Credit Risk Transfer in Banking Markets with Hard and Soft Information[†]

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Abstract:

We present a banking model with imperfect competition in which borrowers' access to credit is improved when banks are able to transfer credit risks. However, the market for credit risk transfer (CRT) works smoothly only if loans are based on hard (verifiable) information. When information is soft, banks have an incentive to grant unprofitable loans in order to transfer them to other parties, leading to an increase in aggregate risk. Nevertheless, the introduction of CRT generally leads to an increase in welfare in our setup. However, the combination of CRT with soft information and highly competitive banking markets is detrimental.

Keywords: Credit risk transfer, credit derivatives, hard and soft information, access to credit, bank competition.

JEL-Classification: G21, L11, G13.

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1 Introduction

In the years before the current subprime crisis, many countries have seen an explosion in the use of instruments for credit risk transfer (CRT) by financial institutions. At that time, this development was welcomed by many observers. Most prominently, it was argued that CRT leads to a desirable redistribution and better diversification of credit risks (see, e. g., Allen and Gale, 2005). Another advantage is the potential of CRT to improve the access to credit for firms and households (or, put differently, the ability of banks to "free up" regulatory capital; see, e. g., Chiesa, 2006).[1] However, the advent of the subprime crisis has raised doubts about the overall benefits of credit risk transfer. The recent experience suggests that CRT may also lead to a deterioration of loan quality, with detrimental consequences for financial stability.

From a theoretical perspective, this decline in loan quality did not come unexpectedly. The early literature on credit risk transfer emphasized the reduced monitoring incentives of banks, once a loan has been transferred to a third party (see, e. g., Pennacchi, 1988; Gorton and Pennacchi, 1995).[2] However, recent empirical findings also suggest that there has been an expansion of loans that were unprofitable from the very beginning.[3] Many of the loans granted during the credit boom preceding the subprime crisis were of such a bad quality that banks must have known of the poor loan quality when the loan was granted (an extreme example are the notorious "ninja" loans). It seems that banks knowingly granted unprofitable loans, just to transfer them to other parties. In addition, the decrease in lending standards on the eve of the subprime crisis has been shown to be related to the market structure in the banking sector: Dell'Ariccia, Igan, and Laeven (2008) show that loan denial rates decreased more in areas with highly competitive local financial markets and that the market entry of new financial institutions induced a further decrease in lending standards. The role of banking competition in the presence of credit risk transfer has to our knowledge not yet been dealt with in the theoretical literature.

[1]For an excellent survey on credit risk transfer, see Duffie (2007).

[2]Other papers dealing with the effects of CRT on monitoring incentives include Morrison (2005), Chiesa and Bhattacharya (2007), Parlour and Plantin (2008), and Cerasi and Rochet (2008). See Ashcraft and Santos (2008) for empirical evidence.

[3]Dell'Ariccia, Igan, and Laeven (2008) document a decline in loan denial rates, especially in regions with higher securitization rates. Keys, Mukherjee, Seru, and Vig (2008) show that loans eligible for securitization defaulted much more frequently than loans with similar observable risk characteristics that were not eligible for CRT.

Our paper models banks' moral hazard problem in the *origination* of loans and shows how it is affected by the degree of competition in the banking sector. We start from a banking model with imperfect competition, in which the access of risky, but profitable borrowers to bank credit is constrained due to banks' limited risk-bearing capacities. Such constraints may arise from regulatory constraints, bankruptcy costs, or bankers' risk aversion. We show that the credit constraints are especially tight if banking markets are highly competitive. The reason is that the rents from relatively safe loans, which can serve as a buffer for riskier activities, will be small in the presence of fierce competition.

We then show that such credit constraints may be relaxed by allowing banks to transfer risks to outside investors. However, the functioning of CRT markets depends crucially on the type of information on which bank loans are based. If loans are granted on the basis of "hard," i. e. verifiable, information, a transfer of credit risk works smoothly and the access to credit for risky, but profitable borrowers is improved. Since the information is hard, there is no moral hazard problem at the originating bank. The bank does not have an incentive to extend unprofitable loans because nobody will be willing to insure the risks from such loans. Hence, CRT is desirable from a welfare perspective.

If, however, loans are granted on the basis of "soft," i. e. non-verifiable, information, the transfer of credit risks is hampered by problems of asymmetric information. If credit insurers cannot verify a loan's quality, banks have an incentive to grant unprofitable loans and to transfer the risks from these loans to the insurers. This is anticipated by the credit insurers who will demand a lemons premium for credit risk transfer. CRT generally still improves the access to finance for risky, but profitable borrowers, but it also improves the access to finance for unprofitable borrowers. As a result, the aggregate risk in the economy increases. If the problems of asymmetric information are too severe, the CRT market breaks down. Note that, in our model, the overall welfare effect of CRT is positive even with soft information. The reason is that the positive welfare effects from a better access to finance for profitable borrowers overcompensate the welfare losses from financing projects with negative net present values (NPV).

We show further that competition generally reinforces the positive effects of credit risk transfer: The higher competition in the banking sector, the better is the access to credit. However, with soft information, an increase in competition may be detrimental when the loan market for profitable loans is saturated. Then, a further increase in competition only improves the access to credit for unprofitable borrowers. This last finding coincides nicely with the observations from the current crisis: During the late years of the credit boom preceding the crisis, it appears that most of the newly extended loans were of a relatively poor quality. At the same time, these years saw an increase in competition through the market entry of new financial institutions (see Dell'Ariccia, Igan, and Laeven, 2008).

To sum up, our paper illustrates two important points: First, it describes how CRT may lead to a moral hazard problem in the origination of loans. When information is soft, CRT induces banks to knowingly extend negative NPV loans, leading to an increase in aggregate risk as seen in the recent crisis. Second, it shows that the welfare consequences of CRT depend on the degree of competition in the banking sector and on the type of information on which loans are based. The introduction of CRT markets generally leads to an increase in welfare because it improves the access to finance for profitable borrowers. However, the combination of CRT with soft information and highly competitive banking markets may be detrimental.

The paper proceeds as follows: Section 2 presents the basic model setup. Section 3 describes the equilibrium of the model in the absence of credit risk transfer. Section 4 analyzes the functioning of CRT markets when loans are granted on the basis of hard and soft information, respectively. Section 5 concludes. Proofs are in the Appendix.

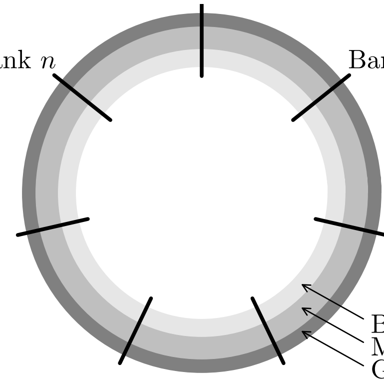
2 Model Setup

Our model has several important ingredients: First, we allow for heterogenous borrowers who differ in their creditworthiness. Second, competition among banks is imperfect; specifically, we use a model of Salop competition. Third, banks have limited risk-bearing capacities, for example due to regulation. These features allow us to model lemons problems in CRT markets and the importance of competition for banks' risk-bearing capacities and hence for the potential of CRT to improve borrowers' access to credit. Later, we will distinguish between loans based on "hard" (verifiable) or "soft" (non-verifiable) information. This will be important in the discussion of CRT markets because the type of information will substantially affect the functioning of these markets.

Entrepreneurs. Consider an economy with a continuum of entrepreneurs. Each entrepreneur has access to a project that requires an investment of one unit of money. In order to finance their projects, entrepreneurs must take up a bank loan. Projects have one of three qualities, they are either good (G), medium (M), or bad (B).[4] Entrepreneurs

[4] These entrepreneurs can also be interpreted as borrowing households with different risk profiles.

Figure 1: Structure of the Market for Loans



The figure shows a Salop circle with $n = 7$ banks that are distributed equidistantly on the Salop circle. The three types of entrepreneurs who are located on the Salop circle have the following shares: good ones (dark gray) have a share of $q_G = 25\%$, medium ones (medium gray) a share of $q_M = 45\%$, and bad ones (light gray) a share of $q_B = 30\%$.

with good (medium, bad) projects are called good (medium, bad) entrepreneurs. Projects have a positive return of Y with probability p_i, $i \in \{G, M, B\}$; otherwise they fail and return nothing. Projects of the same type are perfectly correlated. A share q_G of all projects is good. Good projects succeed with probability $p_G = 1$. They have a positive net present value, $p_G Y - r > 0$, where r is the opportunity cost of one unit of money. A share q_M of all projects is medium. Medium projects succeed with probability $p_M < 1$, but they also have a positive net present value, $p_M Y - r > 0$. A share $q_B = 1 - q_G - q_M$ of all projects is bad. Bad projects succeed with probability $p_B < p_M < 1$, and their net present value is negative, $p_B Y - r < 0$. As a result, there are two kinds of projects that are desirable from a social perspective: the good projects, which are safe, and the medium project, which are risky. The third class of projects is so risky that they are undesirable from a social perspective.

Banking Market Structure. Banks compete for loans à la Salop (1979).[5] They announce loan rates R_G, R_M, and R_B for entrepreneurs with good, medium, and bad projects. The entrepreneurs are uniformly distributed on a circle of length L (see Figure 1). The aggregate volume of potential projects is L; $q_i L$ is the aggregate volume of projects of type i. In order to obtain a loan, an entrepreneur must travel to the bank,

[5] The Salop model has frequently been used to model loan market competition in the banking sector, see Freixas and Rochet (1997) for an overview. Alternative models of price competition, e. g. monopolistic competition as in Monti (1972), Klein (1973), and Shubik and Levitan (1980), yield similar results.

incurring transportation costs t per unit of distance.[6] When choosing a bank, the entrepreneurs take into account both transportation costs and interest rates. The banks are distributed equidistantly on the Salop circle. There is no equity; the only source of refinancing is deposits, which are offered at a gross interest rate r, including the repayment of the principal. Deposits are fully insured, and the costs of deposit insurance are normalized to zero. If a bank's liabilities exceed the returns from its loans, it defaults.

Entry costs. There is a (non-monetary) fixed entry cost f into the banking market. This cost comprises the costs of adopting a screening technology to find out the quality of an entrepreneur's project. The screening technology produces a noiseless signal. Hence, any bank that has paid the fixed entry cost can perfectly observe an entrepreneur's quality. Later in the paper, we will distinguish between two kinds of screening technologies, based on either hard (verifiable) or soft (non-verifiable) information. We assume that the number of banks, n, is fixed. We will also consider free entry into the banking sector.

Banks' Probability of Default. Finally, we assume that banks are regulated to have a probability of default below some level α.[7] As we will see later, this assumption constrains the banks' risk-bearing capacities and hence firms' access to credit, yielding a rationale for credit risk transfer.[8]

The time structure of the game is given in Figure 2.

3 No Credit Risk Transfer

We will now show that the described setup with no possibility of transferring risks to other parties leads to a situation where banks are constrained in their lending due to their restricted risk-bearing capacities. In particular, the loans to medium entrepreneurs will be below the optimal level. Interestingly, fiercer competition (through bank entry) is shown to tighten banks' lending constraints.

[6] See Degryse and Ongena (2005) for empirical evidence that transportation costs are important in loan markets.

[7] This could be achieved by imposing capital requirements on the basis of a bank's value at risk at a confidence level $1 - \alpha$.

[8] Pennacchi (1988) was the first to motivate credit transfer by regulation. Alternatively, the desire for CRT could arise from bankruptcy costs (as in Wagner and Marsh, 2004) or from bankers' risk aversion (as in Morrison, 2005).

Figure 2: Timing

- $t = 0$: Banks announce loan rates, depending on the borrowers' qualities
- Borrowers choose a bank and invest
- Banks enter the market for credit risk transfer (if applicable)
- $t = 1$: Borrowers repay their loans if they are successful, otherwise they fail. If a loan to a failing borrower has been insured, the credit insurer repays the loan. Banks repay deposits if they can, otherwise they fail.

Access to credit. The loan volume granted by a bank to borrowers of type i is denoted by l_i. Bad projects have a negative net present value, hence bad entrepreneurs do not have access to loans in equilibrium, i. e., $l_B = 0$. A bank's probability of default is determined by its loan volumes and loan rates. With probability p_M, both good and medium loans repay, and the bank's profit is $(R_G - r)\, l_G + (R_M - r)\, l_M > 0$. With probability $1 - p_M$, only the good loans repay, and the profit is $(R_G - r)\, l_G - r\, l_M$. If this term is (weakly) positive, then the bank's probability of default (PD) is zero. If this term is negative, then the bank's PD is $1 - p_M$. For the solvency regulation to be effective, the required maximum PD α has to be smaller than $1 - p_M$, implying that

$$(R_G - r)\, l_G - r\, l_M \geq 0. \tag{1}$$

In the following, we assume that the regulation is effective, such that condition (1) binds in equilibrium.

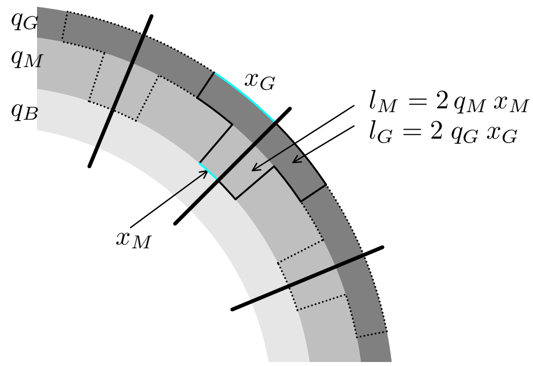
We restrict our attention to situations where the good loan market is covered completely, such that banks compete for loans at least in this loan segment. This will always be true when banking markets are sufficiently competitive (e. g., n is sufficiently large or t is sufficiently small). We can then calculate l_G by deriving the distance (x_G) of a good borrower from her bank who is just indifferent between a loan from one bank at a loan rate R_G and a loan from the neighboring bank at a loan rate R'_G,

$$p_G\,(Y - R_G) - t\, x_G = p_G\,(Y - R'_G) - t\,(L/n - x_G). \tag{2}$$

Solving for x_G and considering that $l_G = 2\, q_G\, x_G$, we get

$$l_G = q_G \left(\frac{L}{n} + p_G \frac{R'_G - R_G}{t} \right). \tag{3}$$

Figure 3: Market Penetration



The figure shows a typical market share of a bank. Note that the good market segment is covered completely, but not the medium market segment. Banks do not grant any bad loans.

However, condition (1) implies that banks cannot grant as many medium loans as they would like to in the absence of regulation; the access to credit is constrained for medium entrepreneurs due to the limited risk-bearing capacities of banks. Hence, the market for medium loans is not covered and banks enjoy local monopolies in the segment for medium loans, as depicted in Figure 3.

We can then calculate the distance of a medium borrower (x_M) who is just indifferent between a loan from a bank at a loan rate R_M and no loan at all,

$$p_M\,(Y - R_M) - t\,x_M = 0. \tag{4}$$

Solving for x_M and considering that $l_M = 2\,q_M\,x_M$, we get

$$l_M = 2\,p_M\,q_M\,\frac{Y - R_M}{t}. \tag{5}$$

Banks maximize their expected profits,

$$\Pi = (R_G - r)\,l_G + (p_M\,R_M - r)\,l_M - f, \tag{6}$$

subject to condition (1). This maximization yields R_G, R_M and λ, the shadow price of condition (1). The main results are summarized in the following proposition.

Proposition 1a (Access to Credit) *If condition (1) binds,*

- *the market for medium loans is not covered completely,* $L_M < q_M\,L$*,*

- *the shadow price of condition (1) is strictly positive,* $\lambda > 0$*.*

Some socially beneficial, but risky projects (of type M) are not carried out because banks have to avoid default to satisfy regulatory constraints. We will see later that this restriction can be eased by introducing a market for credit risk transfer (Section 4).

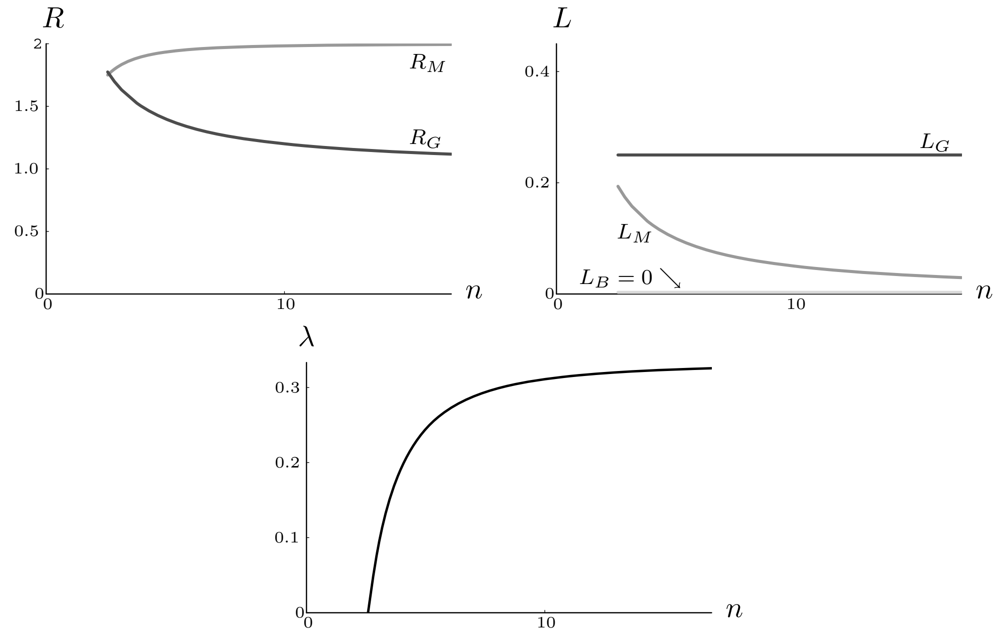
Competition. According to condition (1), a bank's risk-bearing capacity is determined by its profits from the good loan segment. These depend on the intensity of competition in the banking sector. This leads to the interesting result that the access to credit for medium firms is *reduced* by fiercer competition. Proposition 1b summarizes the effects of competition on firms' access to credit.

Proposition 1b (Competition) *Higher competition (higher* n*)*

- *leaves the aggregate amount of good loans unaffected,* $dL_G/dn = 0$*,*
- *lowers the aggregate amount of medium loans,* $dL_M/dn < 0$*,*
- *increases the shadow price of condition (1),* $d\lambda/dn > 0$*.*

Surprisingly, *more* banks lead to a *lower* market penetration for medium loans (see the second chart of Figure 4, which is based on a numerical simulation). The reason is the following: When competition intensifies, the banks' margins in the good loan segment shrink due to decreasing loan rates for good loans, R_G (see the first chart of Figure 4). These margins determine how aggressive banks are in the medium loan segment because banks have to observe condition (1). The lower the profits in the good loan segment, the lower are the banks' buffers against default, and the fewer medium loans are they willing to grant. Hence, the market penetration in the medium segment is reduced and loan rates R_M increase. In other words, the underprovision of loans in the medium segment (i. e., profitable, but risky loans) is most severe when there is fierce competition in the banking sector. λ is a measure of how much a bank suffers from having to adhere to condition (1). A higher λ implies a higher marginal profit of the banks when condition (1) is relaxed. The third chart of Figure 4 shows that a higher number of banks leads to an increase in λ, reflecting the tighter constraints on banks' lending in the medium segment.

Figure 4: Comparative Statics with Respect to n



Colors are the same as in Figure 1: Light gray stands for bad borrowers, medium gray for medium borrowers, and dark gray for good borrowers. Parameters for the numerical example are $q_G = 0.25$, $q_M = 0.45$, $q_B = 0.30$, $p_G = 1$, $p_M = 2/3$, $p_B = 1/3$, $Y = 2$, $r = 1$, $t = 2$, and $L = 1$. The larger the number of banks, the higher the competition for good borrowers, which shows up in a lower loan rate R_G. The volume of good loans L_G is constant because the whole market is always covered. As n increases, banks' buffers decrease and banks become less aggressive in the medium loan segment and raise R_M. Hence, the aggregate volume of medium loans L_M decreases. The shadow price of condition (1) increases in n because banks are more constrained in their lending to medium borrowers.

Market Entry. Let us now briefly consider the effects of free entry in the banking sector. With free entry, banks enter until $\Pi = 0$. Hence, the number of entering banks is

$$n = L \sqrt{q_G \, t \, \frac{p_M Y + \sqrt{p_M^2 Y^2 - 2 f t / q_M}}{2 f r}}. \tag{7}$$

Note first that the number of banks is proportional to L. Second, the fixed entry costs f deter banks from entering, $dn/df < 0$, as is always the case in Salop models with free entry. The reason is that the higher fixed costs can only be earned in equilibrium if there is less competition and, hence, higher margins. As a result, all other endogenous variables (l_G, l_M, R_G, R_M, and λ) respond to a change in fixed costs f. The comparative statics with respect to f are analogous to those with respect to n (but with the opposite sign). An increase in f leaves the aggregate amount of good loans unchanged, but it increases the market penetration in the medium loan segment. The shadow price of condition (1) decreases in f because banks are less constrained in their lending to medium borrowers.

As a result, higher entry costs lead to larger banks for two reasons. First, fewer banks enter, increasing the loan volume in the good market segment. Second, banks expand their medium loans due to higher buffers in the good segment.

As in the traditional Salop model, there is excessive entry in this model. The reason is that firms do not take into account the negative externality that their entry has on the other firms' profits. In this model, there is a second externality that exacerbates the excessive entry problem: Banks do not take into account the negative externality that their entry has on their competitors' risk-bearing capacities, and hence on the credit availability for medium entrepreneurs.

4 Credit Risk Transfer

We now allow banks to transfer risks from their balance sheets to other investors. For simplicity, we model credit risk transfer as an insurance contract with outside investors. However, the results are analogous to any other kind of institutional arrangement that transfers the risk to another party (such as credit derivatives or a securitization of loans). The possibility of trading credit risk relaxes condition (1). Hence, CRT may improve the access to credit for medium entrepreneurs. The higher the shadow price of condition (1), the higher the benefits of banks from transferring their credit risks. We will see, however, that the functioning of CRT markets depends crucially on the type of information underlying the banks' loans. We will distinguish between two types of information: "hard," i. e., verifiable information and "soft," i. e., non-verifiable information.

4.1 Model Setup

Insurers. Outside of the banking system, there is a continuum of risk neutral investors who are willing to insure the banks against credit default at a fair premium.[9] We assume that the market for CRT is anonymous, such that the amount of transferred credit risk is unobservable to the market. This seems to be reasonable given the opaqueness and complexity of CRT markets.

[9]As an alternative, one could assume that there are several economies, each of which contains a Salop circle. Then banks in different economies can share their credit risk. For a large number of economies, the effect would be the same as with risk neutral insurers: Potentially, banks could perfectly diversify their risk at zero cost.

Hard vs. Soft Information. Assume that the information produced by the banks' screening technologies is either "hard" (verifiable) or "soft" (non-verifiable).[10] If the information is hard, it can easily be communicated to potential insurers. An example of hard information is a credit rating that is produced by a standardized statistical rating system on the basis of balance sheet information. If the screening information is soft, it cannot be communicated to potential insurers. Such information could be the personal impression of the loan officer during the loan interview. In the words of Bolton and Dewatripont (2005), soft information is assumed to be neither contractible nor observable. In the following, we will discuss the properties of an equilibrium with credit risk transfer separately for the cases of hard and soft information. In each section, we will start by analyzing the effect of CRT, holding the number of banks fixed; then we will allow for free market entry.

4.2 Hard Information

In this section, we assume that the banks' screening technologies produce hard, verifiable information about the entrepreneurs. Hence, if a banker wants to transfer her credit risk, she can communicate the quality of the underlying loans to the insurer. As a consequence, only medium loans are insured. Good loans do not entail any risk, so there is no benefit from credit insurance; bad loans are not granted in the first place. Because banks choose not to default in equilibrium, it is irrelevant whether they settle the insurance premia in $t = 0$ or $t = 1$. Without loss of generality, let us assume that all payments are settled in $t = 1$. For each dollar of an insured loan, the bank receives a dollar with probability $1 - p_M$, and it pays the premium π_M with probability p_M.[11] Because insurers are risk neutral and the market is competitive, $\pi_M \, p_M = 1 - p_M$, hence $\pi_M = (1 - p_M)/p_M$. Hence, the insurance contract allows the bank to swap the risky returns from her medium loans against their expected values. Due to the possibility of unloading credit risk, condition (1) no longer applies. The banker can grant more medium loans. Hence, the introduction of credit risk transfer improves firms' access to finance in the case of hard information.

We start by considering the effects of the introduction of a CRT market, holding the number of banks constant. Two kinds of equilibria may result. First, the market penetration for medium loans improves, but banks still do not cover the entire circle. Second,

[10] The distinction between hard and soft information has been popularized by Stein (2002).

[11] This stylized insurance contract is similar to a credit default swap.

the market for medium loans may be covered completely, like the market for good loans. In the second case, the analysis boils down to that of a standard Salop model with two separate loan markets. Let us therefore concentrate on the first case.

The bank again maximizes its expected profits,

$$\Pi = (R_G - r)\, l_G + (p_M\, R_M - r)\, l_M - f, \tag{8}$$

where $p_M\, R_M\, l_M$ is now a safe payment. Condition (1) is no longer binding, implying that λ is equal to 0. Hence, profits are higher than in the absence of a CRT market. The market for good loans is again covered completely. The market for medium loans is not covered, but the penetration is larger than in the situation with CRT. The following proposition summarizes the effects of the introduction of a CRT market with hard information. See Figure 5 for a graphical illustration.

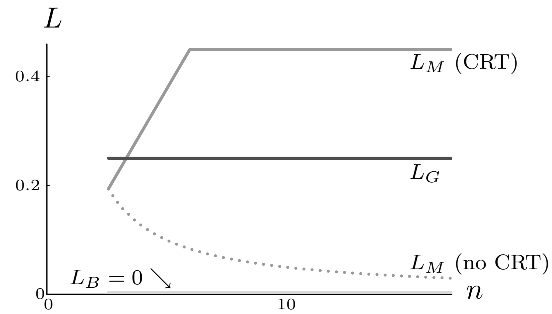
Proposition 2a (Credit Risk Transfer with Hard Information) *With hard information, the introduction of credit risk transfer*

- *leaves the aggregate amount of good loans unaffected,*
- *increases the aggregate amount of medium loans,*
- *reduces the shadow price of condition (1) to zero,* $\lambda = 0$*,*
- *increases banks' expected profits.*

Competition. We can now analyze how competition affects banks' behavior in the presence of CRT with hard information. In the presence of credit risk transfer, the medium loan volume of a single bank does *not* depend on the number of banks, as long as the medium loan segment is not covered completely. As a direct consequence, the penetration in the medium segment is proportional to n. This result stands in contrast to Proposition 1b. A higher number of banks and the resulting increase in competition *improve* the access to credit for medium entrepreneurs when there is a functioning CRT market, whereas they worsen the access to loans in the absence of credit risk transfer (see Figure 5). Proposition 2b summarizes these results.

Proposition 2b (Competition) *In the presence of credit risk transfer with hard information, higher competition (higher* n*)*

Figure 5: Credit Risk Transfer with Hard Information



Colors are the same as in Figure 1: Light gray stands for bad borrowers, medium gray for medium borrowers, and dark gray for good borrowers. The solid lines refer to a situation with hard CRT. The dotted line shows the loan volume in the medium loan segment in the absence of CRT (for good and bad loans the volumes are unchanged by the introduction of CRT). We see that CRT leads to a higher market penetration in the medium loan segment. Moreover, the market penetration for medium loans now increases in n; for large enough n, the market is covered completely.

- *leaves the aggregate amount of good loans unaffected,* $dL_G/dn = 0$,
- *increases the aggregate amount of medium loans until the market is covered completely,* $dL_M/dn \geq 0$.

Welfare. The introduction of CRT with hard information leads to a Pareto improvement. We have seen already that banks' expected profits increase (see Proposition 2a). Moreover, medium borrowers benefit for two reasons. First, the borrowers who had access to credit even in the absence of CRT benefit from lower loan rates. Second, other medium borrowers profit from gaining access to credit.

Proposition 2c (Welfare) *The introduction of credit risk transfer with hard information increases aggregate welfare.*

Market Entry. On the basis of Propositions 2a and 2b, we can easily derive the long-run effects of the introduction of a CRT market with hard information, allowing for market entry. With free entry, the number of banks in equilibrium is

$$n = L\sqrt{\frac{q_G\, t^2}{f\, t - q_M\,(p_M\, Y - r)^2/2}}. \tag{9}$$

Since the introduction of CRT increases expected profits in the short run (cf. Proposition 2a), it attracts more banks in the long run. This implies that there is more competition for good loans. As a consequence, the loan rate R_G decreases. The aggregate volume of good loans cannot change because the market is already completely covered. For medium loans, banks have local monopolies. As argued above, the volume of medium loans l_M of a single bank does not depend on n. Hence, the market penetration for medium loan is proportional to n; it increases as more banks enter the market. Hence, the effects of CRT on medium loans are reinforced in the long run through market entry.

4.3 Soft Information

When loans are based on soft information, banks cannot credibly communicate the quality of a loan underlying an insurance contract. Therefore, the transfer of credit risks becomes more difficult. The asymmetric information about loan qualities leads to a moral hazard problem. Banks knowingly grant bad loans only to resell them to the insurers.[12] This is anticipated by the insurers who demand a lemons premium. Under some circumstances, the market for credit risk transfer even breaks down completely.

In equilibrium, the insurers anticipate the underlying credit risk and set their prices accordingly. When deciding whether to grant a loan and whether to insure against the risk from that loan, banks take the price of CRT as given. Let β be the anticipated probability that the underlying loan has a medium quality. Then, the loan is expected to be bad with probability $1 - \beta$. Good loans are not risky, hence banks never insure such loans. Therefore, the insurer expects an average probability of success of $\bar{p} \equiv \beta\, p_M + (1 - \beta)\, p_B$. With an insurance contract, a bank can turn a risky yield from a loan into a safe payment. For example, a loan with success probability p_M at rate R_M would be swapped against a safe payment of $\bar{p}\, R_M$. Hence, a bank makes a negative expected profit when she insures a medium loan; in contrast, the bank makes a positive expected profit when she insures a bad loan. In both cases, selling risk has the positive effect that condition (1) is relaxed. The bank can thus expand and grant more loans. As a consequence, the bank never resells the entire risk within its portfolio. Condition (1) must bind in equilibrium. If it did not bind, the bank could increase profits by insuring fewer medium risks. Also, a

[12] This is different from the incentive problem analyzed by Pennacchi (1988), Gorton and Pennacchi (1995), and Chiesa and Bhattacharya (2007), where banks have suboptimal incentives to monitor loans transferred to other parties. Here, banks know that a loan is bad, but they still decide to grant it.

bank never grants a bad loan and keeps it within the balance sheet. All bad loans are resold in equilibrium.

Consider an equilibrium in which the market for credit risk transfer does not break down. Then, the loan rates for medium and bad loans have to be identical, $R_M = R_B \equiv R$. The reason is that the marginal (medium or bad) loan is always resold by the bank. As a consequence the return is $\bar{p}\, R_M$ or $\bar{p}\, R_B$, respectively. Hence the loan rates must be equal, independent of the true quality of the loan. In other words, because a bank always resells a marginal medium or bad loan, it does not care about its inherent risk; consequently, it offers the same loan rate on both markets.

If the bank sets a loan rate of R for both medium and bad loans, then, as in (5), the volume of medium loans is $l_M = 2\, p_M\, q_M\, (Y - R)/t$, and the volume of bad loans is $l_B = 2\, p_B\, q_B\, (Y - R)/t$, accordingly. Hence, even though the loan rates are identical, the market for medium loans is penetrated more; bad entrepreneurs profit from the loan with a lower probability than medium entrepreneurs, but the transportation costs must be spent in any case.

Let κ be the fraction of medium loans that a bank insures, and $1 - \kappa$ the fraction of medium loans that remain in the bank's balance sheet. Then, the bank's total loan volume (and hence the balance sheet total) is $l_G + l_M + l_B$. The refinancing costs are $(l_G + l_M + l_B)\, r$. In the best possible case (with probability p_M), all loans are repaid; the bank gets $R_G\, l_G$ from the good loans, $\bar{p}\, R\, (l_B + \kappa\, l_M)$ from the insured bad and medium loans (net of the payments to insurers), and $R\, (1 - \kappa)\, l_M$ from uninsured medium loans. In the worst possible case (with probability $1 - p_M$), medium entrepreneurs do not repay, all other payments are identical. Hence, condition (1) is modified to

$$(R_G - r)\, l_G + \bar{p}\, R\, (l_B + \kappa\, l_M) - (l_M + l_B)\, r \geq 0. \tag{10}$$

Obviously, an increase in the sale of credit risk (i. e., an increase in κ) relaxes (10). Because this condition is binding, it implicitly defines κ. Banks choose R_G and R in order to maximize their expected profits,

$$\Pi = (R_G - r)\, l_G + \bar{p}\, R\, (l_B + \kappa\, l_M) + p_M\, R\, (1 - \kappa)\, l_M - (l_M + l_B)\, r - f, \tag{11}$$

subject to condition (10) and taking β (and hence $\bar{p}$) as given. $\bar{p} = \beta\, p_M + (1 - \beta)\, p_B$ can be determined by using Bayes' law. The probability that an insured loan has medium quality is

$$\beta = \frac{\kappa\, l_M}{\kappa\, l_M + l_B}. \tag{12}$$

Proposition 3a summarizes the effects of the introduction of a CRT market with soft information.

Proposition 3a (Credit Risk Transfer with Soft Information) *With soft information, if the market for credit risk transfer does not break down, its introduction*

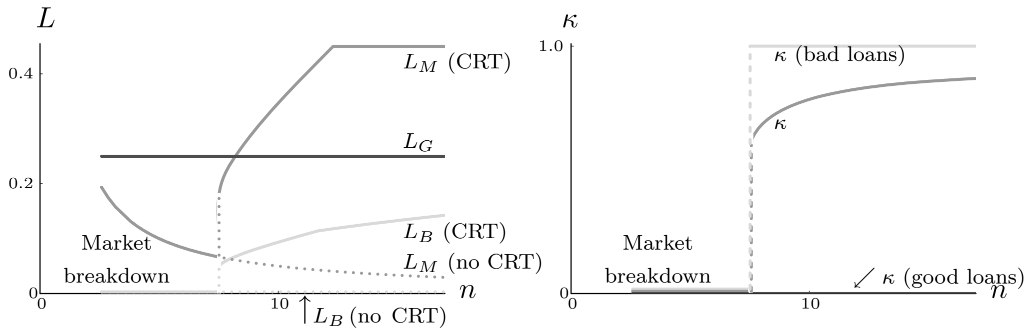
- *leaves the aggregate amount of good loans unaffected,*
- *increases the aggregate amount of medium loans, but less than with hard information,*
- *increases the aggregate amount of bad loans,*
- *reduces the shadow price of condition (1), but not to zero, $\lambda > 0$,*
- *increases banks' expected profits, but less than with hard information.*

The directions of all effects are the same as for CRT with hard information. However, because banks also insure bad loans, they have to pay a lemons premium. As a result, the loan rate for medium loans R_M is higher than for CRT with hard information, and the volume L_M is lower. Because $R_B = R_M$, the loan volume for bad loans is positive. Hence, the introduction of CRT improves the access to credit for medium entrepreneurs less than in the case of hard information. In addition, CRT also improves the access to credit for bad entrepreneurs with negative net present values.

Competition. Consider now an increase in the number of banks. Due to stronger competition for good loans, R_G decreases, but L_G remains constant. As a consequence, the profits from the good loan segment that banks can put at risk in the other loan segments decrease. We have argued above that banks keep only medium loans in their balance sheets; all bad loans are insured. When buffers decrease, banks can keep relatively fewer medium loans in their own balance sheets. The average quality of insured loans improves, and the lemons premium drops. Since the lemons premium is a component of the price of credit risk transfer, the price of CRT drops, and banks can grant more loans. The loan rates R_M and R_B drop.

The opposite happens when the number of banks goes down. Then, CRT becomes more expensive because the banks prefer to keep more medium loans on their own balance sheets. At some point, for small enough n, the market for CRT breaks down completely.

Figure 6: Credit Risk Transfer with Soft Information



Colors are the same as in Figure 1: Light gray stands for bad borrowers, medium gray for medium borrowers, and dark gray for good borrowers. The first chart of the figure shows aggregate loan volumes. The solid lines again refer to a situation with CRT. The dotted lines show the loan volumes in the medium and bad loan segments in the absence of CRT (for good loans the volume is unchanged by the introduction of CRT). If the market for CRT does not break down, there is an increase in both medium and bad loans due to CRT. The market penetration for medium and bad loans increases in n. The second chart shows the fraction of transferred medium loans κ, together with the fractions of transferred good loans (which is always zero) and bad loans (which is equal to 1 as long as the market for CRT is active). The higher n, the fewer medium loans can banks keep in their books. Notice the discontinuity of all curves at $n \approx 7$.

Proposition 3b (Competition) *In the presence of credit risk transfer with soft information, if the market does not break down, higher competition (higher n)*

- *leaves the aggregate amount of good loans unaffected, $dL_G/dn = 0$,*
- *increases the aggregate amount of medium loans until the market is covered completely, $dL_M/dn \geq 0$,*
- *increases the aggregate amount of bad loans, $dL_B/dn > 0$,*
- *increases the fraction of medium loans that is insured, $d\kappa/dn > 0$.*

There exists an $\bar{n} < \infty$ such that for $n \leq \bar{n}$, the market for credit risk transfer breaks down.

These effects are illustrated in Figure 6. There is a critical n (in the numerical example $n \approx 7$) below which the market for CRT breaks down. Only for higher n, a market for CRT with soft information can be maintained. The reason is the following: For low levels of competition, banks earn high profits on good loans, hence they need to insure fewer medium loans; as a consequence, the price for CRT is high, leading to a complete market breakdown because the lemons problem becomes too severe. All variables are then equal to those in the absence of CRT (cf. Figure 4). For higher n, the CRT market is active. As n becomes larger, the penetration of the medium loan segment increases, until at some point ($n \approx 12$ in the figure) the medium market is covered completely. The bad loan segment keeps growing. As a consequence, the lemons premium for CRT increases, and the growth of bad loans is (slightly) smaller. Consequently, competition has the beneficial effect of increasing the market penetration for medium loans, but it inflates the volume of bad loans at the same time. When the medium market is covered completely, a further increase in competition improves only the access to credit for negative NPV firms.

Welfare. When CRT is based on soft information, the effects of an introduction of CRT on welfare is less clear-cut than before. The improved access to credit for medium borrowers raises welfare, but the extension of loans to negative NPV borrowers decreases welfare. Still, the overall effect on welfare is positive: Bad borrowers benefit from gaining access to credit. Medium borrowers benefit due to lower loan rates and to an improved access to loans. The banks ultimately bear the costs of the negative NPV projects of bad borrowers, but they still benefit from CRT due to the possibility of expanding in the medium market. Summing up, we have the following result.

Proposition 3c (Welfare) *The introduction of credit risk transfer with soft information increases aggregate welfare.*

Market Entry. Let us now discuss the long-run effects of CRT with soft information. Since the introduction of CRT increases expected profits in the short run (see Proposition 3a), it attracts more banks in the long run. Because CRT with soft information increases expected profits less then CRT with hard information, fewer additional banks enter the market.

When competition is not too fierce, long-run effects of CRT reinforce short-run effects, as was the case with hard information. Increasing competition through market entry further improves the access to credit for both medium and bad borrowers. However, when competition is so strong that the medium market is covered completely, market entry improves the access to credit only for bad borrowers. In this case, only the detrimental effects of CRT are reinforced.

Under CRT with soft information, entry is again excessive. First, as in any Salop model, firms do not take into account the negative externality that their entry has on the other firms' profits. Second, bank entry exacerbates the problem that banks lend to bad entrepreneurs to finance negative NPV projects.

5 Conclusion

This paper has shown how credit risk transfer can improve the access to finance for risky borrowers by increasing banks' risk-bearing capacities and thereby relaxing lending constraints. Without CRT, a bank may be reluctant to grant loans to risky borrowers because such loans threaten its solvency. An introduction of markets for CRT generally leads to a loan expansion and thereby to an increase in welfare because it enables borrowers to finance profitable projects that would otherwise not have been carried out.

However, a bank's ability to transfer risks depends on whether the bank grants loans on the basis of hard or soft information. If loans are granted on the basis of hard, i. e. verifiable, information, the credit risk transfer works smoothly because banks can easily convey the quality of their borrowers to their insurers and will not have an incentive to grant (and transfer) unprofitable loans.

If loans are granted on the basis of soft, i. e. non-verifiable, information, the transfer of credit risk is more difficult because the insurers cannot verify the quality of a bank's borrowers. This leads to a moral hazard problem at the originating bank: It can exploit the informational asymmetry by granting unprofitable loans and transferring the risk to the insurers. The insurers anticipate this and demand a lemons premium. As a consequence, banks do not insure their loan portfolio to the same degree as with hard information. Here the possibility of transferring risks improves the access to finance not only for "medium" (i. e., risky, but profitable) borrowers, but also for bad (i. e., unprofitable) borrowers, which leads to an increase in aggregate risk in the economy.

Nevertheless, the overall welfare effect of an introduction of CRT markets is always positive in our setup. Even with soft information, CRT is beneficial because the welfare gains from the improved access to credit for medium borrowers overcompensate the welfare losses from the improved access to credit for bad borrowers.

Furthermore, we have emphasized the role of the degree of competition in the banking sector. In our basic setup, we find that the undersupply of risky loans is most severe in a highly competitive environment. The reason is that the banks' margins in other types of business (the good loan segment) and hence the potential to absorb losses from risky loans are small under such circumstances.

With CRT, increasing competition no longer leads to a deterioration in borrowers' access to finance; in fact, the borrowers' access to finance improves both with hard and soft information. However, increasing competition may be harmful in the presence of CRT with soft information. This may happen when the medium loan market is saturated, such that a further increase in competition improves the access to finance only for bad borrowers.

The sharp distinction between banking markets with hard and soft information should not be taken too literally. The pure hard information case can hardly be found in the real world and should rather be seen as a benchmark case in which CRT markets work perfectly. In reality, loan markets are always characterized by some degree of asymmetric information; hence, CRT markets will never work perfectly and will always involve some moral hazard in the origination of loans. Moreover, the welfare analysis presented in this paper abstracts from the costs arising from financial instability. Such costs would have to be balanced against the benefits from CRT, such as the improved access to finance for profitable borrowers.

In this paper, we have stressed the importance of banking competition for social welfare and financial stability. Our results on the destabilizing role of highly competitive banking markets in the presence of credit risk transfer are well in line with the traditional literature on the harmful effects of banking competition on financial stability. They also coincide with the observations from the current subprime crisis: The late years of the credit boom preceding the crisis were characterized by both increasing competition in the banking sector and decreasing loan quality. Further research is needed to explore in more detail the relationship between banking competition and financial stability in the presence of CRT markets.

A Appendix

Proof of Proposition 1a. The argument for the first statement has already been given in the main text. We now derive the condition under which (1) binds in equilibrium and provide solutions for the endogenous variables. Banks maximize their expected profits given by (6), subject to condition (1). Setting up the Lagrangian, taking the derivative with respect to R_G, R_M, and λ, and setting $R'_G = R_G$ in a symmetric equilibrium, we obtain

$$\begin{aligned} R_G &= r + \frac{L\,t}{n}, \\ R_M &= Y - \frac{L^2\,q_G\,t}{2\,n^2\,p_M\,q_M\,r}, \text{ and} \\ \lambda &= \frac{p_M\,Y}{r} - 1 - \frac{L^2\,q_G\,t^2}{n^2\,q_M\,r^2}, \end{aligned} \tag{13}$$

where λ is the shadow price of constraint (1). The assumption that (1) binds in equilibrium is equivalent to the assumption that $\lambda > 0$ in equilibrium, hence that $n > L\,t\,\sqrt{q_G}/\sqrt{q_M\,r\,(p_M\,Y - r)}$. □

Proof of Proposition 1b. Taking derivatives in (13), we find that $dR_G/dn < 0$, $dR_M/dn > 0$, and $d\lambda/dn > 0$, which already proves the third statement of the proposition. Equilibrium loan volumes and profits are

$$\begin{aligned} l_G &= \frac{q_G\,L}{n}, \\ l_M &= \frac{q_G\,L\,t}{n^2\,r}, \text{ and} \\ \Pi &= \frac{L^2\,q_G\,t}{2\,n^4\,q_M\,r^2}\left(2\,n^2\,p_M\,q_M\,r\,Y - L^2\,q_G\,t^2\right) - f. \end{aligned} \tag{14}$$

We see that for an individual bank, $dl_G/dn < 0$ and $dl_M/dn < 0$. In the aggregate, $L_G = q_G\,L$. Hence, the market is still covered completely, such that $dL_G/dn = 0$. For the medium market, we get

$$L_M = n\,l_M = \frac{q_G\,L\,t}{n\,r},$$

which depends negatively on n. □

Proof of Proposition 2a. The bank's profit function is given by (8). Banks can swap risky loans against safe payments with the same expected return by insuring a loan, hence condition (1) is no longer binding. This implies that λ is equal to 0. Hence, profits are higher than in the absence of a CRT market. Taking the derivative of Π with respect to R_G and R_M and taking into account that $R'_G = R_G$, we obtain

$$R_G = r + \frac{L\,t}{n} \quad \text{and} \quad R_M = \frac{Y}{2} + \frac{r}{2\,p_M}. \tag{15}$$

Hence, R_G is unchanged by the introduction of CRT, and the market is covered completely as before. Comparing R_M before and after the introduction of CRT, we find that R_M increases if and only if λ was positive before the introduction of CRT. The same applies for expected profits, which are now

$$\Pi = q_G \frac{tL^2}{n^2} + q_M \frac{(p_M\,Y - r)^2}{2\,t} - f. \tag{16}$$

Possibly, the introduction of CRT leads to a complete coverage of the medium market (see Figure 5 for $n > 8$). The proposition remains true in this case. □

Proof of Proposition 2b. As argued above, the market for good loans is saturated, thus $L_G = q_G\,L$, independent of n. In addition, $l_M = q_M\,(p_M\,Y - r)/t$; the volume of medium loans does not depend on the number of banks. As a result, $L_M = n\,l_M$ increases monotonically in n until the medium loan market is covered completely. □

Proof of Proposition 2c. Welfare consists of the expected profits and utilities of banks, depositors, borrowers, and insurers. Risk insurance if fair, hence insurers' expected profits are zero. The deposit supply is perfectly elastic, hence depositors' expected utility does not change although the aggregate deposit volume increases due to the introduction of CRT. For good borrowers, loan rates R_G remain unchanged. CRT does not help bad borrowers to gain access to credit. Medium borrowers, however, profit from the introduction of CRT in two ways. Those borrower who already had access to credit in the absence of CRT benefit from lower loan rates R_M. Additionally, the volume L_M expands; some medium borrowers gain access to credit due to CRT.

Finally, consider the banks' expected profits. Possibly, CRT could be beneficial from a single banks' perspective, but the benefits could be eaten up by increased competition between banks due to CRT. However, surprisingly, CRT does not change the degree of competition between banks. The reason is the following. Banks compete only for good loans. In the absence of CRT, profits from good loans have a value per se *and* are used as a buffer against losses. With CRT, profits from good loans do not serve as a buffer to help banks to expand into the medium loan market. However, banks maximize profits in both cases, and the degree of competition does not change depending on whether profits serve a double purpose or not. As a result, banks' profits from the good loan segment do not change; expected profits from the medium loan segment increase by the introduction of CRT. Consequently, aggregate welfare increases. □

Proof of Proposition 3a. In a symmetric equilibrium,

$$\frac{\partial \Pi}{\partial R_G} = 0 \iff R_G = r + \frac{L\,t}{n},$$
$$\frac{\partial \Pi}{\partial R} = 0 \iff R = \frac{Y}{2} + \frac{r}{2\,\bar{p}}, \tag{17}$$

where Π is given by (11). The short-run equilibrium is hence determined by equations (17) and (12). Some statements of Proposition 3a follow immediately. *First* statement: R_G (and thus the coverage of the good loan segment) is unaffected by CRT; the determining equation is the same as in the absence of CRT. *Third* statement: The amount of bad loans is positive under soft CRT, hence it increases due to CRT. *Fifth* statement: Expected profits of banks increase less than under hard CRT because banks cannot commit to not granting loans to bad borrowers. Ultimately, they are the ones who bear the costs arising from the lemons problem. *Second* statement: Banks' eagerness to lend to medium entrepreneurs is determined by marginal costs. These consist of refinancing costs r and of the costs from CRT (banks always insure the risk of the marginal medium loan). The latter costs are determined only by β: the higher the probability β that an insured loan is medium, the lower are the costs of insurance. With hard CRT, $\beta = 1$ because no bad loans are granted; with soft CRT, $\beta < 1$. As a consequence, the marginal costs are higher with soft CRT, the loan volume l_M is smaller, and the loan rate R_M is higher. *Fourth* statement: λ is the shadow price of condition (10), which is identical to (1) for $l_B = 0$. A marginal increase in capital at risk increases expected profits by λ. This increase in expected profits is due to the bank's ability to expand lending to medium (and bad) borrowers, and it hence depends on R_M (and R_B). Because R_M is smaller under soft CRT than under hard CRT, the shadow price λ must be smaller. The point $\lambda = 0$ is reached only when the bank keeps all loans on its balance sheet. However, this implies that the lemons problem becomes paramount, and the market for CRT breaks down completely. □

Proof of Proposition 3b. Look at the aggregate version of (10),

$$(R_G - r)\,L_G + \bar{p}\,R\,(L_B + \kappa\,L_M) - (L_M + L_B)\,r \geq 0, \tag{18}$$

and consider an increase in the number of banks n. Competition and loan rates on the market for good loans are the same as in the absence of CRT (just as with hard CRT). Hence, an increase in n implies that $(R_G - r)\, L_G$ decreases: R_G decreases, and r and L_G remain constant. Keeping R fixed for the moment, both L_M and L_B increase proportionally as n increases. Hence, bankers need to raise κ in order to fulfill (18). Because the ratio of L_M and L_B remains unchanged, the ratio of l_M and l_B remains unchanged. (12) reveals that β increases. Insurers anticipate a better quality of insured loans; $\bar{p} = \beta\, p_M + (1-\beta)\, p_B$ increases. The marginal profit from an insured loan is $\bar{p}\, R - r$. Consequently, bankers will expand volumes L_M and L_B by lowering loan rates $R_M = R_B = R$. This triggers off a reinforcing multiplier effect: Due to (18), banks need to increase κ even further. The final equilibrium has higher aggregate volumes L_M and L_B at lower loan rates R, and a higher share of insured medium loans κ. Of course, L_M can only rise until the medium market segment is covered completely. □

Proof of Proposition 3c. Again, aggregate welfare consists of the expected profits and utilities of banks, depositors, (good, medium, and bad) borrowers, and insurers. Depositors, good borrowers, and insurers are unaffected by the introduction of soft CRT; banks and medium borrowers profits. Given that CRT is now based on soft information, loans are also granted to bad borrowers with negative NPV projects. Bad borrowers profit from the improved access to credit. Summing up, the introduction of CRT increases aggregate welfare in spite of the expansion of negative NPV loans. □

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