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

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Abstract: Banking sector globalization has caused an expansion in foreign-owned bank assets. In this paper we analyse the effects of a MNB's liability structure upon its investment in a foreign country. We develop a model in which capital adequacy requirements introduce some deliberate underinvestment which counters deposit insurance-induced overinvestment. Diversification is unattractive with fixed bank capital requirements, because it reduces the expected value of the deposit insurance net. This effect applies in multinational banks (MNBs), where shocks to the home country economy alter the value of the deposit insurance net and hence affect overseas lending incentives. Thus, MNBs act as a channel for financial contagion. We discuss the policy implications of our results.

Keywords: multinational bank, capital adequacy requirements, deposit insurance, financial contagion.

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 analyse the effects of a multinational bank's liability structure upon its investment incentives in a foreign country. We use a simple model in which capital regulation trades off the moral hazard problems associated with an

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insured depositor base against the costs of raising equity capital. 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. Appendix A documents the recent expansion of foreign bank ownership of bank assets. The trend is particularly striking in emerging markets and, 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.

A growing literature attempts to explain the operation of multinational banks. The problem of limited supervisory information on a MNB's activities is analyzed by Repullo (2001), Holthausen and Rønde (2002), Calzolari and Lóránth (2002) and Harr and Rønde (2003). Acharya (2003) and Dell'Ariccia and Marquez (2005) model the incentives and disincentives for cross-border regulatory cooperation. Morrison and White (2004) examine the effects of foreign bank entry upon real investment decisions. At the same time, a substantial empirical literature examines the effect that foreign bank entry has upon host economies. One strand of this literature examines the effect of MNB entry upon financial stability in the host country (see de Haas and van Lelyveld, 2003; Martinez Peria, Powell and Vladkova Hollar, 2002; and Galindo, Micco and Powell, 2004); another studies the implications of foreign bank entry for local credit markets (see Denzier, 1999; Barajas, Steiner and Salazar, 2000; Clarke et al. 2001; Claessens, Demirgüç-Kunt and Huizinga, 2001; and Martinez Peria and Mody, 2004).

Kahn and Winton (2004) analyse the incentive effects of a bank's liability structure. In a model with uninsured depositors, they show that an appropriate choice of liability structure can be used to separate low- from high-risk assets, and so mitigate a managerial moral hazard problem. Kahn and Winton are concerned only with incentives to increase portfolio risk, and do not directly examine investment incentives.

In the context of a multinational bank, we also examine the incentive consequences of bank liability structure, concentrating specifically upon investment decisions. However, we adopt a different approach to Kahn and Winton. We examine a model of banking with insured depositors, in which banks 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 under-investment 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.

A number of earlier papers also study the interaction between capital adequacy requirements and moral hazard.[1] To our knowledge, however, the framework that we employ has not been adopted elsewhere. It gives us a simple model of capital requirements based upon the trade-off between the overinvestment induced by deposit

1 See Dewatripont and Tirole (1993a and 1993b), Bhattacharya (1982), Rochet (1992), Morrison and White (2005), Hellman, Murdock and Stiglitz (2000) and Milne (2002).

insurance, and the deadweight under-investment costs that are a consequence of costly capital requirements. The simplicity of our basic model enables us to extend it to cover the more complex problem of cross-border expansion.

We assume in our model of multinational banking 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 that is optimal for a national bank results in under-investment 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 that increases the volatility of returns of its portfolio. Without a corresponding change in capital requirements, this immediately increases the value that 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 institutions: 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. While the choice between branch and subsidiary structure is too complex to be fully captured by a simple model like the one in this paper, we use this observation in Section 5(*ii*) to provide one explanation for an observed preference amongst MNBs for subsidiaries over branches. Since diversification lowers the value of the deposit insurance safety net, we argue that when capital requirements are constant across organizational forms, shareholders will prefer to run subsidiaries, because they induce less diversification than branches. We show that although this behaviour increases the expected payout from the deposit insurance fund, for a fixed capital requirement it need not be welfare-reductive. We also argue that 'cherry picking' of the safest loans by foreign banks is a rational response to their under-investment incentives relative to local banks that face the same capital requirements.

Finally, our model has welfare implications that may help in policy design. The inefficiency that 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 it should increase welfare.[2] In our model this is not the case. Capital requirements for standalone banks introduce some deliberate underinvestment that optimally counters the over-investment induced by

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

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.[3]

In contrast to the new Basle Accord, our work therefore suggests that diversified institutions 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.[4]

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 that 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 Appendix B.

2. STANDALONE BANK REGULATION

(i) 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 that 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 that 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 uniformly distributed over $\mathcal{A} \equiv \{(B, R) \in \Re^2 : R_l \leq R \leq R_h, 0 \leq B \leq R\}$, 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 that the bank deploys. As we discuss in the Introduction, this assumption reflects pecking order effects that have been studied elsewhere in the literature.[5] κ is a wealth transfer

3 See Furfine et al. (1999) for evidence of this effect.

4 See for example J.P. Morgan (1997).

5 Kahn and Winton (2004) and Milne (2002) also present models of banking regulation in which equity capital has an exogenously higher cost than debt.

and its only impact upon welfare calculations will therefore be through the investment distortions that 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).

(ii) 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 $R \geq 1$.[6] 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 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:

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

The expected shareholder payoff from prudent investments is $R - 1 - C\kappa$ and from speculative investments is $\frac{1}{2}(R + B - 1 - C) - C\kappa = \frac{1}{2}(R - [1 - B + C(1 + 2\kappa)])$.

6 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.

The banker will invest in any project that 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, $H^P(B) = H^S(B)$.[7]

The intuition 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.

(iii) Optimal Capital Adequacy Requirement

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 $\mathbf{A}_1\mathbf{A}_2\mathbf{A}_3\mathbf{A}_4\mathbf{A}_1$. The line $\mathbf{P}_1\mathbf{P}_2$ 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 $\mathbf{U}_1\mathbf{U}_2$ (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.

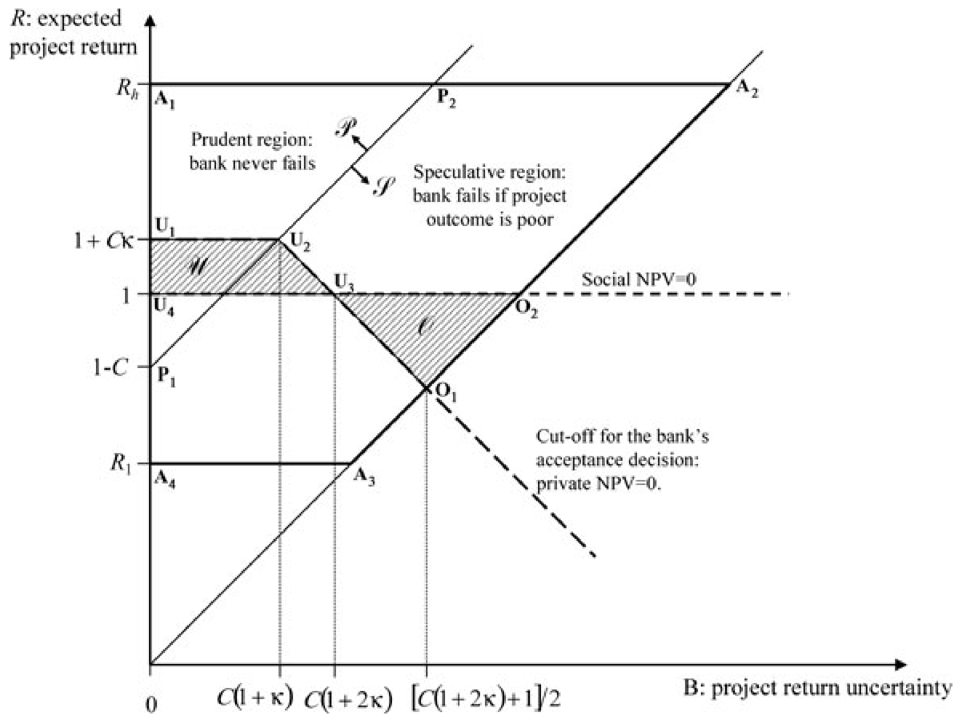
In other words, the flat capital requirement C induces the banker to turn away some safe profitable investment opportunities (region $\mathcal{U}$), and to accept some unprofitable risky ones (region $\mathcal{O}$). This is precisely the behaviour observed in response to the first Basle Accord on bank 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

7 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 1

Investment Decision of a Standalone Bank in Response to a Capital Requirement of **C**.



Notes:
The banker will invest in projects for which the expected return R lies above the line $\mathbf{U}_1\mathbf{U}_2\mathbf{U}_3\mathbf{O}_1$ where the private NPV is zero. This compares to the socially first best region for which the expected return lies above the horizontal $R = 1$, where the social NPV is zero. The regions $\mathcal{U}$ and $\mathcal{O}$ respectively represent under- and over- investment.

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 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 that forces the banker to internalise some of the associated social costs. The flat risk-insensitive capital requirement that 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 that 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 that concern us.[8]

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(i) to discuss the regulation of a simple multinational bank consisting of a home bank and one foreign bank.

Investment incentives in multinational banks differ from those in standalone banks because of the effects that each of the constituent banks' projects has upon the returns derived from the others'. These effects arise as a result of diversification effects: when possible, losses in one of the constituent banks will be met from profits in another. This has two consequences. First, the failure of one bank may force the failure of another. The diversification benefits achieved within multinational banks therefore come at a cost: they may open up new channels for financial contagion. Second, when one constituent bank is forced to meet losses sustained by another, the value of the deposit insurance safety net is diminished. This serves to raise the effective investment hurdle rates within multinational banks. While the first of these effects has been noted elsewhere, to our knowledge the second has not been analyzed.

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 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. Hence the contagion effects that we identify above can occur either from the home bank to the branch, or in the opposite direction.

(i) 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

8 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 (2005) argue that, as deposit insurance premia are a sunk cost, they will have no *ex post* effect upon risk-taking incentives.

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(i).

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(i).

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 branch: this takes the form of an investment hurdle rate $I_B(B)$, which is a function of the investment opportunity's riskiness B.[9]

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 that is identical to but independent of that from which (B_H, R_H) is drawn. The returns of the home bank and branch bank's projects are independent.

At time t_4 the branch bank'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 branch 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.

Because it moves first, the home bank's investment decisions will be precisely those derived for a standalone bank in Section 2.[10] We therefore restrict our analysis in this section to the investment decisions of the branch when the home bank has made a time t_1 investment, distinguishing the cases where the home bank is speculative (region $\mathcal{S}$ of Figure 1), and where it is prudent (region $\mathcal{P}$ of Figure 1).

(ii) Diversification and Contagion Effects in Branch Bank MNBs

In a branch bank MNB failure of either the home bank or the branch bank can trigger the failure of the entire institution. Hence there are five possible solvency patterns for branch bank MNBs, which we illustrate in Table 1. At one extreme, the *contagious MNB*, the failure of either of the component divisions individually leads to the failure of the entire bank; at the other, the *safe MNB*, simultaneous failure of the branch and the home division is insufficient to trigger MNB insolvency. If failure of the branch division triggers MNB insolvency but failure of only the home division does not then we say that the MNB is *branch-contagious*, while if the failure of the home bank can trigger branch bank failure we say that the MNB is *home-contagious* . Finally, we refer to a branch bank MNB as *diversified* if contagion effects never arise: in other words, if the success of one division is always sufficient to ensure MNB solvency in the wake of failure by the other division, although failure of both divisions results in MNB insolvency.

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

10 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.

Table 1
Branch MNB Solvency

		Safe MNB			*Diversified MNB*	
	Home:	Succeed	Fail	**Home:**	Succeed	Fail
Branch:	Succeed	Solvent	Solvent	Succeed	Solvent	Solvent
	Fail	Solvent	Solvent	Fail	Solvent	Insolvent
		Branch-Contagious MNB			**Home-Contagious MNB**	
Branch:	Succeed	Solvent	Solvent	Succeed	Solvent	Insolvent
	Fail	Insolvent	Insolvent	Fail	Solvent	Insolvent
		Contagious MNB				
Branch:	Succeed	Solvent	Insolvent			
	Fail	Insolvent	Insolvent			

Notes:
The table shows the possible solvency properties of a branch multinational bank as a function of the success or failure of the home and branch banks.

We now derive precise conditions for a branch MNB to be safe, diversified, home- or branch- contagious, or contagious. We denote by (B_H, R_H) and (B_B, R_B) the home and branch bank investments, and we denote outcomes by ordered pairs in which the home bank's result (success S or failure F) appears first. The payoff (gross of costs) to the shareholders from each outcome is then as follows, where the superscript b appears because the MNB has branch structure:

$$V^b_{SS} \equiv R_H + B_H - (1 - C_H) + R_B + B_B - (1 - C_B)\,; \tag{5}$$

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

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

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

where, by analogy to equation 1:

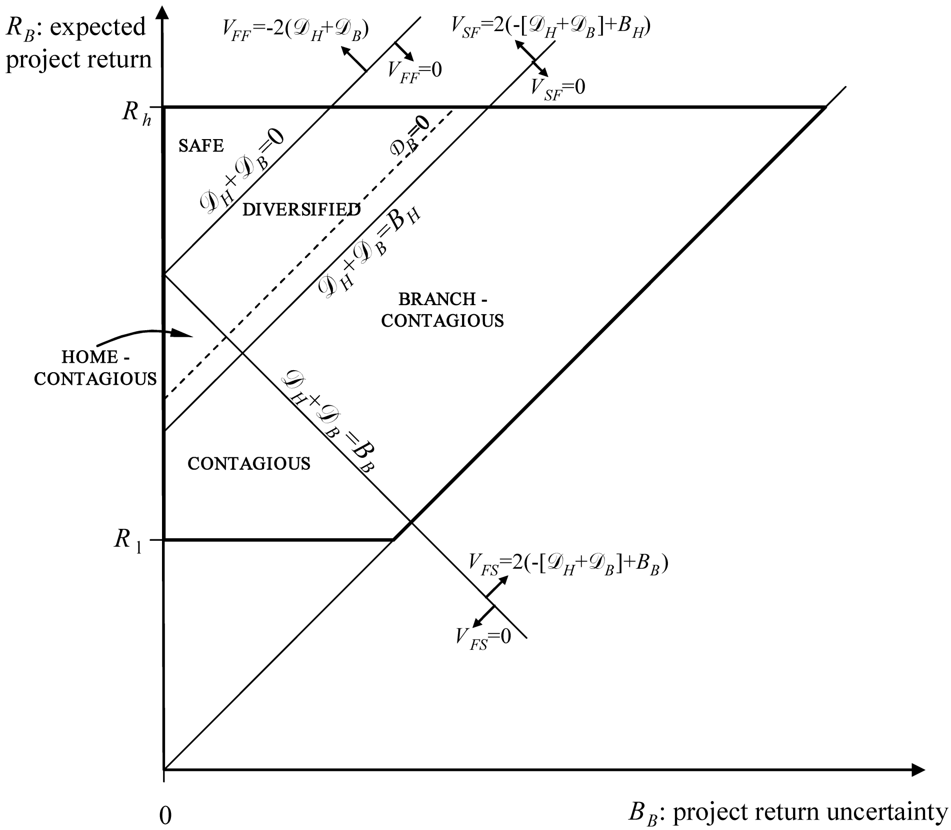
$$\begin{aligned} \mathcal{D}_H &\equiv \frac{1}{2}\left[(1 - C_H) - (R_H - B_H)\right]; \\ \mathcal{D}_B &\equiv \frac{1}{2}\left[(1 - C_B) - (R_B - B_B)\right]. \end{aligned}$$

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:

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

Figure 2
Diversification and Contagion Effects with Branch Banks



Notes:
For possible combinations of the branch bank's expected project return R_B and project return uncertainty B_B, the figure shows for a branch bank MNB which of the solvency properties illustrated in Table 1 will obtain.

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 divide $\mathcal{A}$ into five regions which correspond to the bank types identified in Table 1, and which we illustrate in Figure 2.

(iii) Branch Bank Investment Decisions with a Speculative Home Bank

In this subsection we consider a home bank that has accepted a speculative project (B_H, R_H), so that $R_H - B_H + C_H < 1$, and hence $\mathcal{D}_H > 0$. Whether or not a particular type of bank (say, a contagious MNB) is observed in practice depends not only upon which of the regions in Figure 2 a given project (B_B, R_B) falls into, but also upon whether investment in the project is individually rational: in other words, upon whether the return R_B exceeds the hurdle rate I_B^s communicated to the branch bank by the home bank at time t_1. We now turn to an analysis of the hurdle rate, which determines the probability that a multinational bank is safe, diversified, home-contagious, branch-contagious, or contagious.

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 out one another. It follows that when branches and standalone banks have common capital requirements, the branch will invest in strictly fewer projects: in other words, its hurdle rate will be higher than that of a standalone institution.

Intuitively, the difference between the hurdle rate in a branch bank and the hurdle in a standalone bank depends upon the value $\mathcal{D}_H$ to the home bank of the deposit insurance safety net. Higher values of $\mathcal{D}_H$ raise the opportunity cost of branch bank investment in terms of foregone subsidies from the deposit insurance fund, and so raise the branch bank hurdle rate.

The value of $\mathcal{D}_H$ also affects the likelihood of contagion across the MNB. The margin of insolvency in the home bank is low when $\mathcal{D}_H$ is low. The likelihood of contagion from the home bank to the branch bank is therefore very low; similarly, a branch bank with low $\mathcal{D}_B$ will not trigger failure of the home bank. Safe multinationals therefore are more likely to occur when $\mathcal{D}_H$ is low.

In diversified multinational banks the losses of one failing institution can always be absorbed by the other. This is less likely to be the case when $\mathcal{D}_H$ is very small, so that the home bank project has low risk and hence makes small profits when it succeeds, or when it is very large, in which case the project has high risk and so is more likely to force branch insolvency when it fails. Hence diversified multinationals are mostly likely to be observed when $\mathcal{D}_H$ assumes an intermediate value.

Finally, recall that when $\mathcal{D}_H$ is high, the margin of insolvency in a failed home bank is also high. As a result, the likelihood that it drags even a successful branch bank under is correspondingly high. Both home-contagious and contagious MNBs are therefore more likely to arise for higher $\mathcal{D}_H$ values.

Branch bank investment will be attractive either when it generates sufficient profits to compensate for the loss of the home deposit insurance subsidy, or when it brings with it a compensating deposit insurance subsidy of its own. The latter case can obtain only if branch bank failure is sufficient to ensure MNB failure, and so to trigger a payout from the deposit insurance fund. This corresponds to the branch-contagious region. As $\mathcal{D}_H$ increases, the hurdle rate in Figure 2 drops for every B_H. The proportional increase in the size of the individually rational branch-contagious region is matched by the corresponding increases in the diversified and home-contagious regions. Hence the probability of observing a branch-contagious MNB remains approximately constant.

These effects are analysed in detail in Appendix B. Lemmas 2 and 3 derive the investment hurdle rate for branch banks as a function of the home bank's deposit insurance subsidy, $\mathcal{D}_H$. There are three cases, according to whether $\mathcal{D}_H$ is below $C_B(1 + \kappa)$, between $C_B(1 + \kappa)$ and $\frac{1}{2}B_H + C_B(1 + \kappa)$, or above $\frac{1}{2}B_H + C_B(1 + \kappa)$. These cases are illustrated in Figure 5 in Appendix B. We provide an illustrative numerical example for each of the three cases in Table 2.

Our example is based upon currently observed parameter values. In line with the current Basel Accord, we set capital requirements $C_H = C_B = 0.08$. We set the cost κ of capital equal to 0.1: this is consistent with research that suggests that the *direct* costs of capital raising are of the order of 7% (see Chen and Ritter, 2000). With these values, we select three pairs (B_H, R_H), which correspond to the three ranges for $\mathcal{D}_H$ studied in Appendix B. In each case, investment for a standalone institution would be incentive-compatible at these values, so these cases could arise in practice. The calculations that

Table 2
Numerical Example: Branch of Speculative Home Bank

$\mathcal{D}_H$	R_H	B_H	$\wp\{Safe\}$	$\wp\{Div.\}$	$\wp$ {*Home – contagious*}	$\wp$ {*Branch – contagious*}	$\wp$ {*Contagious*}
0.01	1.05	0.15	0.20	0.20	0.00	0.60	0.00
0.16	0.90	0.3	0.05	0.35	0.01	0.59	0.00
0.31	0.70	0.4	0.00	0.19	0.15	0.61	0.05

Notes:
Each row shows, conditional upon a specific level of the deposit insurance exposure $\mathcal{D}_H$ arising from the home bank's investment, the probabilities of observing a safe, diversified, home-contagious, branch-contagious and contagious MNB, respectively. In every example, $C_B = C_H = 0.08$, $\kappa = 0.10$ and $R_h = 1.5$, and in every row, $R_H > H^S(B_H)$, so that the home bank investment is individually rational. The first row satisfies $\mathcal{D}_H < C_B(1+\kappa)$, the second, $C_B(1+\kappa) < \mathcal{D}_H < \frac{1}{2}B_H + C_B(1+\kappa)$, and the last, $\mathcal{D}_H > \frac{1}{2}B_H + C_B(1+\kappa)$.

generate the numbers in the table are outlined in Appendix B, and are available upon request from the authors.

For every value of $\mathcal{D}_H$, the branch-contagious case is the most likely to arise. Moreover, changes in the value of the home bank's deposit insurance subsidy $\mathcal{D}_H$ have little effect upon its likelihood. The probability of observing a safe MNB is greatest for low $\mathcal{D}_H$, and in our example is zero for high $\mathcal{D}_H$. As discussed above, the probability of observing a diversified MNB is greatest for intermediate $\mathcal{D}_H$ values.

Finally, the likelihood of observing both home-contagious and contagious multinational banks is increasing in $\mathcal{D}_H$. In fact, we prove in Appendix B that home-contagious MNBs will never occur when $\mathcal{D}_H$ is low, and that contagious MNBs will never occur when $\mathcal{D}_H$ is low or intermediate values. Moreover, the likelihood of observing a contagious MNB even for high $\mathcal{D}_H$ is extremely low.

The difference between the hurdle rate for a standalone bank and for a branch bank with a speculative home bank is indicated on Figure 5. We have already argued that the margin should be increasing in the value $\mathcal{D}_H$ of the home institution's deposit insurance fund. Using the parameters employed in the table yields a margin of between 1% and 15% for the low $\mathcal{D}_H$ value; of between 8.8% and 30% for the intermediate $\mathcal{D}_H$ value, and between 8.8% and 80% for the high $\mathcal{D}_H$ value. In every case, the lower margin is far more likely to arise: for example, the 80% figure for high $\mathcal{D}_H$ applies only in the contagious region. Nevertheless, even the lower margin is economically significant.

(iv) Branch Bank Investment Decisions with a 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 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 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, the combined entity cannot be home-contagious or contagious. For other MNB types, the home bank's bailout of the branch bank replaces

Table 3
Numerical Example: Branch of Prudent Home Bank

$\mathcal{D}_H$	R_H	B_H	$\wp\{Safe\}$	$\wp\{Div.\}$	$\wp\{Home-contagious\}$	$\wp\{Branch-contagious\}$	$\wp\{Contagious\}$
−0.065	1.15	0.1	0.31	0.14	0.00	0.55	0.00
−0.19	1.4	0.1	0.53	0.15	0.00	0.32	0.00

Notes:
Each row shows, conditional upon a specific level of the deposit insurance exposure $\mathcal{D}_H$ arising from the home bank's investment, the probabilities of observing a safe, diversified, home-contagious, branch-contagious and contagious MNB, respectively. In every example, $C_B = C_H = 0.08$, $\kappa = 0.10$ and $R_h = 1.5$, and in every row, $R_H > H^P(B_H)$, so that the home bank investment is individually rational.

the deposit 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 or prudent branches; for safe MNBs, only prudent branches are feasible; and for branch-contagious, only speculative branches are possible.

The precise hurdle rate for a branch bank with a prudent home bank is derived in lemmas 5 and 6 in Appendix B. In an analogous fashion to Section 3(*ii*), it can be used to determine the probability that an observed MNB with a prudent home bank is safe, diversified, or branch-contagious. The hurdle rate expression is not contingent upon $\mathcal{D}_H$; however, we illustrate our results in Table 3 with two numerical examples, for low and high values of $|\mathcal{D}_H|$. Since with a prudent home bank, a high $|\mathcal{D}_H|$ value corresponds to a high solvency level even for an unsuccessful home bank, the likelihood of observing a safe MNB is higher for such a bank, while the probability of a branch-contagious MNBs is correspondingly lower.

Figure 6 in Appendix B indicates the difference between the standalone and branch bank hurdle rates when the home bank is prudent. Again, we can insert the parameters used Section 3(*ii*) into the formulae to obtain numerical differences. In the case with low $|\mathcal{D}_H|$, the margin varies from 0%, when the branch bank derives no benefit from deposit insurance, to 23%, when its benefit is large; in the high $|\mathcal{D}_H|$ case, the margin varies from 0% to 48%.

(v) Investment and Optimal Capital Requirements for Branch Bank MNBs

The analysis of branch bank MNBs in Sections 3(*ii*) – 3(*iv*) has shown 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. This observation suggests the following result, which is proved in Appendix B:

Proposition 2. The extent of branch bank underinvestment relative to the corresponding standalone bank is an increasing function of the magnitude $|\mathcal{D}_H|$ of the home bank's deposit insurance safety net.

The effect identified in proposition 2 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 2.

Corollary 1. 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 $I_S(B)$ that it transmits to the subsidiary bank. The model that we employ is therefore identical to that used in Section 3(i) 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(i). 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.

(i) Subsidiary Bank Investment Decisions with a 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(ii): 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:

$$V^s_{SS} \equiv (R_H + B_H) - (1 - C_H) + (R_S + B_S) - (1 - C_S)\,; \tag{10}$$

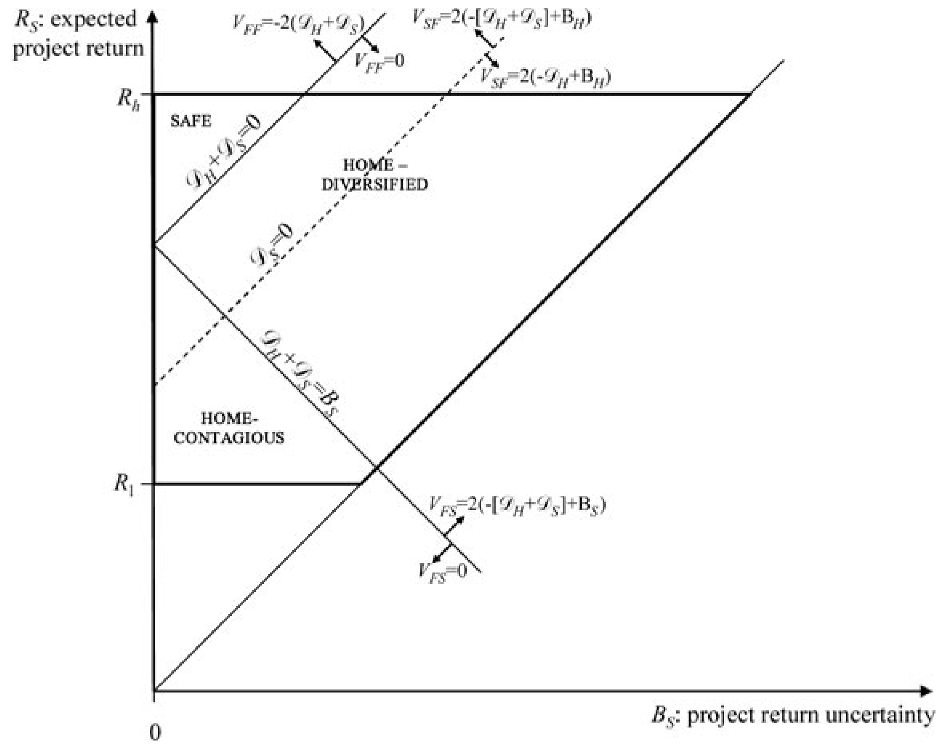
$$\begin{aligned} V^s_{SF} &\equiv (R_H + B_H) - (1 - C_H) + \max\left[(R_S - B_S) - (1 - C_S)\,,0\right] \\ &= 2\left\{-\mathcal{D}_H + B_H + \max\left[-\mathcal{D}_S, 0\right]\right\}; \end{aligned} \tag{11}$$

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

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

Figure 3

Diversification and Contagion Effects with Subsidiary Banks



Notes:

For possible combinations of the subsidiary bank's expected project return R_S and project return uncertainty B_S, the figure shows the solvency properties of a subsidiary bank MNB.

These expressions reflect the liability structure of the multinational bank. The home bank has limited liability towards the subsidiary, and this 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}.

When the home bank is speculative, equations (10) to (13) partition the project space as illustrated in Figure 3. As in Section 3(*ii*), within the ' home-contagious' region, failure of the home bank causes the insolvency of the MNB, while failure of the subsidiary does not. Below the dashed line on the figure, this latter statement is true only because the home bank has limited liability with respect to the subsidiary: if the home bank could not walk away from a failing subsidiary, its losses would be sufficient to cause MNB insolvency.

Within the ' home-diversified' region, the subsidiary absorbs the losses sustained by an unsuccessful home bank. Once again, because it has limited liability, the home bank does not absorb losses from a failing subsidiary. As in the home-contagious case, these losses would be sufficient to force MNB insolvency below the dashed line in the figure.

When they are solvent, subsidiaries bear the costs of home bank failure. This lowers the value to the home bank of the deposit insurance subsidy and hence raises the subsidiary hurdle rate above that of a standalone bank. Unlike a branch bank, however, the subsidiary enjoys the full value of its own deposit insurance net, because the home bank is not required to bail it out when it fails. Hence, the hurdle rate for subsidiary investment is lower than that for branch bank investment in those states of the world where the subsidiary stands to gain from deposit insurance: namely, in the home-diversified and home-contagious regions of Figure 3. As a result, for a given set of parameter values, the probability of observing home-diversified and home-contagious multinational banks is higher for MNBs with subsidiaries than for those with branches.

The above point is developed in Appendix B. Lemmas 7 and 8 derive the hurdle rates for the subsidiary as a function of the home bank's deposit insurance subsidy, $\mathcal{D}_H$. As in the branch bank case, there are three cases, according to whether $\mathcal{D}_H$ is below $C_S(1+\kappa)$, between $C_S(1+\kappa)$ and $2C_S(1+\kappa)$, or above $2C_S(1+\kappa)$. In each case, the hurdle rates for both subsidiaries and branch banks are illustrated in Figure 7.

We provide a numerical illustration of our results in Table 4. For a subsidiary-organized multinational bank, this shows the probabilities of safe, home-diversified and home-contagious banks for the three pairs (B_H, R_H) that we used to compute the results in Table 2. The sum of the home-contagious and contagious probabilities in Table 2 corresponds to the home-contagious region in Table 4, while the sum of the diversified and branch-contagious regions in Table 2 corresponds to the home-diversified probability in Table 4. In line with our earlier discussion, the likelihood that a given MNB will be safe is lower for subsidiary structures than for branch structures, while subsidiaries are more likely to be both home-diversified and home-contagious.

The difference between standalone bank and subsidiary bank hurdle rates in this case is indicated on Figure 7 in Appendix B. The parameterisations used in this section correspond to a margin of 1% in the low $\mathcal{D}_H$ case, to a margin of between 8.8% and 16% for the intermediate $\mathcal{D}_H$ case, and to a margin of between 8.8% and 17.6% in the high $\mathcal{D}_H$ case.

(ii) Investment and Optimal Capital Requirements for Subsidiary Bank MNBs

The previous section demonstrates that the subsidiary of a speculative home bank will have a higher investment hurdle rate than a standalone bank would. The reason is that

Table 4

Numerical Example: Subsidiary of Speculative Home Bank

$\mathcal{D}_H$	R_H	B_H	$\wp\{Safe\}$	$\wp\{Home-Diversified\}$	$\wp\{Home-Contagious\}$
0.01	1.05	0.15	0.19	0.81	0.00
0.16	0.90	0.3	0.05	0.94	0.01
0.31	0.70	0.4	0.00	0.72	0.28

Notes:
Each row shows, conditional upon a specific level of the deposit insurance exposure $\mathcal{D}_H$ arising from the home bank's investment, the probabilities of observing a safe, home-diversified and home-contagious conglomerate, respectively. In every example, $C_S = C_H = 0.08$, $\kappa = 0.10$ and $R_h = 1.5$, and in every row, $R_H > H^S(B_H)$, so that the home bank investment is individually rational. The first row satisfies $\mathcal{D}_H < C_S(1+\kappa)$, the second, $C_S(1+\kappa) < \mathcal{D}_H < 2C_S(1+\kappa)$, and the last, $\mathcal{D}_H > 2C_S(1+\kappa)$.

the subsidiary may be forced to support a failing home bank that could otherwise have drawn on the deposit fund.

Note that home bank shareholders can walk away from failing subsidiaries and hence that they are able to extract the full value of the subsidiary's deposit insurance subsidy. It follows that, because a standalone prudent bank does not receive a deposit insurance subsidy, its subsidiaries will have the same investment policy as a standalone bank.

This discussion suggests the following result, whose proof is similar to that of Proposition 2 and hence is omitted.

Proposition 3. 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 $\mathcal{D}_H \leq 0$.

The disincentive effects that 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 2. In contrast, underinvestment in subsidiary banks 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 2. 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.

(i) 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.

(ii) Choice of Organisational Form

The literature on MNB organizational form is small. A recent contribution by Cerutti, Dell'Ariccia and Martinez Peria (2005) examines the choice between expansion via branches and subsidiaries using data concerning the penetration into Latin America and Eastern Europe by the hundred largest internationally active banks. They find that institutional features in the host country are important: branches are less common in highly regulated countries, are more common in highly taxed economies, and are less common in highly risky macro economic environments, where banks appear to prefer the shield of ' hard' limited liability provided by subsidiaries.

Some evidence suggests that, where they have a choice, multinational banks prefer to establish subsidiaries rather than branches. Cerutti et al. document (Table 4) that there are few restrictions on MNB form in Eastern Europe and Latin America, and also (Table 2) that within these regions there are 292 foreign subsidiaries and only 95 foreign branches. Similarly, although a 'single passport' in Europe (EEC, 1989) entitles any home EU bank to establish branches elsewhere within the European Union, in 2003 of 953 foreign banks with EU home banks operating within the European Union, 390 elected to operate as subsidiaries (ECB, 2004).

Our simple model cannot capture every element of the choice between branches and subsidiaries. However, it does provide one possible explanation for the apparent preference for subsidiaries. For a given capital requirement, shareholders extract a higher value from the deposit insurance fund in subsidiary MNBs than they do in branch MNBs, because they can abandon a failing subsidiary, while they are forced to use their own funds to bail out a failing home bank. Hence *ceteris paribus* they will opt to open subsidiaries rather than branches.

When shareholders select a subsidiary over a branch MNB structure in order to maximize the expected value of their deposit insurance subsidy they are not necessarily reducing social welfare. Suppose that capital requirements *for every bank* are set so as to achieve the optimal trade-off between the overinvestment induced by deposit insurance and the underinvestment caused by capital requirements *for a standalone bank*. Because MNBs are more diversified and hence earn a lower expected return from the deposit insurance safety net than standalone banks they should have lower capital requirements. Hence when all banks have the optimal capital requirement for a standalone bank, MNBs will under-invest relative to the level achievable through optimal capital requirements. The degree of underinvestment will be increasing in the degree of diversification. Hence, because they achieve a lower level of diversification than branches, subsidiary banks will induce less distortion relative to the optimum, and hence in this case will be more socially desirable.

A number of authors have documented 'cherry picking' by multinational banks: foreign banks tend to accept only the highest quality projects in their host country (see Bank for International Settlements, 2001; Berger et al., 2001; Mian, 2006; and Clarke et al., 2005). In the context of our model, cherry picking 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 that are marginal for the local banks.

(iii) Stability

Our model suggests a possible channel for financial contagion. Suppose that the home bank's economy experiences an exogenous shock that alters the expected value $\mathcal{D}_H$ of the deposit insurance subsidy. Propositions 2 and 3 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 that either raises the volatility of its earnings or reduces its expected 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 and 2000). The response by US branches of Japanese MNBs to the crisis was a sharp reduction in US lending. Japanese banks were particularly active in the commercial real estate loan market in the US 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 banks at home and our model therefore provides an explanation for their observed lending behaviour. As the returns on 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 2 and 3 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 US GDP growth is negatively correlated with the level of US 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 US banks are essentially prudent, the Asian effect identified by Goldberg is readily explicable in terms of our analysis. In this case, higher US GDP and hence US 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 US 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 that 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 that 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 that 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 that 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.

We believe that our formal results may cast some light upon several real world phenomena. As we discuss in Section 5, they can help us to understand optimal capital requirements, an observed preference amongst MNBs for subsidiary over branch organization, and international financial contagion.

The simple model that we present in this paper may have wider applications. Since a branch-based MNB is a unitary banking structure, the diversification effects that we identify in Section 3 should apply equally within a single country bank. Our discussion of branch banking could therefore be extended to examine capital regulation of diversified institutions within a single country, rather than across borders, as in this paper.[11] Allowing for multiple projects in this framework would generate a model of capital requirements in broadly diversified portfolios whose returns were binomially generated. Our work suggests that diversification in these portfolios should be rewarded with lower capital requirements. We leave a detailed investigation of this question for future research.

APPENDIX A
Foreign Ownership of Banking Assets

Tables 5 and 6 show the share of assets held by foreign banks in selected industrialised and emerging economies, respectively.[12] The expansion of foreign bank ownership of banking assets is particularly striking in emerging markets (Table 6). Bank for International Settlements (2001) reports a similar trend based on aggregate figures not reported by Domanski (2005): between December 1994 and December 1999, foreign ownership of aggregate bank assets increased from 7.7% to 52.3% in Central Europe, from 7.5% to 25% in Latin America, and from 1.6% to 6% in Asia.

Table 5

Market Shares of Branches and Subsidiaries in Europe and the United States of America

	Asset share (%)		
	1997	**2000**	**2003**
Belgium	30.4	24.9	22.9
Denmark	4.5	5.2	16.0
Germany	4.3	4.1	6.0
Greece	15.8	11.6	22.0
Spain	12.5	9.0	11.0
France	10.4	15.0	11.1
Ireland	53.4	57.9	43.9
Italy	7.0	6.5	5.8
Luxembourg	92.5	92.2	93.9
Netherlands	7.2	11.2	11.8
Austria	3.4	2.8	19.6
Portugal	14.8	21.9	26.5
Finland	8.4	8.9	7.4
Sweden	2.5	3.6	7.6
UK	52.2	44.0	49.8
USA	20.7	19.9	19.7

Source: Europe from ECB, 2004; USA from Federal Reserve data.

11 We thank the anonymous referee for identifying this line of enquiry.
12 Note that the high asset shares in Ireland, Luxembourg and the UK to a large extent reflect offshore banking activities in these countries, and hence that the numbers in Table 5 are not completely accounted for by the genuine cross-border provision of banking services.

Table 6
Share of Bank Assets Held by Foreign Banks, Expressed as a Percentage of Total Assets

	1990	*2004*	*In per cent of GDP*	*In billions of USD*
Central and Eastern Europe				
Bulgaria	0	80	49	13
Czech Republic	10	96	92	99
Estonia	–	97	89	11
Hungary	10	83	67	68
Poland	3	68	43	105
Emerging Asia				
China	0	2	4	71
Hong Kong	89	72	344	570
India	5	8	6	36
Korea	4	8	10	65
Malaysia	–	18	27	32
Singapore	89	76	148	159
Thailand	5	18	20	32
Latin America				
Argentina	10	48	20	31
Brazil	6	27	18	107
Chile	19	42	37	35
Mexico	2	82	51	342
Peru	4	46	14	11
Venezuela	1	34	9	9

Notes:
Where 2004 figures are not available, figures for the latest available year is reported.
Source: Domanski (2005).

APPENDIX B
Proofs

Proof of Proposition 1

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

Lemma 1:

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

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 illustrated in Figure 1; in the latter, which is illustrated in Figure 4, region $\mathcal{O}$ vanishes.

Case 1: $\mathbf{C(1 + 2\kappa) \leq 1}$. This is the case that 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 $R = C(1+2\kappa) + 1 - B$:

$$\upsilon(C) = \frac{1}{A}\int_0^{C(1+\kappa)}\int_0^{C\kappa} R\,dR\,dB + \frac{1}{A}\int_{C(1+\kappa)}^{C(1+2\kappa)}\int_0^{C(1+2\kappa)-B} R\,dR\,dB$$
$$= \frac{C^3\kappa^2}{2A}(1+\kappa) + \frac{1}{6A}\left[\{C(1+2\kappa) - B\}^3\right]_{C(1+2\kappa)}^{C(1+\kappa)} = \frac{C^3\kappa^2}{6A}(4\kappa+3).$$

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

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

Adding these expressions yields equation (14).

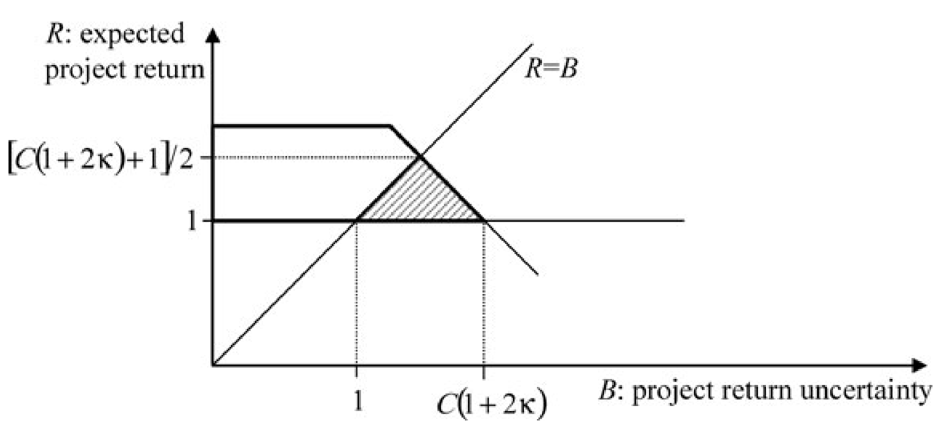
Case 2: $\mathbf{C}(\mathbf{1}+\mathbf{2}\kappa) > \mathbf{1}$. This case is illustrated in Figure 4. In this case region $\mathcal{O}$ vanishes and region U is the region with the bold outline, with the shaded area removed. α (C) can therefore be obtained by subtracting the welfare that could be attained 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:

$$\frac{2}{A}\int_1^{\frac{C(1+2\kappa)+1}{2}}\int_0^{B-1} R\,dR\,dB = \frac{1}{24A}(1 - C(1+2\kappa))^3,$$

from which the required result follows immediately.

Figure 4

The Underinvestment Region $\mathcal{U}$ when $C(1+2\kappa)$



The proposition follows immediately from lemma 1 and the following observation:

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

Investment Policy for a Speculative Home Bank's Branch

This section of the appendix contains proofs of results that support the discussion in Section 3(*ii*). Firstly, we establish in lemma 2, hurdle rates for each type of MNB. The superscript s on the R term 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:*** $R_B \geq R^s_{B,Sf} \equiv H^P(B_B) + \mathcal{D}_H$;
2. ***Diversified MNBs:*** $R_B \geq R^s_{B,Dv} \equiv H^P(B_B) + \frac{1}{2}(\mathcal{D}_H - \mathcal{D}_B) = H^S(B_B) + (\mathcal{D}_H + \mathcal{D}_B)$;
3. ***Branch-Contagious MNBs:*** $R_B \geq R^s{}_{B,Br} \equiv H^S(B_B) + B_H$;
4. ***Home-Contagious MNBs:*** $R_B \geq R^s_{B,Hm} \equiv H^P(B_B) + (-\mathcal{D}_B + \frac{1}{2}B_B) = H^S(B_B) + B_B$;
5. ***Contagious MNBs:*** $R_B \geq R^s_{B,Ct} \equiv H^S(B_B) - (\mathcal{D}_H + \mathcal{D}_B) + (B_H + B_B)$.

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

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

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- contagious, and contagious multinational banks:

$$R_B \geq 1 + C_B\kappa + \tfrac{1}{2}[1 - C_H - (R_H - B_H)]; \qquad \textbf{InvSafe}$$
$$R_B \geq \tfrac{1}{3}(1 - C_H - R_H + B_H) + 1 - \tfrac{1}{3}B_B + \tfrac{1}{3}C_B(1+4\kappa); \qquad \textbf{InvDiv}$$
$$R_B \geq 1 - B_B + C_B(1+2\kappa); \qquad \textbf{InvBranch}$$
$$R_B \geq 1 + C_B(1+2\kappa); \qquad \textbf{InvHome}$$
$$R_B \geq C_B(3+4\kappa) - B_B + (R_H + B_H + C_H). \qquad \textbf{InvCont}$$

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 required expressions. □

The hurdle rate adjustments for the branch bank can be understood intuitively with reference to Table 1. Firstly, speculative branch banks are possible provided the MNB is not safe. The standalone profits $\frac{1}{2}[R_B - H^S_B(B_B)]$ 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-contagious banks is reduced by $2\mathcal{D}_H$ if the home bank fails and the branch succeeds, and by $2(-\mathcal{D}_H + B_H)$ if the home bank succeeds and the branch succeeds. Since each of these occurs with probability $\frac{1}{4}$ investment will occur provided $\frac{1}{2}\left[R_B - H_B^S(B_B)\right] \geq \frac{1}{2}\left[-\mathcal{D}_H + B_H + \mathcal{D}_H\right]$, or when $R_B \geq H_B^S\ (B_B) + B_H$.

Prudent branch banks are possible for safe, diversified and home-contagious MNBs. The standalone profits $[R_B - H_B^P(B_B)]$ 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 Table 1. In the right hand columns the branch bank bails out the home bank, replacing the deposit insurance bailout partially 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 $\mathcal{D}_H$.

For each B_B, the investment policy $I_B^s\ (B_B)$ defined in Section 3(i) is given by the unique hurdle rate above B_B on Figure 2 that lies inside the region to which it applies.[13] Lemma 3 provides expressions for $I_B^s\ (B_B)$.

Lemma 3: *The investment policy I_B^s depends upon the hurdle rates established in lemma 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*

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

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

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

Proof. For a given B_B, at most one of the regions above B_B can contain the hurdle rate identified in lemma 2. The corresponding hurdle rate is the value of I_B^s (.) at B_B. Proof of lemma 3 is therefore a simple matter of determining the conditions that must obtain for each region to contain its hurdle rate.

13 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.

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

Lemma 4:

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

It follows immediately that I^s_B 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 $I^s_B\,(0) = R^s{}_{B,Sf}$ 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 2 and part 2 of the lemma that $I^s_B\,(B_B)$ 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 $I^s_B\,(0) = R^s_{B,Hm}$. 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 $I^s_B = R^s_{B,Hm}$ for $B_B \leq 2\,[\mathcal{D}_H - C_B(1+\kappa)]$. For higher values of B_B, reasoning about the slope of $R^s{}_{B,\Pi}$ as in the above paragraph implies that $I^s_B = R_{S,Dv}$ 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 $I^s_B = R^s_{B,Hm}$ for $B_B \leq 2\,[B_H - \mathcal{D}_H + C_B(1+\kappa)]$ after which, because $R^s_{B,Ct}$ has slope -1, it has value $R^s_{B,Ct}$.

The hurdle rate I^s_B is illustrated in Figure 5 for each of the cases identified in lemma 3. The area above the hurdle rate line on each graph corresponds to the range of possible MNBs; the proportion of this area corresponding to a particular type of MNB is the probability that it arises in practice. This method yielded the figures in Table 2: the precise calculations are available upon request from the authors.

Investment Policy for a Prudent Home Bank's Branch

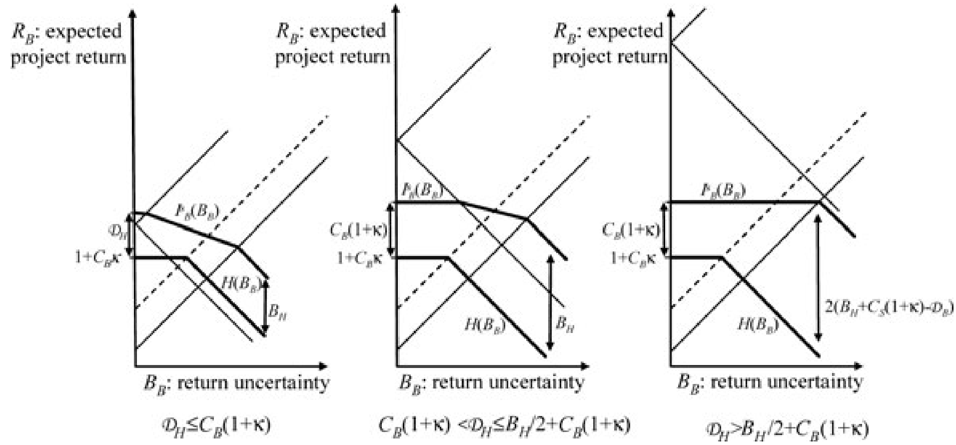
Lemma 5 characterises the type-contingent hurdle rates for a prudent home bank's branch bank. Its proof is entirely analogous to that of lemma 2 and hence is omitted. The superscript p in the lemma refers to the fact that the home bank is prudent.

Lemma 5. *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:*** $R_B \geq R^p{}_{B,Sf} \equiv H^P\,(B_B)$;
2. ***Diversified MNBs:*** $R_B \geq R^p_{B,Dv} \equiv H^P(B_B) - \frac{1}{2}\mathcal{D}_B = H^S(B_B) + \mathcal{D}_B - \mathcal{D}_H$;
3. ***Branch-Contagious MNBs:*** $R_B \geq R^p_{B,Br} \equiv H^S(B_B) + B_H - 2\mathcal{D}_H$.

Figure 5

Investment Policy for a Branch Bank with a Speculative Home Bank



Notes:
The investment policy is illustrated as a function of the value $\mathcal{D}_H$ of the home bank's deposit insurance subsidy. The lower line on each graph is the hurdle rate for a standalone bank; the upper line is the hurdle rate for the branch bank.

Lemma 6 is analogous to lemma 3, and provides a precise characterisation of the investment policy I_B^p of the branch bank:

Lemma 6. *The investment policy I_B^p for a prudent bank's branch depends upon the hurdle rates established in lemma 5 as follows*:

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

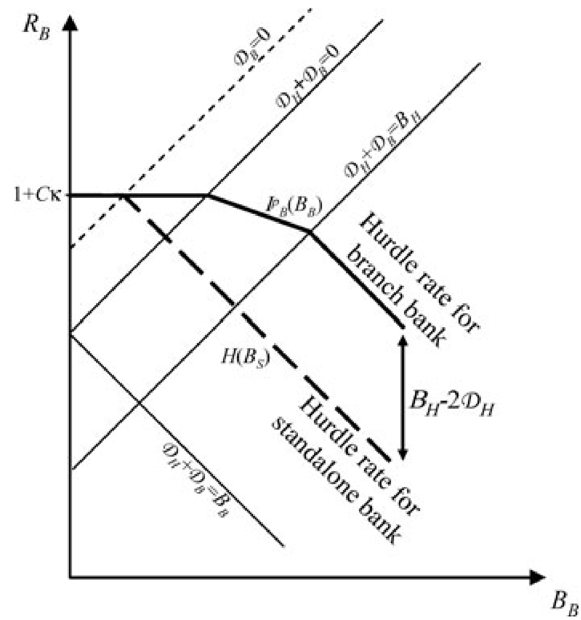
Proof. $I_B^p(0) = R_{B,Sf}^p(0)$ whenever $B_B \geq 0$ at the intersection of $R_{B,Sf}^p$ with the line $\mathcal{D}_H + \mathcal{D}_B = 0$; this is true whenever $\mathcal{D}_H \leq C_B(1+\kappa)$, which is always true for prudent home banks. The remainder of the proof involves a straightforward application of the methods used to prove lemma 3 and is omitted. □

Figure 6 illustrates the hurdle rate derived in lemma 6. The lower bold line in the figure 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. Since $\mathcal{D}_H$ is negative for prudent banks, it is immediate from the figure that the branch bank hurdle rate increases with $|\mathcal{D}_H|$, and hence that the proportion of branch-contagious and contagious MNBs drops as $|\mathcal{D}_H|$ increases.

Proof of Proposition 2

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

Figure 6
Investment Policy for a Branch of a Prudent Home Bank



Notes:
The lower line in the figure is the hurdle rate for a standalone bank; the upper line is the hurdle rate for the branch bank.

line $H(B_B)$ is invariant to $\mathcal{D}_H$ the result follows trivially by inspection of Figures 5 and 6.

Derivation of Investment Policy for MNB with a Subsidiary

Lemma 7 establishes the hurdle rates for the various regions in Table 1. The intuition for the results is similar to that for lemma 2.

Lemma 7. *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:*** $R_S \geq R^s_{S,Sf} \equiv H^P_S(B_S) + \mathcal{D}_H$;
2. ***Home-Diversified MNBs***(*above dashed line*)**:** $R_S \geq R^s_{S,Dv} \equiv H^P_S(B_S) + \frac{1}{2}(\mathcal{D}_H - \mathcal{D}_S) = H^S_S(B_S) + (\mathcal{D}_H + \mathcal{D}_S)$;
3. ***Home-Diversified MNBs*** (*below dashed line*)**:** $R_S \geq R^s_{S,Pd} \equiv H^S_S(B_S) + \mathcal{D}_H$;
4. ***Home-Contagious MNBs*** (*above dashed line*)**:** $R_S \geq R^s_{S,Hm} \equiv H^P_S(B_S) + (-\mathcal{D}_S + \frac{1}{2}B_S) = H^S_S(B_S) + (-\mathcal{D}_S + B_S)$;
5. ***Home-Contagious MNBs***(*below dashed line*)**:** $R_S \geq R^s_{S,Pc} \equiv H^S_S(B_S) - \mathcal{D}_S + B_S$.

Proof. Parts 1, 2 and 4 are immediate from lemma 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 parts 3 and 5 of the lemma:

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

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

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

Lemma 8 establishes the investment policy $I_S(B_S)$ for a speculative home bank's subsidiary.

Lemma 8. *The investment policy I_S^s depends upon the hurdle rates established in lemma 7 and upon $\mathcal{D}_H$ as follows:*

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

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

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

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

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

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

Proof. The proof is similar to that of lemma 3. It is easy to establish the following lemma.

Lemma 9.

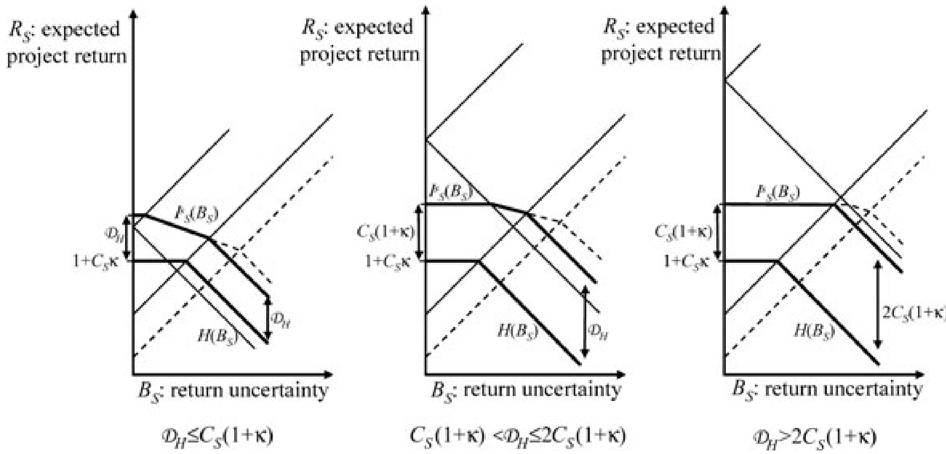
1. *$R^s{}_{S,Sf}$ and $R^s{}_{S,Dv}$ both intersect the line $\mathcal{D}_H + \mathcal{D}_S = 0$ where $B_S = C_S\,(1+\kappa) - \mathcal{D}_H$;*
2. *$R^s{}_{S,Dv}$ and $R^s{}_{S,Pd}$ both intersect the line $\mathcal{D}_S = 0$ where $B_S = C_S(1+\kappa) + \tfrac{1}{2}\mathcal{D}_H$;*
3. *$R^s{}_{S,Dv}$ 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 lemma 3 it follow that I_S^s must be continuous and that its path through the regions of figure 3 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 $C_S(1+\kappa) < \mathcal{D}_H$, $I_S^s(0) = R_{S,Hm}^s$ .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 lemma follows mechanically using the same reasoning as the proof of lemma 3. □

Figure 7

Investment Policy for a Subsidiary Bank with a Speculative Home Bank



Notes:

The investment policy is illustrated as a function of the value $\mathcal{D}_H$ of the home bank's deposit insurance subsidy. The lower line on each diagram shows the hurdle rate for a standalone bank; the higher line shows the hurdle rate for the subsidiary.

The hurdle rate I_S^s is illustrated in Figure 7. The dashed lines in the figure indicate the investment policy for the corresponding branch-organised MNB, which for risky projects is strictly higher than the rate for subsidiaries. As discussed in Section 4(*ii*), this is because the home bank has limited liability with respect to the subsidiary and hence can extract more value from the deposit insurance net with a subsidiary than with a branch structure.

As in the branch bank case, the area above the hurdle rate on each graph corresponds to the range of possible MNBs, and the proportion of this area corresponding to a particular type of MNB is the probability that it occurs in practice. Computing these areas yielded the numbers in Table 4.

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