Deposit Insurance, Capital Regulations, and Financial Contagion in Multinational Banks*

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This version: February 2004

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.

KEY WORDS: Capital adequacy requirements; deposit insurance; multinational bank.
JEL CLASSIFICATION: G21, G28.

*An earlier version of this paper was circulated with the title "Multinational Bank Capital Regulation with Deposit Insurance and Diversification Effects." We are grateful to Xavier Freixas, Pete Kyle, Robert Marquez, Alistair Milne, Hyun Shin, Lucy White, and Andrew Winton and to seminar participants at the 2003 Oxford Finance Summer Symposium, the Bank of England and Cass Business School for helpful comments.

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1. Introduction

In the last decade the banking system has been subject to a process of globalisation, with a rapid expansion in foreign ownership of bank assets. The possible systemic consequences of this expansion and the appropriate regulatory response are still not fully understood. In this paper we examine these questions and their relationship to the organisational structure of multinational banks. We highlight the critical role of deposit insurance in determining lending policy, and we exhibit an international contagion channel for financial fragility.

A multinational bank (MNB) consists of a home bank and a number of foreign banks. Figures 1 and 2 show the share of assets held by foreign banks in selected industrialised and emerging economies, respectively.

	Asset shares (%)	
	1995	**1997**
Belgium	28.4	36.3
France	12.2	12.2
Germany	4.2	4.3
Italy	5.4	6.8
Japan	2.1	4.9
Netherlands	9.7	7.7
Sweden	9.8	1.6
Switzerland	11.8	n.a.
U.K.	51.6	52.1
U.S.	21.7	20.7

Figure 1: Markets shares of the branches and subsidiaries of foreign banks in industrialised countries (source: Berger, DeYoung, Genay and Udell, 1999).

The expansion of foreign bank ownership of banking assets is particularly striking in emerging markets (figure 2). In the light of recent experiences of fragility in emerging financial markets, possible interactions between the home and foreign banks of a MNB are of clear importance.

We examine these phenomena using a simple model of banks whose depositors are protected by a deposit insurance net and which are subject to an exogenous cost of capital; this 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). 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. The regulator cannot observe the contents of the bank's portfolio and 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 then extend our reasoning to examine cross border expansion. We assume that foreign banks

	Foreign Control (%)	
	Dec 1994	Dec 1999
Central Europe	7.8	52.3
Latin America	7.5	25
Asia	1.6	6

Figure 2: Foreign bank ownership in selected emerging markets (source: Bank for International Settlements, 2001).

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 MNB opens a foreign bank, diversification effects across the two portfolios reduce the value to both banks' shareholders of the deposit insurance net subsidy. As a result the foreign bank sets a higher hurdle rate than a standalone bank faced with the same investment opportunity set.

Our simple framework also highlights 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 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.

At present a MNB's foreign banks are run either as subsidiaries of the home bank, or as branches. We present our analysis for each of these organisational forms. 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.

The effects of diversification are therefore greater in branch banks than in subsidiaries. As a consequence, we find that, for a fixed capital adequacy regime, underinvestment and contagion effects are more pronounced in MNBs organised as branches. In section 5.2 we use this observation to explain an observed preference amongst MNBs for subsidiaries over branches, even when legally it is easier to establish branch banks. Moreover, we argue that "cherry picking" by foreign banks is a rational response to their underinvestment incentives relative to local banks which face the same capital requirements.

Finally, our model has welfare implications which may help in policy design. 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.[1] 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.[2]

In contrast to the new Basle Accord, our work therefore 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.[3]

Our work extends a substantial literature on bank capital and bank regulation. Dewatripont and Tirole (1993*a*, 1993*b*), Bhattacharya (1982), Rochet (1992), Morrison and White (2002), Hellman, Murdock and Stiglitz (2000) and Milne (2002) also study the interaction between capital adequacy requirements and moral hazard.

There is a growing literature on multinational banks. Repullo (2001), Holthausen and Rønde (2002), Calzolari and Lóránth (2002) and Harr and Rønde (2003) discuss the problems of limited supervisory information on a MNB's activities. The structure of financial institutions is also examined by Kahn and Winton (2003). They also show that when financial assets are hard for outsiders to evaluate, the organisational structure of financial institutions has an impact upon their risk-taking and project selection. Their model also hinges upon risk-shifting incentives, but unlike us they consider uninsured depositors. In this case they show that a subsidiary structure which separates low- from high- risk assets may dominate a unitary one by reducing the incentives for shareholders in the low-risk institution to engage in risk-shifting. In contrast, risk-shifting occurs in our model as a result of deposit insurance and the regulator, rather than the depositors, attempts to correct it by selecting a capital requirement. Our results, which show that with a flat capital requirement subsidiary structures are more efficient than branches, are complementary to theirs.

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 discusses some practical implications of our results and section 6 concludes. 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

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

[2] See Furfine, Groeneveld, Hancock, Jackson, Jones, Perraudin, Radecki and Yoneyama (1999) for evidence of this effect.

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

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 at the end of this section, where we argue that in practice, information asymmetries between the banker and the regulator are such that these payments cannot precisely reflect the riskiness of the bank's assets. It follows that risk-sensitive deposit insurance premia cannot resolve the problems which we model.

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 cost κ per unit of equity capital which the bank deploys. As we discuss in the introduction, this assumption reflects pecking order effects which have been studied elsewhere in the literature.[4] κ is a wealth transfer and its only impact upon welfare calculations will therefore be through the investment distortions which it induces.

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.

We examine in this paper the extent to which the cost κ of equity capital can be exploited by the regulator to overcome via capital requirements the overinvestment problem caused by deposit insurance. As we are concerned primarily with agency effects between the regulator and the banker we ignore 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 $R \geq 1$.[5] 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.

[4] Kahn and Winton (2003) and Milne (2002) also present models of banking regulation in which equity capital has an exogenously higher cost than debt.

[5] Note that since κ represents a wealth transfer which is brought about by information asymmetries, it will be absent in the first best world and hence will not feature in the first best investment decision.

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 gain from the free insurance 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

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

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, $H^P(B) = H^S(B)$.[6]

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

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

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

2.3. Optimal Capital Adequacy Requirement

The discussion thus far is illustrated in figure 3. The region $\mathcal{A}$ from which nature selects the banker's investment opportunities is bordered by the bold line $\mathbf{A}_1\mathbf{A}_2\mathbf{A}_3\mathbf{A}_4\mathbf{A}_1$. The line $\mathbf{P}_1\mathbf{P}_2$

[6] 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.

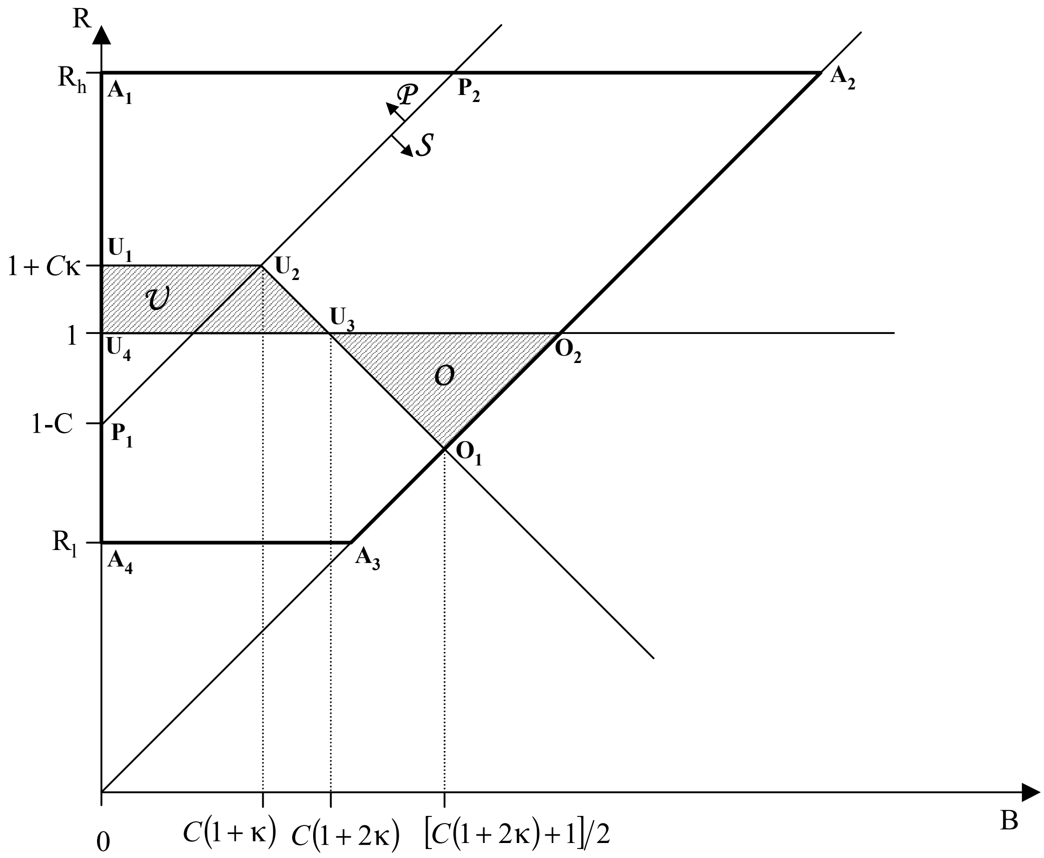

Figure 3: **Investment decisions in response to a capital requirement C**. The banker will invest in projects bordered by $\mathbf{A}_1\mathbf{A}_2\mathbf{O}_1\mathbf{U}_2\mathbf{U}_1\mathbf{A}_1$. This compares to the socially first best region $\mathbf{A}_1\mathbf{A}_2\mathbf{O}_2\mathbf{U}_4\mathbf{A}_1$: the regions $\mathcal{U}$ and $\mathcal{O}$ respectively represent under- and over- investment.

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 $\mathbf{U}_1\mathbf{U}_2$ (equal to H^P) in the prudent region and by line $\mathbf{U}_2\mathbf{U}_3\mathbf{O}_1$ (equal to H^S) in the speculative region. It follows that the banker will accept any project (B, R) in the region bordered by $\mathbf{A}_1\mathbf{A}_2\mathbf{O}_1\mathbf{U}_2\mathbf{U}_1\mathbf{A}_1$. 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

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

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

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

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*.*

In our model deposit insurance causes overinvestment by bankers. Capital requirements function as a Pigouvian tax which force the banker to internalise some of the associated social costs. The flat risk-insensitive capital requirement which we model here is of course a rather blunt weapon. We argue that risk insensitivity is inevitable when there is a moral hazard problem between the regulator and the banker: if risk levels were perfectly observed then deposit insurance could be priced accurately and the problems which we study would not exist. While it may be possible to generate rough data about a loan's risk class it seems implausible to argue that this type of information would entirely resolve the problems which concern us.[7]

Given a degree of risk-insensitivity, capital requirements will inevitably be distortive. The optimal capital requirement induces a constrained optimal level of underinvestment to counter the overinvestment induced by deposit insurance.

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* . The most important implication of this statement is that, in case of bank failure or closure, the multinational bank is wound up as one

[7] Laeven (2002) presents data which demonstrates that in most countries banks do not pay a fair premium for their deposit insurance. Cull, Senbet and Sorge (2003) argue that, as deposit insurance premia are a sunk cost, they will have no *ex post* effect upon risk-taking incentives.

legal entity and branches are treated only as offices of the larger corporate entity. In other words, neither of the constituent banks in a branch-organised MNB can walk away from the other.

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. This assumption reflects the importance of the home bank's pre-existing portfolio in determining the investment policy of the home bank, and allows us to examine how changes in the home bank's portfolio will affect foreign bank lending patterns.

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.[8]

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 determined in precisely the same way as those of the standalone bank which we studied in section 2.[9] The home bank will accept any investment (B_H, R_H) which lies in region $\mathbf{A}_1\mathbf{A}_2\mathbf{O}_1\mathbf{U}_2\mathbf{U}_1\mathbf{A}_1$ of figure 3.

[8] 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.

[9] To see this, suppose that the home bank accepts an investment with an NPV of V. The branch bank may turn away positive NPV investments because they reduce the value of the home bank's deposit insurance net. But this will never happen when the branch bank's investment has an NPV in excess of the deposit insurance net, which is itself worth less than V. So the branch bank will certainly accept any investment worth at least V and turning away the home bank's investment opportunity therefore cannot raise the expected value of the MNB.

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 $R_H - B_H + C_H < 1$.

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:

$$
\begin{aligned}
V^b_{SS} &\equiv R_H + B_H - (1 - C_H) + R_B + B_B - (1 - C_B)\,; && (5)\\
V^b_{SF} &\equiv \max\left[R_H + B_H - 1 + C_H + R_B - B_B - 1 + C_B, 0\right] \\
&= 2\max\left[-\left(\mathcal{D}_H + \mathcal{D}_B\right) + B_H, 0\right]; && (6)\\
V^b_{FS} &\equiv \max\left[R_H - B_H - 1 + C_H - R_B + B_B - 1 + C_B, 0\right] \\
&= 2\max\left[-\left(\mathcal{D}_H + \mathcal{D}_B\right) + B_B, 0\right]; && (7)\\
V^b_{FF} &\equiv \max\left[R_H - B_H - 1 + C_H - R_B - B_B - 1 + C_B, 0\right] \\
&= 2\max\left[-\left(\mathcal{D}_H + \mathcal{D}_B\right), 0\right]. && (8)
\end{aligned}
$$

where, by analogy to equation 1:

$$
\begin{aligned}
\mathcal{D}_H &\equiv \frac{1}{2}\left[(1 - C_H) - (R_H - B_H)\right]; \\
\mathcal{D}_B &\equiv \frac{1}{2}\left[(1 - C_B) - (R_B - B_B)\right].
\end{aligned}
$$

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 branch banks are by assumption independent. The net expected shareholder return from investing in both projects is therefore

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

The respective cases where $-\left(\mathcal{D}_H + \mathcal{D}_B\right) + B_H$, $-\left(\mathcal{D}_H + \mathcal{D}_B\right) + B_B$ and $-\left(\mathcal{D}_H + \mathcal{D}_B\right)$ are greater than and less than zero divide $\mathcal{A}$ into five regions, as illustrated in figure 4. The regions are named according to the solvency properties of the associated multinational bank, and are illustrated in figure 5.

In general, the value to shareholders of the deposit insurance safety net is less in a MNB. The size of the bailout to shareholders when one bank fails is reduced because the liability structure of the combined banking group forces the home and the branch banks at least partially to bail one another

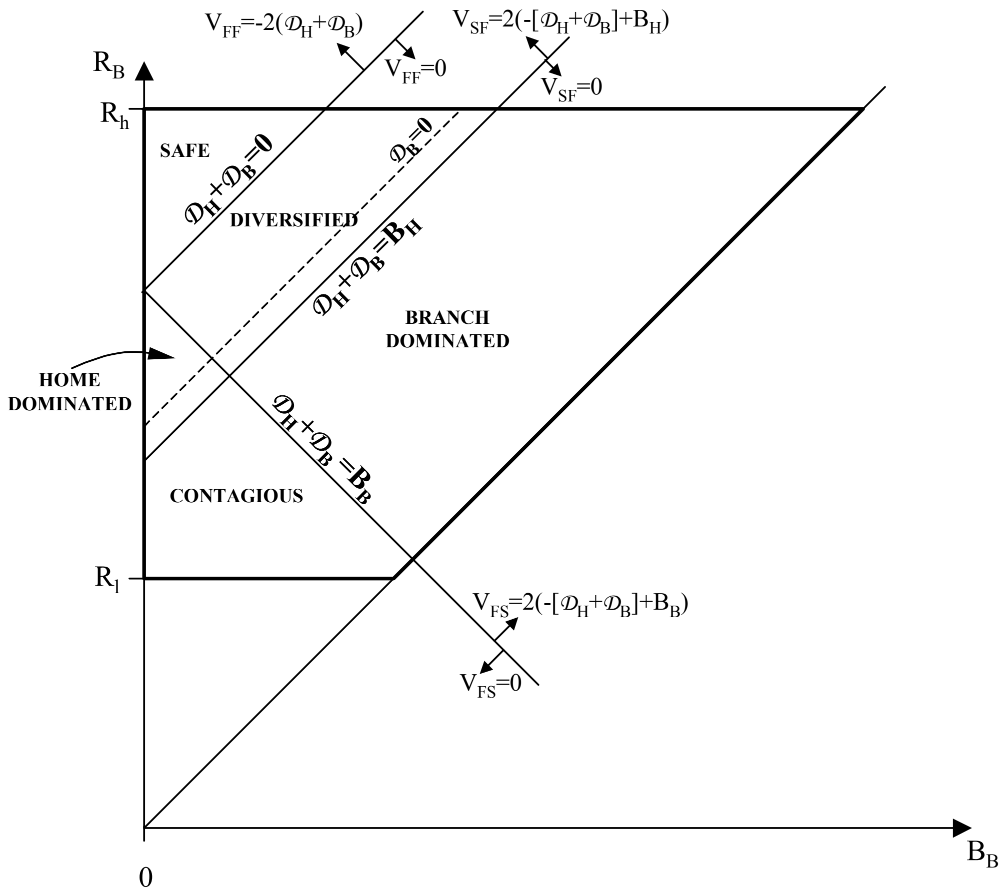

Figure 4: Branch bank projects, speculative home bank.

out. It follows that when branches and standalone banks have common capital requirements, the branch will invest in strictly fewer projects.

The hurdle rate adjustments for the branch bank can be understood with reference to figure 5. Firstly, speculative branch banks are possible provided the MNB is not safe. The standalone profits $\frac{1}{2}\left[R_B - H_B^S\left(B_B\right)\right]$ of these branches must exceed the reduced value of bailouts in a MNB. Bailouts are unaffected for the leading-diagonal terms in the figure. The cases where one bank bails out the other correspond to the off-diagonal terms in the figure: the deposit insurance bailout is replaced partially by the successful bank for insolvent MNBs, and completely for solvent MNBs. For example, the deposit insurance payout for branch dominated banks is reduced by $2\mathcal{D}_H$ if the home bank fails and the branch succeeds, and by $2\left(-\mathcal{D}_H + B_H\right)$ if the home bank succeeds and the branch succeeds. Since each of these occurs with probability $\frac{1}{4}$ investment will occur provided $\frac{1}{2}\left[R_B - H_B^S\left(B_B\right)\right] \geq \frac{1}{2}\left[-\mathcal{D}_H + B_H + \mathcal{D}_H\right]$, or when $R_B \geq H_B^S\left(B_B\right) + B_H$.

Prudent branch banks are possible for safe, diversified and home dominated MNBs. The standalone profits $\left[R_B - H_B^P\left(B_B\right)\right]$ of these branches must exceed the reduced value of bailouts in a MNB. In this case bailouts are unaffected for the left hand columns in figure 5. In the right hand columns the branch bank bails out the home bank, replacing the deposit insurance bailout partially

SAFE

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

DIVERSIFIED

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

BRANCH DOMINATED

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

HOME DOMINATED

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

CONTAGIOUS

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

Figure 5: **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.

for insolvent MNBs and completely for solvent MNBs. For example, in the case of safe MNBs the deposit insurance bailout is entirely replaced by the branch bank and the investment hurdle for these banks is therefore raised by $\mathcal{D}_H$.

The hurdle rates for each type of MNB are presented in lemma 2, where the superscript s on the R terms in this proposition reflects the fact that the home bank is speculative.

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

Proof. In the appendix. □

For each B_B, the investment policy $I^s_B(B_B)$ defined in section 3.1 is given by the unique hurdle rate above B_B on figure 4 which lies inside the region to which it applies.[10] A precise characterisation of I^s_B appears in the appendix as lemma 9 and is illustrated in figure 6, which shows the branch bank's hurdle rate I^s_B and also the hurdle rate H for a standalone project with the same capital requirements.

[10] To see that this rate is unique, 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.

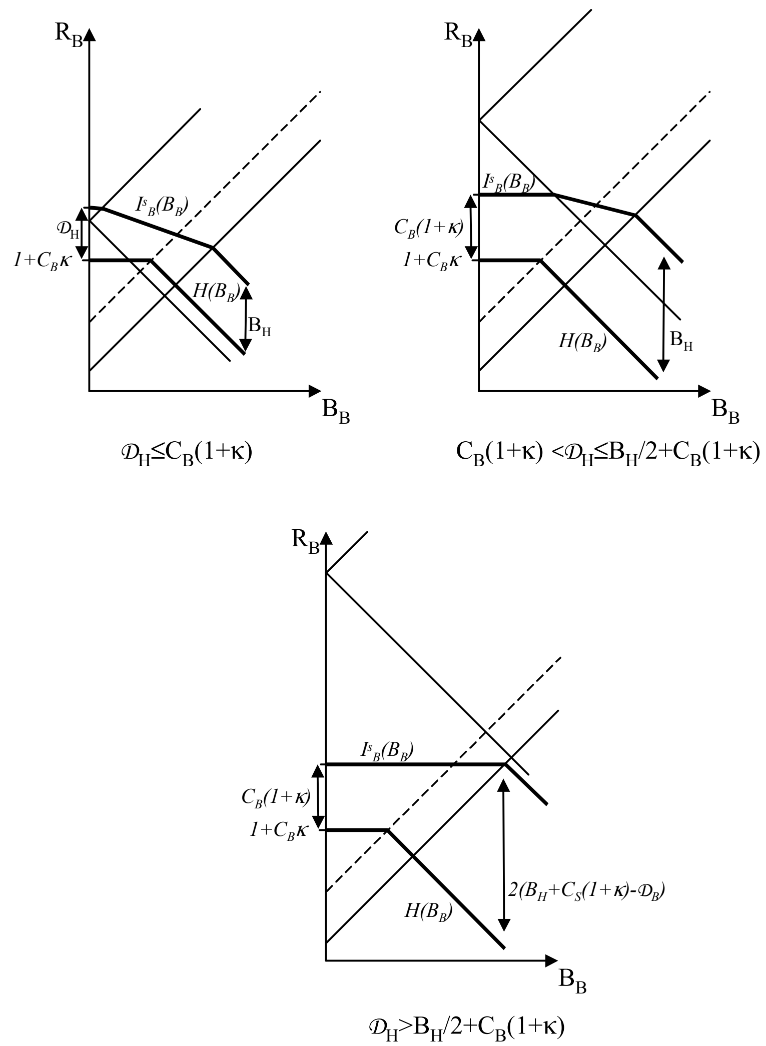

Figure 6: Investment policy for a branch bank with a speculative home bank as a function of $\mathcal{D}_H$.

3.5. Investment Policy: Prudent Home Bank

Suppose that the home bank has accepted a prudent project (B_H, R_H), so that $R_H - B_H + C_H > 1$ and hence $\mathcal{D}_H < 0$.

In this case the project space is again partitioned as in figure 4. 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 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.

With a prudent home bank, bailouts cannot occur for the top rows in figure 5. It follows that the combined entity cannot be home dominated or contagious. For other MNB types the home bank's bail out of the branch bank replaces the desposit insurance fund fully or partially according to whether the MNB is solvent or insolvent on the bottom rows of the figure. Diversified MNBs could have speculative of prudent branches: for safe MNBs only prudent branches are feasible, and for branch dominated, only speculative branches are possible.

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.

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

A precise characterisation of the investment policy I^p_B of the branch bank appears in the appendix as lemma 11: we illustrate our findings in figure 7.

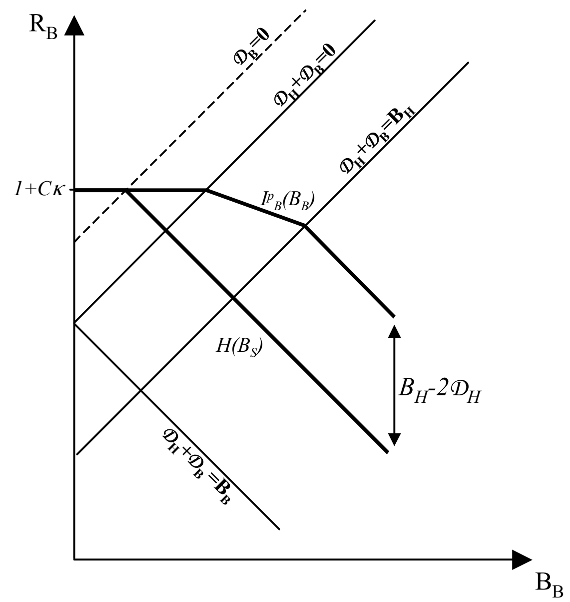

Figure 7: Investment policy for a branch of a prudent mother bank.

The lower bold line in figure 7 shows the hurdle rate for a standalone bank. Once again for a given capital adequacy requirement the branch bank performs less investment than the standalone bank.

3.6. Discussion

We have argued that, when the various branches of the bank have insured depositors, hurdle rates in MNBs will be higher because diversification reduces the value to the shareholders of the deposit insurance subsidy. Since a branch-based MNB is a unitary banking structure, the diversification effects identified in this section will apply equally within single country bank. We return to this observation in section 5.1.

These observations suggest the following result, which is proved in the appendix:

Proposition 4 *The extent of branch bank underinvestment relative to the corresponding standalone bank is an increasing function of the magnitide $|\mathcal{D}_H|$ of the home bank's deposit insurance safety net.*

The effect identified in proposition 4 applies to branch MNBs with both speculative and prudent home banks. The argument in the former case is straightforward: a successful branch bank will reduce the size of the deposit insurance bailout for an unsuccessful home bank. In the latter case, $\mathcal{D}_H$ is negative and a failing home bank will be able to bail out a failing branch bank up to $-\mathcal{D}_H$.

This result has important implications for capital adequacy policy. Since capital requirements for a standalone bank are set optimally to counter the expected level of deposit insurance-induced overinvestment, capital requirements for a MNB should be altered insofar as the incentive effects of deposit insurance are altered. Hence, increased branch bank hurdle rates should be countered with lower capital adequacy requirements. This argument is summarised in the following corollary to proposition 4.

Corollary 5 *Optimal capital requirements for branch bank MNBs are lower than those for standalone banks, and they are dropping in the absolute 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. 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.

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:

$$V_{SS}^{s} \equiv (R_H + B_H) - (1 - C_H) + (R_S + B_S) - (1 - C_S)\,; \quad (10)$$

$$\begin{aligned} V_{SF}^{s} &\equiv (R_H + B_H) - (1 - C_H) + \max\left[(R_S - B_S) - (1 - C_S), 0\right] \\ &= 2\left\{-\mathcal{D}_H + B_H + \max\left[-\mathcal{D}_S, 0\right]\right\}; \end{aligned} \quad (11)$$

$$\begin{aligned} V_{FS}^{s} &\equiv \max\left\{(R_H - B_H) - (1 - C_H) + (R_S + B_S) - (1 - C_S), 0\right\} \\ &= 2\max\left\{-\left(\mathcal{D}_H + \mathcal{D}_S\right) + B_S, 0\right\}; \end{aligned} \quad (12)$$

$$\begin{aligned} V_{FF}^{s} &\equiv \max\left\{(R_H - B_H) - (1 - C_H) + \max\left[(R_S - B_S) - (1 - C_S), 0\right], 0\right\} \\ &= 2\max\left\{-\left(\mathcal{D}_H + \mathcal{D}_S\right), 0\right\}. \end{aligned} \quad (13)$$

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_{SF}^{s} and V_{FF}^{s}. The combined institution has limited liability, reflected in the curly bracketed max {.} terms in V_{FS}^{s} and V_{FF}^{s}.

Equations 10 to 13 partition the project space in an analogous way to equations 5 to 8 in section 3.4. Proceeding precisely as in section 3.4 we can determine the dependence of the subsidiary bank's investment policy $I_S^s(B_S)$ upon $\mathcal{D}_H$. The details of the calculations appear in the appendix: I_S^s is illustrated in figure 8. The dashed lines in the figure indicate the investment policy for the corresponding branch-organised MNB.

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.

4.3. Discussion

As for a branch bank MNB, international diversification effects reduce the value to the home bank's shareholders of the deposit insurance net. However, unlike the branch bank case, the home bank need not bail out a failing subsidiary bank. As a result, there is no disincentive to invest when $\mathcal{D}_H$ is negative: this is the result outlined in section 4.2.

This discussion suggests the following result, whose proof is similar to that of proposition 4 and hence is omitted.

PROPOSITION 6 *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. In particular, there is no underinvestment when $\mathcal{D}_H \leq 0$.*

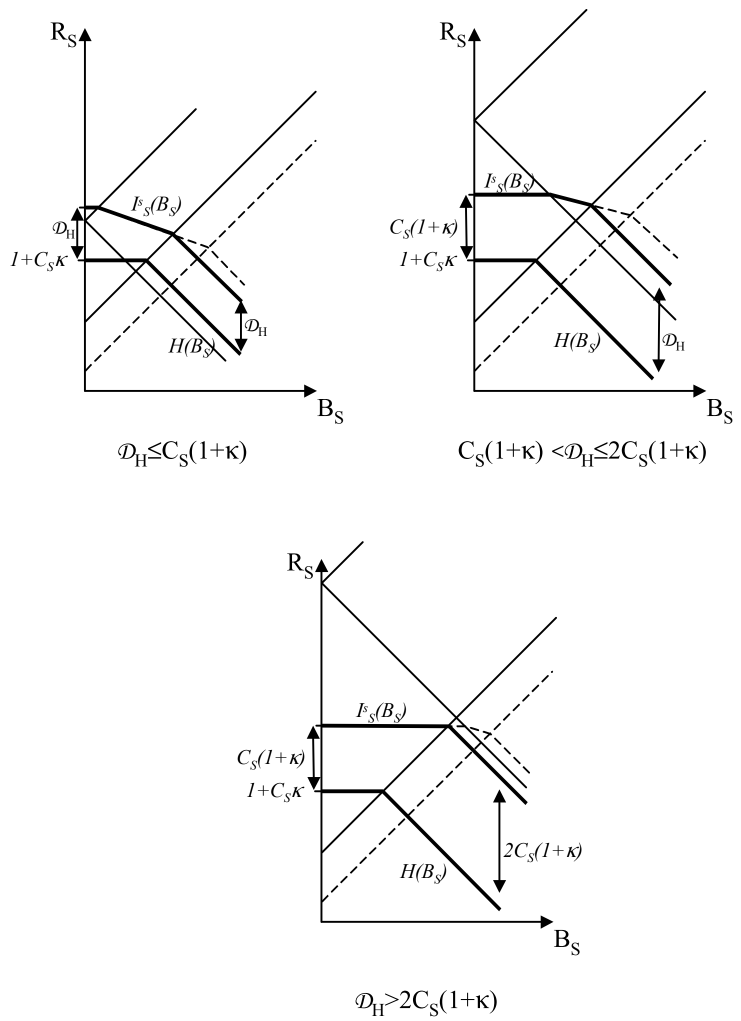

Figure 8: Subsidiary investment policy as a function of $\mathcal{D}_H$.

The disincentive effects which the branch bank MNB experiences when the home bank is prudent ($\mathcal{D}_H < 0$) cause underinvestment to be a U-shaped function of $\mathcal{D}_H$, as in proposition 4. In contrast, underinvestment is a monotone increasing function of $\mathcal{D}_H$. In general, therefore, the limited liability structure of the subsidiary reduces underinvestment effects. The following corollary is immediate:

COROLLARY 7 *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.*

5. Policy Implications

In this section we examine the implications of our model for some important policy questions.

5.1. Capital Adequacy Requirements

We can evaluate the new Basle Capital Accord (Basle Committee, 2003) in the light of our model. Firstly, recall that a branch bank MNB has the same liability structure as a unitary single-country bank. If we interpret the home bank of section 3 as a unitary bank and the branch bank as a possible new investment then we can draw conclusions about the appropriate marginal capital requirement for a new investment.

When the home bank is speculative ($\mathcal{D}_H$ is positive) we find in section 3 that diversification should be rewarded with lower capital requirements. This recommendation is in accordance with the received wisdom of practitioners, although their argument appears to be based upon reduced bankruptcy probability rather than investment incentives. Nevertheless, the new Basle Accord does not allow for diversification effects.

However, for a prudent home bank ($\mathcal{D}_H$ negative) the hurdle rate is reduced by the fear that the home bank will be forced to bail out failing branches. We could interpret our model in this instance as recommending a reduced capital requirement for institutions whose existing portfolio has a higher credit rating. This is precisely the innovation of the new Accord.

Secondly, our results show that when establishing optimal capital requirements, the *representation form* of the MNB matters as well as the level of *diversification*. In fact, we have shown that for a given investment, the optimal marginal capital requirement for a subsidiary bank is higher than for a branch bank. This observation has yet to be reflected in policy but, as we argue below, it may be the root cause of observed liability structure choices.

Thirdly, note that the capital of a branch bank is not clearly defined (Benston, 1994). As a result, 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). Our work implies that a single capital requirement below that of the standalone institution is appropriate. In contrast, host regulators could in principle set different capital requirements for subsidiaries than for the host. When capital requirements are allowed to vary internationally one would therefore expect the home bank to be charged the standalone capital requirement and the requirement for the subsidiary bank to be lower. We argue that the extra degree of freedom in the subsidiary structure is likely to allow for more accurate capital adequacy calculation.

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.

5.2. Choice of Organisational Form

There is considerable evidence that MNBs prefer to establish subsidiaries rather than branches. A "single passport" scheme exists in Europe (EEC, 1989) which attempts to demolish protective barriers to entry by allowing any home E.U. bank to establish branches elsewhere in the E.U.

Notwithstanding this legislation, many home banks have elected instead to expand within the European Union via the creation of foreign subsidiaries (Dermine, 2002). Moreover, while bankers in both Latin America and Eastern Europe have a free choice between subsidiary and branch structures, the subsidiary bank predominates (BIS, 2001).

Our model explains this phenomenon. While the capital requirement for a standalone bank is excessive for both branch and subsidiary bank MNBs, we have shown above that it is more distortive for branch than for subsidiary bank MNBs. It is therefore rational for bankers to favour the subsidiary structure so as to minimise the distortive effects of capital adequacy requirements.

Related arguments can be used to explain the "cherry picking" documented by the Bank for International Settlements (2001): foreign banks tend to accept only the highest quality projects in their host country. In the context of our model, this is rational behaviour even in the absence of an informational advantage for the home bank. Foreign banks have higher hurdle rates and so will naturally turn away investments which are marginal for the local banks.

5.3. Stability

Our model suggests a possible channel for financial contagion. Suppose that the home bank's economy experiences an exogenous shock which alters the expected value $\mathcal{D}_H$ of the deposit insurance subsidy. Propositions 4 and 6 imply that the foreign bank's hurdle rate and hence its lending policy will be affected. The nature of this effect will depend upon whether the home bank is speculative or prudent, and also upon the representation form (branch or subsidiary) of the MNB.

Underpricing in both branch and subsidiary foreign banks is increasing in the expected value $\mathcal{D}_H$ of the deposit insurance subsidy whenever the home bank is speculative. An exogenous adverse shock to the home economy which either raises the volatility of its earnings or reduces its exected returns will increase $\mathcal{D}_H$. This will increase the hurdle rate in the foreign bank and hence may therefore precipitate a credit crunch in the foreign country. This prediction is consistent with evidence concerning the international consequences of the Japanese banking crisis presented by Peek and Rosengren (1997, 2000). The response by U.S. branches of Japanese MNBs to the crisis was a sharp reduction in U.S. lending. Japanese banks were particularly active in the commercial real estate loan market in the U.S. and their actions precipitated a credit crunch in this sector. The banking crisis must have increased the value of the deposit insurance net to the Japanese home banks and our model therefore provides an explanation for their observed lending behaviour. As the returns South East Asian loans were more highly correlated with those on Japanese loans one would expect the effects of the banking crisis to be somewhat attenuated in these economies: Peel and Ronsegren report that this was indeed the case.

When the MNB has a prudent home bank the impact of changes in $\mathcal{D}_H$ will depend upon the representational form of the MNB. We consider the consequences of an increase in home bank profitability, which in this case correspond to an increase in the absolute value of $\mathcal{D}_H$. Propositions 4 and 6 respectively show that increased home bank profitability will result in a lower level of branch bank lending, and an unchanged level of subsidiary bank lending. Goldberg (2001) reports that U.S. GDP growth is negatively correlated with the level of U.S. bank claims in Asia, and positively correlated with the level in Latin America. Due to local regulation, foreign banks expansion into Asian economies has largely been via branches: free of such restrictions, MNBs have expanded into Latin America via subsidiaries (B.I.S., 2001). Taking the view that U.S. banks are essentially prudent, the Asian effect identified by Goldberg is readily explicable in terms of our analysis. In this case, higher U.S. GDP and hence U.S. home bank profitability would reduce the value to the MNB of the branch bank's deposit insurance safety net, raising its hurdle rate and hence lowering the volume of foreign lending. While the model presented here implies that Latin American lending should be unaffected by changes in $\mathcal{D}_H$, we argue that a repeated game extension of our analysis would yield Goldberg's results. Increased U.S. bank profitability would then reduce the likelihood of later investment distortion in subsidiaries and hence would reduce the subsidiary lending hurdle.

In summary, an increase in the profitability of a prudent home bank has two effects. Firstly, for both branch and subsidiary bank structures, it reduces the likelihood that the foreign bank will be required to bail out the home bank. Secondly, it increases the expected cost to the home bank of bailing out a branch bank. For branch bank MNBs the second effect dominates; for subsidiary MNBs only the first effect is at work. Hence increased home bank profitability tends to *increase* branch bank hurdle rates and to *reduce* subsidiary rates. The B.I.S. (2001, p. 30) state that many Asian regulators prefer to license branch banks as they are more likely to obtain financial support from their home bank. While this rationale seems plausible *ex post*, our analysis identifies an important *ex ante* effect which should also be considered.

Goldberg also observes that lending by smaller MNBs in both Latin American and Asian markets has been more volatile than lending by larger banks. Again, this observation is susceptible to explanation in terms of our framework. As larger banks are better diversified they can better absorb a shock to their portfolio. This implies that the value $\mathcal{D}_H$ of the deposit insurance net, and hence the foreign bank lending policy, should be more stable for larger banks.

6. Conclusion

We demonstrate in this paper how capital requirements may be justified in an environment where deposits are insured and bank capital is costly. 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.

Our formal results cast light upon several real world phenomena. As we discuss in section 5, they can help us to understand optimal capital requirements, observed organisational form choices, and international financial contagion.

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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 8

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

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: $\mathbf{C}(1 + 2\kappa) \leq \mathbf{1}$. This is the case which is illustrated in figure 3. $\mathcal{U}$ 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:

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

Adding these expressions yields equation 14.

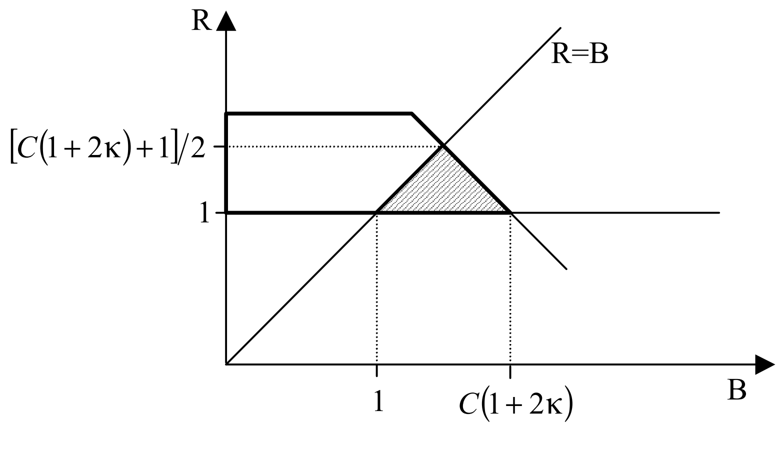

Figure 9: Region $\mathcal{U}$ when $C(1 + 2\kappa) > 1$.

Case 2: $\mathbf{C}(1 + 2\kappa) > \mathbf{1}$. 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

$$\frac{2}{A}\int_{1}^{\frac{C(1+2\kappa)+1}{2}}\int_{0}^{B-1} R dR dB = \frac{1}{24A}\left(1 - C\left(1+2\kappa\right)\right)^{3},$$

from which the required result follows immediately. □

The proposition follows immediately from lemma 8 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 Lemma 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 4. 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:

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

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 lemma 2.

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

LEMMA 9 *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*

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

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

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

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

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

Proof. 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 9 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 10

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

It follows immediately that I_B^s must be continuous and that its path through the regions of figure 4 is completely determined by its value when $B_B = 0$.

Part 1 of the lemma implies that $I_B^s(0) = R^s_{B,Sf}$ 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 $R^s_{B,Dv}$. Since $R^s_{B,Dv}(B_B)$ has slope $-\frac{1}{3}$ (equation **InvDiv**) and $\mathcal{D}_H + \mathcal{D}_B = B_B$ has slope -1 it is immediate from figure 4 and part 2 of the lemma that $I_B^s(B_B)$ has value $R^s_{B,Dv}$ until $B_B = C_B(1+\kappa) + \frac{3}{2}B_H - \mathcal{D}_H$, after which it takes value $R^s_{B,Br}(B_B)$ and, since $R^s_{B,Br}(B_B)$ 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 $R^s_{B,Hm}$ and $R^s_{B,Ct}$ intersect and hence that when $C_B(1+\kappa) < \mathcal{D}_H$ we must have $I_B^s(0) = R^s_{B,Hm}$. The intersection of $R^s_{B,Hm}$ 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 $R^s_{B,Hm}$ 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 $I_B^s = R^s_{B,Hm}$ for $B_B \leq 2\left[\mathcal{D}_H - C_B(1+\kappa)\right]$. For higher values of B_B, reasoning about the slope of $R^s_{B,II}$ 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 $R^s_{B,Br}$.

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

Investment Policy for a Prudent Home Bank's Banch

LEMMA 11 *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 9 and is omitted. □

Proof of Proposition 4

Let $\bar{R}_B$ and $\underline{R}_B$ be the respective intersection points of the lines $\mathcal{D}_H + \mathcal{D}_B = 0$ and $\mathcal{D}_H + \mathcal{D}_B = B_H$ with the R_B axis. It is easy to see that $\frac{\partial \bar{R}_B}{\partial \mathcal{D}_H} = \frac{\partial \underline{R}_B}{\partial \mathcal{D}_H} = 1$. Since the line $H(B_B)$ is invariant to $\mathcal{D}_H$ the result follows trivially by inspection of figures 6 and 7.

Derivation of Investment Policy for MNB with a Subsidiary

Equations 10 to 13 partition the project space when the home bank is speculative as illustrated in figure 10. The "partially diversified" region and the "partially contagious" regions differ from the branch dominated and contagious regions respectively of figure 5 in that the home bank remains solvent in the event of subsidiary failure and home bank success: this is a consequence of the liability structure of the subsidiary, which allows the home bank to walk away in the event of failure.

Lemma 12 establishes the hurdle rates for the various regions in figure 5. The intuition for the results is similar to that for lemma 2.

LEMMA 12 *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:*

1. ***Safe MNBs:*** $R_S \geq R_{S,Sf}^s \equiv H_S^P(B_S) + \mathcal{D}_H$;
2. ***Diversified MNBs:*** $R_S \geq R_{S,Dv}^s \equiv H_S^P(B_S) + \frac{1}{2}(\mathcal{D}_H - \mathcal{D}_S) = H_S^S(B_S) + (\mathcal{D}_H + \mathcal{D}_S)$;
3. ***Partially Diversified MNBs:*** $R_S \geq R_{S,Pd}^s \equiv H_S^S(B_S) + \mathcal{D}_H$;
4. ***Home Dominated MNBs:*** $R_S \geq R_{S,Hm}^s \equiv H_S^P(B_S) + \left(-\mathcal{D}_S + \frac{1}{2}B_S\right) = H_S^S(B_S) + (-\mathcal{D}_S + B_S)$;
5. ***Partially Contagious MNBs:*** $R_S \geq R_{S,Pc}^s \equiv H_S^S(B_S) - \mathcal{D}_S + B_S$.

Proof. 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:

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

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

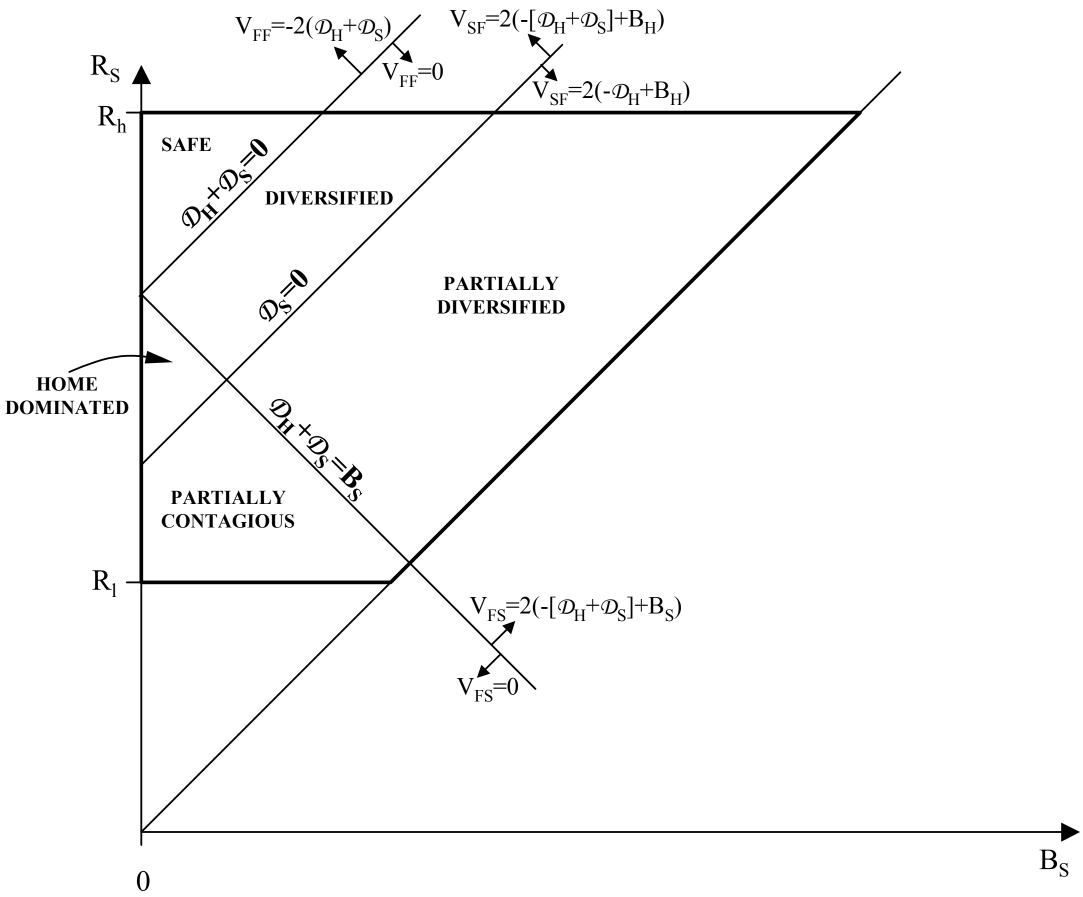

Figure 10: Subsidiary bank projects, speculative home bank.

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

Finally, lemma 13 estabishes the investment policy $I_S(B_S)$ for a speculative home bank's subsidiary.

LEMMA 13 *The investment policy I_S^s depends upon the hurdle rates established in proposition 12 and upon $\mathcal{D}_H$ as follows:*

PROPOSITION 14 *1. If $\mathcal{D}_H \leq C_S(1+\kappa)$ then*

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

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 9. It is easy to establish the following lemma.

LEMMA 15

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 9 it follow that I^s_S must be continuous and that its path through the regions of figure 10 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 9 □