,Hm}^s$ for $B_B \leq 2[B_H - \mathcal{D}_H + C_B(1+\kappa)]$ after which, because $R_{B,Ct}^s$ has slope -1, it has value $R_{B,Ct}^s$. 2

Investment Policy for a Prudent Home Bank's Banch

Proposition 12 The investment policy I_B^p for a prudent bank's branch depends upon the hurdle rates established in proposition 3 as follows:

$$I_B^p(B_B) = \begin{cases} R_{B,Sf}^p, & \text{if } B_B \leq C_B(1+\kappa) - \mathcal{D}_H \\ R_{B,Dv}^p, & \text{if } C_B(1+\kappa) - \mathcal{D}_H < B_B \leq C_B(1+\kappa) + \frac{3}{2}(B_H - \mathcal{D}_H) - \frac{1}{2}\mathcal{D}_H \\ R_{B,Br}^s, & \text{if } B_B > C_B(1+\kappa) + \frac{3}{2}(B_H - \mathcal{D}_H) - \frac{1}{2}\mathcal{D}_H \end{cases}$$

Proof. $I_B^p(0) = R_{B,Sf}^p(0)$ whenever $B_B \geq 0$ at the intersection of $R_{B,Sf}^p$ with the line $\mathcal{D}_H + \mathcal{D}_B = 0$; this is true whenever $\mathcal{D}_H \leq C_B(1+\kappa)$, which is always true for prudent home banks. The remainder of the proof involves a straightforward application of the methods used to prove proposition 10 and is omitted. 2

Proof of Proposition 6

Parts 1, 2 and 4 are immediate from proposition 2, as discussed in the text. For parts 3 and 5, simply insert equations 10 to 13 into condition 15 to obtain the following necessary and sufficient conditions for investment in partially diversified and partially contagious multinational banks:

$$R_S \geq \frac{1}{2}(1 + B_H - C_H - R_H) + 1 - B_S + C_S(1+2\kappa); \tag{InvParD}$$

$$R_S \geq 1 - B_S + C_S(3+4\kappa). \tag{InvParC}$$

Rearranging equations InvParD and InvParC yields parts 3 and 5 of the proposition.

Investment Policy $I_S(B_S)$ for a Speculative Home Bank's Subsidiary

Proposition 13 The investment policy I_S^s depends upon the hurdle rates established in proposition 6 and upon $\mathcal{D}_H$ as follows:

1. If $\mathcal{D}_H \leq C_S(1+\kappa)$ then

$$I(B_S) = \begin{cases} R_{S,Sf}^s, & \text{if } B_S \leq C_S(1+\kappa) - \mathcal{D}_H \\ R_{S,Dv}^s, & \text{if } C_S(1+\kappa) - \mathcal{D}_H < B_S \leq C_S(1+\kappa) + \frac{1}{2}\mathcal{D}_H \\ R_{S,Pd}^s, & \text{if } B_S > C_S(1+\kappa) + \frac{1}{2}\mathcal{D}_H \end{cases}$$

2. If $C_S(1+\kappa) < \mathcal{D}_H \leq 2C_S(1+\kappa)$ then

$$I(B_S) = \begin{cases} R_{S,Hm}, & \text{if } B_S \leq 2[\mathcal{D}_H - C_S(1+\kappa)] \\ R_{S,Dv}, & \text{if } 2[\mathcal{D}_H - C_S(1+\kappa)] < B_S \leq C_S(1+\kappa) + \frac{1}{2}\mathcal{D}_H \\ R_{S,Pd}, & \text{if } B_S > C_S(1+\kappa) + \frac{1}{2}\mathcal{D}_H \end{cases}$$

3. If $\mathcal{D}_H > 2C_S(1+\kappa)$ then

$$I(B_S) = \begin{cases} R_{S,Hm}, & \text{if } B_S \leq 2C_S(1+\kappa) \\ R_{S,Pc}, & \text{if } B_S > 2C_S(1+\kappa) \end{cases}$$

Proof. The proof is similar to that of proposition 10. It is easy to establish the following lemma.

Lemma 14

1. $R^s_{S,Sf}$ and $R^s_{S,Dv}$ both intersect the line $\mathcal{D}_H + \mathcal{D}_S = 0$ where $B_S = C_S(1+\kappa) - \mathcal{D}_H$;
2. $R^s_{S,Dv}$ and $R^s_{S,Pd}$ both intersect the line $\mathcal{D}_S = 0$ where $B_S = C_S(1+\kappa) + \frac{1}{2}\mathcal{D}_H$;
3. $R^s_{S,Dv}$ and $R^s_{S,Hm}$ both intersect the line $\mathcal{D}_H + \mathcal{D}_S = B_S$ where $B_S = 2[\mathcal{D}_H - C_S(1+\kappa)]$;
4. $R^s_{S,Hm}$ and $R^s_{S,Pc}$ both intersect the line $\mathcal{D}_S = 0$ where $B_S = 2C_S(1+\kappa)$;

As for proposition 10 it follow that I^s_S must be continuous and that its path through the regions of figure 6 is completely determined by its value when $B_S = 0$.

Part 1 of the lemma implies that $I(0) = R_{S,I}$ precisely when $C_S(1+\kappa) \geq \mathcal{D}_H$. For $C_S(1+\kappa) < \mathcal{D}_H$, $I^s_S(0) = R^s_{S,Hm}$.When $I^s_S(0) = R^s_{S,Hm}$, there exists B_S for which $I^s_S(B_B) = R^s_{S,Dv}$ precisely when $R^s_{S,Hm}$ intersects $\mathcal{D}_H + \mathcal{D}_S = B_S$ to the left of $\mathcal{D}_S = 0$; this happens if and only if $\mathcal{D}_H \leq 2C_S(1+\kappa)$. The remainder of the proposition follows mechanically using the same reasoning as the proof of proposition 10. 2