

# The effects of credit risk transfer on bank monitoring and firm financing\*

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## Abstract

This paper examines the effects of the transfer of credit risk associated with bank loans. We are interested in (a) whether the transfer of credit risk has any impact on the intensity with which banks monitor their borrowers and (b) whether credit risk transfer influences the amount of financing that is provided to firms in an economy. Our model first develops conditions under which bank finance is available to firms, mainly in the spirit of Holmstrom/Tirole (1997). We then introduce projects with uncorrelated pay-offs and argue that one possible economic rationale for credit risk transfer is diversification. We analyze whether and how within this scenario the transfer of the credit risk of loans changes a bank's incentives to monitor its debtors. Finally we investigate whether and what kind of impact this may have on the amount of financing available to firms in an economy. Our results indicate that the monitoring incentives are being eroded indeed and that credit risk transfer can increase the overall amount of obtainable funds in an economy.

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# 1 Introduction

Diamond (1984) showed that one of banks' main functions and reasons for their existence is that they monitor the actions of their borrowers on behalf of the fund providers, the depositors. These - because of free riding problems and excessive transaction costs - can not undertake efficient monitoring themselves. The necessity of monitoring stems from the asymmetric distribution of information between banks and their debtors. Since the actions of a firm are not fully observable the firm may have incentives to undertake actions that are not desirable for a bank, i.e., actions that may increase the risk of non-repayment of the bank loan.<sup>1</sup> To prevent their debtors from such actions banks monitor firms in order to induce them to behave in the way that is desirable for the bank. But what happens if banks' monitoring incentives are eroded, say, because banks do not carry the risk that a firm defaults on a loan anymore? Or to a lesser extent? Less or no monitoring incentives at all can be expected to reduce the level of monitoring a bank undertakes. A condition under which it would be of reduced value for a bank to monitor is given when a bank transfers the loan risk to a third party which, in turn, can not effectively induce the bank to exert the amount of monitoring the bank would have chosen if the loan risk had remained on the balance sheet of the bank. As markets for the transfer and trading of credit risk have greatly evolved over the past few years<sup>2</sup> it has become feasible for banks to transfer the risk inherent in bank loans to third party investors, particularly to other banks and insurance companies.

In this paper we are interested in analyzing what effects credit risk transfer (CRT) has on the properties of financial intermediation, particularly the price of credit and the level of monitoring banks exert. Building on theoretical work by Rajan (1992) and particularly Holmstrom/Tirole (1997) we provide answers to the following two questions: a) What impact does the possibility of CRT have on the intensity with which banks monitor their debtors? and b) How does this affect the level of firm financing made available to firms in an economy?

As in Holmstrom/Tirole (1997) we first develop conditions under which it is feasible for a firm to be bank financed and assess the optimal amount of monitoring a bank exerts in this case. We then introduce the possibility for banks to transfer the credit risk of their loan engagements to a third party by means of exchanging parts of their assets with another bank. We show that such credit risk transfer indeed reduces a bank's incentives to monitor its borrowers. In addition, we investigate whether the possibility to transfer credit risk to third party banks has any impact on the overall volume of financing provided to firms in an economy. Our results indicate that this volume increases if there is the possibility to diversify the credit risk inherent in bank loans. This stands in contrast to what is often argued to be the effect of reduced monitoring, namely that, because of the heavier asymmetric distribution of information, there is less financing provided to firms.

In a recent work Arping (2002) investigates whether an insurance against credit risk may erode banks' monitoring incentives. He shows that such an insurance contract, which in his work is modelled as a financial instrument with perfect negative correlation, leads to a reduction of the monitoring incentives and thus to a lower level of monitoring. This result is equal to ours. Our formal approach differs, however, largely to the one applied in his work. Whereas in his work banks can liquidate the loan contract if they observe a moral hazard behavior of the firm we

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<sup>1</sup>This risk is referred to as credit or default risk. If repayment does not occur the borrower defaults on the loan. We will henceforth use the expressions credit risk and default risk interchangeably.

<sup>2</sup>A study published in May 2004 by the European Central Bank reports of a rapid growth of markets for credit risk transfer in the Euro-Zone. The study also predicts that markets for credit risk will continue to grow at a high pace (ECB (2004)).

introduce a penalty function that imposes a non-pecuniary deadweight penalty on the bank in the spirit of Diamond (1984). Moreover, our framework enables to draw conclusions about the effects of CRT on the real sector. In Arping's work this issue is not addressed and credit risk insurances, due to the lowering effect on monitoring, are seen as *per se* negative. We argue that this must not necessarily be the case. Cerasi/Daltung (2000) analyze the effect of diversification on monitoring and the optimal size of a bank. They conclude that asset side diversification leads to more monitoring. The main assumption this result is based on is that they allow banks to make non-zero profits. Contrary to that, we assume perfect competition among banks. This leads to a different effect of diversification on monitoring. A third related paper is the work by Carletti et al. ((2004)). This paper investigates why it should be beneficial for firms to make use of multiple-bank lending and whether multiple bank relationships erode banks' monitoring incentives. Their result is that due to the diversification effect banks' monitoring incentives may be improved. This improvement is so high that it overcompensates free-riding and duplication of efforts effects.

The contribution of our paper to the literature is a) a methodical and b) an economic one: At first, we complement existing work on the effects of CRT on monitoring. We do this by applying a new modelling approach and confirm the results obtained by Arping (2002). The innovation of our modelling approach lies in the combination of a diversification model à la Diamond (1984) with the problem of team production. In our formal approach we explicitly model the trade-off between risk-sharing and monitoring incentives. Our second contribution to the literature is to provide a theory of firm financing in a world with CRT. To our best knowledge our model allows for the first time an assessment of the consequences of CRT on the real sector by analyzing how CRT impacts the amount of financing made available to firms in an economy.

The paper is organized as follows: In Section 2 we present the underlying conditions of our formal approach. Section 3 is devoted to the analysis of the optimal intensity with which banks monitor their debtors. We also provide insight about the kind of firms that have access to bank financing. We refer to this case without the possibility of CRT as the basic model. In section 4 we introduce the option to transfer the credit risk inherent in loan engagements to a third party bank and derive again the optimal monitoring intensity. Additionally, we investigate the effects CRT has on the real sector. We do this by analyzing the impact CRT has on the price of credit banks charge their debtors. Section 5 discusses the model. Our findings are summarized in section 6.

Our formal approach draws heavily from modelling techniques employed in Holmstrom/Tirole (1997), Diamond (1984), and Carletti (2004).

## 2 The Basic Model

### 2.1 The Real Sector

Consider an economy with a continuum of entrepreneurial firms (henceforth referred to as 'entrepreneur' or 'firm') each with a single investment project. At date 1, each firm bears costs of 1 to invest in the project. We have a two-state economy: the project pays out  $R$  with probability  $q$  and 0 otherwise.

We introduce a simple principal-agent problem of the following kind: At date 3, each entrepreneur expends personal effort ( $e$ ). She can either work hard ( $e = h$ ) or shirk ( $e = l$ ). In the former case the probability  $q$  is  $q_h$ ; in the latter it is  $q_l < q_h$ . If she shirks, she enjoys a private benefit,  $B$ .<sup>3</sup> In the absence of proper incentives

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<sup>3</sup> $B$  could be, for instance, quiet life, on-the-job consumption, pet projects, profit transfers to

or monitoring, she may therefore deliberately reduce the prospect of the firm.

Entrepreneurs are risk-neutral and have no initial wealth. They must seek external funds. The risk-free market interest is 0. They will only undertake a project, if their expected profit is positive.

## 2.2 The Financial Sector

The financial sector consists of financial intermediaries (henceforth 'banks') who can monitor firms and thereby alleviate the moral hazard problem. We allow only *debt* contracts. Banks lend at date 1 and collect their repayment ( $r_B$ ) at date T.

Banks fund their loans through deposits at date 0. Deposits are but debt contracts, too. Depositors lend to the bank at date 0 and collect their repayment ( $r_D$ ) at date T. The relationship between banks and depositors is subject to two kinds of moral hazard. First, monitoring effort is private knowledge. Thus, banks cannot ex ante commit to an arbitrary  $M$  so that monitoring becomes endogenous. (This is the 'second-tier' counterpart to the hidden action problem on the firm level.) Second, we posit an additional hidden information problem: We assume that the actual loan repayment at date T cannot be observed by the depositors. Therefore, banks have an incentive to falsely state their returns. Diamond (1984) has shown that one way to deal with this problem is to use a debt contract with non-pecuniary penalties. Such a contract induces the debtor, here the bank, to reveal the true state.<sup>4</sup> The reason why we omit this problem for the bank-firm relationship is because we assume monitoring banks to observe the true project state directly.

At the interim date 3, banks can expend a monitoring effort ( $M$ ). The value of  $M \in [0; 1]$  represents the probability with which the bank improves firm behavior. But monitoring is costly; an intensity  $M$  costs  $C(M) = mM^2/2$ . The convex cost function reflects increasing marginal cost of information or a scarcity of human resources.<sup>5</sup> The coefficient  $m$  captures the extent of the resulting diseconomies of scale. It can be interpreted as the quality of the monitoring technology. If  $m$  is large, the technology is poor and monitoring is relatively more costly.

Banks are active in credit markets with perfect competition, while depositors are so in the market for deposits.<sup>6</sup> In equilibrium, their expected profit is zero.

## 2.3 Information

We would like to point out that only the states at date T and all efforts are private knowledge. Firm effort and project state at date 2 are observed only by the firms and partially by the banks who are privy to inside information. Banks' monitoring effort and credit returns can only be observed by the banks. Neither type of effort and state can be verified by the courts. The courts, however, can observe and verify the monetary transfers that the parties choose to record. Everything else is common knowledge or a public signal including the firms' ex ante quality, that is, the  $R_s$ . Depositors can only observe public signals.

## 2.4 Contracts

We obviously allow only debt contracts, that is, it is not possible to obtain outside equity. We justify this assumption by appealing to the already mentioned costly state verification problem, as exhibited, for instance, in Diamond (1984).<sup>7</sup> We

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other firms, or other managerial perks. Cf. Carletti (2004)

<sup>4</sup>Cf. Diamond (1984) for proof and thorough discussion.

<sup>5</sup>Cf. Carletti (2004) and Cerasi/Daltung (2000).

<sup>6</sup>We concretize the competitive conditions of the deposit market at the end of Section 3.

<sup>7</sup>Alternatively, we may refer to Diamond (1991) or Gale/Hellwig (1985). In the model, however, we have implemented the optimal penalty function that was introduced by Diamond (1984).

consider only pure discount debt contracts where the firms borrow at date 1 and are required to make a *single* repayment at date T.

### 3 Absence of Credit Risk Transfer

In this section we present the model without CRT. That is, the loans and their inherent risks remain on the balance sheet of the loan-granting bank. We assume all loans are perfectly correlated. All proofs are in the Appendix.

#### 3.1 The Different Loan Contracts

Consider a firm that borrows from a single bank. At date 1, the bank lends 1 to a firm and demands a repayment of  $r_B$  at date T. At the interim date 3, both the bank and the firm simultaneously choose their efforts with respect to monitoring and management. Furthermore, we let the bank raise its loanable funds externally at date 0 via deposits. We model the deposits as pure discount debt contracts which also have to be repaid at date T. Date 2 will not be introduced until section 3.



Figure 1: Timetable without CRT

**The deposit contract** The deposit contract requires the bank to repay the amount  $r_D$  at date T. Let  $z$  be the actual repayment made by the firm. Then the associated penalty function  $\theta(r_D, z)$  is such that, whenever  $z$  falls short of  $r_D$ , the bank incurs a non-pecuniary disutility equal to their difference. Formally, the penalty function takes the form

$$\theta(r_D, z) = \begin{cases} r_D - z & \text{if } z < r_D \\ 0 & \text{if } z = r_D. \end{cases} \quad (1)$$

It is easy to grasp the revelation mechanism. Lying (which is only possible in the good state) would cause the bank a non-pecuniary loss of  $r_D$ , while telling the truth would result in a monetary loss of the same amount  $r_D$ . We assume that the bank prefers to be honest in this case. Thus, the bank will incur the penalty only in the bad state. Therefore, the expected measure of penalty is

$$E[\theta] = (1 - q)r_D. \quad (2)$$

Note that the expected penalty depends on  $q \in [q_l, q_h]$ .

**Choice of e** The firms' expected profit ( $\Pi_F$ ) depends on their own effort  $e$  and the bank's monitoring intensity  $M$ .<sup>8</sup> At date 3, the choices of  $M$  and  $e$  constitute a simultaneous-move game. We find a simple Nash equilibrium in dominant strategies. First, let us represent  $\Pi_F$  as follows:

$$\Pi_F = \begin{cases} q_h(R - r_B) & \text{if } e = h \\ Mq_h(R - r_B) + (1 - M)[q_l(R - r_B) + B] & \text{if } e = l. \end{cases}$$

<sup>8</sup>Unless explicitly noted, we will henceforth speak of 'profit' but mean 'expected profit'.

Note that  $\Pi_F^h \geq \Pi_F^l$ <sup>9</sup> for *all* values of  $M$ , if and only if  $q_h(R - r_B) \geq q_l(R - r_B) + B$ . Thus, the firm's incentive constraint (FIC) is independent of  $M$ :

$$R \geq B/\Delta q + r_B^h. \quad (3)$$

Firms which satisfy this FIC strictly choose  $h$  ( $h$ -firms). All others strictly choose  $l$  ( $l$ -firms). We denote with  $r_B^h$  the loan repayment charged to  $h$ -firms. We can use  $r_B^h$  in the FIC because it is a strictly dominant strategy for banks not to monitor  $h$ -firms. Since banks can perfectly observe the ex ante firm 'quality' ( $R$ ), they can offer these firms  $M = 0$  and  $r_B = r_B^h$ . We call this combination 'Contract I'.<sup>10</sup>

**Choice of  $M$**  We have already argued that banks offer Contract I to  $h$ -firms. With respect to the  $l$ -firms, banks offer 'Contract II' with  $M = M^*$  and  $r_B^l$  where

$$M^* = \arg \max M q_h r_B^l + (1 - M) q_l r_B^l - r_D - m M^2 / 2. \quad (4)$$

The banks' profit function varies by contract type.

$$\Pi_B^e = \begin{cases} q_h r_B^h - r_D & \text{(Contract I)} \\ M q_h r_B^l + (1 - M) q_l r_B^l - r_D - m M^2 / 2 & \text{(Contract II).} \end{cases} \quad (5)$$

Assuming no synergies between these two 'business lines' we can state that  $\Pi_B = \Pi_B^h + \Pi_B^l$ . Thus, total bank profit can be maximized by separately maximizing the profits from each segment. Note that, regardless of the contract type, the refinancing costs consist of the repayment due if  $R$  materializes *and* the non-pecuniary penalty due otherwise. This effectively suspends 'limited liability'.

$$r_D = q r_D + (1 - q) r_D = q r_D + E[\theta]. \quad (6)$$

The solution to (4) is

$$M^*(r_B^l) = \begin{cases} 1 & \text{for } m < \Delta q r_B^l \\ \frac{\Delta q r_B^l}{m} & \text{otherwise.} \end{cases} \quad (7)$$

**Choice of  $r_B^h$  and  $r_B^l$**  At date 1, the bank chooses the  $r_B$  which yields a date 1 expected profit of zero. The decision premises are  $r_D$  as set by the depositors at date 0 and the subgame-perfect choices of effort which will ensue at date 3 as calculated in the previous paragraph.

Under Contract I, it must hold that  $r_B^h = r_D/q_h$ . The proof is intuitive. On the one hand,  $r_D/q_h$  is the lowest possible repayment the bank can choose. Any lower rate inevitably implies  $\Pi_B^h < 0$ . On the other hand, all firms which satisfy

<sup>9</sup>The superscript indicates the effort chosen.

<sup>10</sup>This only partially specifies a contract. A full contract consists of a vector  $\Gamma(r_D, r_B, M)$ . Note that the use of the term 'contract' in this context is misleading. It does not conform to its usage in the literature. In fact, we assumed that  $M$  is *not* contractible. The variable fixed in the loan contract is  $r_B$ .  $M$  and  $r_D$  are the player's rational actions in this sequential game. Thus, what we term 'contract' here is simply the representation of a subgame-perfect Nash equilibrium. The reason why we keep to this terminology becomes clear when we interpret the results.

<sup>11</sup>Another type of contract is imaginable. The bank could choose  $M = 0$  and charge the maximum repayment  $r^{max}$  to reflect the maximal risk. But obviously the promise of  $M = 0$  would not be credible because the bank would have a date 3 incentive to monitor. So unless we allow contracts which effectively rule out any interim intervention on the part of the creditor (e.g. a high-yield loan or bond with little or no covenants), this type of contract cannot be enforced. The problem of allowing such contracts is that we would make monitoring effectively *contractible* which we explicitly ruled out. Of course, another way of making this third type feasible would be to design a distinct agent, say an arm's length investor, who simply is *not able* to monitor at date 3 even if he had the incentive to do so. Note that under Contract I the choice of  $M = 0$  is subgame-perfect because effort is already maximal.

the FIC for any higher rate will also do so when  $r_B^h = r_D/q_h$ . Moreover, any higher rate strictly implies  $\Pi_B^h > 0$  which the assumption of perfect competition rules out. Thus,  $r_B^h = r_D/q_h$  uniquely ensures a competitive return and furthermore maximizes the number of  $h$ -firms.

The required credit repayment under Contract II is not so trivial. We have to substitute the case solutions for  $M^*$  from (7) into the zero-profit condition  $\Pi_B^l = 0$  derived from (5) and solve for  $r_B$ . The solution is subsumed in Proposition 1 which follows in the next paragraph.

**Choice of  $r_B^h$  and  $r_D^l$**  At date 0, the investors set their deposit repayment subject to the ensuing subgame-perfect values of  $r_B$  and  $M$ . Again, the solution for Contract I is rather simple to compute. Under Contract I the zero-profit condition is  $q_h^h r_D = 1$ . Therefore,  $r_D^h = 1/q_h$ . We can now fully specify Contract I.

$$\text{Contract I: } \Gamma_I(1/q_h, 1/q_h^2, 0)$$

The difference  $\delta = 1/q_h^2 - 1/q_h$  can be interpreted as the 'cost of delegation' (Diamond 1984). It arises because the bank prices in the non-pecuniary penalty which it will incur in the case of default.<sup>12</sup> Contract I is offered to all  $h$ -firms. The complete FIC becomes  $R > B/\Delta q + 1/q_h^2$ .

Again, the solution for  $l$ -firms is more complicated. First, we rewrite (5) for the case of Contract II:

$$\Pi_B^l = q_M r_B^l - r_D - mM^2/2$$

where  $q_M = q_l + \Delta q M$  is the post-monitoring success probability. Depositors require

$$r_D^l(M) = 1/q_M.$$

As  $M \in [0, 1]$ , note that  $r_D \in [1/q_l, 1/q_h]$ . We can now fully specify Contract II.

**Proposition 1** Contract II :  $\Gamma_{II}(r_D^l, r_B^l, M^*)$  which satisfies the system below.

$$\begin{aligned} r_D^l &= \begin{cases} 1/q_h & \text{for } m < \bar{m} \\ 1/q_{M^*} & \text{otherwise.} \end{cases} \\ r_B^l &= \begin{cases} \frac{1/q_h + m/2}{q_l + \Delta q} & \text{for } m < \bar{m} \\ \frac{-mq_1 + \sqrt{(mq_1)^2 + 2m\Delta^2 q r_D^l}}{\Delta^2 q} & \text{otherwise.} \end{cases} \\ M^* &= \begin{cases} 1 & \text{for } m < \bar{m} \\ \frac{-mq_1 + \sqrt{(mq_1)^2 + 2m\Delta^2 q r_D^l}}{m\Delta q} & \text{otherwise.} \end{cases} \\ \text{with } \bar{m} &= \frac{2\Delta q 1/q_h}{q_h + q_l} \end{aligned}$$

A straightforward implication hereof is the bank's participation constraint.

**Corollary 1** In the competitive equilibrium, Contract II is feasible if and only if

$$R > \frac{2r_D^l}{q_h + q_l} \quad \text{and} \quad m \leq \frac{R^2 \Delta^2 q}{2(r_D^l - q_l R)}.$$

The first part states the minimum quality for firms to be eligible for 'Contract II', whereas the second part represents an upper bound on per unit monitoring cost.

<sup>12</sup>Note that, if the depositor were to finance the  $h$ -firm directly via a debt contract plus penalty function, the firm would have a fixed cost of  $1/q_h$  (just like the bank). With the bank credit, the firm - protected by limited liability - has an expected cost of  $q_h \cdot 1/q_h^2$  which is but the same.

**Corollary 2** *In addition, a positive demand for Contract II exists iff further*

$$\frac{2r_D^l}{q_h + q_l} < \frac{1}{q_h^2} + \frac{B}{\Delta q}.$$

Otherwise, firms which are eligible for Contract II are eligible for Contract I as well. Obviously, they would prefer the latter. Among the exogenous variables, only B's effect is unambiguous. Large private benefits broaden the market for monitoring.

**Remarks** We need to make remarks on three aspects of the result. First, Contract I can clearly be interpreted as an *arm's length loan contract*, while Contract II represents a *monitored bank loan*.<sup>13</sup> We gain or lose nothing by having banks offer arm's length contracts or, in fact, making such an endogenous choice of our banks. Risk-neutral firms face the same financing costs either way (cf. previous footnote). It simply saves us the trouble of introducing another financial agent into the model. We just let banks perfectly screen firms and offer Contract I (II) to *h*-firms (*l*-firms).

But implicit herein - and this is our second point - is the assumption that each deposit contract can be made contingent upon the type of loan financed by that deposit. This is but a simplification. Recall that we have assumed the population of firms to be common knowledge. A uniform  $r_D$  would, therefore, take the form  $r_D^u = \frac{n_h}{n_h+n_l} \cdot r_B^h + \frac{n_l}{n_h+n_l} \cdot r_B^l$ . Note that  $r_B^h \leq r_D^u \leq r_B^l$  so that *l*-firms would effectively 'subsidize' *h*-firms. If the amount  $n_h + n_l$  is deposited, the bank's optimal policy is to clear the market for debt finance. The alternative would be to lend to *h*-firms and put the rest in the risk-free market. But this would make the bank worse off. In general, risk-shifting behavior by the bank would result in the following 'pecking order' for the use of loanable funds: *h*-firms  $\rightarrow$  *l*-firms  $\rightarrow$  risk-free asset. Anticipating this, the depositors can always set a uniform rate which ensures the competitive return for a given aggregate amount of deposits.<sup>14</sup>

Third, we have neglected the possibility that a bank may corner the credit market by absorbing all funds in the deposit market via price competition. Of course, if banks were subject to Bertrand competition with regard to deposit procurement, then the only feasible equilibrium deposit rate would correspond to the maximal risk which the banks can take on in the credit market. This is similar to the effect deposit market competition has on banks' risk-shifting behavior in Hellmann et al. (2000). The way we choose to circumvent this problem is to assume that market power in the deposit market rests with the banks. Formally, we need total amount of deposits for *each* bank to be inelastic to price changes. As we will later see, this is no problem because credit market competition will ensure that banks choose that risk-profile which ensures a competitive deposit return. Also, banks will offer the competitive return because they need their funding to be *cheap* in order to effectively compete in the date 1 credit market. Intuitively, we might envision a world where each bank has its own depositor's base.

<sup>13</sup>This is the terminology of Rajan (1992). Tirole/Holmstrom (1997) speak of direct and indirect finance. Others use the term intermediated finance for the latter type.

<sup>14</sup>Of course, the assumptions about the information sets of the depositors are quite strong. Yet, to rule out additional intricacies of adverse selection in our model it is necessary. The legitimate question how deposit contracts are designed rationally when depositors do not know the balance sheet or the *post-deposit* lending behavior of the bank should be a separate subject. We suggest that an adequate way to frame this problem would be to model repeated games where risk choices (or ex post defaults) of banks have consequences for the refinancing conditions of the following periods. There are models which do not face this problem because they separate the two types of contract by designing for each of them a distinct agent, e.g. arm's length investors and banks.

### 3.2 Loan Market Segments

The population of firms is segmented in the loan market. On the upper hand, we have the  $h$ -firms which satisfy the FIC. Next are the  $l$ -firms.

**Corollary 3** *The complete condition for  $l$ -firms is*

$$\frac{2r_D^l}{q_h + q_l} < R < \frac{1}{q_h^2} + \frac{B}{\Delta q}.$$

Among the remaining entrepreneurs we may distinguish those who have positive NPV ( $s$ -firms) but have no access to external finance and those with negative NPV-projects ( $n$ -firms). The condition for  $s$ -firms is  $(1 - B)/q_l \leq R < 2r_D^l/(q_h + q_l)$ .<sup>15</sup>

Figure 2 summarizes our results. Because  $h$ -firms strictly choose high effort, they get the cheapest external funding. On the other hand,  $l$ -firms shirk and in order to procure outside funds must allow banks to inhibit their opportunistic behavior by monitoring. Finally,  $s$ -firms can only resort to self-financing, while projects of  $n$ -firms are not undertaken.

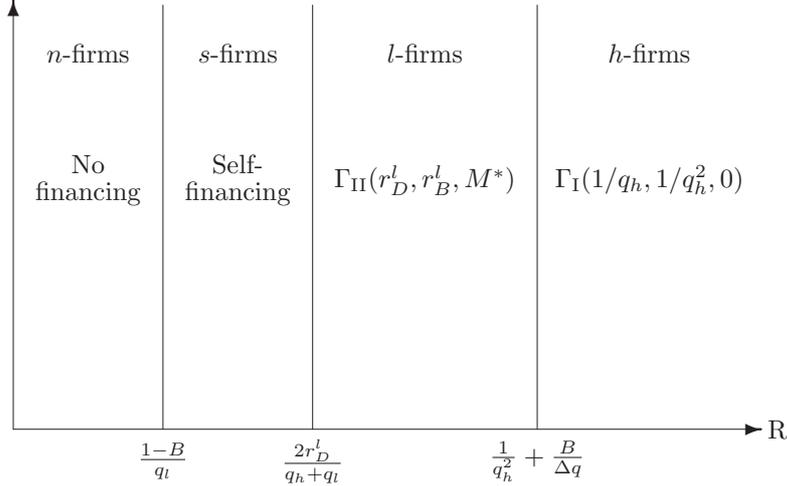


Figure 2: Financing ranges without CRT

<sup>15</sup>Note that a positive NPV, in principle, implies  $R > \min(1/q_h, (1 - B)/q_l)$ . For a positive FIC, however, which we assume because otherwise the moral hazard problem would be irrelevant, straightforward calculation shows that  $\min(1/q_h, (1 - B)/q_l) = (1 - B)/q_l$ .

## 4 The Possibility of Credit Risk Transfer

In this section we extend the basic model and introduce a very simple way for banks to transfer parts of the credit risk associated with their loan engagements to other banks. First, we want to analyze the effect of this on the monitoring intensity of the bank. Second, we investigate whether the transfer of credit risk has any impact on the overall amount of financing provided to firms in an economy.

### 4.1 Limits to Diversification and Transfer Modes

Generally, banks can transfer credit risk via credit derivatives (e.g. credit default swaps) or structured products (e.g. collateralized loan obligations). The banks in our model choose to transfer the credit risk of their loan engagements by entering into a simple swap structure. We argue that one economic rationale for CRT to another party arises from diversification. Obviously, diversification can only be regarded as the motivation for CRT if the banks involved in the transaction can not achieve the diversification in different ways. Therefore, we assume banks in our model to be subject to limitations to diversification which prevent them from doing loan business to the extent that is desirable from a diversification point of view.

Limitations to diversification can be restrictions of the geographical scope of banks or sector specialization. Geographical scope may be limited due to regulatory restrictions. Even though many of such restrictions have been abolished in the last years (e.g. the abolishment of the interstate banking prohibition in the US or the introduction of the European banking pass) there are still factors that limit a bank's ease to lend in distant regions. Such factors can be differences of legal systems, different corporate governance schemes or diverging supervisory regimes (Acharya et al. (2004)). Therefore, monitoring customers in distant regions incurs much higher monitoring costs and, in turn, detains banks from lending to firms in distant regions. Lending to customers in different sectors may also require the need of particular expertise, thus increasing monitoring costs (Almazan (2002)) and worsening the effectiveness of monitoring (Winton (1999)). Both would limit banks' lending capacities across sectors. Besides the effects of the barriers to lending on monitoring, banks lending in distant regions<sup>16</sup> also face the drawback of having less efficient screening mechanisms. The argument is the same as before: Banks do not have the expertise to efficiently screen their borrowers such that screening borrowers which operate in distant regions will incur higher screening costs and reduce the effectiveness of screening.

For banks facing these kinds of limitations to diversification the transfer of credit risk to another party can be an appropriate, if not the only, way to diversify. Figure 3 shows a setting in which banks cannot lend to distant customers but only within the own region. As the figure shows we assume the counterparty of the CRT to be another bank operating in a different region. In doing so we let the credit risk not spread to the capital market but *remain* in the banking sector. This stands in contrast to the prevailing idea that CRT takes place between banks and the capital market (e.g. insurance companies, institutional investors) therewith shifting the risk out of the banking sector. Empirical figures reveal, however, that both, originators and investors in credit risk transactions, are primarily banks.<sup>17</sup> This strongly supports our assumption about the counterparties of CRT transactions.

Banks 1 and 2 can only grant credits in their own region. Direct loans to customers from any other region are not possible due to the constraints described

<sup>16</sup>We will henceforth speak only of region(s) but always also refer to region(s) and sector(s).

<sup>17</sup>The ECB reports that in most European countries the most frequent counterparties of such transactions are banks, with a peak of 80% in Germany, while insurance companies and other investors do not play a dominant role, cf. ECB (2004).

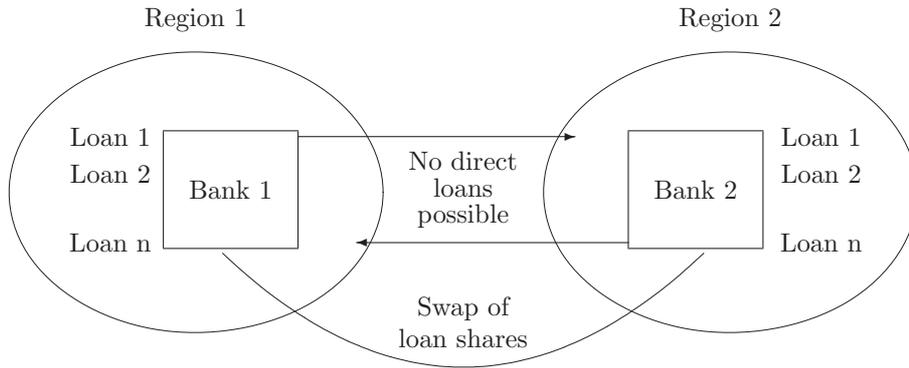


Figure 3: Back-door diversification via credit risk swap

above. A diversification effect can, however, be achieved by agreeing to swap parts of the loans on the respective balance sheet. In exchange for a share of a loan/the loan portfolio of bank 1, bank 2 offers some share of its loan(s), and vice versa. To keep matter simple, we assume that within any region there is perfect correlation between all loans. Loans from different regions, on the contrary, are assumed to be uncorrelated. Therefore, it becomes feasible and sound for banks to diversify by trading parts of their loan(s) with other banks that face the same restriction. Thus, the banks in our world are able to diversify not directly but, so to say, through the 'back door'.<sup>18</sup> We further assume that all banks and all regions are otherwise completely identical (with regard to the population of firms, the monitoring technology, the market for deposits, etc.) and that there is no asymmetric information between the banks with regard to the nature of loans to be swapped. The last assumption implies that in our model banks can distinguish between Contract I and II loans of the other bank.<sup>19</sup>

## 4.2 The Sources of Benefits and Costs

We have assumed that all agents in the financial sector are risk-neutral. Thus, the transfer of risk in whatever form should in principle affect the utility of neither banks nor investors, since these will always adjust the 'risk premium' in the face values merely to achieve the competitive return. What reducing credit risk to a certain extent may, however, achieve is a reduction of that 'risk premium'. This reduction would accrue to all the firms including some of those which would be credit-rationed otherwise. The credit risk transfer as we model it decreases the risk of a shortfall in the credit repayment by shifting more of the expected credit returns from already-in-the-money states to shortfall states. Therefore, the *benefit* of credit risk transfer in our model lies in *diversifying the returns* of the credit portfolio.

Usually this should directly affect the expected return of the banks. In our model, however, banks are fully debt-financed via deposit contracts with non-pecuniary penalties. As the penalty equals the difference of the deposit face value and the actual return from the credit portfolio, all which diversification can achieve for the bank is a relative shift between monetary and non-pecuniary costs and benefits. For example, if the bank achieved to budge some of the cash-flow from

<sup>18</sup>The formerly mentioned report of the ECB underlines our assumption that credit risk transfer takes mainly place between banks that do not operate in the same (geographical) area. According to this report over 80% of all credit risk transfers are cross-border transactions (ECB (2004))

<sup>19</sup>Of course, this screens out an important problem of real-world credit risk transfers. We omit it because we aim to isolate the effects we are concerned with.

a sufficiently in-the-money state into a shortfall state, this would reduce the non-pecuniary *cost* in the latter but to the same extent the monetary *gain* in the former. The expected return of the bank would remain unaffected, for both effects would offset each other.<sup>20</sup> This would not be the case with depositors who are not subject to such penalties. Their expected deposit return would actually increase, were they not forced by market pressure to adjust, i.e. reduce, their rates. To speak with Diamond (1984), the dead-weight penalty which is priced is lessened. Thus, in our model *the initial effect of credit risk transfer concerns the depositors* who, all else being equal, should reduce their face values which are, on the flip side, the bank's refinancing costs. The banks being themselves subject to perfect competition would have to carry this cost saving over to their prices. So, ultimately, it is the firms who would, again: all else being equal, benefit from the credit risk transfer.

But as it usually is, all else remains not equal. The liberation from parts of the credit risk naturally diminishes the bank's urge to monitor because, while still bearing the full cost of monitoring, it enjoys only parts of its benefits.<sup>21</sup> Thus, the original *cost* of diversification is a *decline in bank monitoring*. It is the root of all inefficiencies in our model. Less monitoring counters the effect of diversification. By decreasing the success probability of the *single* projects, it evidently increases the shortfall probability of the bank's portfolio vis-à-vis the investors' deposit claims. This erosion of monitoring incentives obviously works to increase the demanded deposit and credit rates and thus against the diversification benefit.

The composite effect of diversification and lesser monitoring is ambiguous. That is, theoretically, CRT can ultimately lead to either an improvement or a worsening of the firms' financing constraints.

### 4.3 The Possible Effect on Bank Finance

As already mentioned, we now consider two banks. The banks are identical except for the fact that their credit portfolios are i.i.d., that is, have zero correlation. In all other aspects, their worlds are completely alike. The possibility of credit risk transfer also adds a new period to our basic model. While the other dates introduced in section 3 remain the same, we add a new date 2. At this date the two banks decide to swap a share,  $(1 - \alpha)$ , of their loan portfolios. We call  $\alpha$  the *retention rate*. Naturally,  $\alpha \in [0, 1]$ .<sup>22</sup> The choice of the optimal monitoring intensity as well as the choice of the effort level of the firm take place after the credit risk has been transferred. At date T all payments and penalties are realized.

Unlike in Section 3, we will solve the model separately for Contract I and II. But in both cases, we will first assume that the retention rate  $\alpha$  is initially but a promise at date 0. We will later show that the respective equilibrium solutions are time consistent. We will focus on the decisions of bank 1. Bank 2 is simply a mirror image thereof. We add a number to the subscripts to discern the regions.

<sup>20</sup>The literature on 'asset substitution' or 'asset-shifting' provides the standard rationale for debt-financed entities, here the bank, to make their cash-flows riskier, or to *not* make it safer. In our model, this moral hazard is eliminated due to the non-pecuniary penalty imposed on the bank. Since the bank always receives the penalty, which amounts to the actual shortfall, the gains and losses of shifting returns between different states always level out. Thus, the banks should in principle be indifferent towards CRT.

<sup>21</sup>This is analogous to moral hazard in the insurance industry or the problem of investment in (quasi-)public goods, i.e. free-riding.

<sup>22</sup>The assumption that all banks retain  $\alpha$  and swap  $1 - \alpha$  implies a proportional risk sharing. This stands in contrast to the prevailing idea of asymmetric risk sharing that underlies asset backed securities transactions. We refer to Plantin (2003) for a discussion of this aspect. We would like to point this out here since it adds a further particular note to our approach.

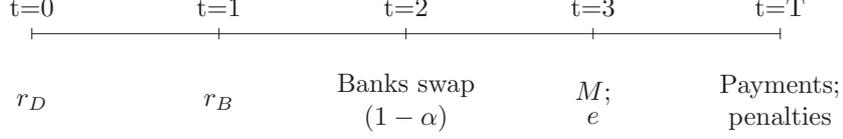


Figure 4: Timetable with CRT

### 4.3.1 Swapping Contract I

**Choice of  $e_1$  and  $M_1$**  As can be seen in (3), the only way in which the credit risk transfer can influence the FIC is via the interest rate. This provided, the relevant question becomes whether  $\alpha$  has any effect on  $r_{B1}^h$ . The underlying idea is plain: The lower  $r_{B1}^h$  is, the more firms can be financed by Contract I.

**Choice of  $\alpha$  and  $r_{B1}^h$**  So which  $\alpha$  should the bank promise? It is clear that, since the negative monitoring effect can have no bearing on  $h$ -firms, diversification should be carried out to its extreme. Under these circumstances, the risk-reducing effect peaks out at  $\alpha = 1/2$ . Assuming the symmetric solution  $r_{B1} = r_{B2}$ , the bank's profit function under Contract I

$$\begin{aligned}\Pi_B^h &= q_h^2[\alpha r_{B1}^h + (1-\alpha)r_{B2}^h] + q_h(1-q_h)\alpha r_{B1}^h + q_h(1-q_h)(1-\alpha)r_{B2}^h - r_{D1}^h \\ &= q_h r_{B1}^h - r_{D1}^h\end{aligned}$$

shows without further proof that

**Lemma 1** *Diversification has no **direct** bearing on the bank's profit function.*

Obviously,  $r_{B1}^h = r_{D1}^h/q_h$  is equal to the solution from Section 3.

**Choice of  $r_{D1}^h$**  Provided that  $\alpha = 1/2$  (which at this date is still only a promise) the expected profit of the depositors as a function of  $r_{D1}^h$  is

$$\Pi_{D1}^h = \begin{cases} q_h^2 r_{D1}^h + q_h(1-q_h)r_{B1}^h & \text{for } q_h > 1/2 \\ q_h^2 r_{D1}^h + 2q_h(1-q_h)r_{D1}^h & \text{for } q_h \leq 1/2 \end{cases}$$

for, if  $q_h \leq 1/2$ , then  $1/2 \cdot r_{B1}^h \geq r_{D1}^h$  so that  $z = r_{D1}^h$  even in the states when exactly one bank's credit (portfolio) fails. Otherwise,  $z = 1/2 \cdot r_{B1}^h$ . The zero-profit condition yields

$$r_{D1}^h = \begin{cases} \frac{1}{1-q_h(1-q_h)} & \text{for } q_h > 1/2 \\ \frac{1}{q_h(2-q_h)} & \text{for } q_h \leq 1/2 \end{cases}$$

where simple calculations show that  $r_{D1}^h \leq r_D^h$  strictly. This is because the increase in the expected return of the depositors lowers the expected non-pecuniary penalty. These reduced 'delegation costs' are mirrored in the lower price for deposits so that

**Lemma 2** *Diversification decreases the **refinancing costs** of the bank.*

We can now fully specify Contract I $\alpha$ .<sup>23</sup>

$$\text{Contract I}\alpha : \begin{cases} \Gamma_{I\alpha}\left(\frac{1}{1-q_h(1-q_h)}, \frac{1}{q_h-q_h^2(1-q_h)}, 1/2, 0\right) & \text{for } q_h > 1/2 \\ \Gamma_{I\alpha}\left(\frac{1}{q_h(2-q_h)}, \frac{1}{q_h^2(2-q_h)}, 1/2, 0\right) & \text{for } q_h \leq 1/2 \end{cases}$$

Note that  $r_{D1}^h \leq r_D^h$  implies  $r_{B1}^h \leq r_B^h$ . Thus,

<sup>23</sup>By the way, a full contract now consists of  $\Gamma(r_D, r_B, \alpha, M)$ .

**Corollary 4** *Diversification decreases the cost of arm's length credit.*

**Financing range** So far, we found that the price for arm's length credit has been lowered. But the benefit of diversification does not stop here. Moreover, note that the FIC is lowered from

$$B/\Delta q + r_B^h \longrightarrow B/\Delta q + r_{B1}^h.$$

The number of  $h$ -firms thus grows. This allows two connate interpretations:

**Proposition 2** *Diversification reduces the number of shirking firms which is equivalent to an increase in the volume of arm's length financing*

Except for the last proposition, the main findings of this subsection are basically the results of Diamond (1984). The setting under Contract  $I\alpha$ , in principle, describes 'Diamond's world' as (i) the moral hazard problem is quasi-*absent* due to the satisfied FIC, whereas (ii) it is the state verification problem which leads to the benefit of having a *diversified* delegated monitor. In contrast to Diamond's world, however, the 'latent' existence of moral hazard produces the additional implications of Proposition 2 that diversification eliminates this hazard for a subset of firms.

#### 4.3.2 Swapping Contract II

**Choice of  $e_1$  and  $M_1$**  At the outset of the preceding subsection we have already said that the FIC is independent of  $\alpha$ . Thus, just as in the case without CRT, all firms which do not satisfy the FIC will strictly choose  $e_1 = l$ . With regard to  $M_1$ , given  $r_{B1}^l$  and  $\alpha$ , the bank's optimal behavior at date 3 is

$$M_1^*(r_{B1}^l, \alpha) = \begin{cases} 1 & \text{for } m < \alpha \Delta q r_{B1}^l \\ \frac{\alpha \Delta q r_{B1}^l}{m} & \text{otherwise.} \end{cases} \quad (8)$$

For a derivation of this result see Appendix A.3.

**Choice of  $r_{B1}^l$**  After substituting  $M_1^*$ , we set  $\Pi_{B1}^l = 0$ . Solving for  $r_{B1}^l$  yields

$$r_{B1}^l(r_{D1}^l) = \begin{cases} \frac{r_{D1}^l + \frac{m}{2}}{q_h} & \text{for } m < \frac{2\alpha \Delta q r_{D1}^l}{(2-\alpha)q_h + \alpha q_l} \\ \frac{-mq_1 + \sqrt{(mq_1)^2 + 2m\alpha(2-\alpha)\Delta^2 q r_{D1}^l}}{\alpha(2-\alpha)\Delta^2 q} & \text{otherwise.} \end{cases}$$

As a result,

$$M_1^*(r_{D1}^l) = \begin{cases} 1 & \text{for } m < \frac{2\alpha \Delta q r_{D1}^l}{(2-\alpha)q_h + \alpha q_l} \\ \frac{-mq_1 + \sqrt{(mq_1)^2 + 2m\alpha(2-\alpha)\Delta^2 q r_{D1}^l}}{m(2-\alpha)\Delta q} & \text{otherwise.} \end{cases}$$

Let us take a quick glance at the differences between the case with CRT and the one without. With regard to  $r_B$  the effect is so far twofold. The additional term  $\alpha(2-\alpha)$  in  $r_{B1}^l$ , its codomain being  $[0, 1]$ , is contained both in the nominator and denominator. In the nominator it has a decreasing effect. This results from the fact that the bank *saves on monitoring costs*. In the denominator, on the other hand, it has an increasing effect due to the fact that less monitoring *lowers the probability of firm success*. That there is less monitoring can be proven.

**Proposition 3** *With credit risk transfer, monitoring is strictly lower. Specifically,*

$$\begin{aligned} M_1^* &= M^* \quad \text{for } \alpha = 1 \\ dM_1^*/d\alpha &> 0 \end{aligned}$$

**Corollary 5** *Diversification increases the risk of shirking firms.*

This is the *negative* effect which CRT has on monitoring. *Ceteris paribus*, this must strictly increase  $r_{B1}^l$  (despite the just mentioned fact that there are two contrarian effects). This can be explained by the same account as in the proof of Proposition 3. Given that there is no direct effect of  $\alpha$  on  $\Pi_{B1}^*$  (as shown in Lemma 1), it cannot be that both monitoring and credit face value fall compared to the equilibrium values in the case without CRT. This would have to violate the zero-profit property in equilibrium. However, as said, this holds only *ceteris paribus*. Still unaccounted for at this point remains the effect of  $\alpha$  on  $r_{D1}^l$ , that is, the *positive* effect of diversification on the bank's refinancing costs.

**Choice of  $r_{D1}^l$**  To determine  $r_{D1}^l$ , we introduce a reasonable restriction on  $\alpha$ .

**Lemma 3** *Any rational  $\alpha$  must satisfy the following condition:*

$$\alpha \geq \max(r_D/r_B, 1 - r_D/r_B).$$

This allows us to formulate the next proposition.

**Proposition 4**  $\forall$  rational  $\alpha \exists$  a Contract  $\Pi\alpha$ :  $\Gamma_{II\alpha}(r_{D1}^l(\alpha), r_{B1}^l(\alpha), \alpha, M_1^*(\alpha))$  which satisfies the system below:

$$r_{D1}^l = \begin{cases} \frac{1-q_h(1-q_h)(1-\alpha)r_{B1}^l}{q_h} & \text{for } m < \bar{m}_1 \\ \frac{1-q_{M_1^*}(1-q_{M_1^*})(1-\alpha)r_{B1}^l}{q_{M_1^*}} & \text{otherwise.} \end{cases}$$

$$r_{B1}^l = \begin{cases} \frac{r_{D1}^l + \frac{m}{2}}{q_h} & \text{for } m < \bar{m}_1 \\ \frac{-mq_1 + \sqrt{(mq_1)^2 + 2m\alpha(2-\alpha)\Delta^2 qr_{D1}^l}}{\alpha(2-\alpha)\Delta^2 q} & \text{otherwise.} \end{cases}$$

$$M_1^* = \begin{cases} 1 & \text{for } m < \bar{m}_1 \\ \frac{-mq_1 + \sqrt{(mq_1)^2 + 2m\alpha(2-\alpha)\Delta^2 qr_{D1}^l}}{m(2-\alpha)\Delta q} & \text{otherwise.} \end{cases}$$

with  $\bar{m}_1 = \frac{2\alpha\Delta qr_{D1}^l}{(2-\alpha)q_h + \alpha q_l}$

**Choice of  $\alpha$**  Any given  $\alpha$  constitutes an equilibrium. Thus, a choice among the set of rational  $\alpha$  is basically a choice between multiple equilibria. Note that, for instance,  $\alpha = 1$  lets the system converge to the one in Proposition 1. Since, by assumption, investors and banks always make zero profits, they are indifferent between the various  $\alpha$ . But the firms have a clear preference. They favor that  $\alpha$  which yields the lowest ensuing  $r_{B1}^l$ . This allows us to determine an *optimal*  $\alpha$ .

Imagine an initial world which has neither monitoring nor CRT technologies. Banks offering only arm's length contracts (Contract I) compete perfectly and make zero profits. Consider now a bank which develops a monitoring technology and, thus, makes Contract II feasible. This financial innovation will allow it to be the first to service *l*-firms. At first, the innovating bank will use its market power to make a positive profit on these firms. This will lure other banks into this 'market for monitored loans'. In time, more will adopt the technology and erode the first-mover advantage. Eventually, Bertrand competition will push the profit to zero. This is the equilibrium situation as described in Section 3.

Assume that next some of these banks devise a CRT technology. Say, they can now offer Contract  $I\alpha$  and  $II\alpha$  where the price of credit is lower than under Contract I and II. These banks will be able to profitably underbid the other banks

in both segments. They also shift the borders between the segments, all in all to generate non-competitive rents. But, again, their advantage will not last forever. Other banks will follow and Bertrand competition will once more push profits to zero. It achieves even more. Say banks choose  $\alpha = x$ . Unless Contract  $I(I)x$  yields the lowest possible  $r_{B1}^l(x)$  over the whole set of  $\alpha$ , then financial deepening has not come to its end yet. Any Contract  $I(I)\hat{x}$  where  $r_{B1}^l(\hat{x}) < r_{B1}^l(x)$  will be able to 'beat' the  $x$ -offer and attract all credit demand. Thus, this process of 'bidding' for clients will eventually lead to the lowest possible value for  $r_{B1}^l$ . In fact, it does so by forcing it to adopt the cheapest available 'production technology'. In the case of Contract  $I\alpha$  it is obviously  $\alpha = 1/2$ . Generally, without further proof,

**Proposition 5** *The optimal  $\alpha^*$  is the rational  $\alpha$  for which  $r_{B1}^l$  is minimal. Given Bertrand behavior in the market,  $\alpha^*$  is the equilibrium outcome.*

**Corollary 6** *In a competitive market credit risk transfer leads to **financial deepening**.*

**Time consistency** We now return to our assumption that the bank merely makes a retention rate or credit transfer *promise* at date 0. We assume that this promise is not enforceable by courts. Thus, it is only credible, if it is suboptimal for the bank to deviate from its informal commitment. First note that, besides the fact that it is not feasible due to Proposition 5, the promise of any  $\alpha \neq \alpha^*$  is not time consistent. Since  $r_{B1}^l(\alpha) > r_{B1}^l(\alpha^*)$ , the vector  $\Gamma(r_{D1}^l(\alpha), r_{B1}^l(\alpha), \alpha^*, M_1^*(\alpha^*))$  would strictly yield a positive profit for the bank and/or the depositors. With regard to the promise of the optimal  $\alpha^*$ , it holds true that

**Proposition 6** *The promise of  $\alpha^*$  is time consistent and, therefore, credible.*

**Interim result** We have shown that in the competitive equilibrium, the optimal degree of credit risk transfer will emerge. It is the one which yields the lowest credit rates for the real sector. The promise of the optimal retention rate or risk transfer is credible because it is time consistent.

## 5 Model discussion

This section is devoted to the description of some model implications, robustness checks, possible model extensions, and the relaxation of some of the main model assumptions.

**Implications** Our results strongly indicate that credit risk transfer, though it leads to a lower monitoring intensity, can have a positive impact on how much finance is provided to firms in an economy. Therefore we cannot confirm that reduced monitoring incentives are per se negative, as was stated by Arping (2002) and other authors that argue that in a relationship banking system more finance is provided to firms. On the other hand, we cannot provide a solid welfare analysis because our model falls short of including all effects necessary to undertake a welfare analysis. Although more firms may obtain external finance when banks transfer credit risk, reduced monitoring incentives can have negative external effects. By monitoring a firm's behavior banks induce firms' top management to behave less risky with regard to what sort of projects they choose. Therefore, banks implicitly act in favor of a firm's employees who, in case the firm goes insolvent due to an overly risky firm policy, will lose their jobs. As banks become safer due to the positive diversification effects of credit risk transfer, firms will become riskier. While riskier firms are more prone to become insolvent, jobs will become riskier, too. This

counter-effects the positive impact of CRT on firm financing in the context of welfare analysis. Another negative effect on the welfare of the whole economy may stem from a shift away from commercial banking activities towards investment banking activities. The transfer of credit risk exerted by some banks may have an impact on their and other banks' business strategy. To the extent to which credit risk is transferred to other parties, there must be banks which act as issuers, underwriters or structurers. These banks may focus on those activities and turn away from commercial lending, therewith leaving a financing gap. If this gap is not fully closed by other market participants it may (partially) erode the positive effect of CRT on firm financing.

As was shown, CRT leads to a lower level of bank monitoring. In the context of relationship lending this could have strong implications. One of the main characteristics of a relationship lender or Housebank is that it has better and timelier information about its borrowers (Cole (1998)). This should increase the monitoring ability and effectiveness of a Housebank, especially in comparison with arm's length lenders. The particular value of the close relationship between a borrower and her Housebank for the latter arises mainly from the improvement of monitoring, i.e. from the fact that a Housebank gets insight into a firm's investment policy and risk affinity. Given this, reduced monitoring incentives can lead to an erosion of this value because monitoring becomes less important for the bank. The erosion of the relationship value might heavily hit a financial system where relationship lending is the predominant source of (external) finance, as is the case in Germany or Japan. Although the analysis does not allow us to pass clear judgement we may predict that, with the evolution of well-functioning markets for CRT, one will be able to observe a shift away from relationship lending. Such a shift can severely impact the overall stability of a financial system. This is particularly true if one believes that a financial system should be consistent. As consistency comes along with complementarity of the individual parts of a financial system, the change of single elements of a consistent system may lead to inconsistency.<sup>24</sup> Thus, a shift of single elements of a system would incur high costs for the whole system, in the extreme case system instability.

**Robustness checks** Consider a bank that is run by a manager in spite of the bank owners. The bank manager is likely to monitor more if the bank is in a risky situation and the manager fears to lose her job. In contrast to that she may monitor less if the bank is not in a risky situation. Either way, she will not always choose the *optimal* monitoring intensity. A reduction of risk in our model has the same lowering effect on monitoring. Though we cannot say anything about whether the decrease in monitoring intensity is equal in both cases the model predicts an effect that is directed in the same way.

The results of our model indicate that it is economically sound for banks to merge with banks operating in different regions. The soundness of such a merger comes from the diversification effect associated with the merger. As banks are subject to limitations in diversification, optimal diversification is only possible by diversifying through what we labelled the 'back-door'. A bank merger brings along the possibility of diversification by making the deposit repayment less risky. A reduction of risk of deposit repayments results in a lower rate of interest charged by depositors, the effect being passed on to the firms. This would eventually enlarge the overall volume of obtainable funds in an economy. Though banks are risk-neutral and therefore indifferent with regard to a merger for firms bank mergers would always involve positive effects.

Note that because the swap is agreed upon/promised at date 0 and is time

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<sup>24</sup>The concept of complementarity is sketched out in Hackethal/Tyrell (1999)

consistent, it really does not make a difference whether the actual swap is made before or after monitoring. That is, the results we present hold true for the ex ante monitoring case as well.

**Model extensions** As we have not addressed the issue of optimal security design this is a straightforward extension of our model. Every mechanism that diminishes the negative effect on monitoring discussed above positively impacts the overall effect. As a financing deepening is only achieved if the negative effect of lower monitoring intensity is outweighed by the positive effect of diversification, every mechanism that increases the difference between both effects in favor of the positive one will increase financing deepening. The issue of optimal security design is mainly concerned with mitigating the moral hazard problem inherent in CRT transactions. Therefore we argue that via optimally designing CRT contracts, e.g. by establishing an incentive-compatible tranching structure, the negative effect on monitoring is diminished and the positive overall effect emphasized. Optimal security design should therefore result in a further increase in the overall volume of finance available to firms in an economy.

**Relaxation of assumptions** We have assumed that banks operating in different regions act in *symmetric* environments. With regard to the default risk in different regions this will surely not be the case. The inclusion of different degrees of risk in different regions into our model is likely to change the results on monitoring. Winton (1999) provides a discussion of the effect of different risk degrees (low, moderate and high loan downside risk) on banks' monitoring incentives. Generally, we can state that if the cost of CRT (the reduction of monitoring) is mitigated through different risk degrees in different regions the positive effect on the real sector will be more pronounced.

## 6 Summary

In this paper we have examined whether and what effects the transfer of credit risk by means of changing parts of the assets between two banks has on the monitoring intensity of banks and the overall volume of finance available in an economy. We have shown that the transfer of credit risk might serve to diversify the credit portfolio of a bank and lowers the incentives for a bank to monitor its debtors. Our results are similar to the ones derived by Arping (2002) though our approach differs significantly from his. Whereas many researchers often argue that the erosion of monitoring incentives leads to a reduction of financing sources provided by banks, we come to the opposite conclusion. The analysis showed that the possibility to transfer credit risk can increase the overall volume of finance available in an economy. However, since our model is somewhat restricted in this respect, the question of how CRT impacts the financing situation of firms, remains an issue to be explored further.

## A Appendix

### A.1 Proof of Proposition 1

Since l-firms always choose the low effort at date 3, the bank's profit function is

$$\Pi_B^l = q_M r_B^l - r_D^l - \frac{m}{2} M^2. \quad (9)$$

Let  $r_B^*$  be the solution to  $\Pi_B^l = 0$  after we substitute  $M^*$  from (7). In doing so, we must distinguish two cases: (i) For  $M^* = 1$ ,

$$r_B^l(r_D^l) = \frac{r_D^l + \frac{m}{2}}{q_l + \Delta q},$$

whereas (ii) for  $M^* < 1$ ,

$$r_B^l(r_D^l) = \frac{-mq_l + \sqrt{(mq_l)^2 + 2m\Delta^2 q r_D^l}}{\Delta^2 q}.$$

Next, we substitute these values back into (7) to receive optimal monitoring values as a function of  $r_D^l$  as well as a new 'monitoring cost restriction'.

$$M_1^*(r_D) = \begin{cases} 1 & \text{for } m < \frac{2\Delta q r_D^l}{q_h + q_l} \\ \frac{-mq_l + \sqrt{(mq_l)^2 + 2m\Delta^2 q r_D^l}}{m\Delta q} & \text{otherwise.} \end{cases}$$

The principle applied in the rest of the proof is simple: The choice of the deposit repayment and the choice of success probability (via the choice of monitoring effort) must be mutually best responses. We continue to distinguish the two cases:

(i) We know from the monitoring cost restriction that, if  $m < \frac{2\Delta q r_D^l}{q_h + q_l}$ , then  $M^* = 1$  which implies  $q_{M^*} = q_h$ . Now assume depositing investors choose  $r_D^l = 1/q_h$ . If the monitoring cost restriction, now  $m < \frac{2\Delta q 1/q_h}{q_h + q_l}$  still holds, the bank will choose maximal monitoring effort and the probability of success, which is also the probability of deposit repayment, will become  $q_h$ . The investors' best response to  $q = q_h$  is  $r_D^l = 1/q_h$ . Thus, this is a stable solution. In comparison,  $r_D^l > 1/q_h$  ( $r_D^l < 1/q_h$ ) obviously leads to a strictly positive profit (negative loss). This proves the upper part of the first equation in the proposition.

(ii) If the monitoring cost restriction does not hold, the bank will choose  $M^*$  according to the lower part of the second equation in the proposition. Note that here the optimal monitoring effort, is a function of  $r_D^l$ . On the other hand,  $r_D^l = 1/q_{M^*} = 1/(q_l + \Delta q M^*)$  is, in turn, a function of  $M^*$ . Substituting  $r_D^l = 1/(q_l + \Delta q M^*)$  into  $M^*(r_D^l)$  yields the implicit function

$$M^* = \frac{-mq_l + \sqrt{(mq_l)^2 + \frac{2m\Delta^2 q}{q_l + \Delta q M^*}}}{m\Delta q}.$$

We now have to show that this function has a unique solution for  $M^*$  in the interval  $[0, 1]$ . We bring everything to the left-hand side and denote the *cubic* term as  $f(M^*)$ .

$$f(M^*) = m\Delta^2 M^{*3} + 3mq_l \Delta q M^{*2} + 2mq_l^2 M^* - 2\Delta q$$

Any  $M^*$  for which  $f(M^*) = 0$  solves the implicit function.

**Lemma 4** *The limit behavior of  $f(M^*)$  is  $\limsup = +\infty$  and  $\liminf = -\infty$ .*

**Lemma 5** *The local maximum lies to the left of the origin.*

*Proof:* Solving the quadratic first-order condition of  $f(M^*)$  yields the following two solutions:

$$M_{1/2}^* = -\frac{q_l}{\Delta q} \pm \sqrt{\frac{q_l^2}{3\Delta^2 q}}$$

of which  $M_1^*$ , the left-hand one, is strictly negative. We know from Lemma 4 that this must be a local maximum.  $\square$

**Lemma 6** *There is at least one solution to  $f(M^*) = 0$  within  $[0, 1]$ .*

*Proof:* We determine the value of  $f(0)$  and  $f(1)$ . If the signs are different,  $f(M^*)$  intersects the  $x$ -axis within  $[0, 1]$ . We get  $f(0) = -2\Delta q$  which is strictly negative. The condition for  $f(1)$  to be positive turns out to be

$$m > \frac{2\Delta q 1/q_h}{q_h + q_l}$$

which is identical to our monitoring cost restriction.  $\square$

Given that  $f(M^*)$  is a cubic function, Lemmas 5 and 6 together prove that there exists only one solution within  $[0, 1]$ .

## A.2 Proof of Corollary 1

Substituting  $r_B^l$  from Proposition 1 into the bank's PC,  $R \geq r_B^l$ , implies

$$\begin{aligned} (i) \quad m &< 2[R(q_l + \Delta q) - 1/q_h] & \text{if } m &\leq \frac{2\Delta q(1/q_h)}{q_h + q_l}, \text{ and} \\ (ii) \quad m &\leq \frac{R^2 \Delta^2 q}{2(r_D^l - q_l R)} & \text{if } m &> \frac{2\Delta q(1/q_h)}{q_h + q_l}. \end{aligned}$$

For (ii) to be possible, it must hold

$$\frac{R^2 \Delta^2 q}{2(r_D^l - q_l R)} > \frac{2\Delta q(1/q_h)}{q_h + q_l}.$$

This requires  $R > 2r_D^l/(q_h + q_l)$ , which implies that  $2[R(q_l + \Delta q) - 1/q_h]$  from (i) is greater than the monitoring cost restriction. Thus, if  $R > 2r_D^l/(q_h + q_l)$ , condition (i) is always satisfied with the second inequality binding and the corollary follows.

## A.3 Derivation of $M_1^*$

Given that the bank transfers some amount of its loans and receives some amount of the loans of the counterparty bank, the profit function of bank 1 becomes<sup>25</sup>:

$$\Pi_B = q_{M1} q_{M2} [\alpha r_{B1} + (1-\alpha) r_{B2}] + q_{M1} (1-q_{M2}) \alpha r_{B1} + q_{M2} (1-q_{M1}) (1-\alpha) r_{B2} - r_{D1} - m M_1^2 / 2 \quad (10)$$

This equation considers all possible states in which the bank receives a pay-off. Given that we have two *identical* regions, we assume the *symmetric* solution for the

<sup>25</sup>To get the profit function of the bank 2 one has to switch 1 and 2 in the indices.

entire game. Therefore  $r_{D1} = r_{D2} = r_D$  and  $r_{B1} = r_{B2} = r_B$ . Substituting these into (9) and calculating the first-order condition yields:

$$\Delta q \cdot q_{M2} r_B + \Delta q \cdot (1 - q_{M2}) \alpha r_B - \Delta q \cdot q_{M2} (1 - \alpha) r_B - m M_1 = 0 \quad (11)$$

The condition can be reduced to

$$\alpha \Delta q r_B - m M_1 = 0 \quad (12)$$

This is the mirror image of the analogous condition for bank 2. Thus, we get the solution shown in the lemma. Note that this is a symmetric Nash equilibrium so that  $M_1^* = M_2^*$ . This changes the profit function of the bank to

$$\Pi_B = q_{M^*} r_B - r_D - m M_1^* / 2.$$

Just as in the case of Contract I,  $\alpha$  has no *direct* bearing on the bank's profit.

#### A.4 Proof of Proposition 3

First, note that in the expression  $M_1^l = M_1^l(r_D 1^l(\alpha), \alpha)$  so that

$$\frac{dM_1^*(r_{D1}^l(\alpha), \alpha)}{d\alpha} = \frac{\partial M_1^*}{\partial \alpha} + \frac{\partial M_1^*}{\partial r_{D1}^l} \cdot \frac{\partial r_{D1}^l}{\partial M_1^*} \cdot \frac{\partial M_1^*}{\partial \alpha} \quad (13)$$

with  $\partial r_{D1}^l / \partial M_1^* < 0$  and all other partials being positive. It can be seen that the direct and indirect effect work in opposite directions. The adjustment of  $r_{D1}^l$  mitigates the direct negative effect on monitoring (as will be shown later). The reason why it does not overcompensate it is quite simple to understand. The value  $r_{D1}^l$  is a *zero-profit* value. Say, there was a reduction in  $\alpha$  and  $(r_{D1}^l, M_1^l)$  were the ex ante and  $(\hat{r}_{D1}^l, \hat{M}_1^l)$  the ex post values which allegedly are to satisfy the zero-profit condition. If the indirect effect of  $d\alpha < 0$  were greater than the direct effect, then according to (13) it would be that

$$\hat{r}_{D1}^l > r_{D1}^l, \quad \text{and} \quad (14)$$

$$\hat{M}_1^* > M_1^*. \quad (15)$$

For the expected return of a depositor,  $\Pi_{D1}$ , it holds obviously true that  $\partial \Pi_{D1} / \partial M_1^* > 0$  and  $\partial \Pi_{D1} / \partial r_{D1}^l > 0$ . Consequently, if the ex ante values satisfied the zero-profit condition,  $\hat{r}_{D1}^l$  and  $\hat{M}_1^*$  could not possibly do so. Therefore, the overall effect of  $\alpha$  on  $M_1^*$  must be positive.

#### A.5 Proof of Lemma 3

The proof is very crude and simple. We must reconsider what diversification achieves in our model. First, look at the case without risk transfer,  $\alpha = 1$ , from the perspective of the depositors of Bank A.

State	$S_{12}$	$S_{10}$	$S_{02}$	$S_{00}$
Default event	None	Credit 2 only	Credit 1 only	Both
Probability	$q_{M^*}^2$	$q_{M^*}(1 - q_{M^*})$	$q_{M^*}(1 - q_{M^*})$	$(1 - q_{M^*})^2$
Credit repayment	$r_{B1}^l$	$r_{B1}^l$	0	0
Deposit repayment	$r_{D1}^l$	$r_{D1}^l$	0	0

Since  $r_{B1}^l - r_{D1}^l > 0$ , what diversification achieves is to take some of the bank's surplus in  $S_{10}$  and shift it into  $S_{02}$ . Doing so increases the depositors' expected repayment, since the cash is not taken from its repayment in  $S_{10}$  but *from the bank*.

State	$S_{12}$	$S_{10}$	$S_{02}$	$S_{00}$
Default event	None	Credit B only	Credit A only	Both
Probability	$q_{M^*}^2$	$q_{M^*}(1 - q_{M^*})$	$q_{M^*}(1 - q_{M^*})$	$(1 - q_{M^*})^2$
Credit repayment	$r_{B1}^l$	$\alpha r_{B1}^l$	$(1 - \alpha)r_{B1}^l$	0
Deposit repayment	$r_{D1}^l$	$\min(r_{D1}^l, \alpha r_{B1}^l)$	$\min(r_{D1}^l, (1 - \alpha)r_{B1}^l)$	0

Thus, it is good for the depositors to shift credit returns from  $S_{10}$  to  $S_{02}$  *as long as* the money is taken from the bank's surplus. As soon as  $\alpha r_{B1}^l \leq r_{D1}^l$  any more diversification reduces as much in the one state as it adds to the other. There would be no more benefit from the reallocation, while the negative monitoring effect would continue to rise. Thus,  $\alpha$  should be no more reduced. This leads to the condition  $\alpha \geq r_{D1}^l/r_{B1}^l$ . We call this the upper *limit to diversification*.

There is a second limit here. Imagine now that already so much has been shifted to  $S_{02}$  that  $(1 - \alpha)r_{B1}^l \geq r_{D1}^l$ . Adding any further state-contingent returns to this state now serves to increase the bank's surplus rather than the depositors' return. Again, an additional reduction in  $\alpha$  bears no more benefits but still increases costs. Thus,  $\alpha \geq 1 - r_{D1}^l/r_{B1}^l$ . This is the second upper limit. The first one is binding when  $r_{B1}^l < 2r_{D1}^l$ ; the second one when  $r_{B1}^l > 2r_{D1}^l$ . They are identical for  $r_{B1}^l = 2r_{D1}^l$ .

## A.6 Proof of Proposition 4

Lemma 3 allows us to represent the depositors' PC as

$$q_{M^*}^2 r_{D1}^l + q_{M^*}(1 - q_{M^*})r_{D1}^l + q_{M^*}(1 - q_{M^*})(1 - \alpha)r_{B1}^l = 1$$

where the left-hand side is the expected repayment if Lemma 3's *first* limit binds. Solving this equation for  $r_{D1}^l$  yields

$$r_{D1}^l = \frac{1 - q_{M^*}(1 - q_{M^*})(1 - \alpha)r_{B1}^l}{q_{M^*}}$$

which includes the second limit case, as, for  $\alpha = 1 - r_{D1}^l/r_{B1}^l$  and  $r_{B1}^l \geq 2r_{D1}^l$ , this term turns into

$$r_{D1}^l = \frac{1}{q_{M^*}(2 - q_{M^*})}.$$

Also, for  $m < \bar{m}_\alpha$ ,  $q_{M^*} = q_h$ . This completes the derivation of the first equation in the proposition. The other have been derived previously in the text.

## A.7 Proof of Proposition 6

The retention rate promise  $\hat{\alpha}$  is time-*inconsistent* only if the bank has an incentive to deviate from it *ex post*. Assume (i) that the bank has promised  $\hat{\alpha}$  at date 0 and (ii) that the depositors, in good faith, have chosen to demand  $\hat{r}_{D\hat{\alpha}}$  as the face value of the deposit repayment. The bank now has two possible deviation strategies:

Strategy A: Deviate both from  $\hat{r}_{B\hat{\alpha}}$  at date 1 as well as  $\hat{M}_{\hat{\alpha}}$  at date 2.

Strategy B: Deviate only from  $\hat{M}_{\hat{\alpha}}$  at date 2.

**Strategy A** The bank could now choose a *higher* credit repayment rate along with a different retention rate and monitoring to make a positive profit at the expense of the depositors who, in hindsight, have demanded too little. This moral hazard on part of the bank is, however, *eliminated* by Bertrand competition at date 1 when  $r_B$  is set (see Proposition 5).

**Strategy B** Assume the bank has chosen  $\hat{r}_{B\hat{\alpha}}$  at date 1. At date 2, it could now deviate by choosing  $\alpha_x \neq \hat{\alpha}$ . But any such  $\alpha_x$  would require a  $\hat{r}_{B\alpha_x} > \hat{r}_{B\hat{\alpha}}$  in order to make zero profit. Since the bank has already set  $\hat{r}_{B\hat{\alpha}}$ , it would make a loss if it deviated from the optimal  $\alpha$ .

Let us take a brief look at what would happen, if competition were not perfect. The bank could then price credits higher than optimally at date 1 and, afterwards at date 2, choose the optimal retention rate for the risk transfer. The bank would thus make an ex post profit. In the real world this implies banks pricing credits as *stand-alone* risks, but via credit portfolio diversification actually bearing less risk than they are compensated for by the firms. In our example, this is the kind of profit those banks could make which are among the credit risk transfer *innovators* and are, for a time, not forced by competition to transmit the diversification benefits to the population of firms.

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