Working Paper

Collateral and repeated lending

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Collateral and Repeated Lending[*]

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Abstract

Lending is often associated with significant asymmetric information issues between suppliers of funds and their potential borrowers. Banks can screen their borrowers, or can require them to post collateral in order to select creditworthy projects. We find that the potential for longer-term relationships increases banks' preference for screening. This is because posting collateral only provides the information that the current project of a given borrower is of good quality, whereas screening provides information that can be used in evaluating future projects as well as the current ones.

Keywords: Collateral, screening, bank relationships

JEL classification numbers: G21, L13

1 Introduction

Banks are confronted with asymmetric information when making their lending decisions. They can invest in various instruments that allow them to select their potential borrowers, and the quality of that selection is important in getting an appropriate allocation of capital in the economy. At the same time, most such instruments are costly, and banks will consider those costs when choosing their selection methods.

In our paper we examine collateral and screening as tools that can be used to identify creditworthy borrowers. Both of them can improve the quality of a bank's loan portfolio, but at the same time both can be expensive for the bank. Screening involves bearing the cost of acquiring information about borrowers, while the use collateral can lead to losses when borrowers default and the collateral is liquidated.

We analyze the banks' choice with respect to the two selection instruments. We find that when the potential for longer-term relationships is more significant - that is, current borrowers are more likely to apply again for loans - screening is more likely to be preferred to collateral.

The intuition behind this result is as follows. When a borrower posts collateral in order to receive a loan, this indicates that her current project is of relatively high quality. However, that may say little about the possible quality of the future projects of that particular borrower. In contrast, screening their potential borrowers provides banks with additional information about their overall business ability. That information can be used both to assess the quality of their current projects, and to get a glimpse about the likely quality of their future projects. This makes screening more useful in the case of repeated interaction between banks and borrowers.

The use of collateral as an instrument to reduce adverse selection has been formally analyzed since the seminal paper by Bester (1985). Borrowers with better projects may be more willing to pledge collateral, since they also have a lower probability of not being able to repay and therefore losing the assets they have pledged. Of course, the potential for liquidation costs in case of default

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and repossession can make collateral an expensive separation device. Both the use of collateral to deal with asymmetric information problems and the prevalence of liquidation costs have been empirically documented (see for instance Leeth and Scott (1989), Berger et al. (2011)).

Manove et al. (2001) show that under some circumstances banks can be "lazy", that is, they may screen too little when borrowers can post collateral. This is because screening can be more sensitive than collateral to the average quality of borrowers in a pool. If that average is too low, high-quality borrowers will prefer to post collateral rather than be screened, even though that may lead to higher loan losses and be inefficient from a social point of view.

In contrast, we examine one of the possible circumstances that can work in favor of screening. Since screening provides long-term informational benefits, longer-term relationships may make it more attractive and reduce the potentially damaging use of collateral. This can help make banks more "active" and enhance information acquisition in the economy.

Our findings can be extended to include other factors that make screening more attractive in long-term relationships. For instance, it may be that, while their currently available collateral is satisfactory, borrowers worry that future shocks may reduce the value of their assets in place and make them unable to post sufficient collateral at some point in the future. Without sufficient collateral, borrowers may be excluded from credit markets even if they have high-quality projects. In that case, borrowers may prefer screening, even though screening also involves costs and they have sufficient collateral. This is because screening provides information that can be reused in the future, and may make it likely that they receive loans in the future even in the absence of sufficient collateral.

Future shocks to the market value of available collateral can swing the pendulum back towards screening. Another factor working in the same direction is the likelihood of high growth opportunities in the future. If firms anticipate large and potentially profitable projects in the future, there is the possibility that their current collateral, given the current scale of their firm, is insuf-

ficient to guarantee them debt financing for those future projects. As a result, firms with high growth opportunities may prefer to be screened even though they may have enough high-quality collateral to provide them with bank financing.

Our main predictions therefore are that the use of collateral is less likely - even when sufficient assets are present - if the anticipated time horizon of a bank relationship is longer, and if the borrowers' growth rates and asset value volatility are higher.

We do not examine collateral as a monitoring device (Chan and Thakor (1987), Rajan and Winton (1995)). Banks may either monitor borrowers directly or ask them to pledge collateral in order to reduce the potential for opportunistic behavior. The link between the time horizon of a bank relationship and the choice between direct monitoring and collateral may be an interesting issue for further research.

In what follows, Section II presents the general setup of the model, Section III looks at the case of a monopolistic bank, Section IV looks at the competitive case, and Section V concludes.

2 The Model

2.1 The Setup

We look at an economy in which there are different borrowers types, with higher-quality types more likely to have good, creditworthy projects.

We have a continuum of borrowers with total mass equal to 1. There are two types of projects available to entrepreneurs in our economy: good projects (G) and bad projects (B). Both projects require an initial investment of 1. Good projects G produce $X > 0$ with probability p_G and 0 with probability $1 - p_G$. Bad projects B have a success probability $p_B < p_G$: they produce $X > 0$ with probability p_B and 0 with probability $1 - p_B$.

There are two types of entrepreneurs in the economy: talented (high-quality H) and untalented

(low-quality L). High-quality borrowers represent a proportion λ of the population, while low-quality borrowers are $1 - \lambda$ of the population. Talented entrepreneurs have a probability $p_H = 1$ of having a good project. In the case of untalented entrepreneurs, the probability of getting a good project is p_L, and the probability of getting a bad project is $1 - p_L$. Entrepreneurs know their own types and the quality of their projects.

Borrowers do not have any funds of their own and have to borrow from one of two competitive banks. Banks get funding at a (gross) cost of $\bar{R}$.

Good projects are creditworthy: $p_G X - \bar{R} > 0$, while bad projects are not: $p_B X - \bar{R} < 0$. Since good projects are creditworthy, high-type borrowers should obviously receive a loan. However, the average borrower is not creditworthy, which also implies that low-type borrowers should not receive a loan:

$$(\lambda p_G + (1 - \lambda)(p_L p_G + (1 - p_L)p_B))X < \bar{R}.$$

As it is standard in the literature, we assume that borrowers with a bad project derive non-monetary utility from being in business, and they will apply for a loan even if they know they are not creditworthy.

Banks cannot immediately distinguish between borrower types and projects of different quality. In order to tell apart good and bad projects banks and borrowers can use collateral and/or screening.

Since they have a lower probability of failure, borrowers with good projects can use collateral to separate themselves from borrowers with bad projects.[1] When a project has been financed by

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[1] The use of collateral to separate borrowers of different quality has been the focus of a fairly large literature. See for instance Bester (1985).

a loan backed by collateral and the project fails, the collateral is liquidated by the bank and loses a fraction α $(0 \leq \alpha \leq 1)$ of its value in that process.

Screening involves a cost s per borrower, but it reveals both the quality of the current project and the *type* of the entrepreneur. As usual (Manove et al. (2001)), screening is assumed to be nonobservable and non contractible, and it cannot be sold to borrowers as a service.

We first consider the one-period interaction between banks and borrowers. Given the common-knowledge proportions of the borrower types and their success probabilities, banks offer screening or collateral-based contracts to their potential borrowers. Borrowers choose their banks, apply for loans and receive funding if their application is successful. At the end of the period, payoffs for borrowers and banks are realized.

We then consider the interaction between banks and borrowers over two periods. We assume that borrowers have a new project in the second period, that also requires an investment of one unit of capital, and that capital needs to be borrowed. We have the same borrowers in the population, with the same success overall proportions and success probabilities for good and bad projects. The type of a given borrower remains the same across periods.

The two banks will offer first-period screening and/or collateral contracts. This will result in some information acquisition about their first-period borrowers. In the second period, they will offer loan contracts to those borrowers, and perhaps also to borrowers with which they did not have a lending relationship in the first period.

As in Manove et al. (2001) we define equilibrium outcomes as those in which banks make nonnegative profits, borrowers have a nonnegative payoff, banks are maximizing their profits and borrowers are maximizing their payoffs, and there are no viable contracts, i.e. contracts offered by bank that provide them with nonnegative profits and provide at least one borrower with a strictly larger payoff.

We present the one- and two-period equilibria below. The comparison between the two cases

will show that having a longer-term horizon increases the use of screening in bank lending.

3   The monopolistic bank

We first examine the case of a bank monopoly - there is just one bank that can supply funds to potential borrowers. It needs to screen or use collateral in order to do so.

Suppose first that borrowers and banks interact over just one period. If the bank uses collateral to separate good- and bad-project borrowers, then the amount of collateral required should be large enough so that bad-project borrowers are not willing to choose the collateral contract. At the same time, good-project borrowers should still find it worthwhile to pledge collateral. The conditions for collateral-based separation are:

$$p_G(X - R) - (1 - p_G)C \geq 0, \qquad p_B(X - R) - (1 - p_B)C < 0,$$

which means that, for a given interest rate R, the required amount of collateral is at least $\frac{p_B(X-R)}{1-p_B}$.

The bank's profit is going to be:

$$\Pi = (\lambda + (1 - \lambda)p_L)(p_G R + (1 - p_G)(1 - \alpha)C - \bar{R}).$$

This profit is maximized when the interest rate R is just below X $(R = X - \epsilon)$ and the collateral is just above zero $(C = \frac{p_B \epsilon}{1 - p_B})$. The total profit will therefore be $(\lambda + (1 - \lambda)p_L)(p_G(X - \epsilon) + (1 - p_G)(1 - \alpha)\frac{p_B \epsilon}{1 - p_B}$.

If the bank screens its potential borrowers, its profits are going to be:

$$\lambda(p_G R - \bar{R}) + (1 - \lambda)p_L(p_G R - \bar{R}) - s.$$

Unless screening costs are negligible, collateral will be preferred to screening.

If borrowers exist for two periods, i.e. we have longer bank relationships with repeated lending, then collateral will have to be used twice, with the associated potential losses in case of default.

If the bank chooses initial screening, there is no need to screen high-type borrowers again in the second period. The bank can use either screening or collateral to separate good- and bad-project low-quality borrowers. Thus as we move from a single-period to a multiple-period horizon the cost of screening decreases, while the cost of using collateral does not. That being said, a monopoly bank can charge very high interest rates and a "minimal" amount of collateral is enough to separate good and bad projects. This may imply that collateral is relatively cheaper even over longer time horizons.

4 Bank competition

The previous section compared collateral and screening as tools to separate good and bad projects under a bank monopoly. We now move on to look at the situation when more than one bank is present on the market. We consider the case of two banks that compete for borrowers over one or two periods.

4.1 The one-period equilibrium

We first examine the case where borrowers only apply once for a loan. Given our assumptions, the average borrower is not creditworthy, and banks cannot lend without screening or requiring

collateral.

In case banks choose the *collateral* contract, they will have to require enough collateral to separate borrowers with good projects from borrowers with bad projects. At the same time, given that banks compete for borrowers based on the same initial information, their profits will be zero.

Proposition 4.1 *When both banks use collateral:*

1. *The collateral requirement is given by* $C = p_B \frac{p_G X - \bar{R}}{p_G(1-p_B)-(1-\alpha)p_B(1-p_G)}$, *while the interest rate charged by banks is* $R = \frac{(1-p_B)\bar{R}-(1-\alpha)p_B(1-p_G)X}{p_G(1-p_B)-(1-\alpha)p_B(1-p_G)}$.

2. *Banks make zero profits.*

3. *Borrowers with good projects get a loan and their final expected payoff is* $p_G X - \bar{R} - \frac{\alpha(1-p_G)p_B}{p_G(1-p_B)-(1-\alpha)(1-p_G)p_B}(p_G X - \bar{R})$.

4. *Borrowers with bad projects do not get a loan.*

Proof See Appendix.

The amount of collateral has to be sufficient to separate good and bad projects. At the same time, competition between banks will push their profits to zero. The interest rates are going to be lower and the required collateral higher than in the monopoly case. As in the monopoly case, bad projects are not financed.

We now turn to the use of screening to identify good projects.

Proposition 4.2 *When both banks screen their potential borrowers:*

- *The interest rate charged by banks will be* $R = \frac{1}{p_G}\left(\bar{R} + \frac{s}{\lambda+(1-\lambda)p_L}\right)$.

- *Banks make zero profits.*

- *Borrowers with good projects get a loan and their final expected payoff is* $p_G X - \bar{R} - \frac{s}{\lambda+(1-\lambda)p_L}$.

- *Borrowers with bad projects are screened, but they do not get a loan.*

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Proof See Appendix.

Both screening and collateral contracts allow banks to separate good from bad projects. At the same time, both types of contracts are costly: screening involves investment in acquiring information about borrowers, and using collateral leads to losses in case of liquidation. The condition for screening contracts being preferred to collateral is given below.

Proposition 4.3 *If screening costs are relatively low compared to the liquidation costs of collateral, $s < (\lambda + (1-\lambda)p_L)\frac{\alpha(1-p_G)p_B}{p_G(1-p_B)-(1-\alpha)(1-p_G)p_B}(p_G X - \bar{R})$, then screening is preferred to collateral in the one-period game.*

Proof See Appendix.

As in Manove et al. (2001), screening is relatively more expensive if low-type borrowers represent a higher proportion of the population. This is because both high- and low-type borrowers need to be screened, and low-type borrowers are less likely to have profitable projects. In contrast, collateral-based contracts only factor in the difference between the success probabilities of good and bad projects, not their relative frequencies.

4.2   Two periods

Suppose now that we have two periods in which investors need to borrow to finance their projects[2]. Borrowers need to obtain one unit of capital in each period. The proportions of the two types in the overall population and their success probabilities are the same in the two periods. Also, as stated above, the type of a borrower does not change from the first period to the second.

In the one-period case, there was no practical difference between high- and low-type borrowers with good projects. In the two-period case, however, the two groups are no longer identical. If a

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[2]As it is standard in the literature, we assume that at the end of the first period successful borrowers consume their surplus and they need to borrow again to finance their second-period projects

borrower is found to be of high quality in the first period - and that can be done only through screening - then it is obvious that they will have a good project in the second period. The same cannot be said of low-type borrowers.

At the beginning of the second period, the incumbent bank has an informational advantage with respect to its first-period borrowers.

If banks have used collateral to select their borrowers, then the incumbent bank knows that its borrowers had a good project in the first period. Based on that, the updated probability that they have a good project in the second period is

$$P(G|C) = \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L}.$$

This is higher than the initial unconditional probability for the whole population $P(G) = \lambda + (1 - \lambda)p_L$.

If banks have used screening, then the incumbent bank can distinguish between high-type borrowers (that will have a good project in the second period with probability 1), and low-type borrowers, that have a probability p_L of having a good project in the second period. The bank can choose to screen or require collateral from its first-period low-type borrowers. Their quality is similar to that of borrowers that did not receive a loan in the first period from either bank. There is no need to screen or require collateral from high-type borrowers.

The incumbent bank is the first to make an offer to its first-period borrowers. The outside bank can then make a counteroffer, and borrowers choose their preferred contract[3].

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[3]We could also model the competition between banks as a simultaneous-move game. The main results would be qualitatively similar, but the algebra is more complicated, given that we would have a mixed-strategy equilibrium.

We now look at second-period competition between banks. The shape that competition takes depends on whether collateral or screening were used in the first period.

A. Suppose first that both banks used *collateral* in the first period. The incumbent knows that its first-period borrowers had a good project. The probability that they will again have a good project in the second period is given by $P(G|C)$ as stated above.

The successful first-period borrowers consist of both high- and low-type borrowers. We assume that the average borrower in this pool is creditworthy:

$$P_{G_1} X = \Big(\frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} p_G + \frac{1-\lambda)p_L(1-p_L)}{\lambda + (1-\lambda)p_L} p_B \Big) X \geq \bar{R}$$

The proportion of high-type borrowers in this pool is obviously higher than that in the overall pool of borrowers, since the low-type, bad-project first-period borrowers are missing.

The outside bank will try to poach the incumbent bank's borrowers. Its problem is that it cannot distinguish between good- and bad-project first-period borrowers that have not had a contract with it. The "outside" borrowers are both the other bank's first-period borrowers (who pledged collateral and had a good project) and all borrowers that did not pledge collateral and did not receive a loan from either bank. The outside bank is therefore faced with a pool whose quality is below that of the pool of all borrowers in our economy. In that pool, the average borrower is not creditworthy. As a result, the outside bank will have to use collateral or screening in order to select potential borrowers.

The inside bank has an informational advantage over its outside competitor, and it can offer a contract which is at least as good from the point of view of first-period borrowers that have a good contract in the second period. Those borrowers will have to receive a payoff which as least as good as the best possible alternative offered by the outside bank - whether that bank would

use collateral or screening.

The outside bank will end up actually lending to part of the first-period bad-project borrowers. All of those borrowers are obviously low-type, so their success probability is low. As a result, we can have the situation where the actual contract offered to second-period outside borrowers is a collateral contract, while potential contract that would be offered in case of successful poaching is a screening contract.

The profit of the inside bank and the borrowers' surplus in the second period depend on the more profitable poaching attempt by the outside bank - whether screening or collateral. The outside poaching attempt governs the ceiling on the inside bank's information rents, and the floor on borrowers' surplus.

The possible second-period equilibria are as follows.

Proposition 4.4 *When banks use collateral in the first period, in the second period we can have the following outcomes:*

- *The inside bank lends without screening or monitoring to its incumbent borrowers. The outside bank could use either collateral or screening to try to poach those borrowers.*

- *The inside bank screens its incumbent borrowers. The outside bank could use either collateral or screening to try to poach those borrowers.*

- *The inside bank uses collateral to select its incumbent borrowers. The outside bank also uses collateral.*

A discussion of these outcomes can be found in the Appendix. The interesting case for us is that where the inside bank screens, and the outside bank uses collateral. This is because we can to compare the borderline cases in the one- and two-period framework respectively.

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We now examine the case when both banks used *screening* in the first period.

After having screened their borrowers in the first period, banks know the type of their incumbent borrowers at the beginning of the second period. They can actually distinguish between two groups among those borrowers. High-type borrowers will have a good project for sure, and they do not require additional screening or collateral-based separation. Low-type borrowers are not creditworthy on average and require screening or collateral in order to get a loan. Given that the borrowers that did not receive a loan from either bank in the first period are also all low-type, and the borrowers with good projects among them get the best possible contract, inside banks do not have any advantage with respect to their first-period low-type borrowers. As a result, they make zero profits on those borrowers.

Once again, the banks' profits and the borrowers' surplus are governed by the outside bank's virtual poaching attempt.

Proposition 4.5 *1. The outside bank would use screening in its attempt to poach the inside bank's first-period borrowers if $s < (p_G X - \bar{R}) \frac{\alpha p_B (1-p_G)}{p_G - p_B + \alpha p_B (1-p_G)} \frac{\lambda + (1-\lambda) p_L (2-p_L)}{\lambda + (1-\lambda)(2-p_L)}$.*

2. If the outside bank poaching attempt uses collateral,then the inside bank's profits are $\Pi_2 = \frac{\lambda}{2}(p_G X - \bar{R}) \frac{\alpha p_B (1-p_G)}{p_G - p_B + \alpha p_B (1-p_G)}$. The interest charged by the inside bank is $R_2 = \frac{1}{p_G}\left(\bar{R} + (p_G X - \bar{R}) \frac{\alpha p_B (1-p_G)}{p_G - p_B + \alpha p_B (1-p_G)}\right)$.

3. If the outside bank poaching attempt uses screening,then the inside bank's profits are $\Pi_2 = \frac{\lambda}{2} s \frac{\lambda + (1-\lambda)(2-p_L)}{\lambda + (1-\lambda) p_L (2-p_L)}$. The interest charged by the inside bank is $R_2 = \frac{1}{p_G}(\bar{R} + s \frac{\lambda + (1-\lambda)(2-p_L)}{\lambda + (1-\lambda) p_L (2-p_L)})$.

Proof See Appendix.

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4.3 The first period

The banks' total profits will consist of the sum of expected profits over the two periods. Assuming a zero discount rate between periods, we have $\Pi_{total} = \Pi_1 + \Pi_2$.

First, suppose that banks use collateral in the first period, and the outside bank's poaching attempt is also based on collateral. If the inside bank uses screening we have that $\Pi_2 = \left(\frac{\lambda}{2} + \frac{1-\lambda}{2}p_L^2\right)(p_G X - \bar{R})\frac{\alpha p_B(1-p_G)}{p_G(1-p_B)-p_B(1-p_G)(1-\alpha)} - (\frac{\lambda}{2} + \frac{1}{2}(1-\lambda)p_L)s$.

The second-period expected surplus for high-type borrowers is

$$S_2 = p_G X - \bar{R} - (p_G X - \bar{R})\frac{\alpha p_B(1-p_G)}{p_G(1-p_B)-p_B(1-p_G)(1-\alpha)}$$

$$S_2 = (p_G X - \bar{R})(1 - Y),$$

where $Y \equiv \frac{\alpha p_B(1-p_G)}{p_G(1-p_B)-p_B(1-p_G)(1-\alpha)}$.

The expected high-type borrower surplus over the two periods is

$$S_{collateral} = (p_G X - \bar{R})\left(2 - 2Y - Y\frac{p_G p_L}{p_B} + Y(1-Y)\frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L}\right) - s(1-Y).$$

Let us now look at the case where screening is used in the first period, and the outside bank's second-period virtual attempt is based on collateral.

The interest rate charged in the first period, R_1, will drive per-borrower expected profits to zero: $(\lambda + (1-\lambda)p_L)(p_G R_1 - \bar{R}) + \lambda \times \frac{s}{2}\frac{\lambda+(1-\lambda)(2-p_L)}{\lambda+(1-\lambda)p_L(2-p_L)} = 0$.

The expected surplus of a high-type borrower is $p_G(X - R_1) + p_G(X - R_2)$. Plugging in the original parameters we get the following surplus:

$$S_{screening} = (p_G X - \bar{R})(2 - \frac{\alpha p_B(1 - p_G)}{p_G - p_B + \alpha p_B(1 - p_G)}) + \lambda \times \frac{s}{2} \frac{\lambda + (1 - \lambda)(2 - p_L)}{\lambda + (1 - \lambda)p_L(2 - p_L)} \frac{1}{\lambda + (1 - \lambda)p_L}$$

$$S_{screening} = (p_G X - \bar{R})(2 - Y) + s \times \frac{\lambda}{2} \frac{\lambda + (1 - \lambda)(2 - p_L)}{\lambda + (1 - \lambda)p_L(2 - p_L)} \frac{1}{\lambda + (1 - \lambda)p_L}$$

Screening will pe preferred to collateral in the first period if the surplus accruing to high-type borrowers is higher in the former case: $S_{screening} > S_{collateral}$. We can use this condition to compare the highest level of screening costs at which screening is preferred to collateral in the one-period and two-period case.

Proposition 4.6 *The cutoff point s above which screening is no longer feasible is higher under two-period bank relationships than under single-period bank relationships.*

The higher cutoff point indicates that, in longer bank relationships, screening becomes more attractive relative to collateral. Banks and borrowers are more willing to incur the cost of screening given the long-term benefits.

This switch in preference can be enhanced by additional factors, such as the volatility of borrowers' assets and their growth rates, which can increase the possibility that the borrower will not have enough collateral in the future, even if enough collateral is present today. In longer bank relationships, these factors can push banks and borrowers in the direction of screening and away from collateral.

5 Conclusion

Both collateral and screening can be used by banks to select their borrowers. At the same time, both have their costs. Appropriating and liquidating collateral can destroy value, and

screening requires the bank to expend resource on collecting and analyzing information about borrowers.

Our paper looks at the relative costs of screening and collateral. It finds that screening becomes cheaper and therefore the favored solution over longer time horizons. The reason is that the information acquired through screening is more likely to be useful in the future than the information acquired through the use of collateral. The flip side is that screening will also generate larger information rents for banks in later stages of the bank relationship. However, this also involves lower interest rates in the initial stage of the bank relationship, and that can be beneficial to young firms.

Our findings suggest that firms and banks may well prefer screening even though there is enough collateral available. Moreover, the preference for screening may be stronger if shocks to the value of collateral are more likely, and if growth opportunities are higher. The relative costs and benefits of collateral and screening are an interesting area for future empirical research.

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1 Appendix

1.1 Proof of proposition 4.1

The expected payoff for a borrower with a good project that uses collateral is given by

$$p_G(X - R) - (1 - p_G)C.$$

The expected payoff for a borrower with a good project that uses collateral is given by

$$p_B(X - R) - (1 - p_B)C.$$

The bad-project borrowers will not find it worthwhile to pledge collateral if the amount required is high enough:

$$p_B(X - R) - (1 - p_B)C < 0,$$

which means that, for a given interest rate R, the required amount of collateral is at least $\frac{p_B(X-R)}{1-p_B}$.

The banks' per contract profit on loans to good-project borrowers pledging collateral will be

$$p_G R + (1 - p_G)(1 - \alpha)C - \bar{R}.$$

Competition among banks will lower the interest rate R and draw expected profits down to

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zero. Therefore the amount of collateral pledged by banks will be

$$C = p_B \frac{p_G X - \bar{R}}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}$$

while the interest rate will be

$$R = \frac{(1 - p_B)\bar{R} - (1 - \alpha)p_B(1 - p_G)X}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}.$$

The payoff for good-project borrowers using collateral will be

$$Payoff = (p_G X - \bar{R})\frac{p_G(1 - p_B) - (1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}$$

$$= p_G X - \bar{R} - \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}(p_G X - \bar{R}).$$

The expected payoff for good-project borrowers that are screened and offered an interest rate R is given by

$$p_G(X - R).$$

Borrowers with bad projects that are screened will not receive a loan, since they are not creditworthy.

The bank's profits from screening a pool of borrowers with out of which a proportion p have good projects is:

$$p(p_G R - \bar{R}) - s$$

The highest profits will be realized when good-project borrowers are screened: $p = \lambda + (1 - \lambda)p_L$.

Competition will draw bank profits to zero; the competitive interest rate offered to borrowers will be $R = \frac{1}{p_G}\left(\bar{R} + \frac{s}{\lambda + (1-\lambda)p_L}\right)$.

The expected payoff for a good-project borrower will therefore be $p_G(X - R) = p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L}$.

Borrowers have a higher payoff under screening than under collateral if the per contract screening cost s is lower than $(\lambda + (1 - \lambda)p_L)\frac{\alpha(1-p_G)p_B}{p_G(1-p_B)-(1-\alpha)(1-p_G)p_B}(p_G X - \bar{R})$.

1.2 Proposition 4.4

When banks have used collateral in the first period (case A) we have the following possible outcomes in the second period.

A1. The incumbent bank lends to first-period borrowers without screening or collateral. This is possible if both screening and collateral liquidation costs are high. The outside bank could use collateral or screening if it were to attempt to poach the incumbent's borrowers. In equilibrium, it will be unable to poach those borrowers, and will only compete for the low-type borrowers that had a bad project in the first period and therefore did not receive a loan. It will use collateral to lend to those borrowers. However, whether the possible attempt would be using screening or collateral is important in determining the inside bank's profits.

A11. The outside bank attempt uses collateral

The second-period profit of the incumbent bank is

$$\Pi_2 = \frac{\lambda}{2}(p_G X - \bar{R})\frac{\alpha p_B(1 - p_G)}{p_G - p_B + \alpha p_B(1 - p_G)}$$
$$+ \frac{1}{2}(1 - \lambda)p_L^2(p_G X - \bar{R})\frac{\alpha p_B(1 - p_G)}{p_G - p_B + \alpha p_B(1 - p_G)}$$
$$+ \frac{1}{2}(1 - \lambda)p_L(1 - p_L)\left[\frac{p_B}{p_G}\left(\bar{R} + (p_G X - \bar{R})\frac{\alpha p_B(1 - p_G)}{p_G - p_B + \alpha p_B(1 - p_G)}\right) - \bar{R}\right]$$

The payoff of an inside borrower that has a good second-period project is that from a one-period collateral contract.

A12. The outside bank attempt using screening

The second-period profit of the incumbent bank is

$$\Pi_2 = \frac{\lambda}{2}s\frac{\lambda + (1 - \lambda)(2 - p_L)}{\lambda + (1 - \lambda)p_L(2 - p_L)}$$
$$+ \frac{1}{2}(1 - \lambda)p_L^2 s\frac{\lambda + (1 - \lambda)(2 - p_L)}{\lambda + (1 - \lambda)p_L(2 - p_L)}$$
$$+ \frac{1}{2}(1 - \lambda)p_L(1 - p_L)\left[\frac{p_B}{p_G}\left(\bar{R} + s\frac{\lambda + (1 - \lambda)(2 - p_L)}{\lambda + (1 - \lambda)p_L(2 - p_L)}\right) - \bar{R}\right]$$

The payoff of an inside borrower that has a good second-period project is that from a one-period screening contract.

A2. The incumbent bank uses collateral

If the inside bank uses collateral, then the outside bank uses collateral as well, since its potential borrower pools are of lower quality and a screening contract is even less likely.

A3. The incumbent bank screens

A31. The outside bank's attempt is also based on screening

The second-period profit of the incumbent bank is

$$
\begin{aligned}
\Pi_2 = {} & \frac{\lambda}{2} s \frac{\lambda + (1 - \lambda)(2 - p_L)}{\lambda + (1 - \lambda)p_L(2 - p_L)} \\
& + \frac{1}{2}(1 - \lambda)p_L^2 s \frac{\lambda + (1 - \lambda)(2 - p_L)}{\lambda + (1 - \lambda)p_L(2 - p_L)} \\
& - \left(\frac{\lambda}{2} + \frac{1}{2}(1 - \lambda)p_L\right)s
\end{aligned}
$$

A32. The outside banks' attempt is based on collateral:

The second-period profit of the incumbent bank is

$$
\begin{aligned}
\Pi_2 = {} & \frac{\lambda}{2}(p_G X - \bar{R}) \frac{\alpha p_B(1 - p_G)}{p_G - p_B + \alpha p_B(1 - p_G)} \\
& + \frac{1}{2}(1 - \lambda)p_L^2(p_G X - \bar{R}) \frac{\alpha p_B(1 - p_G)}{p_G - p_B + \alpha p_B(1 - p_G)} \\
& - \left(\frac{\lambda}{2} + \frac{1}{2}(1 - \lambda)p_L\right)s
\end{aligned}
$$

1.3   Proof of Proposition 4.5

If both banks use collateral to select their borrowers among the low-type pool, the equilibrium outcome will be similar to that in the one-period with collateral as far as those borrowers are concerned.

The required collateral will be

$$C = p_B \frac{p_G X - \bar{R}}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)},$$

while the interest rate will be

$$R = \frac{(1 - p_B)\bar{R} - (1 - \alpha)p_B(1 - p_G)X}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}.$$

The payoff for good-project, low-quality borrowers using collateral will be

$$
\begin{aligned}
Payoff &= (p_G X - \bar{R}) \frac{p_G(1 - p_B) - (1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B} \\
&= p_G X - \bar{R} - \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}(p_G X - \bar{R}) \\
&= p_G X - \bar{R} - \frac{\alpha(1 - p_G)p_B}{p_G - p_B + p_B(1 - p_G)\alpha}
\end{aligned}
$$

As stated above, the banks' payoff on outside borrowers and inside low-type borrowers will be zero.

If screening costs are low enough:

$$s \le p_L \frac{\alpha(1 - p_G)p_B}{p_G - p_B + p_B(1 - p_G)\alpha}(p_G X - \bar{R})$$

then banks will choose to screen the pool of low-type borrowers.

The interest rate charged to low-type borrowers will be

$$R = \frac{1}{p_G}\left(\bar{R} + \frac{s}{p_L}\right)$$

and the payoff for good-project, low-type borrowers will be

$$Payoff = p_G X - \bar{R} - \frac{s}{p_L}.$$

Once again, the banks' profits on low-type borrowers will be zero.

The contracts offered to inside, high-type borrowers will depend on the best possible payoff that they could receive from the outside bank. The outside bank could offer the standard collateral contract or choose to screen the pool consisting of the other bank's first-period borrowers and those borrowers that did not receive a loan from either bank in the first period.

If screening costs are relatively low, that is if

$$s \le \frac{\lambda + (1-\lambda)p_L(2-p_L)}{\lambda + (1-\lambda)(2-p_L)} \frac{\alpha p_B(1-p_G)}{p_G(1-p_B) - p_B(1-p_G)(1-\alpha)}(p_G X - \bar{R}),$$

the outside bank would choose a screening contract to poach the inside bank's first-period high-type borrowers.

In that case, the inside bank has to provide high-type borrowers with a payoff which is at least what they would get from the outside option

$$Payoff = p_G X - \bar{R} - s\frac{\lambda + (1-\lambda)(2-p_L)}{\lambda + (1-\lambda)p_L(2-p_L)}.$$

The second-period bank profits can therefore be written as

$$\Pi_2 = \frac{\lambda}{2}(p_G X - \bar{R}) \frac{\lambda + (1-\lambda)(2 - p_L)}{\lambda + (1-\lambda)p_L(2 - p_L)} s.$$

If screening costs are above that level, then collateral becomes the preferred contract, since it can provide a higher payoff to potential good-project borrowers. The payoff of those borrowers will be the same as in the case of the collateral equilibrium in the one-period model (Payoff $=$ $p_G X - \bar{R} - (p_G X - \bar{R}) \frac{\alpha p_B (1 - p_G)}{p_G (1 - p_B) - p_B (1 - p_G)(1 - \alpha)}$).

The incumbent banks will be able to charge their first-period high-type borrowers an interest rate that makes them slightly better off than the collateral contract.

$$p_G(X - R^{2,0}) \geq p_G X - \bar{R} - \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}(p_G X - \bar{R})$$
$$R^{2,0} = \frac{1}{p_G}\left(\bar{R} + \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}(p_G - \bar{R})\right)$$

The incumbent bank's profit per high-type borrower will be:

$$p_G R^{2,0} - \bar{R} = \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}(p_G - \bar{R}),$$

therefore the total profits will be

$$\Pi_2 = \frac{\lambda}{2}(p_G R^{2,0} - \bar{R})$$
$$= \frac{\lambda}{2}(p_G X - \bar{R}) \frac{\alpha p_B (1 - p_G)}{p_G(1 - p_B) - p_B(1 - p_G)(1 - \alpha)}.$$