Loan Origination under Soft- and Hard-Information Lending

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Abstract

This paper presents a novel model of the lending process that takes into account that loan officers must spend time and effort to originate new loans. Besides generating predictions on loan officers' compensation and its interaction with the loan review process, the model sheds light on why competition could lead to excessively low lending standards. We also show how more intense competition may fasten the adoption of credit scoring. More generally, hard-information lending techniques such as credit scoring allow to give loan officers high-powered incentives without compromising the integrity and quality of the loan approval process.

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1 Introduction

This paper develops a simple model of the loan-origination process that explicitly takes into account that loan officers must spend time and effort to generate new loan applications. It allows to derive new implications on the determinants of banks' lending standard and the adoption of hard-information lending techniques such as credit scoring.

To mitigate their *internal* agency problem vis-á-vis loan officers, banks have a tendency to implement too low lending standards, if judged solely by the NPV of newly made loans. The lending standard further decreases under competition, leading to a further deterioration of the average quality of the loan portfolio.

Our model also suggests that more competition can trigger a switch from soft- to hard-information lending. When relying solely on hard information, loan officers can be given high-powered incentives to generate new loan applications without compromising the integrity and quality of the loan approval process. In contrast, under soft-information lending high-powered incentives induce loan officers to feed potentially biased information into the loan approval process, unless the bank provides sufficiently strong countervailing incentives through its loan review process.

While it has been frequently observed that the switch to hard-information lending intensifies competition as it reduces the importance of closeness, our model suggests a reverse causality.[1] This novel perspective may help to explain why the adoption of credit scoring to commercial lending seems not to have gathered pace equally across countries.[2] Our model would predict a faster adoption in countries where competition has significantly intensified through deregulation and other developments. Taken together, the two hypotheses thus jointly suggest a strong complementarity between competition and the adoption of hard-information lending techniques. Furthermore, as we discuss in more detail below, our model yields novel predictions on why and how banks' lending standards adjust to an increase in competition through market opening, deregulation or, as it is sometimes

[1] Such a shrinking distance between lenders and small-business borrowers has been documented for the US by, for instance, Petersen and Rajan (2002). For a contrasting European perspective based on Belgian data see, however, Degryse and Ongena (2005).

[2] See Berger and Frame (2005) for a detailed account of the spread of small business credit scoring in the US, as well as Akhavein et al. (2001) for a quantitative analysis. Clearly, the evolution of credit scoring also depends crucially on developments in IT, as a main benefit lies in the lower costs of processing applications. Though this should equally apply to Europe, in their detailed analysis of the small business loan data from a large Belgian bank, Degryse, Laeven, and Ongena (2006) note that credit scoring was virtually non existing in the late 90s.

suggested, business cycle conditions.

In our model, a switch to a hard-information lending regime reduces the loan officer's role to that of a salesperson. This seems to have indeed happened in some cases. As James and Houston (1996) observe for the case of Wells Fargo:

> "Wells Fargo, recognized by American Banker as the "runaway leader in small business lending," has taken great strides to develop an expertise in the application of technology to small-business lending. [...] Individual lenders are now able to go out in the field armed with a laptop computer loaded with information from the firm's large data base. This enables the lender to "plug in" the borrower's information into the computer model – and, in many cases, to approve loans on the spot that in the past might have taken a great deal of time and a great number of people to process."

More lately, Wells Fargo has even proceeded towards delegating the origination of loans to community banks, which use Wells Fargo's proprietary system and are paid a fee per loan (see Berger and Frame, 2005). While a loan origination system that enlists other banks' employees may be rare in *commercial* lending, the job description of loan officers by the US Department of Labor suggests that by now commercial loan officers are indeed often treated like salespeople and receive a substantial fraction of their pay through commissions or loan-origination fees:[3]

> "In many instances, loan officers act as salespeople. Commercial loan officers, for example, contact firms to determine their needs for loans. If a firm is seeking new funds, the loan officer will try to persuade the company to obtain the loan from his or her institution. [...] The form of compensation for loan officers varies. Most are paid a commission that is based on the number of loans they originate. In this way, commissions are used to motivate loan officers to bring in more loans. Some institutions pay only salaries, while others pay their loan officers a salary plus a commission or bonus based on the number of loans originated."

Our model suggests that loan officers who still have the twin roles of originating new loan opportunities and of feeding their "soft" information into the approval process will

[3] See http://www.bls.gov/oco/ocos018.htm

have less high-powered incentives. Loan officers are in turn paid more like salespeople and less like bureaucrats as competition increases.

At the heart of this paper is a novel model of the loan-origination process. As noted above, in the case of soft-information lending the loan officer has two tasks to perform: firstly, to spend time and effort on contacting clients so as to generate new loan opportunities and, secondly, to subsequently decide on whether to approve a given borrower. The first task may involve simply the management of existing contacts. That is, the loan officer may inquire in regular intervals about a client's needs to expand existing credit facilities or to extend existing services, say cash management, into lending. However, for more aggressive banks it may also involve active prospecting for new clients.

The second task under soft-information lending has been much discussed in the literature on relationship lending. It entails two key assumptions, namely that the loan officer is, first, the person with privileged access to information about the borrowing firm and that, second, some of this information is "soft" i.e., "hard to quantify, verify and communicate through the normal transmission channels of a banking organization" (Berger and Udell, 2002).[4]

In contrast to the extensive treatment of the role of soft information, to our knowledge the literature has so far largely ignored the first task in the loan origination process, i.e., the task of originating new loan applications in the first place.

We find that the interaction of the two tasks may bias the loan officer towards "overlending". This bias does not arise from collusion with the borrower.[5] Instead, the bias arises endogenously under the optimal compensation scheme. To counter this bias, the bank must put into place a costly process of monitoring the performance of loan officers and it may have to reward better performing loan officers with higher "rents". While nowadays a bank routinely reviews its whole loan portfolio to comply with regulatory requirements, the extent to which a given rating is further scrutinized internally remains still at the bank's discretion. As noted by Treacy and Carey (1998), in their interviews conducted with large banks

[4] On more details on the definition of soft information see Petersen (2004). In our model, the loan officer could well be asked to provide some (ordinal) information about more qualitative factors. Also, some of these factors may be verifiable, albeit only at additional costs through the bank's review process.

[5] On the potential for collusion see Udell (1989) and Berger and Udell (2002), as well as more recently Hertzberg, Liberti, and Paravisni (2006).

"[...] managers indicated that the internal rating system is at least partly designed to promote and maintain the overall credit culture.[...] Strong review processes aim to identify and discipline relationship managers [...]."

Udell (1989) provides evidence that banks invest more in monitoring when more authority is delegated to loan officers, which further testifies to its disciplining role.

Most notably, Stein (2002) has also looked into the organizational "black box" of banks' lending processes, albeit with a focus on the internal capital market operated in large banks. He shows how incentives for local staff to generate information can be undermined if this information can not be communicated to headquarters due to its soft and subjective nature.[6]

With hard-information lending, which is the second lending regime that we study, the loan officer no longer plays an active role at the loan approval stage, apart from keying in the *hard and verifiable* information about the loan applicant. A key implication of this is that the loan officer´s incentives can now be fully directed towards the origination of new loan-making opportunities, allowing the bank to provide loan officers with high-powered incentives at lower overall costs.[7] As in the case of Wells Fargo, this may be part of a bank's strategy to aggressively pursue opportunities in new markets, while for other banks this may simply be necessary in order to counter increased competition on their home turf.

As noted above, we also investigate how a change in competition affects banks' lending standard under a given lending regime. If banks harness loan officers' soft information, we find that they *optimally* lower the prevailing lending standard as competition intensifies.[8] This is the case as it proves to be too costly to fully counteract the effect that more high-powered compensation has on loan officers' willingness to approve also less creditworthy borrowers. While the expansion in lending, which our model predicts as a consequence of more intense competition, could simply be due to lower loan rates, the novel prediction is

[6] On the theoretical side, our model of the double-task problem borrows from Inderst and Ottaviani (2007). There, the focus is, however, on public policy to prevent the (mis-)selling of expert goods through agents.

[7] We conceive here that the adoption of credit scoring does more than just providing the loan officer with a new tool, but that coincides with a fundamental change in the lending regime. Consequently, at the point of switching to hard-information lending the informativeness of the lending decision decreases as soft information is discarded. This contrasts our analysis to that in Hauswald and Marquez (2003), who have studied how borrowing conditions are affected as banks become more efficient in generating or using information.

[8] It should be noted that in our model banks are not fooled by their loan officers but optimize over the implemented lending standard and the incentive scheme.

that banks increasingly make loans to less creditworthy borrowers and, thereby, also raise the fraction of negative-NPV loans in their portfolio. This seemingly excessive expansion is a willingly tolerated by-product of the high-powered incentives that banks give to their loan officers.

This prediction contrasts sharply with those of more standard models of loan-market competition under borrower adverse selection or moral hazard. There, a lower interest rate would either attract more borrowers with a more creditworthy project or, through leaving borrowers with a larger stake in their own venture, would induce more effort and thus on average a higher probability of success (cf. Stiglitz and Weiss 1981 and Boyd and De Nicolo 2005).

If more competition follows from opening up a market, e.g., to foreign banks, then also the extant literature would predict a deterioration of the average loan quality. This follows as new, inexperienced lenders face a lemons' problem (cf. Bofondi and Gobbi 2004). There are, however, still two key differences to our predictions. First, we would predict higher future default rates also for incumbents. Second, while banks facing a more severe problem of adverse selection should optimally raise their internal lending standard, our model would predict lower lending standard as competition between incumbents and entrants intensifies.[9]

We also interpret the relationship between lending standards and competition in terms of the business cycle.[10] That competition intensifies during booms has been suggested based on the documented reduction in banks' margins as well as borrowers' credit spreads (cf. Dueker and Thornton, 1997; Corvoisier and Gropp, 2002).[11] The possibility of an excessively low lending standard in booms has been attributed to organizational inertia by Berger and Udell (2004) and to a more general tendency to misperceive risk by Borio,

[9] At this point, our paper ties in with the large literature that tries to establish, both theoretically and empirically, a relationship between market structure and stability in banking. Though a number of papers have suggested that various proxies of more intense competition are negatively correlated with banking stability, this view is not uniformly shared (cf. most recently the discussion in Beck, Demirgüç-Kunt, and Levine 2006).

[10] The relaxation of lending standards in booms has been more generally documented by, for instance, Asea and Blomberg (1998) in a large panel of commercial and industrial loans or by Lown and Morgan (2004) from a survey of loan officers.

[11] Though our model is agnostic about this, following Dell'Ariccia and Marquez (2006) an increase in competition could be due to a reduction in adverse selection given that the fraction of new borrowers about which no bank has private information increases. They show that this may induce banks to no longer screen borrowers by requiring collateral.

Furfine, and Lowe (2001). In more formal work, countercyclical standards arise in Rajan (1994) from a model specification that allows bank managers to better hide losses when most borrowers do well and in Ruckes (2004), as well as in Weinberg (1995), from an optimal adjustment of screening intensity following changes in the pool of potential borrowers. Finally, there is also a small theoretical literature that jointly endogenizes business cycle conditions and changes in the pool of funded projects and thus the likelihood of future default. For instance, in Suarez and Sussmann (1997) lower margins in the boom create more need for external finance, which through a moral hazard problem triggers more risk taking and thus a higher probability of future default.

The rest of this paper is organized as follows. In Sections 2-5 we analyze our main model, where for tractability the loan officer's effort choice is discrete. Section 6 provides an extension to continuous effort. Section 7 concludes.

2 The Model

We focus first on the lending regime under soft information. Here, the loan officer has to perform two tasks. The first task is to generate new loan applications. In our main analysis, we consider a simple discrete-choice model and stipulate that the loan officer exerts a given level of effort (or no effort at all). By exerting effort at private disutility $c > 0$, the risk-neutral loan officer generates a loan application with probability $\pi > 0$. Without exerting effort the respective probability is zero.

There are two types of borrowers: low types $\theta = l$ and high types $\theta = h$. The *ex-ante* probability that a borrower is of the high type equals $0 < \mu < 1$. A borrower of type θ defaults with probability $1 - p_\theta$, where $0 \leq p_l < p_h \leq 1$, in which case the bank obtains a zero repayment. Otherwise, the bank receives a contractually stipulated repayment of R. Letting k denote the initial loan size, the NPV from the loan is $v_\theta := p_\theta R - k$. We stipulate that $v_h > 0 > v_l$. Normalizing the risk-free rate to zero, from the bank's perspective it is thus only profitable to lend to high-type borrowers. Finally, it is not profitable to indiscriminately grant a loan to all borrowers as $v := \mu v_h + (1 - \mu) v_l < 0$.

By using his soft information, the loan officer can make a more informed decision. We therefore suppose that the loan officer can, in addition, observe a signal $s \in [0, 1]$, which is realized according to the type-dependent distribution function Ψ_θ. Signals are ordered such that Ψ_h dominates Ψ_l according to the Monotone Likelihood Ratio property. With continuous densities satisfying $\psi_h(1) > 0$, $\psi_l(0) > 0$, and $\psi_h(0) = \psi_l(1) = 0$, the signal is also fully informative at the boundaries.

The *ex-post* probability with which the borrower is of the high type is given by

$$\mu(s) := \Pr[\theta = h \mid s] = \frac{\mu\psi_h(s)}{\mu\psi_h(s) + (1-\mu)\psi_l(s)},$$

which is strictly increasing in s. Next, the conditional success probability is given by $p(s) := \mu(s)p_h + [1 - \mu(s)]p_l$ such that the conditional NPV of making a loan equals $v(s) := p(s)R - k$. This is continuous and strictly increasing in s. Together with $v(0) = v_l < 0$ and $v(1) = v_h > 0$, we then have a unique (and from the bank's perspective first-best optimal) threshold $0 < s_{FB} < 1$ where $v(s_{FB}) = 0$.

In what follows, it will be convenient to express the bank's optimization program by working with the conditional values $p(s)$ and $v(s)$ together with the *ex-ante* distribution over the signal s, which is given by $G(s)$ with density $g(s) := \mu\psi_h(s) + (1-\mu)\psi_l(s)$.

If the loan officer was paid like a bureaucrat with a fixed wage w, his preferences at the loan approval stage would be aligned with those of the bank.[12] (Precisely, the loan officer would then always be indifferent.) The crux, however, is that if the loan officer was paid like a bureaucrat, then he would have no incentives to originate a new loan in the first place.

Our key assumption is that neither the signal s nor the time and effort that the loan officer spends on the origination of new loans are observable by his principal, the bank. Realistically, it is also not feasible to remunerate the loan officer on the basis of the number of filled-in applications, which could simply be bogus applications. A compensation scheme can thus only be made contingent on whether a new loan was approved or not.

Before setting up the general compensation scheme, it should be noted that we can suppose without loss of generality that the approval decision is delegated to the loan officer. (Recall that for now we treat the case of soft-information lending only.) That is, it is straightforward to show that this implements the optimal mechanism.[13] Furthermore,

[12] Of course, if observing s required to exert costly effort, then under a fixed-wage contract there would not be any incentive to acquire soft information in the first place. It can, however, be shown that all our following results would go through if next to the cost of originating a loan, c, additional effort at cost $\widehat{c}$ was necessary to acquire information.

[13] An optimal mechanism can in turn be derived from a standard message-game approach, by which the bank would specify a mapping of the loan officer's message $\widehat{s} \in [0,1]$ into the space of contracts and decisions. On the other hand, loan officers with strong relationships seem to indeed enjoy often a high level of discretion (cf. the case described in Hertzberg, Liberti, and Paravisni 2006). This holds despite

another instrument that the bank has at its disposal is the loan review process, through which the loan officer's approval decisions are monitored. For this we stipulate that with probability m the bank observes early on whether the borrower will subsequently default. All that is important for our analysis is that some information is received, irrespective of how noisy it is and irrespective of whether it relates directly to the borrower's type θ or, as presently specified, to subsequent default.

Taken together, in this environment the different states on which a compensation contract can condition are thus the following: first, the state where a loan has not been made; second, the state where a loan has been made and where no negative information was obtained in the loan review process; and finally the state where a loan has been made and where negative information was subsequently revealed. It is immediate that in the final case, given limited liability of the loan officer, it is optimal to set the loan officer's wage equal to zero. This leaves us with two wage levels to specify. We refer to the wage that is paid if no loan was made as the base wage w. Otherwise, a loan-origination fee f is paid in addition to w.

Before proceeding to the analysis, we comment on the chosen specifications. We already discussed the role of the loan review process in the Introduction. As $m < 1$ holds, it is immediate that the bank would want to withhold any payment to the loan officer until it receives itself full payment from the borrower, which provides an additional signal of the type θ.[14] This may, however, lie too far in the future to be of much use for disciplining the loan officer.[15] Based on this observation, one may equally doubt that all of the promised wage payment, $w + f$, may be forfeited by a loan officer in case of a negative outcome of the loan review process. Our results extend, however, to the case where only a fraction α of $w + f$ can be withheld or "clawed back". In fact, the comparative analysis in α would then be completely analogous to that of a change in m.

the fact that due to regulatory requirements loan approvals regularly have to be co-signed by the bank's risk management side.

[14] In an earlier version of this paper we also considered the possibility that m is endogenously chosen. In case the bank jointly optimizes over costly monitoring m next to the contractual variables (w, f) all our results still hold, though for the case with continuous effort (cf. Section 6) we no longer obtain explicit solutions.

[15] The insight that it may be beneficial to withhold wages or, in addition, have workers post a bond until more of the uncertainty surrounding the choice of effort has been resolved is not novel. Incidentally, in the area of consumer loans to high-risk borrowers (e.g., the case of "doorstep lending" in the UK) it is sometimes observed that loan officers are indeed paid exclusively out of the collections that they personally make from borrowers.

3 Loan Officers' Incentives

We currently suppose that the loan officer performs two tasks for the bank: that of originating new loan-making opportunities and that of using his only privatively observed information so as to allow the bank to make more informed approval decisions. In what follows, we derive first the respective incentive constraints.

Suppose first that the loan officer has already generated a new loan application. In case the loan is not approved, the loan officer realizes only his base wage w. Otherwise, his wage depends also on the outcome of the subsequent loan revision process. After observing the signal s and approving a borrower, the loan officer can expect that with aggregate probability

$$1 - m + mp(s)$$

no negative information will subsequently be revealed. (We use here that a loan review will only generate information with probability m and that the conditional success probability is $p(s)$.) In this case, the loan officer's compensation is equal to $w + f$. Consequently, the loan officer prefers to approve a loan whenever

$$[1 - m + mp(s)]\,(w + f) \geq w. \tag{1}$$

Otherwise, i.e., if the converse of (1) holds, the loan officer prefers not to approve the respective loan.

It is straightforward that we can restrict consideration to contracts with $f > 0$ as, otherwise, the loan officer has no incentives at all to generate new loan opportunities at private cost $c > 0$. Consequently, if the loan officer prefers to approve a loan for some signal $s < 1$, then he will strictly do so for all higher signals $s' > s$. From optimality for the bank we can next rule out the case where a loan is never approved. Likewise, as we currently suppose that the bank wants to make use of the loan officer's soft information, we can ignore the case where the loan is always approved. Taken together, we then have an interior threshold $0 < s^* < 1$ at which the loan officer is just indifferent. A loan is thus only approved if $s \geq s^*$,[16] where we have from (1) that s^* solves

$$\frac{f}{w} = \frac{m\,[1 - p(s^*)]}{1 - m\,[1 - p(s^*)]}. \tag{2}$$

[16]Being a zero-probability event, it is immaterial for our subsequent results how the tie at $s = s^*$ is broken.

While currently condition (2) provides us with the respective threshold s^* for a *given* contract (f, w), it is also useful to offer another interpretation. Suppose that the bank wants to change the implemented threshold s^*. As the right-hand side of condition (2) is strictly decreasing in s^*, to obtain a stricter standard s^* the ratio f/w must decrease. Hence, a stricter standard has to go together with a more low-powered compensation scheme.

Note furthermore that the right-hand side of (2) is also strictly increasing in m. Intuitively, if the loan review process is more informative, a lower base wage w is sufficient to ensure that the loan officer follows a given standard s^*.

We turn next to the loan officer's second incentive constraint, which ensures that new loan-making opportunities are created in the first place. Recall for this that through exerting effort at private cost c, the loan officer finds an interested applicant with probability π. Consequently, in case he subsequently applies a threshold s^*, then from an *ex-ante* perspective a loan will only be made with probability $\pi[1 - G(s^*)]$. As the loan officer earns the base wage w without a loan and as he forfeits all compensation in case the loan review reveals negative information, exerting costly effort is only optimal in case

$$\pi \int_{s^*}^{1} [1 - m + mp(s)] (w + f) g(s) ds + w [\pi G(s^*) + (1 - \pi)] \geq c + w. \tag{3}$$

Rearranging (3), we obtain the requirement that

$$\int_{s^*}^{1} [[1 - m + mp(s)] (w + f) - w] g(s) ds \geq D := \frac{c}{\pi}. \tag{4}$$

To incentivize the loan officer to exert effort there must thus be a sufficiently large wedge between the expected compensation in case of making a loan (for all $s \geq s^*$) and the base wage w, which is paid even if no loan was made. Note also that the additional (expected) compensation in case of making a loan must be larger the harder it is for the loan officer to generate a new application.[17] Below we will link the respective measure, D, to competition in the loan market.

Setting up the bank's program, we now proceed in two steps. For the rest of this section we take the standard s^* that the bank wants to implement as given and determine the respective optimal contract. In the subsequent section s^* is endogenized.

[17] Here, we could interpret $D = c/\pi$ also as the expected effort cost that must be incurred until, after possibly repeated attempts, a single loan application was generated.

Taking s^* for now as given, the bank chooses the compensation scheme (w, f) so as to maximize its *ex-ante* profits

$$\Pi = \pi \int_{s^*}^{1} [\nu(s) - [1 - m + mp(s)] (w + f)] g(s)ds - w [\pi G(s^*) + (1 - \pi)], \qquad (5)$$

which takes into account both the conditional NPV from the loan, $\nu(s)$, and the expected wage payment. The optimal contract is straightforward to derive and uniquely characterized by constraint (1) and the binding incentive constraint (4).

Proposition 1 *The optimal contract for a given threshold s^* specifies a base wage*

$$w = \frac{D}{m} \left[\frac{1 - m [1 - p(s^*)]}{\int_{s^*}^{1} [p(s) - p(s^*)] f(s)ds} \right] \qquad (6)$$

and a loan-origination fee

$$f = D \left[\frac{1 - p(s^*)}{\int_{s^*}^{1} [p(s) - p(s^*)] f(s)ds} \right]. \qquad (7)$$

That constraint (4) must be binding, which is what we used for the characterization in Proposition 1, follows immediately from the fact that the base wage w represents a pure *rent* for the loan officer. Intuitively, the loan officer could earn w even without exerting effort. The loan officer's total expected compensation is thus equal to $w + c$, with w characterized in (6).

Proposition 1 also allows to complete the comparative statics of the compensation scheme. From differentiating (6) and (7) respectively, we then obtain the following results.

Corollary 1 *In order to implement a higher lending standard s^*, the bank has to pay both a higher base wage w and a higher loan-origination fee f. Still, the higher s^* the flatter becomes the compensation scheme as f/w decreases. On the other hand, a more informative loan review process is, for given s^*, associated with a steeper compensation scheme.*

In light of our future results it is next worthwhile to comment briefly on the comparative statics of w in s^*, as given by Corollary 1. As the bank wants to implement a higher lending standard, from an *ex-ante* perspective this reduces the likelihood with which a loan will ultimately be made, $\pi [1 - G(s^*)]$. In order to still elicit effort, it is thus necessary to increase the loan-origination fee. As we know, however, when keeping the base wage constant this would induce the loan officer to approve a loan even for *lower* values of s^*, which is the opposite of what was originally intended. Consequently, to raise the lending standard the base wage must indeed increase.

Note finally that from Corollary 1 the two incentive instruments, namely the steepness of the compensation scheme and the loan review process, are complementary: A higher monitoring intensity is associated with a steeper incentive scheme. As we already observed above, this relationship is caused by the fact that to implement a chosen threshold s^* the bank needs to pay only a lower base wage w the higher m.

4 Competition and Lending Standards

Substituting for given s^* the optimal compensation scheme from Proposition 1 into the bank's objective function (5), we obtain

$$\Pi = \pi \int_{s^*}^{1} \nu(s)g(s)ds - (c+w). \tag{8}$$

The bank's expected profit is just equal to the expected profit that it earns from lending minus the expected wage bill $c+w$. Hence, holding the wage bill constant, from an *ex-ante* perspective it would clearly be optimal to set $s^* = s_{FB}$, thereby ensuring that loans are made if and only if they represent a positive NPV investment from the bank's perspective. In fact, it is easy to see that this would be the optimal choice if s was verifiable and the bank could, therefore, impose any choice of s^*, regardless of the chosen compensation.[18]

Maximizing (8), we have that $d\Pi/ds^* = 0$ whenever[19]

$$\pi\nu(s^*)g(s^*) = -\frac{dw}{ds^*},$$

which after substituting from Proposition 1 and using Corollary 1 becomes

$$\pi\nu(s^*)g(s^*) = -\frac{D}{m}\frac{d}{ds^*}\left[\frac{1-m\left[1-p(s^*)\right]}{\int_{s^*}^{1}\left[p(s)-p(s^*)\right]f(s)ds}\right] < 0. \tag{9}$$

Hence, at the optimally implemented standard s^* the respective (marginal) loan represents a negative-NPV investment for the bank: $\nu(s^*) < 0$. The bank optimally chooses

[18] In this case, the bank would also choose $w = 0$ and would thus not pay the loan officer a rent.

[19] We suppose here for convenience that the program is strictly quasiconcave.

$s^* < s_{FB}$ as this allows to reduce the internal agency costs. Hence, the *ex-ante* optimal lending standard is strictly lower than the *ex-post* optimal lending standard, at least from the bank's own perspective.

Proposition 2 *The bank's optimal choice of the lending standard s^* is given by (9) and is strictly below the zero-NPV threshold: $s^* < s_{FB}$.*

Having established the optimal lending standard, we conduct now our key comparative analysis in the parameter $D = c/\pi$. From implicit differentiation of (9), while using strict quasiconcavity, we have the following result.

Corollary 2 *The optimal lending standard s^* is strictly decreasing in D.*

In words, as it becomes increasingly difficult to generate a new loan-making opportunity, either as π decreases or as c increases, the bank optimally responds by lowering the lending standard s^* that the loan officer subsequently applies. More formally, this result hinges on the fact that the *marginal* cost of raising the standard s^*, i.e., $dw/ds^* > 0$, is itself strictly increasing in D:

$$\frac{d^2 w}{ds^* dD} > 0. \tag{10}$$

Our interpretation of Corollary 2 is in terms of competition in the loan market. We would argue that more intense competition makes it harder for an individual loan officer to generate loan applications. In our model, this can be captured either through an increase in the cost c or through a reduction in the probability π. Intuitively, we could imagine that in the extreme case where a bank has a monopoly most entrepreneurs with a viable business prospect or most firms that wish to expand their business will sooner or later end up anyway at the bank's doorstep. With intense competition, in particular if rival lenders' loan officers are themselves actively prospecting for new borrowers, this is no longer the case. When extending the model to the case with continuous effort below, we will, in addition, allow competition to affect not only the *overall* likelihood with which a loan opportunity arises but also the "responsiveness" to changes in effort. As we discuss there, in line with the standard notion from Industrial Organization theory, competition thus makes loan demand more elastic to loan officers' effort.

Our interpretation of Corollary 2 in terms of competition is agnostic about the reasons for why competition could increase. As suggested in the Introduction, this could be linked to deregulation and the opening up of a market to outside competition. Corollary 2 together with Proposition 2 then suggest not only that the average default probability increases, which in our case is given by

$$\int_{s^*}^{1} [1 - p(s)] \frac{g(s)}{1 - G(s^*)} ds,$$

but also that more loans are made that represent a negative-NPV investment for the respective bank. Crucially, however, this is not due to a misperception of risk or herd behavior. Instead, banks willingly tolerate a lower lending standard as they simultaneously increase their loan officers' incentives to originate loans.

Recall now from the Introduction that, according to some empirical studies, more intense competition in the banking market may also be characteristic in booms. Though our model would once more be agnostic about the precise mechanism that triggers more competition, it would imply countercyclical lending standards. Moreover, from Corollary 2 banks would have in booms a higher propensity to make negative-NPV loans, resulting in more subsequent defaults.

5 Soft- vs. Hard-Information Lending

If a bank does not harness a loan officer's soft information, then the respective loan officer faces only a single task, namely that of generating loan applications. Instead, the loan application process becomes fully automated. In this case, we stipulate that based only on hard information, the observed signal $\widehat{s}$ is more noisy as with probability $1 - \lambda > 0$ it is now drawn from the uniform distribution over $\widehat{s} \in [0, 1]$. This specification ensures that soft information always adds value.

The posterior probability $\widehat{\mu}(\widehat{s})$:=$\Pr[\theta = h \mid s]$ is then given by the convex combination $\widehat{\mu}(\widehat{s})$=$\lambda\mu(\widehat{s}) + (1 - \lambda)\mu$. With the *ex-ante* success probability $p := \mu p_h + (1 - \mu)p_l$, we have likewise the new conditional success probability $\widehat{p}(\widehat{s}) := \lambda p(\widehat{s}) + (1 - \lambda)p$ and thus the conditional NPV $\widehat{v}(\widehat{s}) := R\widehat{p}(\widehat{s}) - k$. Finally, the signal is now distributed according to $G(\widehat{s}) := \lambda G(\widehat{s}) + (1 - \lambda)\widehat{s}$, where we use that $\widehat{s} \in [0, 1]$ is chosen from the uniform distribution with probability $1 - \lambda$.

The bank now optimally approves a loan in case $\widehat{v}(\widehat{s}) \geq 0$. In case of an interior optimal lending standard $\widehat{s}_{FB}$, we then have that $\widehat{v}(\widehat{s}_{FB}) = 0$. As the lending standard is now mechanically imposed by the bank, the loan officer's remaining incentive constraint is easily characterized. The loan officer receives a loan-origination fee of

$$f_H = D\frac{1}{1-G(\widehat{s}_{FB})}, \tag{11}$$

which just compensates him for the respective cost of effort, and a zero base wage: $w_H = 0$. (Note that in what follows it will frequently be convenient to denote some key parameters by a subscript H if they refer to the hard-information regime and by a subscript S for the soft-information regime.) Consequently, with $w_H = 0$ the loan officer does not realize a positive rent.

As we explore below, the fact that the loan officer always realizes a strictly smaller rent under hard-information lending carries over to the case with continuous effort choice, though there the bank must leave the loan officer with positive rent in either case. Moreover, with discrete effort and $w_H = 0$ it is currently trivial that the compensation scheme is more high-powered under hard-information lending. We will therefore postpone a comparative analysis of compensation contracts under the two lending regimes until we deal with the case of continuous effort below.

In this Section, we are instead primarily interested in how competition, as expressed again by a shift in D, affects the choice between hard- and soft-information lending. The respective profits under hard-information lending are given by

$$\Pi_H := \pi \int_{\widehat{s}_{FB}}^{1} \widehat{v}(s)\widehat{g}(s)ds - c,$$

as from an *ex-ante* perspective the choice of f_H in (11) just compensates the loan officer for the cost of effort c. For the case with soft-information lending we have to recall that total wage costs are $w_S + c$, where the base wage under soft-information lending $w_S > 0$ is derived in Proposition 1. Taking this into account, expected profits under soft-information lending equal

$$\Pi_S := \pi \int_{s^*}^{1} v(s)g(s)ds - D\frac{1}{m}\left[\frac{1-m\left[1-p(s^*)\right]}{\int_{s^*}^{1}\left[p(s)-p(s^*)\right]f(s)ds}\right] - c.$$

A switch from soft-information lending towards hard-information lending is thus profitable in case $\Pi_H > \Pi_S$. Intuitively, such a shift is less likely the less severe is the agency problem (and thus the smaller is the agency rent) under soft-information lending. This is in turn the case if m is higher. Likewise, a shift to hard-information lending is less likely if this entails a more severe loss in information as represented by a lower value of λ.

If the loan officer has to exert higher effort so as to potentially generate a loan application, the bank must compensate the loan officer for the additional disutility under either lending regime. Under soft-information lending, however, the wage bill increases by more than the differential in effort cost, dc, as also $dw_S/dc > 0$. Holding first s^* constant, this is the case as an increase in the loan-origination fee, which is necessary to still incentivize the loan officer, must be accompanied by an increase in the base wage w_S. Otherwise, the loan officer would choose to approve even less promising applicants.

To see more formally how Π_S adjusts *relative* to Π_H following a marginal increase in c, note that by the envelope theorem we have that

$$\left|\frac{d\Pi_S}{dc}\right| - \left|\frac{d\Pi_H}{dc}\right| = \frac{\partial w_S}{\partial c} = \frac{1}{m}\frac{1}{\pi}\left[\frac{1 - m\left[1 - p(s^*)\right]}{\int_{s^*}^{1}\left[p(s) - p(s^*)\right] f(s)ds}\right] > 0.$$

Next, though here the formal argument is slightly more complicated, the same comparative result applies intuitively for the case where π decreases. Overall, we can thus conclude that if it becomes more difficult to originate a new loan, i.e., if D increases, then it is more likely that the hard-information regime is more profitable. The following Proposition summarizes the comparative results.

Proposition 3 *A switch to hard-information lending becomes more likely, i.e., the difference in the respective profits $\Pi_H - \Pi_S$ increases, if:*
i) hard-information lending is more informative as λ is higher;
ii) the agency problem under soft-information lending is less severe as m is higher;
iv) or if it becomes harder to generate a new loan-making opportunity as either c increases or π decreases (resulting in an increase of $D = c/\pi$).

As we show in the proof of Proposition 3, holding all other parameters fixed, as we shift either one of the parameters λ, m, c, or π, there exists in all cases an interior (and in the case of c bounded) threshold value such that either one of the two regimes is indeed profitable for the parameter values below or above the threshold, respectively.

Proposition 3 implies that a shift towards a hard-information lending regime, e.g., through the adoption of credit scoring, becomes more profitable as competition intensifies.

Cross-sectionally one should thus be more likely to observe the spread of such lending technologies in countries where competition is more intense, while otherwise banks may be more likely to still adopt a soft-information lending regime, with loan officers playing a vital role in the loan approval decision. Though we lack comparative studies, it seems that the use of credit scoring has spread extensively in the United States, at least in the area of small business lending, while this seems to be much less the case in Europe (cf. the Introduction). Proposition 3 suggests that variations in competition could provide an explanation. This perspective contrasts with the view that the adoption of hard-information lending technologies has itself increased competition (cf. the Introduction). Taken together, the two hypotheses also point to a strong complementarity between competition and the adoption of credit scoring, which should thus be mutually reinforcing.[20]

6 Continuous Effort Choice

6.1 The Modified Model

Our basic analysis allowed for a continuous adjustment of the credit policy, as represented by the optimally implemented threshold s^*, while keeping the effort choice problem discrete. Though ideally we would want both choices to be continuous, we found that the resulting complexity heavily obfuscates results. In what follows, we thus allow now effort to be continuous, while stipulating a discrete credit policy. This will allow to obtain a richer set of implications, in particular for the choice of compensation contracts.

The loan officer now chooses a continuous effort level $e \geq 0$. For simplicity, we still suppose that his effort is directed towards the origination of a single new loan, which is now made with probability $q(e)$. Effort comes at private cost $c(e)$. To obtain explicit solutions we set $c(e) = e^2/(2\gamma)$, where γ will always be chosen sufficiently large to ensure that $q(e) < 1$ holds in equilibrium. We postpone a specification of the function $q(e)$ until further below.

Under soft-information lending, we now suppose that the loan officer's signal s is perfectly informative. Formally, we can thus suppose now that $s \in \{0, 1\}$ and that $s = 0$ is

[20] That being said, the analysis of Boot and Thakor (2000), which studies the intensity of relationship loans in the face of increased competition, could also suggest a more differentiated response of banks to more competition. Some banks could find it more profitable to stick to soft-information lending and to focus on the clientele that is either locked-in or for which it can provide superior value-added.

generated with probability one if $\theta = l$, while $s = 1$ is generated with probability one if $\theta = h$. Intuitively, soft-information lending will then only be optimal if the bank wants to implement a credit policy such that type-l borrowers are rejected. Note that in this case a loan will only be made with probability μ once an application has been received.

For the case of hard-information lending, we suppose again that the signal is noisy. Type $\theta = h$ generates the signal $\widehat{s} = 1$ with probability $0 < \lambda < 1$, while with probability $1 - \lambda$ any signal $\widehat{s} \in \{0, 1\}$ is generated with equal probability. The case where $\theta = l$ is symmetric.

We turn now to the specification of the function $q(e)$, for which we choose

$$q(e) = \alpha + \beta e \tag{12}$$

with $\alpha \geq 0$ and $\beta > 0$. In our subsequent comparative analysis we will presume that an increase in competition translates into a reduction of α or an increase in β (or both). Either of the two changes makes loan demand more elastic to the loan officer's effort[21].

In Appendix B we derive from first principles the linear relationship in (12) as well as the stipulated relationship between more competition and a change in α and β. There, a bank faces competition from outside its local turf. Competition can be more intense either as competing offers are more attractive or as competing loan officers are more active in contacting potential borrowers. In the considered model, being contacted by a loan officer tilts a borrower more towards the respective bank as this reduces his respective "transaction costs", which could comprise, for instance, the time and effort that is otherwise spent on locating a branch or finding out about the prevailing loan terms.

For a given level of effort e, a bank makes a loan with a lower probability in a more competitive environment. This corresponds to a reduction of α. Also, if there is more competition then the likelihood of winning a particular borrower will react more sensitively to the loan officer's effort, which is reflected by an increase in β. Intuitively, this holds as a loan officer's effort is only effective if a borrower would otherwise have chosen a competing offer. For instance, in the extreme case where competitors' loan terms are very unattractive and where their loan officers are unlikely to contact the respective borrower, any effort of the former bank's own loan officers should then be largely superfluous. In this case, the respective borrower would very likely have chosen this bank anyway.

[21] Recall that elasticity, here with respect to e, is defined as $(dq/de)/(e/q)$.

6.2 Compensation and Effort under the Two Lending Regimes

It is helpful to analyze first the case of hard-information lending. Given that the *ex-ante* NPV of a loan is negative, it can not be optimal for the bank to approve a borrower after $\widehat{s}=0$ was revealed. To ensure that approving a loan is optimal in case of $\widehat{s}=1$, it must hold that:[22]

$$\upsilon_h \mu(1+\lambda)+\upsilon_l(1-\mu)(1-\lambda)>0. \tag{13}$$

In what follows, we assume that (13) holds so as to ensure that lending takes place also in the hard-information regime. Note that this is always the case if λ is not too low. Furthermore, in this case the probability with which a loan will be made is given by

$$\sigma:=\frac{1}{2}\left[\mu(1+\lambda)+(1-\mu)(1-\lambda)\right].$$

Using next that effort results in a new loan opportunity with probability $q(e)=\alpha+\beta e$ and that it comes at private disutility $c(e)=e^2/(2\gamma)$, the loan officer will optimally choose the effort level

$$e^*=f_H\gamma\beta\sigma. \tag{14}$$

Here, e^* is higher if the loan-origination fee is higher, if loan demand is more responsive to effort, and if the marginal cost of effort is lower.

We denote next the bank's wage costs of inducing effort by $C_H(e^*)$. As for given e^* the bank ends up paying the fee f_H with probability $q(e)\sigma$, we have after substitution from (14) that

$$C_H(e^*)=\frac{e^*}{\gamma\beta}(\alpha+\beta e^*). \tag{15}$$

Given the now continuous effort problem, the loan officer receives a rent even though $w_H=0$ holds in the hard-information lending regime. Precisely, the bank's total expected wage costs $C_H(e^*)$ in (15) are made up of the true costs of effort provision, $(e^*)^2/(2\gamma)$, and of a rent equal to $(e^*)^2/(2\gamma)+\alpha e^*/(\gamma\beta)$. Given the expected profits from an approved loan

$$v_{EH}:=\frac{1}{2}\left[\upsilon_h\mu(1+\lambda)+\upsilon_l(1-\mu)(1-\lambda)\right],$$

[22] We use for this that the conditional probabilities are $\Pr(\theta=h\mid\widehat{s}=1)=\frac{\mu(1+\lambda)}{\mu(1+\lambda)+(1-\mu)(1-\lambda)}$ and $\Pr(\theta=l\mid\widehat{s}=1)=\frac{(1-\mu)(1-\lambda)}{\mu(1+\lambda)+(1-\mu)(1-\lambda)}$.

the bank thus chooses the loan-origination fee f_H and thereby the effort level e^* so as to maximize expected profits

$$q(e^*)v_{EH} - C_H(e^*). \tag{16}$$

From maximizing (16) we have the following result, where we denote the optimally implemented level of effort by e_H^*.

Proposition 4 *If*

$$v_{EH} > \frac{\alpha}{\gamma\beta^2}, \tag{17}$$

then the optimal incentive scheme under hard-information lending specifies a loan-origination fee of

$$f_H = \frac{1}{2\sigma}\left(v_{EH} - \frac{\alpha}{\gamma\beta^2}\right), \tag{18}$$

which induces the loan officer to exert effort

$$e_H^* := \frac{\gamma\beta}{2}v_{EH} - \frac{\alpha}{2\beta}. \tag{19}$$

Otherwise, i.e., if (17) does not hold, then it is optimal to choose $f_H = 0$ *such that also* $e_H^* = 0$.

Condition (17) deserves some comments. If the loan demand function is relatively insensitive to effort or if the marginal cost of effort is high, then for the bank it may not pay at all to incentivize the loan officer to exert effort. (In other words, we could imagine that the loan officer then behaves like a bureaucrat, waiting for potential clients to knock on his door.) Even though we specified that the true marginal cost of providing effort is zero at $e^* = 0$, given that $c(e) = e^2/(2\gamma)$, this follows as the incremental agency rent $e^*/\gamma + \alpha/(\gamma\beta)$ is for $\alpha > 0$ strictly positive for all e^*. Finally, note that the optimally induced level of effort e_H^* is higher if a newly made loan is more profitable to the bank, if effort is less costly, or if the loan demand function is more elastic as either α is lower or β higher. As these comparative results hold invariably under both lending regimes, though, we do not comment on them in more detail.

Under soft-information lending, the agency problem with the loan officer is again determined by both tasks. To ensure that a borrower is only approved after observing $s = 1$, the respective incentive constraint becomes now

$$(f_S + w_S)(1 - m) \geq w. \tag{20}$$

By optimality this will be binding, implying that

$$w_S = f_S \left(\frac{1-m}{m} \right). \tag{21}$$

Furthermore, as a loan application is now approved with probability μ, the loan officer chooses the effort level

$$e^* = f_S \gamma \beta \mu. \tag{22}$$

Substituting from (21) and (22) into the bank's expected wage bill, $w_S + \mu q(e^*) f_S$, the total costs from implementing effort e^* under soft-information lending are

$$C_S(e^*) = \frac{e^*}{\gamma\beta} \left[(\alpha + \beta e^*) + \left(\frac{1-m}{m} \frac{1}{\mu} \right) \right]. \tag{23}$$

Note here that the first term in (23) represents the compensation for the cost of effort plus a rent arising from the continuous effort problem. In contrast, the final term captures again the rent that arises from the double-task problem and that is generated by the fixed wage $w_S > 0$. To see this more formally, we can transform $C_S(e^*)$ by writing

$$C_S(e^*) = C_H(e^*) + \left(\frac{1-m}{m} \frac{1}{\mu} \right) \frac{e^*}{\gamma\beta}. \tag{24}$$

Note next that

$$\frac{dC_S(e^*)}{de^*} = \frac{dC_H(e^*)}{de^*} + \rho \text{ with } \rho := \frac{1}{\gamma\beta} \frac{1-m}{m} \frac{1}{\mu}. \tag{25}$$

Here, $\rho > 0$ captures the difference by which eliciting marginally more effort is more costly in the soft-information lending regime.

Before continuing with a comparison of the two lending regimes, we first complete the characterization of the case with soft information. The bank's objective function is now

$$q(e^*) v_{ES} - C_S(e^*), \tag{26}$$

where we use $v_{ES} := \mu v_h$. Maximizing (26) yields the following result, where we again denote the optimally implemented effort by e_S^*.

Proposition 5 *If*

$$v_{ES} > \frac{1}{\gamma\beta^2} \left(\alpha + \frac{1-m}{m} \frac{1}{\mu} \right), \tag{27}$$

then the optimal incentive scheme under soft-information lending induces the loan officer to exert effort

$$e_S^* := \frac{\gamma\beta}{2}v_{ES} - \frac{\alpha}{2\beta} - \frac{1}{2\beta}\left(\frac{1-m}{m}\frac{1}{\mu}\right), \tag{28}$$

while if (27) does not hold we have that $e_S^* = 0$. *We then have, respectively,* $f_S = e_S^*/(\gamma\beta\mu)$ *and*

$$w_S = e_S^* \frac{1}{\gamma\beta\mu}\left(\frac{1-m}{m}\right).$$

6.3 Comparison of Lending Regimes and Implications

Soft-information lending is more informative, as expressed formally by the higher expected value of a new loan-making opportunity: $v_{ES} > v_{EH}$. As in the case with discrete effort, the disadvantage is that the double-task problem makes the agency problem inside the bank more severe, thereby generating additional costs: $C_S(e^*) > C_H(e^*)$ in case $e^* > 0$. Importantly, we have from (25) that the cost difference increases with the level of induced effort.

We further know from Propositions 4 and 5 that it is optimal to induce higher effort if either α is lower or β is higher, i.e., if the loan-demand function $q(e)$ is more elastic. As noted above (and formalized also in Appendix B), the loan-demand function will be more elastic as competition intensifies. As α decreases, it becomes less likely that a given level of effort will result in a new loan application. This mirrors our previous analysis in the case of discrete effort. An increase in β makes instead loan demand more responsive to effort, implying that the bank will find it profitable to induce higher effort. In either case, the key implication is the same: As loan demand becomes more elastic, the bank will want to provide the loan officer with higher incentives, which can be done more effectively in the hard-information lending regime. Consequently, as competition increases a switch to hard-information lending becomes more likely.

Proposition 6 *If hard-information lending is (weakly) optimal for given* α *and given* β, *then holding all else constant it is strictly optimal for all lower* α *and higher* β, *i.e., if the loan-demand function becomes more elastic, representing an increase in competition.*

Our final observations relate to the steepness of the loan officer's incentive scheme and to the thereby implemented level of effort, which proxies for the "aggressiveness" with which loan officers will operate in the market. Under either lending regime more competition leads to a higher loan-origination fee (and, thereby, to a steeper incentive scheme) as well as to higher effort. Furthermore, we can show that at the point where the bank optimally switches to hard-information lending we have that $e_H^* > e_S^*$, implying that at this point the implemented effort level increases discontinuously. Taken together we thus have the following implications.

Corollary 3 *If competition increases, then the compensation scheme becomes steeper as the bank optimally induces a higher level of effort from the loan officer. This holds, in particular, at the point where the bank optimally switches to hard-information lending. In this case we would observe a notable (discrete) increase in incentives and loan officers' resulting (sales) effort.*

7 Conclusion

At the heart of this paper is a novel model of the loan-origination process. Under soft-information lending, the loan officer performs two tasks, namely that of originating new loan applications and that of using his soft information at the loan-approval stage. A first set of results analyzes the implications for the optimal lending standard that the bank wants to implement. In particular, we find that as competition makes it harder to originate new loans, the bank chooses a lower lending standard. This may also help to explain why lending standards are (excessively) countercyclical. Furthermore, under the chosen lending standard even negative-NPV loans are made, in particular if competition is more intense. As we stressed above, this is optimal as it serves to mitigate the agency problem vis-á-vis the bank's loan officers. In particular, in our model this does not follow from excessively high leverage.

A further set of implications relates to loan officers' incentive schemes and the interaction with the banks' internal loan review process. Our model suggests that loan officers tend to be paid more like salespeople and less like bureaucrats as competition intensifies and, in particular, as the bank switches from a soft- to a hard-information lending regime. In the latter case, the loan officer's task becomes one-dimensional as he no longer has authority at the loan approval stage. Such a switch to hard-information lending, e.g., through the adoption of credit scoring, is again more likely as competition increases. This observation complements the role of other factors such as the cost of adopting credit scoring or the value of the thereby generated information. Moreover, it provides a contrasting perspective to the observation that competition intensifies through the adoption of these techniques, given that they allow more distant lenders to enter an incumbent bank's local turf. As we noted above, the adoption of credit scoring and competition can thus be complementary and mutually reinforcing, which may explain potentially large cross-country differences.

The simple model of the bank's internal agency problem vis-á-vis its own loan officers could be further utilized to explore the relevance of institutional factors that determine the internal employment relationship. It could be conjectured that a bank that enjoys a stronger relationship with its employees, e.g., as it recruits internally for its more senior positions, can discipline loan officers at lower cost and, what is more, based on a more informative track record of pas loan performance than a bank with a hire-and-fire policy over the cycle. We would then conjecture that the agency costs under soft-information lending are higher for the latter banks, implying that they should also be more willing to switch to hard-information lending.

Appendix A: Proofs

Proof of Corollary 2. Implicit differentiation of (9) yields

$$\frac{ds^*}{dD} = -\left(\frac{-d^2w/(ds^*dD)}{d^2\Pi/d(s^*)^2}\right),$$

where we can substitute $d^2\Pi/d(s^*)^2 < 0$ as well as

$$\frac{d^2w}{ds^*dD} = \frac{1}{m}\frac{d}{ds^*}\left[\frac{1-m\left[1-p(s^*)\right]}{\int_{s^*}^1\left[p(s)-p(s^*)\right]f(s)ds}\right] > 0.$$

Q.E.D.

Proof of Proposition 3 . We take first the comparative statics in λ. Existence of an interior threshold λ' such that hard-information lending is optimal for $\lambda > \lambda'$ and soft-information lending for $\lambda < \lambda'$ follows from strict monotonicity of Π_H, from $\Pi_H > \Pi_S$ for $\lambda = 1$, and from $\Pi_H < 0$ for all sufficiently low λ.

For the case of m note next that Π_S is continuous and strictly increasing in m given that monotonicity holds also for w. Moreover, for $m = 1$ we have $s^* = s_{FB}$ and $w = 0$, implying $\Pi_S > \Pi_H$, while as $m \to 0$ we clearly have for any s^* bounded away from zero that Π_S must become negative given that $w \to \infty$. This together implies again existence of an interior threshold for m.

We have further $\Pi_S > \Pi_H$ for $c = 0$ given that then $w = 0$ and $s^* = s_{FB}$. On the other side, as long as s^* remains bounded away from zero we have $w \to \infty$ as $c \to \infty$. Together with strict monotonicity of $\Pi_H - \Pi_S$, this implies existence of a bounded threshold $c' > 0$.

Take finally π. Using the envelope theorem, we have that

$$\begin{aligned} \frac{d(\Pi_H - \Pi_S)}{d\pi} &= \left[\int_{\widehat{s}_{FB}}^1 \widehat{v}(s)\widehat{g}(s)ds - \int_{s^*}^1 v(s)g(s)ds \right] + \frac{1}{\pi} w \\ &= \frac{1}{\pi} \left[\Pi_H - \Pi_S \right]. \end{aligned}$$

This implies monotonicity on either side of a threshold $0 < \pi' < 1$ at which $\Pi_H = \Pi_S$. Such an interior threshold π' exists if $\Pi_S > \Pi_H$ holds at $\pi = 1$. **Q.E.D.**

Proof of Propositions 4 and 5. Substituting for $C_H(e^*)$ into the profit function $q(e^*)v_{EH} - C_H(e^*)$, we can observe that this is strictly quasiconcave in e^*. The characterization of e_H^* follows then from the first-order condition in case (17) applies. This can also be substituted back to obtain profits of

$$\Pi_H = \frac{1}{\gamma\beta^2} q^2(e_H^*) = \frac{(\alpha + \beta e_H^*)^2}{\gamma\beta^2}. \tag{29}$$

Proceeding likewise for the case of hard-information lending, we obtain for $e_S^* > 0$ profits of

$$\Pi_S = \frac{1}{\gamma\beta^2} \left[q^2(e_S^*) + \alpha \left(\frac{1-m}{m} \frac{1}{\mu} \right) \right] = \frac{1}{\gamma\beta^2} \left[\frac{(\alpha + \beta e_S^*)^2}{\gamma\beta^2} + \alpha \left(\frac{1-m}{m} \frac{1}{\mu} \right) \right]. \tag{30}$$

Q.E.D.

Proof of Propositions 6. We consider first a comparative analysis of the difference $\Pi_H - \Pi_S$ in β. We have from (29) and (30) that

$$\Pi_H - \Pi_S = \frac{1}{\gamma\beta^2} \left[q^2(e_H^*) - q^2(e_S^*) - \alpha \left(\frac{1-m}{m} \frac{1}{\mu} \right) \right]. \tag{31}$$

We argue that whenever β is such that $\Pi_H = \Pi_S$, then at this point we must always have that

$$\frac{d}{d\beta}(\Pi_H - \Pi_S) > 0. \tag{32}$$

From the envelope theorem we have that

$$\frac{d}{d\beta}(\Pi_H - \Pi_S) = -\frac{2}{\gamma\beta^3}\left[q^2(e_H^*) - q^2(e_S^*) + \alpha\left(\frac{1-m}{m}\frac{1}{\mu}\right)\right] + \frac{1}{\gamma\beta^2}\left[q(e_H^*)e_H^* - q(e_S^*)e_S^*\right]. \quad (33)$$

At $\Pi_H = \Pi_S$ the first term in (33) is zero, implying that at this point the sign is determined by the second term and is thus strictly positive in case $e_H^* > e_S^*$. However, that $e_H^* > e_S^*$ follows finally from $\Pi_H = \Pi_S$ while using (29) and (30). Observe next that for low β, where $e_H^* = e_S^* = 0$, it holds that $\Pi_H < \Pi_S$. (Precisely, this is the case if both $\beta \leq \sqrt{\frac{\alpha}{\gamma v_{EH}}}$ and $\beta \leq \sqrt{\frac{\alpha + \frac{1-m}{m}\frac{1}{\mu}}{\gamma v_{EH}}}$.) Using finally continuity of Π_H and Π_S we have thus shown that one of the following cases must apply as we increase β: either $\Pi_H < \Pi_S$ holds for all feasible values $\beta \geq 0$ or $\Pi_H < \Pi_S$ holds for $0 \leq \beta < \beta'$ and $\Pi_H > \Pi_S$ for $\beta > \beta'$.[23]

Take next changes in α, where the argument is analogous. Differentiating $\Pi_H - \Pi_S$ at $\Pi_H - \Pi_S = 0$ we now have that the sign is strictly negative whenever

$$2q(e_H^*) - 2q(e_S^*) - \left(\frac{1-m}{m}\frac{1}{\mu}\right) < 0. \quad (34)$$

As in addition $\Pi_H - \Pi_S$ holds if

$$q^2(e_H^*) - q^2(e_S^*) = \alpha\left(\frac{1-m}{m}\frac{1}{\mu}\right),$$

condition (34) holds if $2\alpha < q(e_H^*) + q(e_S^*)$, which from $e_H^* \geq e_S^*$ finally holds (and also strictly if $e_H^* > 0$). **Q.E.D.**

Appendix B: Competition with Loan Officers' Effort

We provide a formal model of how loan officers' effort affects the likelihood of making a new loan. We thereby also endogenize the linear loan-demand function $q(e) = \alpha + \beta e$ as well as the asserted comparative statics in competition.

The model builds on the notion that by directly contacting a potential client, a loan officer reduces the client's "transaction costs". For specificity, we suppose that an incumbent lender faces competition on his home turf. A borrower's choice between the incumbent and an entrant depends then both on the respective loan terms and on whether he was

[23] The range of feasible values for β is restricted by the requirement that $q(e^*) \leq 1$ holds under both regimes.

contacted by a loan officer of either bank. If contacted both by an entrant and by the incumbent, the given borrower chooses the incumbent with probability $q_B \leq 1$. We formalize below how q_B, as well as the other subsequently introduced probabilities, are derived. If only contacted by the entrant, the probability with which the borrower will still choose the incumbent is reduced to $q_E < q_B$. Likewise, q_I denotes the respective probability if only the incumbent's loan officer contacts the borrower, and q_N the respective probability if the borrower is contacted by neither.

In the model specified below we will have that $q_I = q_N = 1$. We further denote by e_n for $n = E, I$ the (independent) probabilities with which a potential borrower is contacted by a loan officer of an entrant or of the incumbent bank.

Summing up, the incumbent bank will then win the borrower with aggregate probability $q = \alpha + \beta e_I$, where

$$\begin{aligned} \alpha &= 1 - e_E(1 - q_E), \\ \beta &= e_E(q_B - q_E). \end{aligned} \tag{35}$$

In the rest of Appendix B we will show, first, how $q_B > q_E$ arises (together with $q_I = q_N = 1$). Given (35), this then implies that $d\alpha/de_E < 0$ and $d\beta/de_E > 0$. Second, we extend the comparative analysis for both α and β to the case where competition intensifies as entrants' loan terms become more attractive.

It is helpful to conduct the analysis first in an auxiliary framework of product market competition. We subsequently map the derived results back into the original case where banks compete in the loan market. In the auxiliary, though more standard, case of product market competition we suppose that a costumer (i.e., later the borrower) can derive gross utility U_n from the offer of firm $n = E, I$.

We start with the case where the customer was contacted by sales representatives (i.e., loan officers in our original model) of either firm. Without further horizontal differentiation, the customer would only compare the respective net utilities $U_n - P_n$, where P_n denotes the respective price. Both for realism as well as for (standard) technical reasons we introduce horizontal differentiation. For the given customer, a random draw from the uniform distribution over $x \in [0, 1]$ determines his preferences in the following way.[24] When

[24] Considering competition for one customer whose preferences are randomly drawn is standard in Industrial Organization models. The formal results are equivalent to those that one obtains with a continuum of customers whose preferences are represented by a uniform distribution.

purchasing from the incumbent the net utility is $U_I - P_I - x\tau$, while when purchasing from the entrant it is $U_E - P_E - d\tau - (1-x)\tau$, with $\tau > 0$ and $d > 0$.[25] Note that $d > 0$ captures the fact that the customer is on average located closer to the incumbent.

Denote $u_n := U_n - P_n$. Suppose the customer was contacted by both firms. If either firm sells with positive probability, the critical interior customer $0 < x_B^* < 1$ who is just indifferent between both offers is given by

$$x_B^* = \frac{1+d}{2} + \frac{u_I - u_E}{2\tau}. \tag{36}$$

Note that $0 < x_B^* < 1$ only holds if

$$\tau(d-1) < u_E - u_I < \tau(d+1). \tag{37}$$

We come now to the cases where the customer is no longer contacted by both firms. Here, we specify that if the customer still purchases from firm n even though he was not directly contacted, then he incurs the additional costs t_n. These costs are higher for the entrant as $t_E > t_I$. In fact, we stipulate that the difference is sufficiently large such that if a customer is not contacted by the entrant, then he will always purchase from the incumbent. This is the case if

$$u_E - u_I < (t_E - t_I) + \tau(d-1). \tag{38}$$

The final case is that where the customer is only contacted by the entrant but not by the incumbent. The respective critical type

$$x_E^* = \frac{1+d}{2} + \frac{u_I - u_E}{2\tau} - \frac{t_I}{2\tau} \tag{39}$$

is then interior with $0 < x_E^* < 1$ if

$$\tau(d-1) - t_I < u_E - u_I < \tau(d+1) - t_I. \tag{40}$$

In what follows, we distinguish between two cases. In Case A condition (37) does not hold as d is sufficiently large such that $x_B^* = 1$. With our previous notation, we would

[25] One standard (Hotelling) interpretation is in terms of "shoe-leather costs", with x representing the physical location of the respective customer. When mapping this set-up back into our model of competition for loans, these costs may also represent the trips to the bank's branch over the duration of the lending relationship. (For a wider discussion of various interpretations of the Hotelling set-up in banking see, for instance, Degryse, Laeven, and Ongena (2006).)

then have, next to $q_I = q_N = 1$, that $q_E = x_E^* < q_B = 1$. Substituting this into (35), we obtain for the subcase with $x_E^* > 0$ that

$$q = 1 - \left(1 - \frac{u_I - u_E}{2\tau} - \frac{1+d}{2} + \frac{t_I}{2\tau}\right) e_E(1 - e_I), \tag{41}$$

while for the subcase where $x_E^* = 0$ we have that

$$q = (1 - e_E) + e_E e_I. \tag{42}$$

Next, in Case B we have $0 < x_B^* < 1$. Again, if x_E^* is interior we have for (35) that

$$q = 1 - e_E\left(1 - \frac{u_I - u_E}{2\tau} - \frac{1+d}{2} + \frac{t_I}{2\tau}\right) + \frac{t_I}{2\tau} e_E e_I, \tag{43}$$

while with $x_E^* = 0$ this becomes

$$q = (1 - e_E) + e_E e_I \left(\frac{1+d}{2} + \frac{u_I - u_E}{2\tau}\right). \tag{44}$$

For both Cases A and Case B we can summarize our results from (41)-(44) as follows, once we substitute α for the intercept and β for the multiplier of e_I. First, α is always decreasing and β always increasing in the effort exerted by entrants' salespeople, e_E. Second, given that u_E is decreasing in P_E, α is also increasing in P_E, while β is decreasing in P_E for Case A but not affected for Case B.

Summing up, in the auxiliary model we can thus confirm that more competition, be it through a higher e_E or a lower P_E, makes demand as a function of e_I more elastic as both α decreases and β increases.

To complete the description of the auxiliary model of product market competition note that the firm's program is to maximize

$$\Pi = q(e_I, P_I)(P_I - \kappa) - C(e_I),$$

where we use a constant marginal cost of κ and costs of effort provision $C(e_I)$.

We finally map the auxiliary model back into that of loan-market competition. To be specific, we now suppose that a low-type borrower defaults for sure and a high-type borrower never. The incumbent (or local) bank stipulates the repayment requirement R_I out of the total payoff of Y in exchange for the loaned funds k. In the terminology of the main text we thus have that $v_l = -k$ and $v_h = R_I - k$. We stipulate that the borrower does not know the type θ. This assumption seems particularly reasonable for loans to small and medium-sized enterprises, where based on past experience with similar types of loans the bank's loan officer may have better information along several key dimensions. (This assumption has recently been invoked in, amongst others, Manove et al. (2001) and Inderst and Müller (2006)). In our context, the main implication of this assumption is to have only a single (type-independent) critical borrower x^*, in analogy to the critical customer in the auxiliary model.

We can finally relabel the "price" $P_n = \mu R_n$, the "marginal cost" $\kappa = \mu k$,[26] and the "utility" $U_n = \mu Y$, while specifying the cost function $C(e_I) = q(e_I, P_I)e_I\phi$ with $\phi := \left(1 + \frac{K}{\rho}\right)/(\gamma\beta)$ for the case with soft-information lending.[27]

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[26] To apply this to $n = E, I$, we suppose here that all use the same lending technology.

[27] As noted in the main text, we focus on e_I as the main strategic variable of the incumbent. A preliminary analysis of the presented Hotelling model shows that the implications for e_I survive in case the bank could also adjust the loan terms R_I, though even in the case where we still take the entrants' strategy as given we lose tractability.

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