

Lending Technologies and Lending Relationships*

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Abstract

We examine banks' choice between two costly instruments used to identify good loan applicants: direct screening by acquiring borrower-specific information and collateral requirements. We show that with longer relationships the preference for screening increases both in initial and in later periods. Total welfare is enhanced as a result of more efficient selection, and access to credit can be improved. The model explains the reduced incidence of collateral, and potentially higher interest rates in later periods for safer borrowers. The results are stronger under more intense bank competition. Our findings support policies conducive to enduring lending relationships.

Keywords: Collateral, screening, bank relationships

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1 Introduction

The recent financial crisis disrupted many lending relationships, with significant effects on the overall economy (Bolton et al. (2016), Ramcharan, Verani, and Van den Heuvel (2016)). Moreover, in recent years bank relationships have increasingly faced competition from nonbank lenders (Nini (2013)), and new bank entrants (Giannetti and Laeven (2012), Claessens (2016)). In this paper, we examine the way in which the expected length of a lending relationship affects the technologies used to identify creditworthy borrowers. Our results show that the prospect of repeated lending can determine the choice of lending technology, with an impact on social welfare, access to credit and the borrowers' surplus. We interpret the results as an argument in favor of policies that increase the stability of the banking system and bank-borrower relationships.

Our model is based on adverse selection. One technology that can be used to identify high-quality borrowers is collateral requirements: higher quality borrowers should be more willing to pledge assets.¹ As an alternative, lenders can identify worthwhile projects by directly acquiring information about borrowers². Both selection instruments are costly. The use of collateral is exposed to liquidation losses in fire sales (Shleifer and Vishny (2011), Degryse et al. (2015)), while the direct analysis of funding applications (which we call *screening* for brevity) involves costs associated with information processing (Hauswald and Marquez (2003)) and the loan officers' time (Berger and Udell (2002)).

We analyze the link between the prospect of repeated lending and the banks' choice between the two selection devices³. For instance, borrowers are more likely to meet again with their local lenders (Christensen and Johansen (2010)) than with distant or foreign banks (Giannetti and Laeven (2012), Beck, Ioannidou and Schäfer (2016)) and relationships are more likely to survive if banks are better capitalized (Cornett et al. (2011)). We find that the prospect of longer lending relationships reduces the incidence of collateral requirements, both in initial and in subsequent lending.

Our first main result is that borrowers who were initially required to post collateral in order to get a loan are likely to be just screened by their bank for subsequent loans. In contrast, borrowers that switch to competing banks are more likely to have to post collateral. Furthermore, borrowers that can only get secured loans from their bank in

¹Theoretical work on the screening role of collateral in an adverse selection setting dates back to Bester (1985). The recent financial crisis has emphasized the importance of reliable information on the borrowers' ability to repay. For recent empirical evidence on ex ante collateral-based selection see Berger, Frame and Ioannidou (2011), Berger et al. (2011), and Cerqueiro, Ongena and Roszbach (2016).

²The importance of information collection by banks about their borrowers has been studied extensively: see Boot (2000) for a review.

³Repeated lending is usually taken as an indicator of the strength of a bank relationship; see for instance Boot (2000), Bharath et al. (2007), Li, Lu and Srinivasan (2013). The tradeoff between information acquisition and collateral requirements has been documented empirically by Jiménez, Salas, and Saurina (2006) and Berger, Frame and Ioannidou (2011).

later stages of lending relationships are more likely to be of low quality and also to switch to other providers of funds.

The intuition behind this finding is as follows. The profitability of screening depends on the average quality of the borrower pool. If there is a higher proportion of creditworthy borrowers, then the probability that analyzing a credit application results in a loan is also higher. In contrast, the required collateral is not linked to average quality: it has to be sufficient to discourage low-quality borrowers from applying, and it is therefore only influenced by the difference in success probabilities of individual projects. Because in subsequent lending banks learn more about their borrowers and are able to weed out the worst among them, the set of borrowers they focus on in later stages is of relatively higher quality, and the per-borrower cost of screening goes down. Conversely, borrowers who are trying to switch to competing banks are of relatively lower quality, and will be required to post collateral by those banks. This prediction is consistent with a long series of empirical results finding a decreased incidence of collateral in later stages of bank relationships, and a higher incidence of collateral for borrowers that switch banks (see for instance Berger and Udell (1995), Degryse and Cayseele (2000), Chakraborty and Hu (2006), Jiménez and Saurina (2006)). A recent empirical study by Severino, Brown, and Coates (2014) confirms the idea that costlier collateral requirements are associated with higher screening. They find that when bankruptcy protection increases, secured lending declines, but without an increase in delinquency.

Unlike collateral requirements, the interest rate for repeat borrowers may actually go up in later stages. There are two reasons for this: on the one hand the hold-up problem (Sharpe (1990), von Thadden (2004)), and on the other hand the switch to screening. Screening is associated with higher interest rates since banks do not receive the post-liquidation value of collateral in case of default. Degryse and Cayseele (2000) and Ioannidou and Ongena (2010) document increases in interest rates as bank relationships progress. In line with our theoretical result, Severino, Brown, and Coates (2014) find that a reduction in secured lending is associated with an increase in interest rates, without a corresponding increase in loan losses.

Our second main result is that when future lending is more likely, screening is also more widespread in the initial stages of the relationship. The explanation behind this finding is linked to the classical hold-up problem in lending. In long-term relationships borrowers anticipate that banks will extract information rents in the later stages, and competition between banks will push them to offer discounts in the initial period. A lower interest rate offered in initial lending will however increase collateral requirements to prevent low-quality borrowers from getting a loan. This will raise the expected liquidation costs. In contrast, screening does not present such a disadvantage: banks can simply lower interest rates and screen at the same cost per borrower. As a result, a higher probability of repeated lending decreases the incidence of collateral in initial lending. Through different mechanisms, the prospect of longer relationships therefore reduces the incidence of collateral in both initial and later stages of bank relationships.

We show that the possibility of repeated lending can enhance overall welfare by

improving the choice of selection instruments. In later periods, selection costs will be reduced by screening higher quality borrower pools (and requiring collateral from low-quality pools). In initial lending, banks will again pick the relatively cheaper selection device. The result is improved welfare in both initial and later periods. Compared to one-period relationships, borrower surplus is significantly higher in initial periods, and can be marginally higher in later ones. Moreover, we show that access to credit can also be improved: marginal projects denied credit under single-round lending can receive financing if repeated lending is likely.

We further analyze the difference between collateral and screening in terms of the reusability of information. 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 information that can be used both to assess the quality of their current projects, and to get a signal about the quality of their future projects. We show that this difference makes screening even more useful in the case of repeated interaction between banks and borrowers⁴.

Our results contrasting screening and collateral are stronger under more intense bank competition. The reason is that without competition banks can charge higher interest rates, and that reduces the amount of collateral that is needed to separate high- and low-quality borrowers. The lower amount of collateral with lower liquidation makes it (relatively) more sustainable in several periods.

Our paper contributes to the literature on banks' choice between various borrower selection technologies, which is still quite limited (Steijvers and Voordeckers (2009)). 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 high-type borrowers unaware of the actual quality of their current project may choose to pledge collateral, leading to lending losses. We examine one of the possible circumstances that can work in the opposite direction: longer-term relationships may make screening more attractive and reduce the potentially damaging use of collateral. This can help render banks more "active" and enhance information acquisition in the economy.

It has been shown empirically that some firm-bank relationships are more long-lasting than others. This may depend both on bank and on firm characteristics. For example, lending relationships with foreign banks or banks from other regions tend to be more "fragile" than those with local banks (Berger, Klapper, and Martinez Peria (2008), Alessandrini, Presbitero, and Zazzaro (2009)). Recent empirical evidence shows that some banks tend to specialize in certain areas - for instance financing foreign trade (Paravisini, Rappoport, and Schnabl (2015)) -, implying that many firms will

⁴Allowing banks to acquire further information during the lending relationship (Boot (2000)) strengthens our results. Better informed banks in later stages are able to select a higher quality borrower pool, which reduces the incidence of collateral in later periods. The superior information also increases their informational rents in later periods, which are compensated by lower initial interest rates, once again unfavorable to secured lending.

only have limited interaction with them. Small local banks have often been shown to have a competitive advantage in relationship lending (Berger et al. (2005), Berger and Black (2011), Christensen and Johansen (2010)), while banks from outside the region (Bofondi and Gobbi (2006)), large banks (Berger et al. (2005)), non-bank institutional investors (Nini (2013)) tend to prefer arm's length funding. Credit lines are more likely to be associated with long-term relationships than other forms of lending (Berger and Udell (1995)). Moreover, better capitalized banks with sufficient liquidity, lower off-balance sheet risk and a higher proportion of core deposit financing are less likely to restrict their lending in a crisis, thus providing for more stable relationships (Ivashina and Scharfstein (2009), Ramcharan, Verani, and Van den Heuvel (2016), Cornett et al. (2011)). Foreign banks and local banks more exposed to foreign shocks are also more likely to cut funding in a global crisis (Giannetti and Laeven (2012), Khwaja and Mian (2008), Puri, Rocholl and Steffen (2011)). On the firm side, small and R&D intensive companies are more likely to choose relationship lending (Mommel, Schmieder, and Stein (2008)), while small, profitable and highly levered firms have shorter relationships (Ongena and Smith (2001)).

Our results imply that the prospect of longer relationships reduces the incidence of collateral. This is confirmed empirically. Longer durations have a lower incidence of secured lending (Bharath et al. (2011), Bodenhorn (2003), Voordeckers and Steijvers (2006), Menkhoff, Neuberger, and Rungruxsirivorn (2012)). Hainz and Wiegand (2013) find that 32.1% of credit lines in their sample are unsecured, compared to 15.7% for other loan types. A similar result is reported by Fraser (2012) comparing overdrafts and term loans. Beck, Ioannidou and Schäffer (2016) find that foreign bank lending is associated both with a higher incidence of collateral and lower relationship durations. External shocks that make the continuation of bank relationships uncertain tend to increase the incidence of collateral. Gormley (2010) finds that the entry of foreign banks, which disrupts relationships with local banks, reduces funding to firms with fewer tangible assets, indicating a higher incidence of collateral. Hainz and Wiegand (2013) find that 47% of the firms in their sample report that their financing was affected by higher collateral requirements during the financial crisis, while Fraser (2012) reports an increase in collateral incidence for new overdrafts. Azariadis, Kaas, and Wen (2016) find that unsecured credit tends to be procyclical, while secured credit is acyclical; Paravisini (2008) finds that following positive liquidity shocks the incidence of collateral decreases, without an increase in defaults.

We find that the lower incidence of collateral in repeated lending improves welfare, access to credit and borrower surplus. Policies that encourage stable lending relationships, for instance by requiring adequate capitalization, promoting small local banks and core deposit financing, may be a salutary idea. Within banks, having a stable base of loan officers, which preserves soft information over time (Uchida, Udell, and Yamori (2012)), can also be useful. The lower incidence of collateral-based lending is also beneficial given that fluctuations in its value can affect credit availability and

aggregate output (Bernanke and Gertler (1989), Kiyotaki and Moore (1997))⁵.

Our work contributes to the literature on arm's length (transactional) vs. relationship lending.⁶ We find that relationship lending can be welfare-enhancing because it allows borrower selection at a lower cost. However, encouraging persistent relationships does not imply artificially raising barriers to entry⁷. The entry of relationship banks will increase competition, and our result suggest it will decrease the incidence of collateral, consistent with empirical evidence (Voordeckers and Steijvers (2006), Zarutskie (2006)). Supporting solid relationship-oriented lending institutions without limiting competition can have positive effects.

We restrict our attention to the role of collateral in reducing adverse selection (Bester (1985), Besanko and Thakor (1987a, b)). Collateral can also be a device used to reduce agency issues either on the borrower's (Boot, Thakor and Udell (1991)) or on the lender's side (Inderst and Mueller (2007), Rajan and Winton (1995)). While the agency-reducing role of collateral is well documented, its use in reducing adverse selection is also important. Several recent empirical papers have brought up rigorous evidence supporting the use of collateral to reduce ex ante adverse selection. Berger, Frame and Ioannidou (2011) show that unobservably riskier borrowers are less likely to pledge collateral, consistent with the adverse selection role of collateral, but as the lending relationship progresses they become more likely to pledge collateral. Jiménez, Salas, and Saurina (2006) also show that borrowers with a higher unobserved quality are more likely to receive secured loans. Becker, Bos, and Roszbach (2016) find that borrowers with higher internal ratings in a bank's portfolio are also more likely to pledge collateral and ultimately have lower default rates.

Townsend (1982) shows that repeated lending can improve contractual outcomes. In his model, repeated lending increases borrowers' incentives to report their cash flows truthfully. Also in a moral hazard context, Boot and Thakor (1994) show that pledging collateral in the early stages of bank relationships can help borrowers build reputation and receive funding on favorable terms in later stages. In our case, we show that repeated lending can also be an improvement in addressing adverse selection issues. Unlike Boot and Thakor (1994), our model explains the lack of collateral in initial stages, which is frequent in the case of credit lines and overdrafts, in contrast to term loans (Fraser (2012), Jiménez and Saurina (2004), Sette and Gobbi (2015)).

A parallel growing literature is based on dynamic agency models. Rampini and Viswanathan (2010; 2013) and Rampini, Sufi, and Viswanathan (2014) show that col-

⁵The side effects of collateral-based financing have been confirmed in recent empirical studies (Gan (2007), Benmelech and Bergman (2011), Chaney, Sraer and Thesmar (2012)).

⁶Overviews of bank relationships can be found in Boot (2000), Ongena and Smith (2000), Degryse and Ongena (2005), Kysucky and Norden (2016).

⁷In recent years governments have tried to support competition between financial institutions. For instance, in September 2013, a major account switching service was launched in the UK, that would facilitate current account switching and reduce necessary time from one month to a week. See <https://www.gov.uk/government/news/bank-account-switching-service-set-to-launch>. A long-term overview of bank relationships can be found in Braggion and Ongena (2014).

lateral constraints link the firm’s financing decisions to decisions about risk management (i.e., conservation of debt capacity for future investment) when enforcement is limited and repayment promises need to be collateralized. As a result, financially constrained firms may not fully hedge. Unlike this literature, we focus on adverse selection issues and the effect of relationships on collateral requirements; we do not address firms’ capital structure and risk management policies.

In what follows, section II presents the setup of the model. Section III presents the results in a competitive banking model, and section IV outlines the findings in the case where banks have market power. Section V discusses borrower surplus, bank profits and overall welfare. Section VI concludes.

2 The Model

2.1 The Setup

Suppose there is a continuum of borrowers with total mass equal to 2. 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 one unit of capital. Good projects G produce a cash flow $X > 0$ 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: high-quality H and untalented low-quality L who represent proportions λ and $1 - \lambda$ in the population respectively. Borrowers do not have any funds of their own and have to borrow the initial investment amount from at most one bank at a time. They do however have (illiquid) assets in place than can be pledged as collateral.

High-quality entrepreneurs have a probability $p_H = 1$ of having a good project, while the low-quality ones have a good project with probability $p_L < 1$, and a bad project with $1 - p_L$. Entrepreneurs do not know their own types, but they are aware of the quality of their current projects. 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, so are high-type borrowers. For simplicity, we assume the average borrower is not creditworthy, which also implies that on average low-type borrowers should not receive a loan: $(\lambda p_G + (1 - \lambda)(p_L p_G + (1 - p_L)p_B))X < \bar{R}$. We assume that borrowers with a bad project derive non-monetary utility from being in the credit market; they enjoy applying for a loan even if they know they are not creditworthy.⁸

We consider both the competitive case (which we model as competition between two banks), and the case in which we have just one monopolistic bank (which is still a price taker on the market for its own funds). Banks get funding at a (gross) cost of

⁸Alternatively, we could assume that there is a positive probability of errors in screening, so that borrowers with bad projects will also have positive expected profits. Our results carry over to that case.

\bar{R} . When we look at repeated lending, we use a discount rate of zero across periods. Both banks and borrowers are risk-neutral.

We examine the distinct cases of one and two-period bank relationships. In the former borrowers live and require funding for just one period. In the latter borrowers live for two periods, have an investment project in each period and require funding for each project.⁹ The success probability of the investment projects is independent across periods for a given borrower. The borrower types remain unchanged across periods, however.

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 pledge collateral to separate themselves from borrowers with bad projects. When a project has been financed by a secured loan 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.¹⁰ Screening involves a cost s per borrower, and it reveals the quality of the current project.¹¹ As usual (Manove et al. (2001)), screening is assumed to be non observable and non contractible, and it cannot be sold to borrowers as a service.

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.

We first consider one-period lending. 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 look at 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. The type of a given borrower, and hence the probability of having a good or a bad project, remains the same across periods; we have the same borrowers in the population, with the same

⁹As usual in the literature, we assume that at the end of the first period successful borrowers consume their surplus and they need to borrow to finance their second-period projects.

¹⁰The assumption of costly liquidation of collateral is well-established in the theoretical literature. The importance of liquidation costs is also supported empirically. Benmelech and Bergman (2009) find that collateral that easier to redeploy is associated with lower credit spreads and higher loan-to-value ratios. Eisfeldt and Rampini (2009) find that ease of repossession is associated with higher debt capacity. Liberti and Mian (2010) confirm that banks are sensitive to the specificity of assets pledged as collateral and thus to their liquidation costs.

¹¹We later consider the case where screening reveals borrower type: it gives deeper information about a potential borrower's business skills, and that information can be reused when examining further loan applications from the same borrower.

success probabilities for good and bad projects. 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, each bank will offer loan contracts to its own first-period 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 a bank that provide it with nonnegative profits and provide at least one borrower with a strictly larger payoff.

3 Bank competition

We first look at the case of a competitive banking system: banks bid for potential borrowers, applicants can freely choose their lender, and competition will drive down bank profits. Lenders can use screening or collateral to identify creditworthy borrowers. We begin by examining the case where screening reveals just the quality of the current project and later on look at the case where it reveals a borrower's type.

3.1 The one-period equilibrium

We consider the case of two banks that compete for borrowers that are offered single one-period loans. Since the average borrower is not creditworthy, banks cannot lend without selecting their borrowers by either requiring collateral or screening them.

The timing of events is as follows:

1. Each bank offers contracts (R, C) sequentially, where R is the interest rate, $C \geq 0$ is the collateral requirement.
2. Each entrepreneur applies to one bank for one loan contract, maximizing their payoff: if offered equal payoffs, borrowers allocate themselves in equal proportions to the two banks.
3. Each bank decides whether or not to screen the applicants that apply for a given contract. Screening entails a cost s per borrower.
4. Banks approve or reject applications.
5. If the approved project is successful, it yields X , from which the borrower repays R to the bank.

We assume that banks do not give loan applicants verifiable evidence of a positive screening outcome until a loan contract is signed, so borrowers are unable to take the screening result and take it to another, competing bank. If such free riding were possible, there would be inefficiently low screening.

Proposition 3.1 *When both banks use collateral, there is a unique separating equilibrium in which*

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 $R_c = \frac{(1-p_B)\bar{R} - (1-\alpha)p_B(1-p_G)X}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)}$.*
2. *Banks make zero profits.*
3. *Borrowers with good projects get a loan and their final expected payoff is $P(C) = p_G X - \bar{R} - \frac{\alpha(1-p_G)p_B}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B} (p_G X - \bar{R})$.*
4. *Borrowers with bad projects do not get a loan.*

Proof See Appendix.

When collateral is used to identify creditworthy projects there is no pooling equilibrium. The intuition behind this result is that a borrower's rate of substitution between interest and collateral is different across the two project types. A new contract can change the interest-collateral mix in a way that appeals only to good project borrowers, and thus reduce the effective credit risk for the lender, so as to make it profitable. At the same time, for separation collateral needs be sufficiently high to yield bad-project borrowers a negative payoff, $p_B(X - R) - (1 - p_B)C \leq 0$. As indicated by the empirical literature (Booth and Booth (2006), Brick and Palia (2007), Cerqueiro, Ongena, and Roszbach (2016)), there is an inverse relationship between interest rates and collateral requirements. Finally, note that in the case above screening borrowers would not add any information for the bank and would not be used at the same time when collateral separates the projects.

When banks instead use screening to identify good projects, competition will again drive the interest rate charged by banks to the level where their profit net of screening costs is zero.

Proposition 3.2 *When both banks screen their potential borrowers:*

- *The interest rate charged by banks will be $R_s = \frac{1}{p_G} \left(\bar{R} + \frac{s}{\lambda + (1-\lambda)p_L} \right)$.*
- *Banks make zero profits.*
- *Borrowers with good projects get a loan and their final expected payoff is $P(S) = p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L}$.*
- *Borrowers with bad projects are screened, but they do not get a loan.*

Proof See Appendix.

A higher level of the per-borrower screening costs s will increase the break-even interest rate R_s charged by banks and will reduce the good-project borrowers' payoff. Another important factor that influences the break-even interest rate is the average

quality of the borrower pool: a lower average quality (a lower proportion of high-quality borrowers in the formula: $\lambda + (1 - \lambda)p_L$) increases the rate. The reason is that the bank screens all borrowers that apply for a loan, but only lends to creditworthy borrowers. This creates an important contrast between screening borrowers and requiring collateral. The per-borrower cost of screening depends on the average quality of the borrower pool, while the cost of collateral does not: the amount of collateral required depends on the gap between the quality of good and bad projects (between p_G and p_B) and the probability that projects that get a loan default ($1 - p_G$), leading to liquidation costs. As a result, a higher frequency of high-quality borrowers in the overall pool will increase the preference for screening relative to collateral. This mechanism is also present in Manove et al. (2001).

Banks will have to compare the liquidation costs of collateral and the screening costs to choose the borrower selection method. Given that banks compete with each other, the choice will be determined by maximizing the surplus obtained by borrowers with good projects. The condition for screening contracts being preferred to collateral is given below.

Proposition 3.3 *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 one may expect, the cutoff point $s^* = (\lambda + (1 - \lambda)p_L) \frac{\alpha(1-p_G)p_B}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B} (p_G X - \bar{R})$ is increasing in the average quality of the borrower pool ($\lambda + (1 - \lambda)p_L$) and the liquidation cost of collateral (α). We use this cutoff point as a benchmark in the following sections as a way to examine whether the possibility of longer lending relationships has a significant influence on the preference for screening or requiring collateral.

3.2 Two periods

We now analyze the interaction between banks and borrowers over two periods¹². There is a probability $\rho > 0$ that borrowers and banks interact for a second period. In each period borrowers need one unit of capital. The proportion of the two types in the overall population and their probabilities of getting a good project are the same in both periods. Also, as stated before, the type of a borrower does not change from the first period to the second. In each of the two periods, borrowers get funding from one

¹²Repeated interaction is the key feature of relationship banking (Boot (2000)). Bharath et al. (2007) find that “the probability of a relationship lender providing a future loan is 42%, while for a non-relationship lender, this probability is 3%. Loan repayments followed by new loans from the same lender are more likely to be a feature of credit lines, overdrafts or loan commitments, which play a major role in corporate lending (Shockley and Thakor (1997)).

of the banks, but they can switch banks between periods. We provide banks' choice of instruments in the initial and subsequent selection of loan applicants¹³.

In the first period, banks will have to either screen potential borrowers or require collateral, since the average borrower is not creditworthy. At the beginning of the second period, each bank has a group of borrowers that received a loan from it in the first period. Those borrowers had a good project in the first period, so they are of relatively high quality¹⁴. However, not all borrowers that had a good project in the first period are guaranteed to also have a good project in the second period; some of them are low-type borrowers that happened to be lucky. As a result, further selection (via collateral requirements or direct screening) by the first-period bank may be warranted before second-period lending. We call the bank the inside (or incumbent) bank with respect to those borrowers. At the same time, each bank may want to attract borrowers it did not lend to in the first period, some of which have received a loan from the other bank. We call the bank the outside bank with respect to those borrowers. The outside bank is at a competitive disadvantage: it faces a pool that borrowers that did not receive a loan from it in the first period. That pool includes not only the other bank's first-period borrowers - that are relatively high-quality -, but also the borrowers that did not get a loan from either bank in the first period and are therefore of poor quality. Since it has superior knowledge of its own borrowers, the incumbent will be able to ward off the poaching attempts of its competitor; it will offer a contract that provides a surplus just above the outside option to second-period borrowers with good projects and make positive profits. This hold-up problem for successful first-period borrowers implies that the incumbent bank can make positive profits on those borrowers.

The timing of events in the second period is as follows:

1. Each bank offers contracts (R_2, C_2) , where R_2 is the second-period interest rate, and $C_2 \geq 0$ is the collateral requirement. 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 the preferred contract.
2. Each entrepreneur applies to one bank for one loan contract, maximizing their payoff: if offered equal payoffs, borrowers allocate themselves in equal proportions to the two banks
3. Each bank decides whether or not to screen the applicants that apply for a given contract.

¹³We only present the two-period case as an example of repeated learning. Alternatively, we could have an infinite time horizon and assume, as in Hachem (2011) that the borrowers' types become public information starting from the third period to keep the state space finite. The intuition would be that borrowers are unknown in the early stages, then they become better known to their bank, and finally they become established and well known by outside institutions. Our results would be similar in that case.

¹⁴For brevity, we present the case where this pool is still not creditworthy without any borrower selection mechanism, i.e., $\left(\frac{\lambda}{\lambda+(1-\lambda)p_L}p_G \frac{(1-\lambda)p_L}{\lambda+(1-\lambda)p_L} (p_L p_G + (1-p_L)p_B)\right)X - \bar{R} < 0$. It is straightforward to verify that our main result regarding banks' first-period choice also holds in the complementary case, where the average borrower is creditworthy and can receive a loan without screening or collateral requirements.

4. Banks approve or reject applications.
5. If the approved project is succeeds, it yields X , from which the borrower repays R .

We solve the game by backward induction. In the first period, the two banks will offer screening or collateral-based contracts and in either case borrowers with good projects will choose the contract that provides them with the higher two-period surplus. At the beginning of the second period, banks know that the inside borrowers had a good project in the first period, so they are of above average quality. We prove the following in the appendix.

Lemma 3.4 *If $s \leq s_2$, where $s_2 = \frac{\lambda+(1-\lambda)p_L^2}{\lambda+(1-\lambda)p_L} \frac{\alpha p_B(1-p_G)}{p_G(1-p_B)-(1-\alpha)p_B(1-p_G)} (p_G X - \bar{R})$, then the inside bank uses screening in period 2. Otherwise, both banks use collateral in both periods.*

Note that, as we show in the proof of the following proposition in the appendix, whenever screening is used by the outside bank in period 2 ($s \leq p_L \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B)-(1-\alpha)p_B(1-p_G)} < s^*$, so we are below the one-period cutoff level of screening costs), screening is also used by both banks in the one-period game. We therefore restrict our attention to the case when the outside bank uses collateral (around the one-period cutoff s^*), to allow collateral to be used in the one-period game.

As we have mentioned above, collateral-based selection is not sensitive to the average quality of the borrower pool. In contrast, the viability of screening depends on the average quality of the borrower pool which is screened. The inside bank is faced with a relative high-quality pool: borrowers that received a loan in the first period had a good project in that period and therefore have a high probability of having good projects in the second period ($p(G|G) = \frac{\lambda+(1-\lambda)p_L^2}{\lambda+(1-\lambda)p_L}$). If screening costs are relatively low ($s \leq s_2$, where $s_2 > s^*$, given the higher quality of the borrower pool), the inside bank will prefer to screen borrowers, since that maximizes the joint surplus. The contract offered to the first-period borrowers will provide them with a surplus which is higher or equal to the surplus they would get by accepting the contract offered by the outside bank.

The outside bank will be faced with a relatively low-quality pool, since it is only borrowers with a bad project in the first period that are willing to switch. If screening costs are around s^* , the benchmark one-period cutoff, the outside bank will offer the one-period collateral contract to the borrowers it is trying to poach.

As a result, when screening costs are low ($s \leq s_2$), the inside bank will screen, while the outside bank will require collateral. The inside bank will offer a screening contract that provides borrowers a surplus which is just above the one-period collateral contract surplus ($P(C)$). To do that, banks will offer (slightly below) the following interest rate: $R_{inside} = \frac{\bar{R}}{p_G} + \frac{1}{p_G} (p_G X - \bar{R}) \frac{\alpha(1-p_G)p_B}{p_G(1-p_B)-(1-\alpha)(1-p_G)p_B}$. At this rate the inside and outside contract payoffs are equalized: $p_G(X - R_{inside}) = P(C) = \frac{(p_G - p_B)(p_G X - \bar{R})}{p_G(1-p_B)-(1-\alpha)p_B(1-p_G)}$ and incumbent banks will make positive profits by lending to their first-period borrowers.

For very high values of screening costs ($s > s_2$), the inside bank has to resort to requiring collateral, and will therefore not be able to profit from its competitive advantage of facing a higher-quality borrower pool. Both the inside and the outside bank make zero expected profits. The first period is then reminiscent of the one-period game, when, at those high of values of screening, collateral would again be chosen.

The interesting case is therefore that of “average” screening costs, where the inside bank screens borrowers and the outside bank requires collateral. In what follows, we restrict our attention to values $p_L \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} < s < \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L}$, an interval which also includes the one-period cutoff s^* ¹⁵. Given this outcome in the second period, we analyze the banks’ choice in the first period.

The collateral-based first-period contract will have to reflect the expected second-period bank profits. Borrowers with good projects will anticipate the banks’ future ability to extract informational rents and will require a discount in the first period. We denote the second-period profit per first-period borrower by $\pi_{2G1} > 0$, where $G1$ stands for having had a good project in the first period. The banks’ new zero-profit condition can be written as

$$p_G R_{1,C} + (1 - p_G)(1 - \alpha)C_1 + \rho\pi_{2G1} = 0,$$

where $R_{1,C}$ and C_1 are the interest rate and collateral required by banks in the first period. The amount of collateral will still have to be large enough to separate good- and bad-project borrowers: $C_1 \geq \frac{p_B(X - R_{1,C})}{1 - p_B}$. These conditions give us the first-period interest rate and collateral.

Proposition 3.5 *The interest rate and collateral in the first period are given by:*

$$R_{1,C} = \frac{(1 - p_B)\bar{R} - (1 - p_B)\rho\pi_{2G1} - (1 - \alpha)p_B(1 - p_G)X}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}$$

$$C_1 = p_B \frac{p_G X - \bar{R} + \rho\pi_{2G1}}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}.$$

Compared to the one-period case, the interest rate will be lower to compensate for the second-period rents extracted by incumbent banks: $R_{1,C} < R_C$. At the same time, however, the amount of collateral required by banks will have to increase to pre-empt bad-project borrowers attracted by the low interest rate: $C_1 > C$.

If screening is used in the first period, interest rate is given by

¹⁵The first term of the inequality is the level of the screening cost $s < s^*$ below which the outside bank also screens; in that case screening is used in all cases in both one-period and two-period lending relationships. The last term is $s_2 > s^*$, the level of the screening above which the inside bank requires collateral, and collateral is used in all cases in both one-period and two-period lending relationships.

$$R_{1,S} = \frac{1}{p_G} \left(\frac{s}{\lambda + (1 - \lambda)p_L} + \bar{R} - \rho\pi_{2G1} \right) < R_S.$$

It is lower than the screening interest rate in the one-period game.

Proof See Appendix.

The proposition provides the first step to our key finding: because collateral is now higher in the first period, the liquidation costs associated with it will be higher as well. If banks have used screening in period one, there will again be positive second-period profits for the banks coming from their informational advantage relative to their initial borrowers. In the first period, banks will have to offer good-project borrowers a discount to compensate them for the rents extracted in the second period, equal to the expected second period profits from first-period good project borrowers. As a result, the break-even interest rate that they charge first-period borrowers will be below the one-period rate. The discount is higher the higher the probability of a continuing relationship ρ .

Proposition 3.6 *In the two-period model, the cutoff level of screening costs, s^{**} , below which screening is preferred to requiring collateral in initial lending is higher than the one-period cutoff level s^* .*

Proof See Appendix.

The proposition establishes our key result: for values of screening costs just above s^* , namely $s^* \leq s \leq s^{**}$ borrowers are required to post collateral under one-period lending relationships, but they are screened under repeated lending.

The proposition indicates that the possibility of repeated lending moves banks away from collateral requirements and makes them more likely to screen borrowers. In practice, this may be good news for borrowers with insufficient collateral: they would be denied credit in short-term relationships, but they may be granted funding if longer-term relationships are likely. The lower incidence of collateral in the case of relationship lending has been consistently documented empirically in many countries (Li, Lu and Srinivasan (2013), Degryse and Cayseele (2000), Elsas and Krahnen (1998)). As suggested by Petersen and Rajan (1994, 1995), long-term relationships may improve access to credit. We identify a mechanism that can generate the advantage of repeated interaction between banks and borrowers.

The intuition behind our result is straightforward. Repeated lending over the length of a bank relationship can create a holdup situation and informational rents to incumbent lenders. To compensate for that, banks will have to offer more favorable conditions in initial lending. In the case of borrower screening, the initial discount will just result

in lower interest rates, without an effect on the screening costs. In the case of collateral, the lower initial interest rate will raise the collateral requirement and therefore the expected liquidation costs. The higher cost of collateral will shift the balance in favor of borrower screening.

The existence of the holdup problem has been documented empirically (see for instance Bharath et al. (2007), Ioannidou and Ongena (2010)). Note that in our case the outside bank can get the same signal quality as the inside bank: it can eventually distinguish between good and bad projects. It also has the same selection techniques available - direct screening and collateral requirements - as the inside bank. The higher degree of adverse selection it faces pushes the outside bank to require collateral rather than screen; nevertheless, even in that case its borrower selection is more expensive than that its competitor. As a result, the inside bank can retain its high-quality borrowers and makes a positive profit. Borrowers anticipate the future rent extraction by the bank and require an initial discount to compensate for it; the discount in turn makes screening more likely in initial lending.

The total two-period payoff for borrowers with good projects in the first period will be $P(S_1, S_2) = p_G(X - R_{1,S}) + \frac{\lambda+(1-\lambda)p_L^2}{\lambda+(1-\lambda)p_L} \times \rho P(C)$, where the last sum denotes expected second-period payoff for borrowers with good projects in period 1. After plugging in the expression for the first-period interest rate one can see that this discount translates into an increase for total borrower payoff: $p_G X - \bar{R} - \frac{s}{\lambda+(1-\lambda)p_L} + \pi_{2G1} + \frac{\lambda+(1-\lambda)p_L^2}{\lambda+(1-\lambda)p_L} \times \rho P(C)$. Here the first two terms denote consumer payoff from the one-period game, while the additional surplus, $\rho\pi_{2G1}$, is equal to the discount. In case of collateral the total two-period payoff for borrowers with good projects in the first period will be $P(C_1, S_2) = p_G(X - R_{1,C}) - (1 - p_G)C_1 + \frac{\lambda+(1-\lambda)p_L^2}{\lambda+(1-\lambda)p_L} \times \rho P(C)$, which then amounts to $P(C) + \frac{(p_G - p_B)\rho\pi_{2G1}}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} + \frac{\lambda+(1-\lambda)p_L^2}{\lambda+(1-\lambda)p_L} \times \rho P(C)$, so that the additional surplus is less than the discount, due to the liquidation costs.

Proposition 3.7 *Whenever $s^{**} \leq s \leq s_2$, banks use collateral in initial lending but then shift to screening for their first-period good project borrowers. First-period bad-project borrowers will pledge collateral, either with the inside or the outside bank. First-period good-project borrowers will face higher interest rates compared to the first period, but will not be required to post collateral.*

Proof In the Appendix we show that $s^{**} < s_2$, after which the result is immediate.

The less pronounced preference for collateral in the first period is matched by a lower incidence of collateral in subsequent periods. After the initial lending, banks have a pool of known borrowers whose quality is relatively high. The higher quality may mean that banks are able to shift from collateral to screening, removing the need for collateral. The reason is that the per-borrower cost of screening depends on average borrower quality; an improved average quality in the subsequent lending makes screening relatively cheaper and more attractive. Again, this may be good news for

borrowers with few assets available to pledge as collateral. This result is supported in the findings of Berger, Frame and Ioannidou (2011), where in initial lending the incidence of collateral is less likely for unobservably riskier borrowers. However, with longer relationship unobservably riskier borrowers are more likely to pledge collateral.

The proof in the appendix shows that, while a higher bank cost of capital \bar{R} always reduces the incidence of screening (higher interest rates reduce the amount of collateral required), the slope is higher for s^{**} and s_2 than for the one-period cutoff s^* . Lower and stable funding costs for the banks (for instance through a higher proportion of core deposits) may therefore reduce the incidence of collateral, with a stronger effect in the case of long-run relationships.

We could also assume that banks learn additional information about their borrowers during the first period, after making the lending decision. That would only serve to strengthen our results. Better information at the beginning of the second period allows banks to select a high quality pool whose projects will be screened for the second period. Banks will also be able to extract higher second-period rents, which will result in deeper initial discounts, which are again more favourable to screening than to collateral.

3.3 Screening and information about borrower types

In the previous section we assumed that screening borrowers only provides information about their current projects. However, it can be argued that screening can provide deeper information about the overall, persistent quality of a borrower. That information can be useful in future lending. In contrast, collateral only provides information about the current project that requires financing. If the success probability of the project is high enough, then borrowers will be willing to pledge collateral, and this will allow banks to separate good and bad projects. However, this may at the same time reduce the bank's incentive to acquire further information about the borrower.

We model this intuition about the role of screening by assuming that screening reveals not just the quality of the current project, but also the borrower's type. In the one-period case, there is no practical difference between high- and low-type borrowers with good projects. In the two-period case, in contrast, the two groups are no longer identical. If a borrower is found to be of high type 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.

We look at the two-period interaction between banks and borrowers under this additional assumption. To make comparisons easier, we once again focus on values of screening costs close to the one-period cutoff s^* .

If banks decide to use collateral to select borrowers in the first period, then the two-period equilibrium is similar to the one described in the previous section. Borrowers receive a contract $(R_{1,C}, C)$ in the first period, where the interest rate $R_{1,C}$ is below the one-period break-even level. In the second period, banks make positive profits on their initial borrowers.

If banks decide to screen in the first period, they can then distinguish between high- and low-type borrowers. At the beginning of the second period, they will have this information available with respect to their first-period customers.

High-type borrowers will again have good projects in the second period, and banks can lend to them without any further selection. To prevent them from switching to the outside bank, the interest rate charged by the inside bank R_2 has to provide borrowers the one-period surplus from collateral contracts $P(C)$. (This is because, as before, if screening costs are around s^* the outside bank will use collateral in contracts dedicated to the initial customers of its competitor bank). The inside bank will make positive profits on those borrowers.

In contrast, the group of low-type initial borrowers is not creditworthy on average and requires collateral or direct screening to identify second-period good projects. The low-type borrowers are of *worse* average quality than the larger pool of borrowers facing one-period lenders. If screening costs are around the cutoff level s^* , then incumbent banks will prefer to require collateral rather than screen those borrowers' projects. Since the competing bank will make collateral-based offers to the same borrowers, the incumbent bank will have no competitive advantage with respect to its initial low-type borrowers and will make zero profits on them.

The second-period profit of the inside bank per first-period good borrower will be

$$\pi'_{2G1} = \frac{\lambda}{\lambda + (1 - \lambda)p_L} (p_G R_{inside} - \bar{R});$$

around s^* , π'_{2G1} is higher than its equivalent when screening only reveals the quality of a borrower's current project ($\pi_{2G1} = \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (p_G R_{inside} - \bar{R}) - \frac{s}{\lambda + (1 - \lambda)p_L}$).

Going to the first period, banks will have to offer initial interest rates $R'_{1,S}$ that compensate good-project borrowers for the information rents the bank will extract in the second period. The banks will have to make zero profits over the two periods on each good-project borrower:

$$\pi_1 + \rho\pi'_{2G1} = p_G R'_{1,S} - \bar{R} - \frac{s}{\lambda + (1 - \lambda)p_L} + \rho\pi'_{2G1} = 0.$$

The good-project borrower surplus over the two periods will be given by

$$P(S_1, S_2) = p_G X - \bar{R} - \frac{s}{\lambda + (1 - \lambda)p_L} + \rho\pi'_{2G1} + \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \times \rho P(C).$$

Borrowers with good projects in the first period will prefer screening to collateral-based initial contracts if the expected two-period surplus is higher: $P(S_1, S_2) > P(C_1, S_2)$. The competing banks will offer them the preferred contract. Once again, for values of screening costs around the one-period cutoff s^* initial screening will be preferred to

collateral.

Proposition 3.8 *If screening costs are equal to the one-period cutoff level s^* , then screening will be preferred to collateral requirements in initial lending.*

Proof See Appendix.

The intuition is once again that offering better initial conditions, including a lower interest rate, to borrowers in the first period will entail increased liquidation costs under collateral contracts. As shown in the appendix, the initial discount is deeper if screening reveals borrower types, and this increases the relative disadvantage of collateral. An additional factor pushing the balance in favor of initial screening is the potential second-period screening costs made necessary by initial collateral contracts. If screening reveals borrower type, the duplication of screening costs is avoided.

The cutoff point s_T^{**} above which collateral is required in the first period is higher than in the case where screening only indicates the quality of the current project, which is in turn higher than the one-period cutoff: $s_T^{**} > s^{**} > s^*$. When collateral is used in the first period, once again for screening costs $s \in (s_T^{**}, s_2)$ screening will be used in the second period by the inside banks for their first-period good-project borrowers, so again banks switch from requiring collateral to screening over time. However, for screening costs below s_T^{**} , inside banks will screen in the first period, and then in the second period either lend without any further selection (to high-type borrowers), or require collateral (in the case of low-type borrowers). In the later stages of the bank relationship what will be observed is a pool of high-quality borrowers that are financed directly and a pool of low-quality borrowers that is required to post collateral.

Summing up, if screening reveals additional information about borrowers, beyond the quality of their current project, that will increase the preference for screening in the initial borrower selection and reduce overall selection costs. The result is stronger the higher the reusability of the information acquired through screening (Chan, Greenbaum and Thakor (1986)), that is, the higher the probability that borrower types remain stable over time.

4 The effect of bank competition

As an extension, we also study the case where the competition among banks is limited for reasons which are not related to superior information about borrowers: we assume it is cheaper to borrow from “local” banks than from “distant” ones. This pattern is documented empirically (Degryse and Ongena 2005, Herpfer, Schmidt, and Mjøs 2016). We show that lower competition (higher costs of applying to distant banks) *increases* the incidence of collateral.

We assume that from a given borrower’s point of view one of the bank is the “local” (L) bank, and the other is the “distant” (“far”, F) bank. Borrowing from the

F bank entails an additional cost of A per loan. A higher cost A will make it relatively more difficult to obtain funding from the competing bank. As before, we assume that borrowers are equally distributed across the two banks.

We first show that in the one-period interaction the cutoff level of screening costs above which collateral preferred is lower than in the case without frictions, and that it is decreasing in A .

Proposition 4.1 *In the one-period game, in the presence of borrowing cost A , screening is preferred to collateral if*

$$s \leq s^{*,L} = (\lambda + (1 - \lambda)p_L) \frac{\alpha p_B(1 - p_G)(p_G X - \bar{R} - A)}{p_G(1 - p_B) - p_B(1 - p_G)(1 - \alpha)}.$$

Proof See Appendix.

In equilibrium, borrowers borrow from their local bank, and the local bank needs to consider the best funding conditions that the competing bank F can offer. When applying to competing banks entails additional costs, the local bank can charge relatively higher interest rates. That reduces the amount of collateral needed to prevent borrowers with bad projects from getting a loan from the bank. As a result of lower collateral requirements and lower expected liquidation costs, collateral becomes more attractive and screening less likely. We can see that the threshold $s^{*,L}$ is increasing in A .

When we have the possibility of repeated interaction, a higher cost A will once again reduce the attractiveness of screening both in initial and in late-period lending. The prospect of repeated interaction will still have the opposite effect of increasing screening thresholds.

Proposition 4.2 *In the two-period game, in the presence of borrowing cost A , screening is preferred to collateral if*

$$s \leq s_2^L = \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \left(\frac{\alpha p_B(1 - p_G)(p_G X - \bar{R})}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)} - \frac{\alpha p_B(1 - p_G)}{p_G - p_B} A \right),$$

in the first period, and

$$s \leq s^{**,L} = \frac{1}{p_G - p_B + \alpha p_B(1 - p_G)(\rho(\lambda + (1 - \lambda)p_L) + \rho(\lambda + (1 - \lambda)p_L^2)P(C))} \\ \times (\lambda + (1 - \lambda)p_L)(\alpha p_B(1 - p_G)) \left((p_G X - \bar{R}) \times \left(1 + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \right) - A \right)$$

in the second period.

Proof See Appendix.

Higher bank market power works in the opposite direction compared to the prospect of repeated interaction: it increases the incidence of collateral. We can see that the cutoff levels of screening costs s_2^L and $s^{**,L}$ are both decreasing in A . However, the prospect of repeated lending increases the cutoff levels compared to one-period lending.

Our results indicate that the prospect of repeated lending in a competitive environment decreases the incidence of collateral requirements. From a policy point in view, this means that banks should be encouraged to have solid balance sheets and shocks to their lending ability should be avoided. At the same time, that should not come at the expense of competition between banks: we show that higher market power actually tends to increase the incidence of collateral.

5 Welfare and access to credit

We now consider the question whether overall welfare is higher under successive arm's length interactions compared to repeated interaction over two periods. The idea is to compare the situation in which a borrower is unlikely to meet the same bank for the next loan to the situation where she can apply to the same financial institution for successive loans. We compare welfare (total borrower and bank surplus) in the one-period case to the average per-period welfare in the two-period case. We focus on the competitive case where screening does not reveal information about borrower type.

Proposition 5.1 *For any value of screening costs s , total welfare in the one-period case is lower or equal to the per-period welfare in the two-period case. The inequality is strict for any value of screening costs between s^* and s_2 .*

Proof See Appendix.

This result indicates that the possibility of repeated interaction between banks and borrowers allows a better management of selection costs and therefore increases overall welfare.

For any value of screening costs above s^* , borrowers are required to post collateral in single-period interaction. In the repeated case, for value of screening costs between s^* and s^{**} borrowers are screened in the first period, and in the second period inside borrowers are screened and outside borrowers are required to post collateral. Since screening costs are above s^* , welfare will be lower in the first period compared to one-period interaction (in both cases good projects receive funding, but expected screening costs are higher than the expected liquidation costs for collateral in the one-period case). However, welfare is higher in the second period, when relatively high-quality inside borrowers are screened, and only outside borrowers are required to post collateral. Overall, per-period welfare is higher in the repeated case, although the difference declines as screening costs increase and we approach s^{**} .

For values of screening costs between s^{**} and s_2 , borrowers are required to post collateral in the first period, and inside borrowers are screened and outside borrowers

required to post collateral in the second period. The first-period collateral requirement C_1 is higher than in the single-period case, and as a result expected liquidation costs are higher and welfare is lower. However, as screening costs increase towards s_2 , the first-period interest rate discount decreases, and therefore collateral requirements and expected liquidation costs decrease. In the second period, welfare is higher than in the single-period case, but the difference is decreasing as the screening costs increase. Overall, per-period welfare is again higher in the case of repeated interaction.

Finally, for values of screening costs just below s^* , banks will choose screening in the case of one-period interaction. In the case of repeated interaction, banks will screen potential borrowers in the first period, screen inside borrowers in the second period, and require collateral from outside borrowers in the second period. First-period welfare will be the same as in the one-period case, while second-period welfare will be higher.

In terms of the big picture, we find that total welfare is higher in the second period compared to one-shot interaction. Better knowledge of the borrower pool allows a more adequate choice of selection instruments. However, welfare in the first period can be lower: the anticipated second-period holdup problem can lead to the use of suboptimal screening-based selection. Overall, average per-period welfare is still higher or equal when we have the possibility of repeated lending.

We can also look at borrower welfare (surplus) and bank profits *separately*. Banks make positive profits in the second period, and negative profits in the first period, and just break even over the two periods. This pattern is consistent with the well-known holdup problem. However, the welfare of good-project borrowers is the same or marginally higher in the second period, and is unambiguously higher in the initial period compared to single-period lending. The reason is the additional surplus created by lower selection costs, which accrues to borrowers under bank competition.

Repeated interaction can also increase access to credit if borrowers do not have enough collateral available, or if collateral is relatively expensive. In the absence of collateral-based selection, borrowers need to be screened, which can be expensive and discourage the financing of marginal projects if screening costs are high. It can be shown that the financing of those projects and borrowers is more likely in the case of repeated lending than in the case of one-shot interaction. (If collateral is available and relatively cheap, then access to credit is not influenced by the length of the bank relationship; this is also a case where access to credit is unlikely to be a problem).

Proposition 5.2 *If collateral is unavailable or costly, access to credit is more likely in repeated lending than in one-period lending.*

Proof See Appendix.

Summing up, repeated interaction between banks and borrowers can enhance overall welfare. This is more likely in later periods, when better knowledge of borrower groups allows banks to optimize selection costs. Banks may have to offer initial discounts to

borrowers; those discounts compensate for the rents they are able to extract in later periods. Borrower surplus is higher in initial periods as a result of the discount, and may be equal or marginally higher in the second period compared to single-period interaction.

6 Discussion and conclusions

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 resources on collecting and analyzing information about borrowers.

Our paper analyzes the equilibrium choice between screening and collateral. We find that screening becomes cheaper and therefore the favored solution in later stages of a bank relationship. Moreover, screening is more likely to be used instead of collateral in the initial stage of repeated relationship. The results are stronger in the presence of a competitive banking system, and when screening allows banks to acquire information about borrower types that can be used again in further lending. Finally, welfare is higher in the case of repeated lending as a result of lower borrower selection costs.

We provide a theoretical explanation for the decline in collateral requirements in the later stages of lending relationships, which has been well documented in empirical studies, including those that have focused on lines of credit (Berger and Udell (1995), Chakraborty and Hu (2006), Berger, Frame and Ioannidou (2011)). Also in line with existing empirical evidence (Ioannidou and Ongena (2010)), we show that interest rates do not necessarily decline over time, as banks switch from requiring collateral to screening inside borrowers.

Our paper is also related to work on unsecured lending contracts, where (partial) debt collection after default is possible at a cost. Using U.S. data Severino, Brown, and Coates (2014) find that an increase in the level of bankruptcy protection increases the amount of unsecured debt with the existing clients, but does not lead to higher delinquency. Their empirical result is consistent with our prediction of a switch from collateral-based selection to direct screening.

Our finding is not conditional on market power allowing banks to accumulate extraordinary rents (Petersen and Rajan (1995)); indeed, we allow banks to compete and the surplus generated by the bank relationship to be captured by potential borrowers. What counts is the possibility to use the information from initial loans when optimizing selection mechanisms for subsequent funding. Moreover, our findings indicate that an environment with competing relationship lenders can lower collateral requirements and increase borrower surplus in initial lending (while borrower surplus in subsequent periods is marginally higher compared to one-period transactional lending). These results may go some way in explaining why bank lending through revolving lines of credit has survived given the growth of bond markets and lending by non-bank institutional investors (Nini (2013)).

The second-period holdup problem can be reduced by information sharing between banks, by using credit lines where the bank can refuse to offer further loans, but the conditions of those future loans are predetermined (as in von Thadden (1995)), or when there are new borrowers coming into the market after the first period, and they are of average quality (as in Dell’Ariccia and Marquez (2005)). In our model, that would have the effect of increasing collateral requirements in first-period lending.

For simplicity, we focus on ex ante information acquisition, at the point where a loan is made. In practice, banks may acquire additional information during the lifetime of the loan. In our model, that would increase the second-period holdup problem, and therefore reduce the likelihood of initial collateral requirements.

The average quality of borrowers may vary over time. In our model, a decrease in average quality in either the first or the second period will increase the likelihood that collateral is preferred to screening. Ruckes (2004) shows that the intensity of screening increases if economic prospects deteriorate. We identify an additional aspect of borrower selection along the economic cycle: we show that when the proportion of good borrowers decreases, banks may actually switch from screening to requiring collateral.

Our findings can be extended to include other factors that change the trade-off in long-term relationships. Future shocks to the market value of available collateral can increase the preference for screening either for the bank or for the borrower. While their currently available collateral is satisfactory, borrowers may worry that future shocks may reduce the value of their assets in place and make them unable to post sufficient collateral. In this case borrowers may be excluded from credit markets even if they have high-quality projects. It has indeed been documented that shocks to the value of assets in place that can be used as collateral affect access to financing (Gan, (2007)).

In light of our findings, supporting stable lending relationships may be a useful policy. Supporting local, small banks (Berger et al. (2005), Agrawal and Hauswald (2010), Beck, Degryse and van Horen (2014)), as well as the integration of international banks in the local network (De Haas and van Horen (2013)), and ensuring that banks are well capitalized (Kapan and Minoiu (2013)), all of which are favorable to long-lasting bank-borrower contacts, may reduce collateral requirements and increase borrower surplus and overall welfare.

7 References

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1 Appendix

Proof of proposition 3.1

Banks offer contracts with an interest rate R and collateral C . Borrowers enter the market choosing from the set of available loan contracts, or opt out and choose the outside option, denoted by θ_0 . For each adopted (R, C) contract we define a contract outcome (R, C, p) where p denotes the average risk of the pool that has adopted the contract. A competitive equilibrium is a collection of Θ of contract outcomes of the form (R, C, p) such that i) each member of Θ earns non-negative profits to the lenders; ii) each contract in Θ provides borrowers a non-negative payoff; iii) each contract in Θ maximizes the borrowers' payoff given the choice of each borrower from the set $\Theta \cup \theta_0$; iv) there exists no new contract $\theta \notin \Theta$ that generates strictly higher payoff for at least one borrower, given other borrowers' choice from $\Theta \cup \{\theta_0, \theta\}$. We normalize the outside option to zero.

We first show that there is no pooling equilibrium.

Suppose instead there is a pooling equilibrium and denote it by (R, C, p) . The expected payoff for a borrower with a good project that uses collateral is given by

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

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

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

Since the pooling contract is selected by both type of borrowers, the expected profit that the lender generates is $pR + (1 - p)(1 - \alpha)C - \bar{R}$, where p is the success probability of the average pool of borrowers: $p = \lambda + (1 - \lambda)p_L$. The borrower surplus maximization condition would require that banks' expected profit be zero, since otherwise a slight decrease in interest rate (or decrease in collateral) could further increase all borrowers' surplus.

It can be shown that a new contract (R', C') can enter, attract only good-project borrowers and make a positive profit for banks, i.e.

$$p_G R' + (1 - p_G) C' < p_G R + (1 - p_G) C \tag{1}$$

$$p_B R' + (1 - p_B) C' > p_B R + (1 - p_B) C \tag{2}$$

$$p_G R' + (1 - p_G)(1 - \alpha) C' - \bar{R} > 0 \tag{3}$$

$$\tag{4}$$

The first inequality means that for good-project borrowers, expected payments are lower (i.e, the surplus is higher) under the new contract. The second inequality means that for bad-project borrowers, expected payments are lower under the original contract. The third inequality means that, when only borrowers with good projects select the new contract, the new contract generates positive profits.

Denote $C' = C + \varepsilon$ and $R' = R - \delta$. Then the first two inequalities reduce to

$$\frac{1 - p_G}{p_G} \varepsilon < \delta < \frac{1 - p_B}{p_B} \varepsilon$$

For every ε we can find δ that satisfies the above. The third inequality can be rewritten as

$$p_G R + (1 - p_G)(1 - \alpha)C + ((1 - p_G)(1 - \alpha)\varepsilon - \delta p_G) - \bar{R} > 0.$$

If ε and δ are small the last term is small (and can be arbitrarily close to zero). By virtue of the (assumed) equilibrium, bank profits are zero for the pooling equilibrium: $pR + (1 - p)(1 - \alpha)C - \bar{R} = 0$. But because $p_G - p > 0$ the first term is strictly positive, thus the third inequality holds and (R', C') undercuts the supposed equilibrium.

We now show that there is a (unique) separating equilibrium.

First, in any separating equilibrium bad-project borrowers must not receive credit since they are not creditworthy projects by assumption.

$$p_B(X - R) - (1 - p_B)C \leq 0,$$

Thus, the bad-project borrowers will not find it worthwhile to pledge collateral if the amount required is high enough: for a given interest rate R the required amount of collateral is at least $C = \frac{p_B(X - R)}{1 - p_B}$.

Second, the banks' per-contract profit on loans to good-project borrowers pledging collateral must be zero:

$$p_G R + (1 - p_G)(1 - \alpha)C - \bar{R} = 0.$$

This stems from the definition of a separating equilibrium and the fact maximizing borrowers' payoff requires that competing banks lower the interest rate R up to where expected profits are zero. As a result, the (R, C) pair in the equilibrium separating contract is unique. To see this, notice that good project borrowers' payoff increases in the interest rate:

$$\frac{\partial P(C)}{\partial R} = -p_G + \frac{p_B(1 - p_G)}{1 - p_B} > 0$$

Solving, the amount of collateral pledged by banks is given by

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

and the interest rate is

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

The payoff for good-project borrowers using collateral will be

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

Proof of proposition 3.2

Suppose the bank screens potential borrowers and offers an interest rate R to borrowers with good projects. 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 per-borrower profits from screening a pool of borrowers out of which a proportion p have good projects is $p(p_G R - \bar{R}) - s$; when screening the average pool of borrowers $p = \lambda + (1-\lambda)p_L$. The market will be shared equally between the banks and competition will draw bank profits to zero: $(\lambda + (1-\lambda)p_L)(p_G R - \bar{R}) - s = 0$. The competitive interest rate offered to borrowers will be the break-even rate: $R = \frac{1}{p_G} \left(\bar{R} + \frac{s}{\lambda + (1-\lambda)p_L} \right)$. The expected payoff for a good-project borrower will therefore be $P(S) = p_G(X - R) = p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L}$.

Proof of proposition 3.3

The payoff for borrowers with good projects is $p_G X - \bar{R} - \frac{\alpha(1-p_G)p_B}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B} (p_G X - \bar{R})$ if banks require collateral, and $p_G(X - R) = p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L}$ if banks choose to screen. In equilibrium, banks will choose the contract that maximizes borrower surplus.

Borrowers have a higher payoff under screening than under collateral if the per contract screening cost $s \leq (\lambda + (1-\lambda)p_L) \frac{\alpha(1-p_G)p_B}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B} (p_G X - \bar{R})$. Therefore the cutoff level of screening costs above which collateral is preferred is $s^* = (\lambda + (1-\lambda)p_L) \frac{\alpha(1-p_G)p_B}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B} (p_G X - \bar{R})$.

Proof of lemma 3.4 and proposition 3.5

At the beginning of the second period, the inside bank has a pool of borrowers which had a good project in the first period, and have a high probability of having a good project in the second period ($p(G|G) = \frac{\lambda+(1-\lambda)p_L^2}{\lambda+(1-\lambda)p_L}$). The inside bank can choose to screen those borrowers, or to require collateral. Given the high quality of the borrower pool, screening is relatively cheap for the inside bank. The outside bank can screen or require collateral in its attempt to poach borrowers. If it tries to attract all borrowers that did not have a loan with it in the first period, the outside bank is faced with a below-average borrower pool; the probability of having good-project borrowers is $\frac{\lambda+(1-\lambda)p_L(3-2p_L)}{\lambda+(1-\lambda)(3-2p_L)}$. The collateral-based contract is not sensitive to the average borrower quality, while the screening contract is. For very low values of screening costs, both banks can offer screening contracts; however, since it can identify a better borrower pool, the inside bank can offer better conditions to its first-period good-project borrowers. The outside bank will offer a contract aimed at the remaining borrowers, where the probability of finding a good project is p_L . For very high values of screening costs, both banks will offer collateral-based contracts; in that case, the inside bank has no competitive advantage and both banks make zero profits. In the intermediary case, around the one-period cutoff s^* , the inside bank will choose screening, while the outside bank will require collateral. We start by looking at this case.

In the equilibrium with sequential bidding, in period 2 the incumbent banks will offer an interest rate that provides first-period good-project borrowers a surplus which is just above what they can get from the competing bank. Thus only first-period bad-project borrowers go to the outside bank. The contract they get from the outside bank will be the usual one-period collateral-based contract presented in the previous section. The share of borrowers with good projects in this population is given by $p(G|B) = \frac{(1-\lambda)p_L(1-p_L)}{(1-\lambda)(1-p_L)} = p_L$, i.e., the probability of having a good project given that the bad project was observed in period 1.

Note that the outside bank prefers screening over collateral whenever

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

which differs from the one-period cutoff $s^* = (\lambda+(1-\lambda)p_L) \frac{\alpha(1-p_G)p_B}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B} (p_G X - \bar{R})$. This is because first-period good-project borrowers are held up, while the switching borrowers with bad project have probability $p(G|B) = \frac{(1-\lambda)p_L(1-p_L)}{(1-\lambda)(1-p_L)} = p_L$ of having a good project in period 2. When the outside bank offers a collateral-based contract, the borrowers' payoff will be equal to the one-period collateral case, $P(C) = \frac{(p_G - p_B)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)}$.

In this case, the interest rate that provides that borrower surplus with screening is $R_{inside} = X - \frac{p_G - p_B}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} (p_G X - \bar{R})$. If screening is used, the inside bank will therefore make a second-period profit (on a borrower who had a first-

period good project) equal to $\pi_2 = (\lambda + (1 - \lambda)p_L^2) \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} - s(\lambda + (1 - \lambda)p_L)$ (i.e., lending profits less screening costs). All first-period good-project borrowers are screened and those that also have a good project in the second period receive a loan. The second-period bank profit per first-period good-project borrower is $\pi_{2G1} = \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} (p_G R_{inside} - \bar{R}) - s = \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} - s$. If collateral was used, both banks would make zero profits in period 2, so that the incumbent bank prefers screening whenever $s \leq \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L}$.

If $s > \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L}$ then clearly $s > p_L \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)}$ so that both the inside and the outside bank use collateral in period 2. This secures zero expected profits in period two for first-period good project borrowers. In the first period, borrowers' and banks anticipate this so that they face the same trade-off as in the one-period game. Since by assumption, $s > s^* = (\lambda + (1 - \lambda)p_L) \frac{\alpha(1-p_G)p_B(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B}$, banks choose to use collateral in period one as well.

Suppose now $s \leq \frac{\alpha p_B(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L}$. The collateral required in period 1 will have to be sufficient to separate good- and bad-project borrowers: $C \geq \frac{p_B(X - R_1)}{1 - p_B}$, where R_1 is the first-period interest rate. The expected positive second-period profits will be competed away in the first-period collateral-based contract.

$$p_G R_1 + (1 - p_G)(1 - \alpha) \frac{p_B(X - R_1)}{1 - p_B} - \bar{R} + \rho \pi_{2G1} = 0.$$

The discount offered in the first period will drive the interest rate below the one-period interest rate with collateral:

$$R_{1,C} = \frac{(1 - p_B)\bar{R} - (1 - p_B) + \rho \pi_{2G1} - (1 - \alpha)p_B(1 - p_G)X}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)} < R_C.$$

The lower interest rate will however lead to higher collateral requirements to deter bad-project borrowers. The minimal amount of collateral will be $C_1 = p_B \frac{p_G X - \bar{R} + \rho \pi_{2G1}}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} > C$.

We next look at the case where banks have used screening to separate borrowers in the first period. At the beginning of the second period, each bank has again a pool of borrowers that had a good project in the first stage and are therefore of high average quality. The second-period competition will be similar to that under first-period collateral, as outlined above. Given the positive expected profits in the second period, banks will be able to offer a discount in the first period. The interest rate in the first-period screening contract will be lower than in the one-period case:

$$R_{1,S} = \frac{1}{p_G} \left(\frac{s}{\lambda + (1 - \lambda)p_L} + \bar{R} - \rho \pi_{2G1} \right) < R_S.$$

Proof of proposition 3.6

The expected two-period surplus for a borrower that has a good project in the first period will be

$$P(C_1, S_2) = p_G(X - R_1) - (1 - p_G)C_1 + \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \times \rho P(C).$$

Using the expressions for R_1 and C_1 we get

$$P(C_1, S_2) = \frac{(p_G - p_B)\rho\pi_{2G1}}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)} + \left(1 + \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L}\right) \times \rho P(C).$$

The expected two-period surplus for a borrower that has a good project in the first period will be

$$P(S_1, S_2) = p_G X - \bar{R} - \frac{s}{\lambda + (1 - \lambda)p_L} + \rho\pi_{2G1} + \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \times \rho P(C).$$

Whether screening or collateral is chosen in the first period depends on the two-period surplus for borrowers with good projects in the first period. That surplus is higher under first-period screening ($P(S_1, S_2) > P(C_1, S_2)$) if

$$\begin{aligned} p_G X - \bar{R} - \frac{s}{\lambda + (1 - \lambda)p_L} + \rho\pi_{2G1} + \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \times \rho P(C) > \\ p_G(X - R_1) - (1 - p_G)C_1 + \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \times \rho P(C). \end{aligned}$$

Cancelling out similar terms, the condition can be rewritten as

$$p_G X - \bar{R} - \frac{s}{\lambda + (1 - \lambda)p_L} + \rho\pi_{2G1} > \frac{(p_G - p_B)\rho\pi_{2G1}}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)} + P(C). \quad (5)$$

We now evaluate the condition at s^* , the one-period cutoff level for screening costs. We know that $p_G X - \bar{R} - \frac{s}{\lambda + (1 - \lambda)p_L} = P(C)$ (the one-period borrower surplus under screening and collateral are equal at s^*). Moreover, $\pi_{2G1} > \frac{(p_G - p_B)\pi_{2G1}}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}$. Therefore the inequality holds around s^* , and screening is used in the first period.

We can also solve for the cutoff s^{**} , where the two sides are equal. We get:

$$\begin{aligned}
s^{**} &= (\lambda + (1 - \lambda)p_L) \frac{\alpha(1 - p_G)(p_G X - \bar{R})}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B} \frac{1 + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}}{1 + \rho(\lambda + (1 - \lambda)p_L) \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}} \\
&= s^* \times \frac{1 + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}}{1 + \rho(\lambda + (1 - \lambda)p_L) \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}},
\end{aligned}$$

which confirms that $s^{**} > s^*$.

Proof of proposition 3.7

We have:

$$\begin{aligned}
s_2 &= \frac{\alpha p_B(1 - p_G)(p_G X - \bar{R})}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)} \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \\
s^{**} &= \frac{\alpha(1 - p_G)(p_G X - \bar{R})}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B} \frac{\lambda + (1 - \lambda)p_L + \rho(\lambda + (1 - \lambda)p_L^2) \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}}{1 + \rho(\lambda + (1 - \lambda)p_L) \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}}
\end{aligned}$$

$s_2 > s^{**}$ is equivalent to $(\lambda + (1 - \lambda)p_L^2) \left(1 + \rho(\lambda + (1 - \lambda)p_L) \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B} \right) > (\lambda + (1 - \lambda)p_L)(\lambda + (1 - \lambda)p_L + \rho(\lambda + (1 - \lambda)p_L^2) \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B})$, or $\lambda(1 - \lambda)(1 - p_L)^2 > 0$, which is obviously true.

Looking at interest rates, we can see that the interest period charged to borrowers that had a good project in the first period (inside borrowers) is higher in the second period than in the first. In the first period, we have $R_{1,C} = \frac{(1 - p_B)\bar{R} - (1 - p_B)\rho\pi_{2G1} - (1 - \alpha)p_B(1 - p_G)X}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}$, which is lower than the one-period rate R_C ; in the second period, we have $\bar{R}_{inside} = \frac{\bar{R}}{p_G} + \frac{1}{p_G}(p_G X - \bar{R}) \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B}$, which is higher than R_C .

Proof of proposition 3.8

Suppose screening was used in the first period. At the beginning of the second period, the inside bank can identify high-type borrowers among its first-period customers. Those customers require no further selection. Low-type borrowers are a relatively low-quality pool; if screening costs are around s^* , the inside bank will require collateral from them. The outside bank requires collateral from the switching borrowers. The inside bank will make positive profits on high-type borrowers, that will be charged an interest rate R_{inside} that gives a surplus just above $P(C)$, which they can get by taking the outside bank's offer. The inside bank's profit per first-period good-contract borrower is $\pi'_{2G1} = \frac{\lambda}{\lambda + (1 - \lambda)p_L} (p_G R_{inside} - \bar{R})$.

In the first period, the interest rate $R'_{1,S}$ charged by the banks will give them zero

profits over the two periods: $p_G R'_{1,S} - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L} + \rho\pi'_{2G1} = 0$. Solving, we get $R'_{1,S} = \frac{\bar{R}}{p_G} \left(1 - \rho \frac{\lambda}{\lambda + (1-\lambda)p_L}\right) + \frac{s}{p_G} - \rho \frac{\lambda}{\lambda + (1-\lambda)p_L} \frac{1}{p_G} \frac{\alpha(1-p_G)(1-p_B)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B}$. Once again we have that $R'_{1,S} < R_S$ (borrowers are offered a discount compared to the one-period case); moreover, if we are around s^* , $R'_{1,S} < R_{1,S}$; the discount is deeper compared to the case where screening only reveals the quality of the current project.

The two-period surplus for a borrower that has a good project in the first period is therefore:

$$\begin{aligned} P(S_1, S_2)' &= p_G(X - R'_{1,S}) + \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} \times \rho P(C) \\ &= p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L} + \rho\pi'_{2G1} + \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} \times \rho P(C). \end{aligned}$$

As mentioned in the text, if collateral is used in the first period, then the equilibrium is similar to that described in the previous section and the two-period borrower surplus will once again be:

$$P(C_1, S_2) = \frac{(p_G - p_B)\rho\pi_{2G1}}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} + \left(1 + \rho \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L}\right) \times P(C).$$

First-period screening will be preferred when it provides a higher payoff to first-period good-project borrowers: $P(S_1, S_2)' > P(C_1, S_2)$, which is equivalent to

$$\begin{aligned} p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L} + \rho\pi_{2G1} + \rho s - \rho(1-\lambda)p_L^2 \frac{\alpha(1-p_G)(1-p_B)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B} > \\ \frac{(p_G - p_B)\rho\pi_{2G1}}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)} + P(C). \end{aligned}$$

The condition holds for screening costs around s^* . Moreover, a comparison to inequality 1 reveals that the difference between the surplus under first-period screening and first-period collateral is larger than in the case where screening only reveals project quality.

Solving, we get the following cutoff level of screening costs:

$$\begin{aligned} s_T^{**} &= (\lambda + (1-\lambda)p_L) \frac{\alpha(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B} \frac{1 + \rho \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} \frac{\alpha(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B}}{\frac{(1-\lambda)p_L}{\lambda + (1-\lambda)p_L} - \rho \frac{\alpha(1-p_G)}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B}} \\ &= s^* \times \frac{1 + \rho \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} \frac{\alpha(1-p_G)(p_G X - \bar{R})}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B}}{1 - \rho \frac{\alpha(1-p_G)}{p_G(1-p_B) - (1-\alpha)(1-p_G)p_B}}, \end{aligned}$$

which shows that $s_T^{**} > s^{**} > s^*$. The cutoff in the two-period case when screening

reveals borrower types is higher than in the case where it only reveals the quality of the current project, and that in turn is higher than the one-period cutoff.

Proof of proposition 4.1

Suppose first that collateral is required by the “local” (L) bank as well as by the “far” (F) bank.

The local bank will choose an amount of collateral which prevents local bad-project borrowers from applying:

$$p_B(X - R_c^L) - (1 - p_B)C^L \leq 0$$

L bank’s offer can be better than F bank’s offer:

$$p_G(X - R_c^L) - (1 - p_G)C^L \geq p_G(X - R_c^F) - (1 - p_G)C^F - A = P(C) - A,$$

where R_c^F and C^F are the interest rate and collateral that generate zero profits for the F bank, and $P(C)$ is the one-period borrower surplus under collateral and without location costs.

Solving, we get

$$R_c^L = X - \frac{1 - p_B}{p_G - p_B}(P(C) - A),$$

$$C^L = \frac{p_B}{p_G - p_B}(P(C) - A).$$

The interest rate is increasing in A , while the collateral requirement is decreasing.

If bank L chooses screening instead when bank F requires collateral, bank L ’s offer is better for its local borrowers if

$$p_G(X - R_s^L) \geq P(C) - A,$$

where $P(C)$ is the one-period borrower surplus under collateral and without location costs.

To retain local borrowers, bank L has to offer an interest rate of at most $R_s^L = X - \frac{P(C) - A}{p_G}$.

When bank F offers a collateral-based contract, bank L will prefer screening to collateral if profits are higher in that case:

$$p_G R_s^L - \bar{R} - \frac{s}{\lambda + (1 - \lambda)p_L} \geq p_G R_c^L + (1 - p_G)C^L - \bar{R},$$

which holds as long as $s \leq s^{F=C} = (\lambda + (1 - \lambda)p_L) \frac{\alpha p_B (1 - p_G)}{p_G - p_B} (P(C) - A)$.

Without location costs ($A = 0$), the cutoff is $s^* = (\lambda + (1 - \lambda)p_L) \frac{\alpha p_B (1 - p_G)}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)} (p_G X - \bar{R})$.

It can be seen that the cutoff for the local bank L with location costs, $s^{F=C}$, is lower than the cutoff without location costs s^* :

$$\frac{s^{F=C}}{s^*} = \frac{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}{p_G - p_B} \frac{(p_G X - \bar{R}) \left(1 - \frac{\alpha p_B (1 - p_G)}{p_G - p_B} - A\right)}{p_G X - \bar{R}} < 1,$$

and the ratio is decreasing in A . Having location costs which make it more difficult to borrow from competing banks increases the local bank's preference for collateral.

When bank F chooses screening and bank L chooses collateral, we get

$$R_c^L = X - \frac{1 - p_B}{p_G - p_B} (P(S) - A),$$

$$C^L = \frac{p_B}{p_G - p_B} (P(S) - A).$$

When bank F chooses screening and bank L chooses screening, we get $R_s^L = X - \frac{P(S) - A}{p_G}$.

As a result, when bank F screens, bank L will prefer screening to collateral if

$$s \leq s^{F=S} = (\lambda + (1 - \lambda)p_L) \frac{\alpha p_B (1 - p_G)}{p_G - p_B + \alpha p_B (1 - p_G)} (p_G X - \bar{R}).$$

The cutoff point is again lower than in the case without location costs:

$$\frac{s^{F=S}}{s^*} = \frac{p_G - p_B - (1 - \alpha)p_B(1 - p_G)}{p_G - p_B + \alpha p_B(1 - p_G)} < 1.$$

Given that bank F will attempt to attract bank L 's local borrowers by screening if $s \leq s^*$ and requiring collateral if $s > s^*$, bank L will screen only if $s < s^{F=S} < s^*$. In sum, location costs that increase the market power of "local" banks increase their preference for collateral.

Proof of proposition 4.2

Looking from the first period, the L bank has to provide a borrower surplus which is higher or equal to the one that can be obtained from borrowing from F .

Suppose the F bank has been able to lend to L bank's borrowers in the first period; as a result it can identify a group of borrowers that had a good project in the first period. In order to remain with the F bank, borrowers need to receive at least the (collateral-based) surplus they would receive from the L bank. The F bank prefers screening.

$$p_G(X - R_s^{2,F}) - A \geq P(C),$$

therefore

$$R_s^{2,F} = \frac{1}{p_G}(p_G X - P(C) - A).$$

The F bank's expected profit on a second-period good-project borrower that also had a good project in the first period is:

$$p_G R_s^{2,F} - \bar{R} - s \frac{\lambda + (1 - \lambda)p_L}{\lambda + (1 - \lambda)p_L^2} = p_G X - P(C) - A - \bar{R} - s \frac{\lambda + (1 - \lambda)p_L}{\lambda + (1 - \lambda)p_L^2}.$$

Going back to the first period, the F bank will prefer a screening-based contract. The expected two-period profits of bank F on a borrower with a good project in the first period will be:

$$p_G R_s^{1,F} - \bar{R} - s \frac{1}{\lambda + (1 - \lambda)p_L} + \rho \left(\frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (p_G R_s^{2,F} - \bar{R}) - s \right) = 0.$$

Solving, we get:

$$R_s^{1,F} = \frac{1}{p_G} \left(\bar{R} + s \frac{1}{\lambda + (1 - \lambda)p_L} + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) + A) + s \right) - \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L}.$$

The two-period borrower surplus for a borrower with a good project in the first period is

$$P(2, F) = p_G(X - R_s^{1,F}) - A + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} P(C),$$

$$P(2, F) = \left(1 + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \right) (p_G X - \bar{R} - A) - \frac{s}{\lambda + (1 - \lambda)p_L} - \rho s.$$

The local bank L has to provide at least as much.

If bank L chooses collateral in the second period, its expected profit per good-project borrower is:

$$\left(1 + \frac{\alpha p_B(1 - p_G)}{p_G - p_B}\right)A.$$

If bank L chooses screening in the second period, its expected profit per good-project borrower is:

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

Bank L prefers collateral to screening if

$$s \geq \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \left(\frac{\alpha p_B(1 - p_G)(p_G X - \bar{R})}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)} - \frac{\alpha p_B(1 - p_G)}{p_G - p_B} A \right).$$

The cutoff point s_2^L is lower than without A .

In the second period, around the one-period cutoff point bank L screens its good-project first-period borrowers and has to provide them with at least the surplus they could get from F , which uses collateral:

$$\begin{aligned} p_G(X - R_s^{2,L}) &\geq P(C) - A \\ R_s^{2,L} &= \frac{1}{p_G}(p_G X - P(C) + A). \end{aligned}$$

Going back to the first period, suppose bank L requires borrowers to post collateral in the first period.

$$\begin{aligned} p_G(X - R_C^{1,L}) - (1 - p_G)C^{1,L} + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) - A) &\geq P(2, F), \\ C^{1,L} &\geq R_C^{1,L} \frac{p_B}{1 - p_B}. \end{aligned}$$

We get

$$R_C^{1,L} = X - \frac{1 - p_B}{p_G - p_B} \left(P(2, F) - \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) - A) \right),$$

$$C^{1,L} = \frac{p_B}{p_G - p_B} \left(P(2, F) - \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) - A) \right).$$

First-period profits per good-project borrower for bank L are therefore

$$p_G X - \bar{R} - \frac{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}{p_G - p_B} \left(P(2, F) - \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) - A) \right).$$

Alternatively, suppose that bank L screens borrowers in the first period.

$$p_G(X - R_s^{1,L}) + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) - A) \geq P(2, F).$$

We get

$$R_s^{1,L} = \frac{1}{p_G} \left(p_G X - P(2, F) + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) - A) \right).$$

First-period profits per good-project borrower for bank L are therefore

$$p_G X - \bar{R} - \frac{s}{\lambda + (1 - \lambda)p_L} - \left(P(2, F) - \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) - A) \right).$$

Bank L will prefer screening in the first period for screening costs up to

$$s^{**,L} = (\lambda + (1 - \lambda)p_L) \frac{\alpha p_B(1 - p_G)}{p_G - p_B} \left(P(2, F) - \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} (P(C) - A) \right),$$

that is,

$$s^{**,L} = \frac{1}{p_G - p_B + \alpha p_B(1 - p_G)(\rho(\lambda + (1 - \lambda)p_L) + \rho(\lambda + (1 - \lambda)p_L^2)P(C))} \\ \times (\lambda + (1 - \lambda)p_L)(\alpha p_B(1 - p_G)) \left((p_G X - \bar{R}) \times \left(1 + \rho \frac{\lambda + (1 - \lambda)p_L^2}{\lambda + (1 - \lambda)p_L} \right) - A \right).$$

We can see that once again the threshold is decreasing in A : lower competition increases the preference for collateral. Comparing with the one-period cutoff $s^{*,L}$, we can also see that the preference for initial screening is still higher (the cutoff is higher)

than in the one-period case.

Proof of proposition 5.1

We compare the per-period welfare in the case of repeated relationships to the per-period welfare in the case of single-loan relationships.

In the one-period case, welfare can be written as the sum between borrower surplus and bank profits, which are zero. At s^* , total welfare can be written as

$$\text{Welfare} = (\lambda + (1 - \lambda)p_L)(p_G X - \bar{R}) - (\lambda + (1 - \lambda)p_L) \frac{\alpha p_B (p_G X - \bar{R})}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}.$$

Put otherwise, welfare can be seen as the surplus produced by good projects less the expected liquidation costs of collateral (which at s^* are equal to the expected screening costs).

If screening costs are between s^* and s^{**} , then borrowers are screened in the first period. In the second period, inside borrowers are screened and outside borrowers are required to post collateral. In the second period, the total borrower surplus will be equal to:

$$\begin{aligned} & (\lambda + (1 - \lambda)p_L^2)p_G(X - R_{inside}) + (1 - \lambda)p_L(1 - p_L) \left(p_G(X - R_C) \right. \\ & \left. - (1 - p_G) \frac{p_B(p_G X - \bar{R})}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)} \right). \end{aligned}$$

Second-period bank profits will be equal to:

$$\begin{aligned} & (\lambda + (1 - \lambda)p_L^2)(p_G R_{inside} - \bar{R}) - (\lambda + (1 - \lambda)p_L) \times s \\ & + (1 - \lambda)p_L(1 - p_L) \left(p_C R_C + (1 - p_G) \frac{(1 - \alpha)p_B(p_G X - \bar{R})}{p_G(1 - p_B) - (1 - \alpha)(1 - p_G)p_B} \right). \end{aligned}$$

Total welfare will be equal to

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

that is, the surplus generated by the good projects, less screening costs for the inside

borrowers and the collateral liquidation costs for the outside borrowers.

In the first period, borrowers are screened and those that have a good project receive loans. Their total surplus is:

$$(\lambda + (1 - \lambda)p_L)p_G(X - R_{S1}),$$

while bank profits are $(\lambda + (1 - \lambda)p_L)(p_GR_{S1} - \bar{R}) - s$. Total welfare is the surplus generated by good projects less screening costs:

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

The one-period welfare is lower than the average per-period welfare in the two-period case if

$$(\lambda + (1 - \lambda)p_L)(1 - p_G)\alpha C > \frac{1}{2}((1 - \lambda)p_L(1 - p_L)\alpha C + (\lambda + (1 - \lambda)p_L)s + s),$$

where C is the one-period collateral requirement.

The level of screening costs at which welfare is equal in the two cases is $s^w = \alpha(1 - p_G)C \frac{\lambda + (1 - \lambda)p_L + \lambda + (1 - \lambda)p_L^2}{1 + \lambda + (1 - \lambda)p_L}$. It can be shown that s^w is higher than the cutoff s^{**} ($s^w > s^{**}$ is equivalent to $(\lambda + (1 - \lambda)p_L^2 - (\lambda + (1 - \lambda)p_L)^2) \left(1 - \frac{\alpha(1 - p_G)p_B}{p_G(1 - p_B) - (1 - \alpha)p_B(1 - p_G)}\right) > 0$, which is true). Therefore, per-period welfare is higher in the case of two-period interaction than in the case of one-period lending.

For screening costs between s^{**} and s_2 , borrowers will be required to post collateral in the first period, and in the second period inside borrowers will be screened and outside borrowers will receive secured loans.

Second-period borrower surplus, bank profits and welfare will have the same expressions as above.

In the first period, borrowers are required to post collateral. Their total surplus is:

$$(\lambda + (1 - \lambda)p_L)p_G(X - R_{C1}) - (1 - p_G)\alpha C_1,$$

while bank profits are $(\lambda + (1 - \lambda)p_L)(p_GR_{C1} + (1 - p_G)C_1 - \bar{R})$. Total welfare is the surplus generated by good projects less liquidation costs:

$$(\lambda + (1 - \lambda)p_L)(p_GX - \bar{R}) - (1 - p_G)\alpha C_1.$$

The one-period welfare is lower than the average per-period welfare in the two-period case if

$$(\lambda + (1 - \lambda)p_L)(1 - p_G)\alpha C > \frac{1}{2}((1 - \lambda)p_L(1 - p_L)(1 - p_G)\alpha C + (\lambda + (1 - \lambda)p_L)(1 - p_G)\alpha C_1 + (\lambda + (1 - \lambda)p_L)s),$$

where C is the collateral requirement for one-period lending and C_1 is the (higher) initial collateral requirement for two-period lending. ($C_1 = C + p_B \frac{\pi_{2G1}}{p_G(1-p_B) - (1-\alpha)p_B(1-p_G)}$),

where $\pi_{2G1} = \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} \alpha(1 - p_G)C - s$.

Plugging in the expression for C_1 , we get that the inequality holds as long as $s < \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} (1 - p_G)\alpha C = s_2$. This means that per-period welfare is higher in the case of repeated interaction for all values of screening costs between s^{**} and s_2 .

Proof of proposition 5.2

Suppose the amount of collateral available to borrowers is less than the amount that needs to be pledged to separate borrowers with a good project from those with a bad project in single-period lending.

The alternative is for borrowers to be screened. The surplus of a borrower with a good project that gets screened in one-period lending is $P(S) = p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L}$. The surplus is positive if $s \leq s_{max} = (\lambda + (1 - \lambda)p_L)(p_G X - \bar{R})$.

In the two-period case, let us once again consider borrowers without sufficient collateral in either period. In the second period borrowers that had a bad project in the first period, but have a good one in the second period can only get a loan if they are screened. Their expected surplus - if screening costs are not very high and they receive a loan - is $P(S, B1G2) = p_G X - \bar{R} - \frac{s}{p_L}$. Borrowers that had a good project in the first period will also be screened; their second-period surplus has to be at least $P(S, G1G2) = p_G X - \bar{R} - s \frac{\lambda + (1-\lambda)(2-p_L)}{\lambda + (1-\lambda)p_L(2-p_L)}$. The second-period bank profit per inside borrower with a good project in the first period will be $\pi_{2G1}^s = \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} (p_G R_{inside} - \bar{R})$, where $R_{inside} = \frac{1}{p_G} (\bar{R} + s \frac{\lambda + (1-\lambda)(2-p_L)}{\lambda + (1-\lambda)p_L(2-p_L)})$.

In the first period, borrowers are screened. The expected two-period surplus for a borrower with a good project in the first period is $p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L} + \rho \pi_{2G1}^s + \rho \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} P(S, G1G2)$.

If the screening cost is around s_{max} , then in the second period borrowers that had a bad project in the first period do not receive a loan. Given their success probability and the screening cost, the surplus from the loan would be negative: $P(S, B1G2) = p_G X - \bar{R} - \frac{s}{p_L} < 0$. Borrowers that had a good project in the first period will also be screened; given the available outside option, their second-period surplus will be driven to zero. The second-period bank profit per inside borrower with a good project in the first period will be $\pi_{2G1}^s = \frac{\lambda + (1-\lambda)p_L^2}{\lambda + (1-\lambda)p_L} (p_G R'_{inside} - \bar{R})$, where $R'_{inside} = X$.

In the first period, borrowers are screened. The expected two-period surplus for a borrower with a good project in the first period is $p_G X - \bar{R} - \frac{s}{\lambda + (1-\lambda)p_L} + \rho \pi_{2G1}^s$. (This

is also the first-period surplus, given that the second-period expected surplus is zero).

We can see that the borrower surplus is higher in the two-period case than in the one-period case. That means that projects with relatively low profitability compared to the screening costs will not be financed in single-period lending, but they may be financed if the prospect of repeated lending exists.