Credit Risk Transfer: To Sell or to Insure

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Abstract

This paper analyzes credit risk transfer in banking. Specifically, we model loan sales and loan insurance (e.g. credit default swaps) as the two instruments of risk transfer. Recent empirical evidence suggests that the adverse selection problem is present in loan insurance as well as loan sales. Contrary to previous literature, this paper allows for informational asymmetries in both markets. Our results show that a bank with a low cost of capital will tend to use loan insurance regardless of loan quality in the presence of moral hazard and relationship banking costs of loan sales. Conversely, a bank with a high cost of capital may be forced into the loan sales market, even in the presence of possibly significant relationship and moral hazard costs that can depress the selling price. We show how credit risk transfer can lead to the efficient investment decision, but that there exists a parameter range in which it improves the investment decision only in banks with low quality loans. Furthermore, even under perfect information, the benefits of credit risk transfer are shown to be at least as high, or higher for banks with low quality loans.

Keywords: credit risk transfer, asymmetric information, banking, loan sales, loan insurance

JEL Classification Numbers: G21, G22, D82.

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1 Introduction

The growth in credit risk transfer (CRT), and specifically, credit derivatives since the mid-90s has been large. The estimated notional size of the CDS market in 1998 was 180 billion dollars, by 2004 this number had grown to 6 trillion, and by the end of 2008 it was 41 trillion dollars (Stulz 2009). Instruments such as bank loans, once virtually illiquid, can now have their risk stripped down and traded away. Indeed, how we view the role of banking institutions is fundamentally changing. With the credit crises of 2007-2009 weakening financial markets, credit risk transfer is fast becoming a topic that academics and practioners alike need to understand better.

In this paper we look at two methods for credit risk dissemination in the banking sector: loan insurance versus loan sales.[1] Duffee and Zhou (2001) gave us our first insight into how these two instruments can coexist. The authors show how credit derivatives can help alleviate the "lemons" problem that plagues the loan sales market and that it is possible that the introduction of credit derivatives could shut down the loan sales market. This paper builds on Duffee and Zhou (2001), but departs from it in two important ways. First, an assumption that is pivotal to their lemons result is that loan insurance is used when no informational asymmetries exist between the bank and the potential insurer. Recent empirical evidence by Acharya et al. (2007) suggests that banks are acting on their privileged information in credit default swaps (loan insurance) markets. In their analysis, they find significant information is revealed within these derivatives markets. This information revelation shows that asymmetric information is relevant in these markets. Thus, we extend the Duffee and Zhou framework by allowing for informational asymmetries in the credit default swap market. Second, Duffee and Zhou (2001) assume that loan insurance is written on the first period of a two period loan. This assumption is restrictive because it implies a maturity mismatch.[2] The Basel Committee on Banking Supervision (2005) found that supervisors penalize banks in terms of regulatory capital if there is a maturity mismatch. There are even cases where this practice would yield no regulatory capital relief at all. The Basel II and now Basel III agreements formalized this by only allowing maturity mismatches in some cases, but reducing the regulatory capital benefit of the hedge in those instances (see BIS (2005) for example). Therefore, we analyze the consequences for the credit derivatives (and sales) market when the insurance contract has the same maturity as the underlying loan.[3] The predictions of our model are significantly different

[1] A loan sale trades in the same way as the sale of any other type of asset: When a loan is sold, the future income stream as well as all default risk is taken off the sellers books (note that we are not considering a situation where the bank does not make a contractual guarantee about the loan's outcome, namely, we consider only loan sales without recourse). Consequently, we are assuming that there is no anti-assignment clause in the loan contract so that a loan sale is possible. Alternatively, in a loan insurance contract, the risk buyer agrees to cover the losses that take place if pre-defined events happen to the underlying firm. (In many cases, this event is the default of the underlying loan. However, some contracts also include things like re-structuring as a triggering event). In exchange for this protection, the risk shedder agrees to pay an ongoing premium. Therefore, the credit risk of the underlying loan is transferred from the risk-shedder's books, but the ownership of the loan still remains with its originator. The instrument we refer to as loan insurance in this paper most closely resembles a credit default swap contract. Note that these are two common and broad methods of risk transfer for banks. We will not attempt to put these two methods in the context of all possible risk transfer techniques, that is, we will not formulate a mechanism design problem in this paper.

[2] A maturity mismatch introduces an example of an additional risk referred to as basis risk.

[3] Although the maturity of the contract is the same, the loan still belongs to the bank. The no maturity mismatch

than Duffee and Zhou (2001) and will be discussed below.

In our model, the asymmetric information problem manifests itself as follows. First, through the unique relationship with the borrower, the bank may learn that a loan is of poor quality. Second, there may be another investment available, which, when combined with the original loan, may create a risk level that is unpalatable for the bank. We seek to differentiate the loan sales and loan insurance within the banking environment by concisely determining under what conditions one is advantageous to the other, and when each can be sustained in an equilibrium setting. In an agency model, where the institution that takes on the bank's risk does not know its quality, we find that two pooling equilibria can exist: one insurance and one sales. Determining when each pooling equilibrium is unique, we find that banks with low costs of capital will wish to exclusively use loan insurance. Alternatively, banks who must utilize more costly capital may need to turn to the loan sales market, even when there are relationship banking[4] and moral hazard concerns that can depress the selling price. The fact that uniqueness of the two possible pooling equilibria can be determined by the cost of capital relative to the severity of the moral hazard and relationship banking costs, constitutes the new predictions of our model, and the main contribution of this paper.

The intuition of our results is as follows. At time $t = 0$, a bank is endowed with a loan. At $t = 1$, the bank learns the loan type, and also learns whether a new investment is available. If the bank holds both the initial loan and new investment, they suffer an additional cost if both fail simultaneously. By allowing a bank to take on the new investment without suffering the this potential cost, CRT can achieve the efficient level of investment. Since the bank with a low quality loan is more likely to incur this cost, CRT is more beneficial to this party. In addition, without CRT, it is the bank with low quality loan that is more likely to forgo the new investment since the *expected* cost that will be incurred by taking on both the loan and new investment are higher.

If the bank uses CRT, it decides whether to use loan sales or loan insurance. The (risky neural and competitive) risk buyer then prices these contracts given the available information. If the perceived probability of default from the risk buyers' perspective is the same for both instruments, then a bank with a good loan would prefer to use insurance, since it need only secure the credit risk (in this case, the initial investment), and the return remains solely the bank's. However, a bank with a bad loan has no incentive to truthfully reveal loan quality by using sales. Therefore, only a pooling insurance, or pooling sales equilibrium can exist. We are left with identifying which pooling equilibrium will prevail. To do this, we extend the previous analysis to the more realistic case in which capital is costly, and where moral hazard and relationship banking issues are present in the bank-firm (loan) relationship. In this case, the results get more complicated, but the intuition is clear. With loan sales, the bank can have less incentive to continue to monitor the loan after a sale and could also lose some of the relationship it has built with the underlying firm. In loan insurance, the underlying firm need not know that an insurance contract was signed, so the relationship is

rule we introduce simply allows the bank to trade all of the credit risk away, instead of just a timed portion of it.

[4]Relationship banking refers to the unique bank-borrower relationship that is established through the course of a loan or loans.

unaffected. Furthermore, the incentive to monitor can decrease when credit risk transfer negatively affects the relationship. It is easy to see that if the relationship banking or moral hazard problems are severe, then the bank will have an incentive to use insurance regardless of the loan quality. However, since insurance requires an upfront premium from the bank, whereas sales does not, costly capital works in the opposite direction. If capital is particularly costly for the bank, it may be optimal to use sales, regardless of loan quality.

The literatures to which we contribute is that of credit risk transfer and banking. Gorton and Pennachhi (1995) provide an early and fundamental discussion of the moral hazard that can arise in loan sales, Duffee and Zhou (2001), on which we build our analysis, as well as Cerasi and Rochet (2008) extend this work and introduce credit derivatives as an instrument of risk transfer. These papers differ from outs in that they do not study the asymmetric information problem on loan insurance and loan sales. Parlour and Winton (2013) analyze the choice between loan sales and credit default swaps and address the tradeoff between efficiency of risk transfer and the optimal amount of monitoring. Although loan sales tend to dominate loan insurance, they find that loan insurance can be supported in equilibrium for safer credits when reputational concerns are considered. Our work differs in that we consider the interaction of the cost of capital with *how* the risk transfer contract is structured, i.e., loan insurance involves an upfront payment by the bank, while loan sales involves an inflow immediately. In addition, we consider the potential asymmetry in how the benefits of CRT accrue to the high and low quality types.

Chiesa (2008), Parlour and Plantin (2008), and Arping (2013) analyze credit risk transfer in terms of efficiency in the bank-borrower relationship. For example, Chiesa (2008) analyzes the optimal form of CRT in the presence of moral hazard and shows that portfolio insurance is optimal. Allen and Carletti (2006), and Wagner and Marsh (2005) consider the effect that credit risk transfer can have on the larger financial system. None of these papers consider how the asymmetric information problem over loan type interacts with the choice between loan sales and loan insurance as we do here.

The paper proceeds as follows. Section 2 outlines the model. Section 3 analyzes the model in the absence of CRT. Section 4 analyzes CRT in the base case with costless capital and no moral hazard/relationship banking problems. Section 5 analyzes these features, and in Section 6 we conclude. The appendix Section 7 contains non-trivial proofs.

2 The Model Setup

The model shares the following features with Duffee and Zhou (2001): There are three dates, indexed as $t = 0, 1, 2$. There are three types of agents: a bank (with corresponding investors), well diversified risk-taking counterparties (which we will refer to as risk buyers) behaving competitively and a firm (or entrepreneur) requiring capital for a project. The risk buying counterparty is risk neutral, while the bank, although maximizing a linear profit function will display risk aversion through an exogenous "regulation" parameter B to be explained below. The firm will be modelled simply as a production technology that can generate a fixed return or fail.

At time $t = 0$, the firm (entrepreneur) requests L_0 units of capital that yields a rate of return to the bank of $R_0 > 1$ if the firm's project succeeds at time $t = 2$.[5] The project is worth nothing if terminated at the interim period, $t = 1$. There are two types of projects: high quality and low quality, which are equally likely for the bank to draw. Define p_h (p_l) as the probability that a high (low) quality project defaults (and returns zero), with $1 > p_l > p_h$. We assume that the bank privately learns the quality of the project at time $t = 1$. Furthermore, we normalize the risk free rate in the economy to zero. We also assume that the projects have positive net present value (NPV) so that it makes sense that the bank would take on such a loan.

We depart from the Duffee and Zhou (2001) framework and consider that bank funding may not be costless. Investors in the bank will be willing to accept lower rates of return if the bank has sufficient equity to cover potential loss in case of default. If this cushion is not there, the risk to the investor is greater, and so a greater amount must be demanded from the bank representing the extra risk. We assume that the risk-buyer is not under this type of constraint.[6] This assumption can be relaxed so that the risk buyer does have a cost, but it is less than that of the bank.

Let there be two investors in the bank: an early investor, and a late investor.[7] The early investor is endowed with unlimited capital at time $t = 0$, but none at times $t = 1, 2$. We represent their preferences as in Allen and Gale (2005) with the following risk-neutral utility function:

$$U(c_0, c_1, c_2) = (R_f - 1)c_0 + c_1 + c_2$$

where $R_f - 1$ represents the rental rate of capital and c_t is the consumption at time t. One of the key insights from the functional form is that investors are indifferent between consumption at $t = 1$ and $t = 2$. Because of this, they will require the same return, $R_f - 1 > 0$, regardless of how long they loan the capital to the bank. The late investor is endowed with unlimited capital at time $t = 1$, but none at time $t = 2$. We represent their utility function as:

$$U(c_0, c_1, c_2) = (R_f - 1)c_1 + c_2.$$

This type of investor simply gives capital at time $t = 1$ and requires a return of $R_f - 1$ at time $t = 2$. Note that we have equalized the outside opportunity cost of each investor type for simplicity.[8] The rental rate of capital deserves some explanation. We use a rental rate to be consistent with the base case that we will pursue in which the bank owns its own capital ($R_f = 1$). Alternatively, we could modify the base case so that the bank does not own its capital, but need not pay a return on

[5] Note that in a previous version of the paper, we allowed the bank to choose the loan size (i.e., the loan size was endogenous), and the project could proceed on a different scale. Since we are able to obtain our results without this additional feature, we opt for the simplicity of making the loan size exogenous.

[6] This can be justified given our assumption that the risk buyer is well diversified.

[7] We will not analyze the choice between investor and depositor financing for the bank in this paper. We simply assume a rate of return that a bank must pay on any capital it uses.

[8] We have also assumed that the two types of investors cannot trade with each other. For example, they may be too small and dispersed so that the bank provides the only means of investment.

it. The results do not change with either way of treating the capital cost. Therefore, we assume the bank will return the principal after the final date, but for simplicity, and without loss of generality, we normalize the principal to zero. Note that we are implicitly assuming that the investment size and cost of capital are not related. For example, the initial investment size is not affected by the cost of capital.[9]

We add another new feature to the model by putting structure on the adverse selection problem. This departure is needed so that the prices can differentiate the two instruments to be introduced below. With no adverse selection in credit derivatives in Duffee and Zhou (2001), this structure was not needed. We add a new investment opportunity that becomes available to the bank with probability q at time $t = 1$ that is private information to the bank. This investment has a return $R_1 > 1$ at time $t = 2$ if it succeeds but returns nothing with probability p_N. L_1 is required to be invested to pursue this new project.[10] This investment represents the dynamic nature of banking. The bank does not know what new opportunities will arise in the future when a loan is issued now.[11]

There is ample evidence that maintaining capital reserves is an important factor in banks' decisions to engage in CRT. Pennacchi (1988) provides the argument that a prime incentive for loan sales is to boost a bank's capital ratio. Dahiya et al. (2003) and Cebenoyan and Strahan (2002) find empirical support for this prediction. To capture this capital consideration in a reduced form, we assume that the bank suffers a cost of $B > 0$ if its losses exceed some level, $\hat{L}$. We will address the interesting case in which $L_0 < \hat{L}$, but $L_0 + L_1 > \hat{L}$ (so a default of both the initial loan and new investment causes this cost to be incurred). B is a loss that can be unique to the banking environment. Because of the nature of their business, falling below certain levels of capital can be more costly for a bank than other types of institutions. One interpretation of B is the cost of fragility or even default of a bank. Alternatively, B could represent simply a regulatory penalty for a bank falling below a pre-determined level of capital.

Turning to the process of credit risk transfer, a risk buyer can insure the bank against losses in its original loan, or purchase that loan outright. Fitch (2005) reports that more than half of the credit derivatives traded remain in the banking system, with the next highest going to the insurance system, and the third highest to hedge funds. We model the risk buyer as simple and general as possible (a risk neutral party), and give no characteristics that distinguish it as any one of the three key players on the risk buying side. The risk buyer does not learn the quality of the firm (while the bank does), and does not learn whether the new investment is available to the bank, but knows it appears with probability q (alternatively, the risk buyer sees the new investment, but is not able to determine if it is profitable for the bank; rather, the risk buyer has

[9] Such an addition would complicate the analysis, and, provided the bank still wishes to use CRT as discussed below, our qualitative results will remain.

[10] As in the case of the initial investment, in a previous version of the paper, the size of the new investment was a choice variable. Again, we opt for the simplest formulation which yields our results and so let the investment size be fixed.

[11] Note that the model could easily be adapted to fit other reasons for which a bank may wish to reduce risk. For example, Parlour and Plantin (2008) use a private stochastic bank discount factor.

a prior belief that with probability q, it is profitable). Note that the firm only enters this model through a project that needs funding. We will assume that the quality of the firm is only deduced through the bank-firm relationship. The following figure presents the timing of the model.

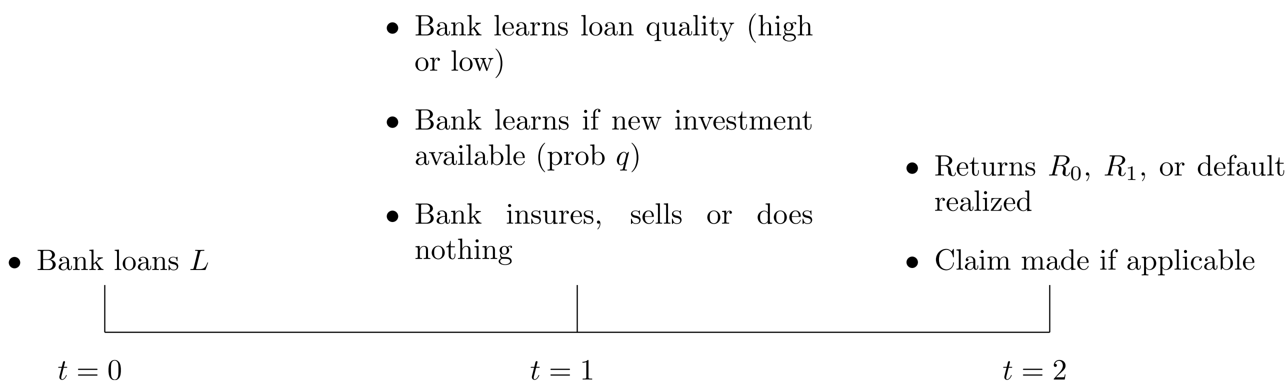

Figure 1: Timing of the Model

3 No CRT Available

We start with the benchmark case in which there are no CRT markets available. It is most instructive to proceed with the simplest case as possible, and then add features to show how it changes the results. Thus, we consider the base case where there no cost of capital for the bank, $R_f = 1$. We will consider costly capital in 5.1.

After the initial loan type is discovered, the bank has the choice at $t = 1$ whether to take on the new investment (if available). The following lemma details how that choice is made.

Lemma 1 *If the loan is discovered to be high (low) quality, the bank pursues the new investment whenever* $B \leq \frac{R_1 L_1 (1-p_N)}{p_N p_h}$ *(*$B \leq \frac{R_1 L_1 (1-p_N)}{p_N p_l}$*).*

Proof. *See appendix.*

Interpreting the condition from this lemma is relatively straightforward. The numerator represents the expected value of the new investment, conditional on it being available. We see that the lower the probability of default of the new investment, the higher B can be and still maintain incentive to pursue it. We also see that the inequality is decreasing in the probability of default of the high or low quality original loan. Alternatively, we can rearrange the condition to $p_j \leq R_1 L_1 (1 - p_N)/(p_N B)$, $j = \{h, l\}$ and the interpretation is simply that the new investment is pursued if and only if the old one is sufficiently safe.

4 CRT Available

With the availability of credit risk transfer markets, the risk buyer must price the loan sale or insurance premium, given the available information. The bank will wish to engage in credit risk transfer (CRT) if either it learns that the loan is of low quality, or the new investment becomes available. This can be assured by an assumption on B that will derived and discussed in Section 4.1. Given the available information, the risk buyer can deduce the probability that a loan is of high quality (h) or low quality (l):

$$Prob(h|CRT) = \frac{q}{q+1}$$

The risk buyer can now form a belief about the probability that the loan will default:

$$Prob(Default|CRT) = \frac{p_l + qp_h}{q+1}$$

We allow the bank to insure its initial investment, or sell the loan outright.[12] Because of the zero profit condition (competitive assumption), the risk buyer must be indifferent between insuring and not insuring, as well as selling and not selling. As in Duffee and Zhou (2001), we assume that the bank insures its initial investment L. If we allow the bank to insure less of their loan, i.e. partial insurance, this will not have any effects on the qualitative results of the paper, so long as the adverse selection problem is maintained. In other words, if the high type can reveal itself by insuring less of the loan, and still be protected from the cost B, the adverse selection problem would be solved. In the credit default swap market for example, this is not realistic since contract are non-exclusive and so separation based on contract size (i.e., a menu of contracts) is not possible as in Rothschild and Stiglitz (1976) for example. Therefore, the risk buyer will demand a premium of $L_0(\frac{p_l+qp_h}{q+1})$. Similarly, the risk buyer would be willing to purchase this loan for $R_0L_0(1-\frac{p_l+qp_h}{q+1})$. The latter is simply the expected payoff of the loan from the risk buyer's perspective.

It is worthwhile pointing out that if the risk buyer can observe the bank engaging in the new investment, the adverse selection problem can still be present so long as the new investment is available. In this case, the risk buyer will use its prior beliefs to determine the probability of default. When the new investment is not available, the risk buyer will know that the loan must be bad. In this paper, we are interested in the consequences for the insurance and sales market when adverse selection is present, so we rule out this revealing case by having the new investment be private information to the bank.

[12] Since the asymmetric information is on this asset, we focus on the most interesting case in which CRT is not available/used for the new investment. We could enrich the model to allow for CRT to be also occur with the new asset; however, it would only complicate the analysis without offering new additional insight into the problem that we study.

4.1 Incentives to engage in CRT

In the previous section we outlined how the risk buyer would price a loan sale or insurance premium under the information structure given. We now outline restrictions on the parameter space in which the bank uses CRT in the correct states. We begin by analyzing the incentives to insure, and then consider sales.

4.1.1 Incentives to Purchase Insurance

We begin by verifying that the bank will wish to purchase loan insurance in the appropriate states. We denote the state where a high (low) quality loan is realized as H (L), and the state where the new investment opportunity is realized (not realized) as NEW (NONEW). Therefore {H,NEW} represents a high quality firm and a new investment available.

It is straightforward to show that if the incentives are such that the bank insures in the high state, then this implies it will insure in the low state. We therefore need to check two states: {H,NEW} to make sure the bank wishes to insure, and {H,NONEW} to make sure it does not wish to insure. Let us analyze {H,NONEW} first. Let π_{NI} denote the bank's payoff from no insurance in the high state, π_I denote the payoff from insurance in the high state, and P_I denote the price per unit of the insurance contract, i.e., $P_I L_0$ is the insurance premium.

$$\pi_{NI} = R_0(1-p_h)L_0$$
$$\pi_I = R_0(1-p_h)L_0 - P_I L_0 + p_h L_0$$

From the above, for $\pi_{NI} \geq \pi_I$, $P_I \geq p_h$ must hold. We will refer to this condition as (I-Bound) and include it as a restriction in the optimization problem to be set out in section 4.3. We now analyze {H,NEW} to see under what condition the bank will use loan insurance.

$$\pi_{NI} = R_0(1-p_h)L_0 + (1-p_N)L_1R_1 - p_h p_N B$$
$$\pi_I = R_0(1-p_h)L_0 - (P_I)L_0 + p_h L_0 + (1-p_N)L_1R_1$$

For $\pi_I \geq \pi_{NI}$ the following condition must hold:

$$B \geq \frac{L_0(P_I - p_h)}{p_h p_N} \tag{1}$$

Since $P_I \geq p_h$ must hold, the R.H.S of (1) is positive, and so we place this restriction on B.

4.1.2 Incentives to Sell the Loan

We can conduct a similar exercise for loan sales. We begin by analyzing {H,NONEW}. Let π_{NS} denote the payoff from no loan sales, and P_S be the price per unit of a sales contract with a net return on the underlying loan of 1.[13]

$$\pi_{NS} = R_0(1-p_h)L_0$$
$$\pi_S = R_0(P_S)L_0$$

For $\pi_{NS} \geq \pi_S$, $P_S \leq 1-p_h$ must hold. As in the insurance case, this condition will be a constraint in our optimization problem. We will refer to this condition as (S-Bound).
We now analyze {H,NEW} to see under what condition the bank will use loan sales.

$$\pi_{NS} = R_0(1-p_h)L_0 + (1-p_N)L_1R_1 - p_Np_hB$$
$$\pi_S = R_0(P_S)L_0 + (1-p_N)L_1R_1$$

For $\pi_S \geq \pi_{NS}$ the following must hold:

$$B \geq \frac{R_0L_0(1-p_h-P_S)}{p_hp_N} \tag{2}$$

Therefore, (2) is the parametrization that we consider to allow loan sales to be possible in equilibrium. If we consider each market in isolation, we get $P_I = Prob(Default|insurance) = Prob(Default|sales) = 1-P_S$. Therefore, one can see that the only difference between (1) and (2) is a factor of R_0. The reason for this difference is intuitive when we look at how the two contracts are priced. Whereas the insurance premium is independent of the return on the initial investment, the sales contract involves an entitlement to the return in the future, and must depend on R_0. If R_0 is very high, B must also be high so that in {H,NEW} the bank still has an incentive to use CRT. It follows that both CRT markets exist when the following holds.

$$B \geq \max\{\frac{L_0(P_I-p_h)}{p_hp_N}, \frac{R_0L_0(1-p_h-P_S)}{p_hp_N}\} \tag{3}$$

So that we can make an assumption in terms of only exogenous assumptions, it is straightforward to show due to competitiveness of the risk buyer that the upper bound of P_I is p_l and the lower bound of P_S is $1-p_R$. Thus we make the following assumption.

Assumption 1 *To permit the existence of both CRT markets, we let* $B \geq \frac{R_0L_0(p_l-p_h)}{p_hp_N}$.

4.2 CRT Available - Either Loan Sales or Loan Insurance (but not both)

We being with the simple and intuitive results that loan sales and loan insurance have the same ex-ante expected payoffs. We denote the expected profit from the bank using loan insurance (sales) by $E(\pi_I)$ ($E(\pi_S)$).

[13] P_S is defined in this way to ease the comparison of loan sales to loan insurance. Therefore, the total price of the loan sale contract is $R_0L_0P_S$.

Lemma 2 *The expected payoff to the bank when using loan sales or loan insurance is*

$$E(\pi_I) = E(\pi_S) = \frac{1}{2}R_0L_0(1-p_h) + \frac{1}{2}R_0L_0(1-p_l) + q[(1-p_N)L_1R_1] \tag{4}$$

Proof. *See appendix.*

The right hand side of (4) shows that the expected payoff to the bank is simply the expected return from the initial loan ($\frac{1}{2}R_0L_0(1-p_h)+\frac{1}{2}R_0L_0(1-p_l)$) plus the expected return from the new investment ($q[(1-p_N)L_1R_1]$), regardless of which type of CRT is used. We are now equipped to show the main proposition of this section. The following proposition analyzes the use of CRT and its effect on investment choice. We refer to 'full investment' as the case in which the bank pursues the new investment.

Proposition 1

1. *CRT is ex-ante more profitable than without and always results in full investment.*
2. *When $R_0L_0(p_l - p_h) < R_1L_1(1-p_N)$, there exists a B such that CRT allows a bank with a low quality loan to achieve full investment, but has no affect on a bank with a high quality loan.*
3. *Under perfect information, the benefit of CRT is at least as high for the bank with low quality loan as for the bank with high quality loan.*

Proof. *See appendix.*

The intuition behind this proposition is that CRT allows the bank to pursue full investment without bearing the cost of B. There exists a parameter range under which a bank with safe loan would pursue full investment even without CDS, whereas a bank with risky loan would not. Then, the availability of CDS allows the efficient level of investment to be achieved for the risky type but has no affect on the safe type's decision (since that type achieves the efficient level without CDS).

It is obvious that with pooling, the bank with low quality loan can benefit more with CRT than the bank with high quality loan. This is because there is always a transfer from the high quality type to the low quality type when pooling occurs due to asymmetric information. This is true, however even when there is perfect information so that CRT is priced fairly for both high and low quality types. There are three cases to consider. First, when both types pursue full investment prior to the introduction of CRT, second, when only the bank with high quality loan pursues full investment, and finally, when both types under-invest (by not pursuing the new investment). In the first case, the low quality type has a higher benefit because this type is more likely to incur the cost B due to the lower quality initial loan. In the second case, the payoff to achieving full investment for the low quality type exceeds the benefit that eliminating the potential loss B has for the high quality type. In the final case, both types have the same benefit since the new investment is assumed identical for the two.

4.3 Both markets available - Equilibrium

The equilibrium concept we apply is that of a Bayesian Nash Equilibrium (BNE). Given Assumption 1, there are only two equilibria that can prevail when both CRT markets are open at the same time. The first equilibrium is where both types use loan insurance, while the second is where both types use loan sales. It is straightforward to rule out a separating equilibrium in which one bank type uses sales, while the other uses insurance. This was done formally in a previous version of the paper, however the intuition is clear: a bank with a low quality loan would always have the incentive to pool with the high quality bank by using the appropriate CRT instrument since they would receive an advantageous price.

4.3.1 Pooling Equilibrium with Insurance

Consider first the case where banks that have either high or low quality loans both choose to insure. Given the information structure in this pooling equilibrium, we know that $Prob(Default|insurance) = \frac{p_l+qp_h}{q+1}$. In this case we will have two participation constraints (I-PC1, I-PC2 - ensuring the bank with either the low or high type loans wishes to engage in CRT) and two incentive constraints (I-IC1, I-IC2 - ensuring that the bank with either the low or high type loans wish to use insurance over sales).[14] We can characterize the optimal prices (P_I,P_S) as follows:

$$(1-p_l)R_0L_0 - L_0P_I + p_lL_0 \geq (1-p_l)R_0L_0 \tag{I-PC1}$$

$$(1-p_h)R_0L_0 - L_0P_I + p_hL_0 + (1-p_N)L_1R_1 \geq R_0L_0(1-p_h) + (1-p_N)L_1R_1 - p_Np_hB \tag{I-PC2}$$

$$(1-p_l)R_0L_0 - L_0P_I + p_lL_0 \geq R_0L_0(P_S) \tag{I-IC1}$$

$$(1-p_h)R_0L_0 - L_0P_I + p_hL_0 + (1-p_N)L_1R_1 \geq R_0L_0(P_S) + (1-p_N)L_1R_1 \tag{I-IC2}$$

$$L_0(P_I - \frac{p_l+qp_h}{q+1}) = 0 \tag{zero-π}$$

$$P_I \geq p_h \tag{I-Bound}$$

$$P_S \leq 1-p_h \tag{S-Bound}$$

From (zero-π), we can see that the only admissible insurance premium is $P_I = \frac{p_l+qp_h}{q+1}$. At this price, (I-PC1) is satisfied, while (I-PC2) is satisfied by assumption 1.
From (I-IC1), we find:

$$P_S \leq (1-p_l) + \frac{q(p_l-p_h)}{(q+1)R_0} \tag{5}$$

Next, from (I-IC2), we find:

$$P_S \leq (1-p_h) - \frac{p_l-p_h}{(q+1)R_0} \tag{6}$$

[14]Recall that we need not check both the low type with and without the new investment as it is redundant.

Since $R_0 > 1$, $q \in (0,1)$ and $p_l < p_h$, it follows that (5)$\Rightarrow$ (6). Therefore, (5) defines the price range that can be assigned to loan sales to sustain this pooling equilibrium, and represents the off-the-equilibrium path beliefs that the risk-buyer assigns to the sales market that can support this pooling equilibrium.[15] It is easy to see that (I-Bound) and (S-Bound) are satisfied at the admissible values of P_I and P_S. Henceforth, if this equilibrium exists, we will refer to it as the *insurance equilibrium*.

4.3.2 Pooling Equilibrium with Loan Sales

Now consider both high and low types using loan sales. We know $Prob(No\ Default|CRT) = 1 - Prob(Default|CRT) = 1 - \frac{p_l+qp_h}{q+1}$. The optimal prices ($P_I$,$P_S$) must satisfy:

$$P_S R_0 L_0 \geq (1-p_l)R_0 L_0 \tag{S-PC1}$$

$$P_S R_0 L_0 + (1-p_N)L_1 R_1 \geq R_0 L_0(1-p_h) + (1-p_N)L_1 R_1 - p_N p_h B \tag{S-PC2}$$

$$P_S R_0 L_0 \geq (1-p_l)R_0 L_0 - LP_I + p_l L \tag{S-IC1}$$

$$P_S R_0 L_0 + (1-p_N)L_1 R_1 \geq (1-p_h)R_0 L_0 - L_0 P_I + p_h L_0 + (1-p_N)L_1 R_1 \tag{S-IC2}$$

$$1 - \frac{p_l+qp_h}{q+1} - P_S = 0 \tag{zero-π}$$

$$P_I \geq p_h \tag{I-Bound}$$

$$P_S \leq 1 - p_h \tag{S-Bound}$$

From (zero-π), we can see that $P_S = 1 - \frac{p_l+qp_h}{q+1}$. Given this, it is easy to verify that (S-PC1) is satisfied. As well, (S-PC2) is satisfied by assumption 1. Plugging the value for P_S into (S-IC1) yields:

$$P_I \geq p_l - R_0[\frac{q}{q+1}(p_l - p_h)] \tag{7}$$

Plugging P_S into (S-IC2) yields:

$$P_I \geq p_h + R_0[\frac{q}{q+1}(p_l - p_h)] \tag{8}$$

Since $R_0 > 1$, it follows that (8)$\Rightarrow$(7) and therefore, the insurance premium can take on any value in the range defined by the off-the-equilibrium path beliefs, (8). With the off-the-equilibrium path beliefs being defined by (8), it is straightforward to show that an appropriate upper bound is $P_I \leq p_l$, as discussed in the context of Assumption 1. Thus, $R_0 \leq \frac{q+1}{q}$ must hold for this pooling equilibrium to exist. We can see that if a project has a large return, then the bank will turn to the loan insurance market. It is easy to see that (I-Bound) and (S-Bound) are satisfied at the

[15]Note that equilibrium refinements like the Cho-Kreps Intuitive Criterion have no bite in this setting (and in all equilibria to be shown in this paper). Therefore, we are able to focus on all off-the-equilibrium path beliefs that sustain the pooling equilibrium.

admissible values of P_I and P_S. Henceforth, if this equilibrium exists, we will refer to it as the *sales equilibrium*.

Duffee and Zhou (2001) conclude that if a sales market exists, and a loan insurance market is introduced, pooling in the sales market may no longer be possible. This in turn would cause the break down of the sales market altogether. Since Duffee and Zhou (2001) have insurance being written on a portion of the loan with no adverse selection, they show that the sales market can break down because of the flexibility of loan insurance. Our model produces a similar result without the flexibility in insurance, but from an entirely different channel. Since the sales market can exist in isolation with $R_0 > \frac{q+1}{q}$, if insurance is introduced under these circumstances, pooling in the sales market would not be possible. This would cause the sales market itself to break down.

All other pure strategy equilibria can be ruled out in essentially the same way as was done above so the proofs are omitted. Note that for brevity, we ignore potential mixed strategy equilibria wherein there is randomization between loan sales and loan insurance.

5 Costly Capital, Moral Hazard, and Relationship Banking

An important point about having multiple equilibria is that there is no way of telling which will occur. To explore this further, we first consider the case in which $R_f > 1$. Second, we will introduce an exogenous cost due to moral hazard and relationship banking and explore this cost in isolation. Finally, we will combine these two features together to determine when each equilibrium can exist.

5.1 Costly Bank Capital: $R_f > 1$

We proceed by considering the case in which CRT is used so that the bank pursues full investment. We now turn to the expected (ex-ante) profit for the bank. Recall we derived the expressions (13) and (14) earlier without costly capital. We can calculate the expected costs of this additional feature. Denote the expected additional cost of insurance and sales with costly capital as $E(C_I)$ and $E(C_S)$ respectively.

$$\begin{aligned} E(C_I) &= \frac{1}{2}(1-q)(R_f-1)L_0 + q[(R_f-1)L_0 + (R_f-1)L_0P_I + (R_f-1)L_1] + \frac{1}{2}(1-q)(R_f-1)L_0 \\ &= (R_f-1)(L_0+qL_1) + (R_f-1)qL_0P_I \end{aligned}$$

$$\begin{aligned} E(C_S) &= \frac{1}{2}(1-q)(R_f-1)L_0 + q[(R_f-1)L_0 + (R_f-1)(L_1 - R_0L_0(P_S))] + \frac{1}{2}(1-q)(R_f-1)L_0 \\ &= (R_f-1)(L_0+qL_1) - (R_f-1)qR_0L_0P_S \end{aligned}$$

We can see that insurance is unambiguously more costly than sales. Thus, loan sales yields more profit (ex-ante) than loan insurance under costly capital. The intuition behind this result is that loan insurance forces the bank to obtain even more costly capital to engage in CRT ($(R_f-1)qL_0P_I$).

At the same time, loan sales allows the bank to free up capital (and reinvest the payoff from the sale) when it wishes to pursue the new investment ($-(R_f - 1)qR_0L_0P_S$).

5.2 Moral Hazard and Relationship Banking Costs

The relationship between a bank and a borrower can allows a moral hazard problem to develop. Consider a bank that has a special technology to verify that the firm is operating in a manner that is in keeping with the bank's interests. We refer to this as a monitoring technology. When the bank transfers away risk from a loan, it may no longer have the incentive to invest in this monitoring technology. In what follows, we will not analyze the origins of the moral hazard problem, but rather, we analyze the effect of its presence. In Appendix B (Section 7.2), we endogenize the moral hazard problem to show that that little lost having this problem exogenous in the model.

The second issue with CRT arises only with loan sales. In a loan sale, the underlying firm and new lender must expend resources to build a new relationship which can devalue the loan.[16] We will refer to this cost as *relationship banking*. In reality, the cost of selling a loan could go farther than just a devaluation of the current loan, as it could hurt future business with the underlying firm.[17] In some loan sale contracts, the underlying firm may even try to prevent a bank from selling their loan by specifying a no-sale stipulation. The costs associated with relationship banking are not generally applicable to loan insurance because the originating bank maintains ownership of the loan and need not inform the underlying firm of their intent to insure. It has been shown empirically that these costs are present in loan sales. With moral hazard and relationship banking costs, conditions can be set so that the bank strictly prefers loan insurance.

To consider the possibility that there are additional costs to using loan sales, we add an exogenous cost parameter $\alpha \in [0, 1]$. This new parameter represents the degree to which the project is worth less in the hands of the risk buyer due to both the moral hazard problem of the bank and the relationship banking cost incurred by the risk buyer. When α is low, the costs associated with selling are high, and the bank must take a significantly lower price for the loan sale if it wishes to pursue this instrument of CRT. For simplicity, we assume that moral hazard and relationship effects are not present in loan insurance; however, the qualitative results will follow through if we allow for moral hazard in the loan insurance market. However, since the originating bank is still tied to the return of the loan, we would expect moral hazard to be smaller with loan insurance.[18] This argument is formalized in Appendix B. If we consider a different setting where the bank maintains no ties to the return on the loan (i.e it insures both the principal and the return), then the moral hazard problem would be the same in insurance as in sales. However, α would still be larger for

[16] Dahiya et al. (2003) find that when a bank sells a loan, the market reacts negatively to it by devaluing the bank's stock.

[17] We will not model this channel here.

[18] Strictly speaking, we could include a parameter with loan insurance to represent a decrease in value of the investment due to moral hazard. In our case, we are most interested in when loan insurance leads to less devaluation, however if the relationship went the other way, the analysis would not change. In that case, it is obvious that loan sales would dominate loan insurance since this feature, as well as the cost of capital discussed in the last section would make loan sales more desirable.

loan insurance because of the relationship banking cost of loan sales. We can show the expected profit from loan sales. Again, we revert to the case in which $R_f = 1$ so that we can analyze this new feature in isolation.

$$E(\pi_S) \quad = \quad \frac{1}{2}R_0L_0[1-p_h(1-q(1-\alpha))] + \frac{1}{2}R_0L_0(1-\alpha p_l) + q[(1-p_N)L_1R_1]$$

Not surprisingly, the expected profit from loan sales is unambiguously lower than that of loan insurance (as determined in (13)) when $\alpha < 1$.

5.3 Costly Capital, Moral Hazard, and Relationship Banking Together

A similar exercise to that of section 4.1 can give us the following assumption that permits the existence of our CRT markets in our generalized framework. The derivation can be found in Appendix C (section 7.3).

Assumption 2 $B \geq max\{\frac{L_0(R_f(p_l)-p_h)}{p_Np_h}, \frac{R_0L_0((1-p_h)-\alpha(1-p_l)R_f)}{p_Np_h}\}$

As in the case of the base model, it is straightforward to rule out a separating equilibrium as was done in a previous version of this paper. Let us now consider the insurance pooling equilibrium where banks with both high and low type loans choose to insure. To differentiate, given the knife-edge case where the incentive compatibility constraints hold with equality, we assume the bank chooses insurance. This will make our incentive compatibility constraints in the sales equilibrium case strict. It can be shown that the incentive and participation constraints of the state {H,NEW} are implied by those in state {L,NEW} so we drop them. In what follows, we assume that the bank wishes to pursue full investment, as we did in the simpler case of the previous section. The optimal prices (P_I,P_S) are given by:

$$(1-p_l)R_0L_0 + p_lL_0 - (R_f-1)L_0 - R_fP_IL_0 \geq (1-p_l)R_0L_0 - (R_f-1)L_0 \qquad \text{(I-PC1)}$$

$$\begin{aligned}(1-p_l)R_0L_0 + p_lL_0 + (1-p_N)L_1R_1 - (R_f-1)L_0 - R_fP_IL_0 - (R_f-1)L_1 \geq \\ (1-p_l)R_0L_0 + (1-p_N)L_1R_1 - (R_f-1)L_0 - (R_f-1)L_1 - p_Np_lB\end{aligned} \qquad \text{(I-PC2)}$$

$$(1-p_l)R_0L_0 + p_lL_0 - (R_f-1)L_0 - R_fP_IL_0 \geq \alpha R_0L_0(P_S) - (R_f-1)L_0 \qquad \text{(I-IC1)}$$

$$\begin{aligned}(1-p_l)R_0L_0 + p_lL_0 + (1-p_N)L_1R_1 - (R_f-1)L_0 - R_fP_IL_0 - (R_f-1)L_1 \geq \\ \alpha R_0L_0(P_S) + (1-p_N)L_1R_1 - (R_f-1)L_0 - (R_f-1)[L_1 - (\alpha RP_SL_0)]\end{aligned} \qquad \text{(I-IC2)}$$

$$L_0(P_I - \frac{p_l + qp_h}{q+1}) = 0 \qquad \text{(zero-}\pi\text{)}$$

$$P_I \geq \frac{p_h}{R_f} \qquad \text{(I-Bound)}$$

$$\alpha P_S \leq 1 - p_h \qquad \text{(S-Bound)}$$

On the left hand side of (I-IC1) and (I-IC2), we see that with insurance, the bank holds the investment for two periods, and incurs a cost of $(R_f - 1)L$. As well, it borrows an additional L_0P_I for one period to pay for the cost of insuring, and incur a cost of $R_fL_0P_I$.

On the right hand side of (I-IC1) and (I-IC2), the cost of capital for loan sales deserves some explanation. The bank acquires the capital for the initial loan at a cost of $(R_f - 1)L$. At time $t = 1$, the bank need not borrow the full amount of capital for the new investment. This is because it can reinvest the proceeds of the loan sale. The cost of the extra capital that is needed for the new investment is $(R_f - 1)[L_1 - \alpha R_0 P_S L_0]$. For simplicity we assume that $L_1 \geq \alpha R_0 P_S L_0$.[19] This assumption is innocuous since we will soon see that our characterizing solutions do not depend on L_1.

Given (zero-π), we know that $P_I = \frac{p_l + q p_h}{q+1}$. (I-PC1) is satisfied when $R_f \leq \frac{p_l}{P_I}$, while (I-PC2) is implied by assumption 2. P_S is given by the off-the-equilibrium path beliefs of the risk buyer and can be defined given α and R_f. We obtain the following parameterizations for (I-IC1) and (I-IC2):

$$\alpha \leq \frac{R_0(1 - p_l) - R_f P_I + p_l}{R_0 P_S} \tag{I-IC1a}$$

$$\alpha \leq \frac{R_0(1 - p_l) - R_f P_I + p_l}{R_0 P_S R_f} \tag{I-IC2a}$$

Since (I-IC1a) and (I-IC2a) differ by a fraction $\frac{1}{R_F}$, it follows that (I-IC2) $\Rightarrow$ (I-IC1). Therefore, (I-IC2) is binding, while (I-IC1) is slack. We can use a standard approach to find out when this equilibrium cannot exist. We let the off-the-equilibrium path beliefs be $P_S = 1 - p_l$. Therefore, if the equilibrium cannot exist under this condition, it cannot exist for any valid off-the-equilibrium path belief. Substituting $P_S = 1 - p_l$ into (I-IC2) yields this range:

$$\alpha > \frac{R_0(1 - p_l) - R_f P_I + p_l}{R_0(1 - p_l) R_f}$$

We continue by analyzing when the equilibrium can exist.

Lemma 3 *The insurance equilibrium exists whenever one of the following two conditions is met*

1. $\alpha < \frac{P_I(1-p_l)}{P_S p_l}$ *and* $1 \leq R_f \leq \frac{p_l}{P_I}$
2. $\alpha > \frac{P_I(1-p_l)}{P_S p_l}$ *and* $1 \leq R_f \leq \frac{R_0(1-p_l)+p_l}{\alpha R_0 P_S + P_I}$

Proof. *See appendix.*

The results of this lemma are relatively straight-forward. The first condition says that if α is small, then the insurance equilibrium will exist when R_f (low cost of capital) is sufficiently small. The second condition says if α is larger, we will require an even smaller value of R_f than what was required in the first condition.

We can conduct a similar exercise for the sales equilibrium. The participation and incentive constraints of state {L,NEW} are implied by those of state {H,NEW} and are dropped. The

[19] This assumption is equivalent to the assumption that the bank has a storage technology with a return of 1.

following setup will yield the optimal prices (P_I,P_S):

$$\alpha P_S R_0 L_0 - (R_f - 1)L_0 \geq (1 - p_l)R_0 L_0 - (R_f - 1)L_0 \tag{S-PC1}$$

$$\begin{aligned} \alpha P_S R_0 L_0 - (R_f - 1)L_0 + (1 - p_N)L_1 R_1 - (R_f - 1)[L_1 - (\alpha R P_S L_0)] \geq \\ (1 - p_h)R_0 L_0 + (1 - p_N)L_1 R_1 - (R_f - 1)L_0 - (R_f - 1)L_1 - p_N p_h B \end{aligned} \tag{S-PC2}$$

$$\alpha P_S R_0 L_0 - (R_f - 1)L_0 > (1 - p_l)R_0 L_0 + p_l L_0 - (R_f - 1)L_0 - R_f P_I L_0 \tag{S-IC1}$$

$$\begin{aligned} \alpha P_S R_0 L_0 - (R_f - 1)L_0 + (1 - p_N)L_1 R_1 - (R_f - 1)[L_1 - (\alpha R P_S L_0)] > \\ (1 - p_h)R_0 L_0 + p_h L_0 + (1 - p_N)L_1 R_1 - (R_f - 1)L_0 - R_f P_I L_0 - (R_f - 1)L_1 \end{aligned} \tag{S-IC2}$$

$$R_0 L_0[\alpha(1 - \frac{p_l + q p_h}{q + 1}) - \alpha P_S] = 0 \tag{zero-π}$$

$$P_I \geq \frac{p_h}{R_f} \tag{I-Bound}$$

$$\alpha P_S \leq 1 - p_h \tag{S-Bound}$$

From (zero-π) we know that $P_S = 1 - \frac{p_l + q p_h}{q+1}$. (S-PC1) holds when $\alpha \geq \frac{1-p_l}{P_S}$, while (S-PC2) holds by assumption 2. P_I is given by the off-the-equilibrium path beliefs of the risk buyer and can be defined given α and R_f. We can find a parametrization in terms of α for (S-IC1) and (S-IC2):

$$\alpha > \frac{R_0(1 - p_l) + p_l - R_f P_I}{R_0 P_S} \tag{S-IC1b}$$

$$\alpha > \frac{R_0(1 - p_h) + p_h - R_f P_I}{R_f R_0 P_S} \tag{S-IC2b}$$

Using the same method as in the insurance case, we can determine when the sales equilibrium cannot exist. By substituting $P_I = p_l$ as the off-the-equilibrium path belief into (S-IC1b) and (S-IC2b), we can obtain the range for which sales cannot exist (if either one of the following two conditions are met):

$$\alpha \leq \frac{R_0(1 - p_l) + p_l - R_f p_l}{R_0 P_S} \tag{9}$$

$$\alpha \leq \frac{R_0(1 - p_h) + p_h - R_f p_l}{R_f R_0 P_S} \tag{10}$$

The following Lemma gives the formal conditions for when the sales equilibrium exists.

Lemma 4 *The sales equilibrium exists whenever one of the following three conditions is met*

1. $\alpha \geq \frac{1-p_l}{P_S}$ *and* $R_f > \max\{\frac{R_0(1-p_h)+p_h}{(1-p_l)R_0+P_I}, \frac{p_l}{P_I}\}$
2. $\frac{R_0(1-p_h)+p_h}{P_I+R_0 P_S} < R_f \leq \frac{R_0(1-p_h)+p_h}{(1-p_l)R_0+P_I}$ *and* $\alpha > \frac{R_0(1-p_h)+p_h-R_f P_I}{R_f R_0 P_S} \geq \frac{R_0(1-p_l)+p_l-R_f P_I}{R_0 P_S}$
3. $\frac{R_0(1-p_l)+p_l-R_0 P_S}{P_I} < R_f \leq \frac{p_l}{P_I}$ *and* $\alpha > \frac{R_0(1-p_l)+p_l-R_f P_I}{R_0 P_S} \geq \frac{R_0(1-p_h)+p_h-R_f P_I}{R_f R_0 P_S}$

Proof. *See appendix.*

The first condition says that so long as α and R_f are sufficiently high, then this equilibrium can exist. The second two conditions simply say that if we force α to be even higher than the first condition, then we can sustain this equilibrium for lower costs of capital (smaller values of R_f).[20] When we combine this lemma with that of Lemma 3, Proposition 2 will show that the bank will tend to rely on loan insurance when α is low or R_f is close to one. For example, it could be that banks have a low cost of capital and/or the moral hazard or relationship banking concerns are troublesome in the loan sales market. When α is low and R_f is high, both markets may not exist. By assumption 2, we can rule out the case where a bank with one type of loan wishes not to participate. We can fix this idea by defining a particular off-the-equilibrium path belief in each of these two equilibria. In the insurance case, we set $P_S = 1 - \frac{p_l + qp_h}{q+1}$, and for the sales case we set $P_I = \frac{p_l + qp_h}{q+1}$, which both satisfy the Cho-Kreps intuitive criterion. The following proposition shows under this off-the-equilibrium path belief, the choice between insurance and sales is unique.

Lemma 5 *Under the off-the-equilibrium path beliefs assigned, the equilibrium is uniquely determined by R_f and α as either insurance, sales or neither.*

Proof. *See appendix.*

We can now give our main result of the section. The following proposition states that when capital is relatively cheap, then the insurance equilibrium can be supported when there is sufficient moral hazard/relationship banking costs. Conversely, when the moral hazard/relationship banking costs are low, the sales equilibrium can be supported for sufficiently high costs of capital. The proof of this proposition follows easily from Lemmas 3 and 4. We can obtain uniqueness of the equilibrium from Lemma 5.

Proposition 2

1. *When the cost of capital is low, the bank will use insurance when α is sufficiently small.*

2. *When the costs of moral hazard/relationship banking are low, the bank will use sales when R_f is sufficiently high.*

The reason for this result has been discussed earlier, but will be reiterated for clarity. The bank may choose sales over insurance when the cost of capital is high because insurance requires an upfront payment, whereas sales frees up capital immediately. Conversely, since the moral hazard and relationship banking problems will tend to be worse for loan sales, the bank will use insurance when these costs are high.

[20]Note that in the second two conditions, one must be careful as the lower bound on R_f cannot be smaller than 1.

6 Conclusion

We use a model where CRT arises because of two factors: first, a bank can use CRT to dump low quality loans, and second, a bank can use CRT when its total risk exceeds a pre-determined level. We show that in the basic setup with no moral hazard or relationship banking costs, only an insurance or sales pooling equilibrium can exist. To determine the conditions under which either equilibrium can be the unique outcome, we extend the model to allow for costly capital, moral hazard and relationship banking issues. We find that banks with a low cost of capital will use loan insurance in the presence of moral hazard and relationship costs of loan sales. Finally, we show that if the bank has a high cost of capital, so that capital is very costly, it may be forced into the loan sales market even in some cases where the loan sale price could be significantly depressed.

An interesting extension of this model is to consider counterparty risk. In comparing loan sales to loan insurance, it is obvious that loan sales are not affected by such risk since no ties remain the counterparty. In this paper, the results boil down to two key factors: bank capitalization and moral hazard/relationship banking costs. The latter cost, if sufficient high, was what made loan insurance more attractive. If we assume that moral hazard/relationship banking issues are no more prevalent in loan sales than insurance (or are worse in loan insurance), we could then analyze a new tradeoff. The choice between insurance and sales would be driven by the relative costs of bank capital and potential cost of counterparty risk.

7 Appendix

7.1 Appendix A

Proof of Lemma 1

We consider the two states in which the bank may want to avoid investment in the new project separately: {H,NEW} (the project is of the high type, and the new investment is available) and {L,NEW} (the project is of the low type, and the new investment is available). We begin by looking at {H,NEW} and finding the range of B where the bank will wish to pursue the new investment:

$$\begin{aligned} R_0L_0(1-p_h)+R_AL_1(1-p_N)-p_Np_hB &\geq R_0L_0(1-p_h) \\ \Rightarrow B &\leq \frac{R_AL_1(1-p_N)}{p_Np_h} \end{aligned} \tag{11}$$

We now derive the condition for full new investment in the state {L,NEW}:

$$\begin{aligned} R_0L_0(1-p_l)+R_AL_1(1-p_N)-p_Np_lB &\geq R_0L_0(1-p_l) \\ \Rightarrow B &\leq \frac{R_AL_1(1-p_N)}{p_Np_l} \end{aligned} \tag{12}$$

Because $p_l > p_h$ (12) $\Rightarrow$ (11), and thus (12) is the only parametrization needed to ensure the new investment is pursued when it is available. ■

Proof of Lemma 2 If the bank uses insurance to reduce credit exposure the expected payoff is:

$$\begin{aligned} E(\pi_I) &= (\frac{1}{2})(1-q)[(1-p_l)R_0L_0+p_lL_0-L_0(\frac{p_l+qp_h}{q+1})] \\ &+ (\frac{1}{2})(q)[(1-p_l)R_0L_0+p_lL_0-L_0(\frac{p_l+qp_h}{q+1})+(1-p_N)L_1R_1] \\ &+ (\frac{1}{2})(q)[(1-p_h)R_0L_0+p_hL_0-L_0(\frac{p_l+qp_h}{q+1})+(1-p_N)L_1R_1] \\ &+ (\frac{1}{2})(1-q)[(1-p_h)R_0L_0] \\ &= \frac{1}{2}R_0L_0(1-p_h)+\frac{1}{2}R_0L_0(1-p_l)+q[(1-p_N)L_1R_1] \end{aligned} \tag{13}$$

If the bank uses sales to reduce credit exposure the expected payoff is:

$$\begin{aligned} E(\pi_S) &= (\frac{1}{2})(1-q)[R_0L_0(1-\frac{p_l+qp_h}{q+1})] \\ &+ (\frac{1}{2})(q)[L_0R_0(1-\frac{p_l+qp_h}{q+1})+(1-p_N)L_1R_1] \\ &+ (\frac{1}{2})(q)[L_0R_0(1-\frac{p_l+qp_h}{q+1})+(1-p_N)L_1R_1] \\ &+ (\frac{1}{2})(1-q)[(1-p_h)R_0L_0] \\ &= (\frac{1}{2})R_0L_0(1-p_h)+(\frac{1}{2})R_0L_0(1-p_l)+q[(1-p_N)L_1R_1] \end{aligned} \tag{14}$$

The equivalence of (13) and (14) has been established. ■

Proof of Proposition 1

We give the expected, ex-ante profits of a bank that does not pursue the new investment in {H,NEW} (denoted by NEW_H), {L,NEW} (denoted by NEW_L) or both (denoted by NONEW).

$$\begin{aligned} E(\pi^{NONEW}_{L_0=L}) &= \frac{1}{2}(1-p_h)R_0L_0 + \frac{1}{2}(1-p_l)R_0L_0 && (15)\\ E(\pi^{NEW_H}_{L_0=L}) &= \frac{1}{2}(1-p_h)R_0L_0 + \frac{1}{2}(1-p_l)R_0L_0 + \frac{1}{2}q(1-p_N)L_1R_1 - \frac{1}{2}qp_Np_hB && (16)\\ E(\pi^{NEW_L}_{L_0=L}) &= \frac{1}{2}(1-p_h)R_0L_0 + \frac{1}{2}(1-p_l)R_0L_0 + \frac{1}{2}q(1-p_N)L_1R_1 - \frac{1}{2}qp_Np_lB && (17)\end{aligned}$$

Comparing (15), (16) and (17) with (13), we see that CRT also ensures that the new investment will be pursued. Comparing the expected profit from full investment under CRT and no CRT, we immediately see that the use of CRT is always more profitable for the bank.

For the second part of the proposition, the following condition ensures that the low quality type does not pursue full investment without CRT, while the high quality type does.

$$\frac{R_1L_1(1-p_N)}{P_Np_l} \le B < \frac{R_1L_1(1-p_N)}{P_Np_h} \tag{18}$$

The sufficient condition so that both types use CRT in assumption 1 is:

$$B \ge \frac{R_0L_0(p_l-p_h)}{P_Np_h} \tag{19}$$

Thus, when $R_0L_0(p_l-p_h) < R_1L_1(1-p_N)$, there exists a B such that (18) and (19) are both satisfied.

For the final part of the proposition, we consider the payoffs for the low and high type bank at $t=1$ when CRT is introduced. *Case 1:* both types pursue the new investment prior to the introduction of CRT. The benefit of CRT for the low type is p_lp_NB which is greater than that of the high type p_hp_NB since $p_l > p_h$. *Case 2:* the low type does not take on the new investment as in part two of the proposition, while the high type fully invests. The benefit of CRT for the low type is $(1-p_N)L_1R_1$ while the benefit of the high type yields p_hp_NB. Combining the two yields the condition under which the low type benefits more from CRT:

$$B < \frac{R_1L_1(1-p_N)}{P_Np_h}, \tag{20}$$

which in this case must be satisfied because of (18). *Case 4:* both types do no take on the new project. The benefit of CRT for both is the same, $(1-p_N)L_1R_1$. ■

Proof of Lemma 3

There are two cases that we need to consider since the binding constraint will depend on the parameters of the model.

The first condition is derived assuming that (I-PC1) is the binding constraint. We then put the necessary restriction on (I-IC2) to make (I-PC1) bind.

$$\frac{R_0(1-p_l)+p_l}{\alpha R_0 P_S + P_I} > \frac{p_l}{P_I}$$
$$\Rightarrow \alpha < \frac{P_I(1-p_l)}{P_S p_l}$$

The second condition assumes (I-IC2) binds. We put the necessary restriction on R_f from (I-PC1) to make sure this is the case.

$$\frac{p_l}{P_I} > \frac{R_0(1-p_l)+p_l}{\alpha R_0 P_S + P_I}$$
$$\Rightarrow \alpha > \frac{P_I(1-p_l)}{P_S p_l}$$

■

Proof of Lemma 4

There are three cases that we need to consider since the binding constraint will depend on the parameters of the model.

The first condition is derived assuming that (S-PC1) is the binding constraint. We find the range of R_f such that the R.H.S of (S-IC1b) and (S-IC2b) are less than $\frac{1-p_l}{P_S}$.

$$\frac{R_0(1-p_l)+p_l-R_f P_I}{R_0 P_S} < \frac{1-p_l}{P_S}$$
$$\Rightarrow R_f > \frac{p_l}{P_I}$$

$$\frac{R_0(1-p_h)+p_h-R_f P_I}{R_f R_0 P_S} < \frac{1-p_l}{P_S}$$
$$\Rightarrow R_f > \frac{R_0(1-p_h)+p_h}{(1-p_l)R_0+P_I}$$

The second condition assumes that (S-IC2b) binds. The condition on R_f allows the R.H.S of (S-IC2b) to be less than $\frac{1-p_l}{P_S}$. The second condition results because for (S-IC2b) to bind, the R.H.S of (S-IC2b) must be greater than the R.H.S of (S-IC1b).

$$\frac{R_0(1-p_h)+p_h-R_f P_I}{R_f R_0 P_S} \geq \frac{1-p_l}{P_S}$$
$$\Rightarrow R_f \leq \frac{R_0(1-p_h)+p_h}{(1-p_l)R_0+P_I}$$

To obtain a lower bound on R_f, we need to make sure that the value or R_f is not so low as to require $\alpha > 1$. To this we compute:

$$\frac{R_0(1-p_h)+p_h-R_fP_I}{R_fR_0P_S} \leq 1$$
$$\Rightarrow R_f \geq \frac{R_0(1-p_h)+p_h}{P_I+R_0P_S}.$$

The third condition assumes that (S-IC1b) binds. The condition on R_f allows the R.H.S of (S-IC1b) to be less than $\frac{1-p_l}{P_S}$. The second condition results because for (S-IC1b) to bind, the R.H.S of (S-IC1b) must be greater than the R.H.S of (S-IC2b).

$$\frac{R_0(1-p_l)+p_l-R_fP_I}{R_0P_S} \geq \frac{1-p_l}{P_S}$$
$$\Rightarrow R_f \leq \frac{p_l}{P_I}$$

To obtain a lower bound on R_f, we need to make sure that the value or R_f is not so low as to require $\alpha > 1$. To this we compute:

$$\frac{R_0(1-p_l)+p_l-R_fP_I}{R_0P_S} \leq 1$$
$$\Rightarrow R_f \leq \frac{R_0(1-p_l)+p_l-R_0P_S}{P_I}.$$

■

Proof of Lemma 5

Plugging in $P_S = 1 - P_I$ into (I-IC1a), (S-IC1b) and (S-IC2b). If (S-IC1b) is the binding constraint for the sales equilibrium, then the set $S\left(\alpha|\text{(I-IC1a)} \cap \text{(S-IC1b)}\right)$ is empty. This implies that sales and insurance are mutually exclusive. Furthermore, we can see that in this case, either of the two cases must occur. If (S-IC2b) is the binding constraint for the sales equilibrium, so that $\frac{R_0(1-p_l)+p_l-R_fP_I}{R_0P_S} < \frac{R_0(1-p_h)+p_h-R_fP_I}{R_fR_0P_S}$, then the set $S\left(\alpha\middle|\frac{R_0(1-p_l)-R_fP_I+p_l}{R_0P_S} < \alpha \leq \frac{R_0(1-p_h)+p_h-R_fP_I}{R_fR_0P_S}\right)$ is non-empty so that neither the insurance nor sales equilibrium exists. Furthermore, it is easy to see that the insurance and sales equilibrium cannot co-exist in this case. ■

7.2 Appendix B

Consider a bank with access to an unverifiable monitoring technology at time $t = 1$ that has a cost, e. Let us assume that without this monitoring, all low quality loans will fail with probability 1.[21] Consider the case in which there is no CRT available. To ensure that the bank wishes to

[21] The qualitative results follow through if we make the assumption that bank monitoring can transform low quality loans into high quality loans.

monitor, the following condition must hold:

$$e \leq R_0 L_0 (1 - p_l)$$

Next, consider the case of loan insurance. There is a trade-off present with this new monitoring technology. The bank can choose not to monitor, but give up the potential return from the low quality loans.[22] We can put the following assumption on e to ensure that it wishes to continue monitoring in the low state when the loan is insured.

$$\begin{aligned} R_0 L_0 (1 - p_l) + p_l L_0 - e &\geq L_0 \\ \Rightarrow e &\leq (R_0 - 1)(1 - p_l) \end{aligned}$$

Finally, if the bank wishes to use loan sales, it can never credibly commit to monitoring the bad loans for any $e > 0$. Therefore, the price of the loan sale will simply be $R_0 L_0 [1 - Prob(Default|sales)] = R_0 L_0 [1 - \frac{1+qp_h}{q+1}]$. We can see immediately that this new loan sales price is smaller than the original price without moral hazard. We therefore use the exogenous variable α to represent the amount that the loan sale price is reduced with moral hazard present.[23] Intuitively, if $\alpha < 1$, all else equal, the bank may not wish to use loan sales and the market may not exist. For example, consider the participation constrain in the state {L,NONEW} of the sales equilibrium:

$$\alpha P_S R_0 L_0 \geq (1 - p_l) R_0 L_0$$

It follows that if $\alpha < \frac{1-p_l}{P_S}$, the participation constraint can never be satisfied, and therefore the loan will not be sold in this state.

7.3 Appendix C

We now consider the resulting equilibrium when moral hazard, relationship banking and costly capital are added to the analysis. We begin the analysis by redefining the parameter space of interest. We turn to the state {H,NONEW} first.

$$\pi_{NI} = R_0 (1 - p_h) L_0 - (R_f - 1) L_0$$
$$\pi_I = R_0 (1 - p_h) L_0 + p_h L_0 - (R_f - 1) L_0 - R_f L_0 P_I$$

It follows that for $\pi_{NI} \geq \pi_I$, the condition $P_I \geq \frac{p_h}{R_f}$ must be added to the optimization problem as (I-Bound). We now analyze {H,NEW} to see under what condition the bank will use loan

[22] If the bank chooses to not monitor the bad loans we know that $Prob(Default) = \frac{1+qp_h}{q+1}$.

[23] Gorton and Pennachhi (1995) and DeMarzo and Duffie (1999) show that if the bank retains a portion of the loan (usually first-loss), the moral hazard can be lowered. A modern example is that of a Collateralized Loan Obligation (CLO). We will not consider tranching in this paper.

insurance.

$$\begin{aligned}\pi_{NI} &= R_0(1-p_h)L_0-(R_f-1)L_0+(1-p_N)L_1R_1-p_Np_hB-(R_f-1)L_1\\ \pi_I &= R(1-p_h)L_0+p_hL_0+(1-p_N)L_1R_1-(R_f-1)L_0-R_fP_IL_0-(R_f-1)L_1\end{aligned}$$

For $\pi_I \geq \pi_{NI}$ the following must hold:

$$B \geq \frac{L_0(R_fP_I-p_h)}{p_Np_h} \tag{21}$$

Therefore, (21) gives us the parameter bound on B. To find a similar bound for loan sales, we begin by looking at {H,NONEW}.

$$\begin{aligned}\pi_{NS} &= R_0(1-p_h)L_0-(R_f-1)L_0\\ \pi_S &= \alpha R_0(P_S)L_0-(R_f-1)L_0\end{aligned}$$

For $\pi_{NS} \geq \pi_S$, we will add $\alpha P_S \leq 1-p_h$ to our optimization problem as (S-Bound). We now analyze {H,NEW} to see under what condition the bank will use loan sales:

$$\begin{aligned}\pi_{NS} &= R_0L_0(1-p_h)-(R_f-1)L_0+(1-p_N)L_1R_1-(R_f-1)L_1-p_hp_NB\\ \pi_S &= \alpha R_0L_0(P_S)+(1-p_N)L_1R_1-(R_f-1)L_0-(R_f-1)[L_1-\alpha R_0P_SL_0]\end{aligned}$$

From above, for $\pi_S \geq \pi_{NS}$, the following must hold:

$$B \geq \frac{R_0L_0((1-p_h)-\alpha P_SR_f)}{p_Np_h} \tag{22}$$

The parametrization that characterizes loan sales is given by (22). Using the upper bound of P_I as p_l and the lower bound of P_S is $1-p_R$, the parametrization which can allow the potential for both markets to exist is then that which is given in assumption 2.

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