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Technology and Credit Market Information Asymmetries

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Technology and Credit Market Information Asymmetries *

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Abstract

This paper studies how technological improvements shape credit market outcomes, focusing on how technology helps lenders alleviate two information asymmetries: adverse selection and moral hazard. I model an economy with asymmetric information on the borrower's creditworthiness and on the amount of borrower's effort to repay a loan. Tech-lenders have a better technology for screening creditworthiness and for monitoring effort. Borrowers, however, have a preference for lenders that monitor less. A trade-off arises in the form of product differentiation (in terms of monitoring, benefiting the traditional bank) and a winner's curse (from the screening asymmetry, benefiting the tech-lender). The preference for a lesser monitor is the relevant parameter when distinguishing which of the two lenders makes profits. Furthermore, I derive bounds and provide comparative statics to understand how these two forces impact credit market outcomes.

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1 Introduction

The emergence of new players in the financial arena, such as FinTechs and BigTechs, brings promises and risks: promises, because the unit cost of financial intermediation has not changed much in over a century (Philippon, 2015); and risks, because the source of many financial crises has been financial innovation unpaired with an understanding of the potential market effects. [1] Traditional banks have been slow to embrace the technology revolution to the same level as other players. A possible reason is legacy costs, which bigger and more established firms face when deciding whether to adopt a new technology (Navaretti et al., 2018).

In this paper I ask the following question: How do technologically-oriented lenders (tech-lenders) shape the equilibrium of the credit market? I model a market for loans with two types of players: entrepreneurs that need funding for a risky project, and financial intermediaries. There are two sources of asymmetry of information in the market: entrepreneurs can be of two different types, which will give rise to adverse selection; and entrepreneurs can affect the probability of project success by exerting effort, which is not contractible and will thus give rise to moral hazard. The financial intermediaries are aware of this moral hazard and monitor the entrepreneur. The entrepreneur prefers lenders that monitor less.

The key assumption of the paper and what differentiates it to other studies (He et al., 2022, Vives and Ye, 2022, Gambacorta et al., 2021) is that, thanks to the better technology and platform position, a tech-lender is a better screener and a better monitor than a traditional bank (Berg et al., 2021).

Therefore, there are two forces present in the model: the first one is a winner's curse caused by the adverse selection with respect to entrepreneurial types. When it comes to facing the winner's curse, the tech-lender is better equipped thanks to its better screening technology. The second force is product differentiation, which gives the traditional bank an advantage: borrowers prefer to contract with a lender that will monitor them less.

The take-away from the paper is the following: a more technologically-enabled player may not always have a market presence if its technology is too intrusive. Therefore, previous studies that only focus on technological advancements at the screening stage are missing an important component of the environment, mainly, the impact of technology on moral hazard. The present paper fills this gap.

The main parameter driving the results of the model is the relative monitoring intensity of the lenders. In equilibrium, one of three situations will arise: either only the traditional bank is present in the market; both lenders are present in the market but only the traditional bank makes positive expected profits; or both lenders are active in the market and only the tech-lender makes positive expected profits. Which of these three mutually exclusive equilibria arises depends on the monitoring intensity of the traditional bank. Finally, I provide some comparative statics for each of the three equilibria to disentangle how the product market competition and the winner's curse affect the equilibrium variables.

The rest of the paper is organized as follows. In the remainder of this section I discuss the relevant literature on which this paper builds; Section 2 provides the building blocks of the model; Section 3 solves the model and provides bounds for each of the characterized equilibria; Section 4 provides comparative static results on the equilibria; Section 5 concludes. Most proofs are relegated to the Appendix.

[1] Appendix A provides a more detailed explanation of FinTech and BigTech players.

Related literature

This paper fits into a growing literature studying the effects of technological innovation in the financial sector.

Theory of lending under asymmetric information

The theoretical papers that study the entrance of technologically oriented lenders in the credit market normally focus their attention on their better screening abilities. These papers stem from the traditional literature of lending under asymmetric information, where generally one lender is informed and the other remains uninformed (Hauswald and Marquez, 2003, von Thadden, 2004, Hauswald and Marquez, 2006). In these models, borrowers undergo a credit worthiness test, the outcome of which is an imperfect and generally private signal about the borrower type.

More recently, He et al., 2022 use a screening model to focus on Open Banking and on the impact of data availability on the screening accuracy. Similarly, Chu and Wei, 2021 study the long-term effects of FinTech entry on credit market competition. Both papers find that FinTech's presence can be detrimental to consumers (in terms of consumer welfare and long-run access to credit). A key consequence of all these screening models is that lenders face a winner's curse: the expected quality of borrowers who contract with a lender is lower than the quality of the overall pool. This implies that, in equilibrium, lenders mix between different interest rates. [2]

Out of these papers, I follow closely He et al., 2022. In their benchmark model, the lenders are endowed with a "bad-news" screening technology with asymmetric accuracy: they can perfectly screen good borrowers, but some bad borrowers are misclassified as good. Since their focus is on the impact of Open Banking on market outcomes, the borrower side is simple as she is only concerned with the interest rate that she will pay. I borrow their structure of the screening technology for the lenders and combine it with a differential ability to monitor the borrowers, which directly affects borrowers' utility.

Other strands of the literature assume that lenders can increase the probability of repayment by monitoring their borrowers (Martinez-Miera and Repullo, 2017, Cerasi and Daltung, 2000). The effect comes either from mitigating borrowers' moral hazard or by directly intervening in the business (Tirole, 2006). Financial intermediaries differ in the way they monitor their borrowers. For example, entrepreneurs are monitored more if they borrow from a bank than if they borrow directly from the market (Repullo and Suarez, 2000).

Furthermore, improvements in information technology translate into better borrower monitoring (Vives and Ye, 2022) or a reduction in strategic default (Gambacorta et al., 2021). Berg et al., 2021 suggest that the new FinTech-like players are not only better screeners than traditional banks but also better monitors. In terms of BigTech lending, Boissay et al., 2021 highlight that the strong reliance in technology and the nature of their platform-based business allows the BigTech to better monitor how a borrower employs the money from a loan. For example, it can monitor if a loan granted to an SME in its platform is being used for the agreed goal (expand business to other markets or develop new products), as the entrepreneur offers its products through the same platform that has granted her credit.

Contribution: I combine a screening and a monitoring approach. Following the literature, I assume that the tech-lender is a better screener and a better monitor. The trade-off for the borrowers arises because borrowers prefer lenders that monitor less, but better screening improves lending

[2] This finding is also common in games of Bertrand competition with decreasing average costs or with asymmetric fixed costs (Varian, 1980, Marquez, 1997).

efficiency and thus lowers interest rates. Therefore, borrowers will only consider contracting with a tech-lender if its interest rate is sufficiently low, compared to what the traditional bank offers.

Empirical evidence of the impact of technology in banking

The empirical literature studying the emergence of these technologically-oriented lenders is vaster than the theoretical literature. Fuster et al., 2022 establish that increases in lending efficiency risk to be coupled with a differential impact on the borrowing population. There is mixed evidence on who benefits and who looses from improvements in technology. On the one hand, Bhutta et al., 2021 study the recommendations of Automated Underwriting Systems (AUS), and find that AUS denied mortgages more often to minority applicants. [3] On the other hand, Howell et al., 2021 find evidence that greater automation at the loan origination stage increases lending to black-owned businesses. Similarly, D'Acunto et al., 2020 show that the introduction of a robo-advisor to make decisions on behalf of investors improved lending efficiency by shutting down the channel of taste-based discrimination. [4]

A different strand of the empirical literature centers around understanding who are the consumers and product-segments that these new players serve. This literature mostly focuses on mortgages or on credit via peer-to-peer (P2P) platforms. FinTech lenders are strong players in mortgage related lending (Berg et al., 2021). Furthermore, Buchak et al., 2018 document that the shift towards online mortgage intermediation and more “FinTech-like” players has gone hand-in-hand with the rise of market-based credit and shadow banking overall. Advances in technology have been more important in this rise than regulatory arbitrage. In turn, marketplace consumer lending and P2P consumer platforms, which were the first to emerge, have stagnated in the last years. P2P lending is likely to benefit borrowers who already have access to bank loans, supporting that P2P lenders are competitors of and hence substitute for bank credit (Tang, 2019, Balyuk, 2022). Furthermore, there is evidence that P2P platforms capture riskier borrowers relative to banks (de Roure et al., 2018).

Contribution: This paper provides a rationale of why some borrowers sort into different lenders. While P2P, originate to distribute platforms empirically seem to engage in bottom-fishing, I predict that tech-lenders whose technology allows for better monitoring will engage in cream-skimming, thus capturing the good borrowers away from banks.

2 The model

2.1 Model setup

The model consists of two types of players, entrepreneurs that need to borrow funds and financial intermediaries that will provide those funds. There will be two sources of asymmetry of information in the model: uncertainty about the entrepreneur's ability to carry out the project, and uncertainty about the entrepreneur's effort to lead the project to success. The two financial intermediaries will differ in their strengths to mitigate the uncertainties: tech-lenders will be better monitors of the level of effort and better at identifying entrepreneurial ability than the traditional banks.

[3] AUS are a software that rates mortgage applicants without using race as an input.

[4] The empirical literature also agrees that non-traditional data is a valuable input for assessing borrowers' quality. For example, lenders can better assess an applicant's probability of default by using text-analysis on the application forms (Gao et al., 2018, Netzer et al., 2019), or by using the digital footprint of users of a website or mobile application, specially when collateral is not available (Agarwal et al., 2020, Berg et al., 2020, Gambacorta et al., 2022).

Entrepreneurs

Consider an economy with a continuum of two types of risk-neutral, penny-less entrepreneurs (she). Entrepreneurs are characterized by their ability to transform a unit of investment into output when undertaking a project, which may be high (A_h) or low (A_l). Low ability entrepreneurs are unable to produce with the unit investment, so we assume that $A_l = 1$. [5] Entrepreneurs' type is private information, but the proportion of high-ability entrepreneurs θ is public. I will denote entrepreneurs with a lowercase subscript $i = \{l, h\}$. [6]

To undertake the project, entrepreneurs must borrow an investment normalized to one. The entrepreneur approaches all lenders in the market to ask for a quote, but ultimately only contracts with one. If successful, the project returns the total investment times the entrepreneur's ability. The project returns zero if it is not successful, and in such a case, borrowers are protected by limited liability. The entrepreneur can impact the project's probability of success by exerting effort $e \in [0, 1]$, related one-to-one to the probability of project success.

$$\text{Project return } = \begin{cases} A_i & \text{prob.} \quad e_i \\ 0 & \text{prob.} \quad 1 - e_i \end{cases}$$

The entrepreneur can also diverge some effort towards private projects, the returns to which the financial intermediary has no access. I will sometimes refer to these non-verifiable private benefits as appropriation of funds by the entrepreneur. The appropriation function $f(A, e, m)$ determines the amount of funds that the entrepreneur can keep privately, and it depends on the entrepreneurial ability A, on the effort she puts in the project e, and on how much the lender monitors her m. The appropriation function has two important characteristics: it is decreasing and concave in effort, and it is decreasing on the monitoring intensity m.

Assumption (A1): Appropriation function.
For the rest of the paper, I use a particular functional form for the appropriation function, taken from Repullo and Suarez, 2000. An explicit functional form will allow us to solve the model analytically, but any decreasing and concave appropriation function would produce similar qualitative results for the effort level (effort increasing in m and between zero and one).

$$f(A, e, m) = A_i \frac{1 - e^2}{2m} \tag{A1}$$

Therefore, each project outcome is comprised of a combination of random verifiable cash flows $e_i^j A_i$, on which the entrepreneur pays the interest rate, and non-verifiable private benefits for the entrepreneur $f(A, e, m)$. The total utility of an entrepreneur of type i contracting with lender j is:

$$u_i^j(R, e) = e_i^j (A_i - R_j) + A_i \frac{1 - {e_i^j}^2}{2m^j} \tag{1}$$

Before proceeding further, I provide some clarifications regarding the assumptions behind these functions and their elements.

First, the utility function for the entrepreneur captures both the verifiable project return in the first term $e_i^j (A_i - R)$ and the non-verifiable return in the second term $A_i \left(1 - {e_i^j}^2\right) / (2m^j)$. This second term represents the private benefit that the entrepreneur derives from decreasing the level

[5] The role of this normalization will be clear in Section 3.1.1.
[6] Throughout the paper, I refer to borrowers and entrepreneurs interchangeably.

of effort in the project. It is akin to a quadratic cost of effort, with the addition that it is affected by the monitoring intensity of the lender m.

In this context, monitoring represents some surveillance mechanism by the lender that renders the diversion of resources towards private uses less profitable for the entrepreneur. Hence, monitoring decreases the incentives the entrepreneur has to misbehave and "appropiate" funds. Increasing the probability of verifiable project success (e) requires a smaller sacrifice of private benefits the higher m.

Furthermore, the ability of the entrepreneur plays a role in both the verifiable and non-verifiable project returns: higher ability entrepreneurs are more skilled at transforming investment into output, and they are also more productive when it comes to generating private benefits.

Financial intermediaries

In this economy there are two risk-neutral financial intermediaries (it) to which the entrepreneurs can go to ask for a loan. [7] Financial intermediaries are denoted by an uppercase superscript $j = \{B, T\}$. The loan contract specifies how the revenues of the project are shared in case of success: E_i^j and R_i^j are, respectively, the incomes of the entrepreneur and the lender, so that $E_i^j + R_i^j = A_i$. [8]

Players are risk neutral in this model, hence I assume that the financial intermediaries can get funds at the alternative risk free rate (in gross terms, equal to 1). In this market the financial intermediaries compete using the repayments (Bertrand price competition).

The financial intermediaries' profit functions (π_i^j) for a quoted repayment (R) are:

$$\pi_i^j(R, e) = e_i^j R – 1 \tag{2}$$

Equation (2) shows that the intermediary's profits depend on the type of entrepreneur it faces and the effort she puts in the project. This means that, when the type of borrower is unknown to the intermediary, it must form believes about the type it is facing, and it needs to correctly anticipate the effort she will put in the project. The financial intermediaries differ in their strengths to mitigate the two asymmetries of information.

Uncertainty about the entrepreneur's ability

When approached by an entrepreneur, each type of lender can costlessly screen the candidate and obtain a private, conditionally independent signal about the borrower's type. The signal each type of intermediary gets can be of two types, either low s_ℓ^j or uninformative $s_\varnothing^j$. The signal has a bad-news structure: the reception of a low signal perfectly identifies the low-ability entrepreneurs, while the reception of an uninformative signal imperfectly identifies the high-ability entrepreneurs. Formally:

$$\begin{aligned} \Pr\left(s^j = s_\varnothing^j | h\right) &= 1 \qquad \forall j = \{B, T\} \\ \Pr\left(s^T = s_\ell^T | l\right) &= \sigma^T \qquad \in (0, 1) \\ \Pr\left(s^B = s_\ell^B | l\right) &= \sigma^B \qquad \in (0, 1) \end{aligned}$$

The screening ability relies mainly on the data available and the algorithm processing it. Hence, I will assume that the tech-lender receives a more accurate signal than the traditional bank: $\sigma^T > \sigma^B$. [9] To make this advantage more salient, I assume that the signal that the traditional bank receives

[7] Throughout the paper, I refer to lenders and financial intermediaries interchangeably.

[8] Therefore, the repayment rate is bounded by the project returns $\overline{R} = A_i$.

[9] This is an approach also adopted by He et al., 2022 and Chu and Wei, 2021. See also: Vives, 2019, Thakor, 2020 or Berg et al., 2020.

from a low-ability entrepreneur is as good as random $\sigma^B = 1/2$. This normalization will help us focus on the screening advantage of the tech-lender, which is the key element in the model. [10]

Uncertainty about the entrepreneur's effort

While the repayment R is contractible, the level of effort is not. Model-wise, this implies a scope for moral hazard in the way the entrepreneur exerts effort after she has received a loan. The intermediary is aware of the moral hazard asymmetry, and it monitors the entrepreneur at a rate $m^j \in (0, 1]$.

The two intermediaries will differ in terms of their monitoring intensity. As argued in Section 1, authors like Berg et al., 2021 suggests that FinTech lenders can be both better at screening and at monitoring. For Boissay et al., 2021, the strong reliance in technology and the nature of BigTech's platform-based business allows them to better monitor that the funds are being used in the correct way. Model-wise, these ideas translate into a tech-lender that is a better monitor than the traditional bank: $m^B < m^T$. [11] To make this difference more salient and for tractability of the results in the subsequent analysis, I normalize the monitoring intensity of the tech-lender to one ($m^T = 1$), so that the monitoring intensity of the bank can vary between zero and one ($m^B \in (0, 1)$). In this model, the financial intermediary does not decide on the level of monitoring: monitoring intensity is exogenously determined by the technology available to it.

A privacy interpretation

The monitoring intensity in this model is costless for both financial intermediaries and it only enters the problem via the borrower's utility to misbehave. Therefore, we can give an alternative explanation in terms of preference for privacy: borrowers prefer intermediaries that are not too invasive of their privacy. There is empirical evidence that borrowers attach value to their privacy (Tang, 2020, Armantier et al., 2021). Consistent with this empirical evidence, the assumption that $m^T > m^B$ means that borrowing from a tech-lender implies a higher loss of privacy than borrowing from a traditional banks.

2.2 The timing

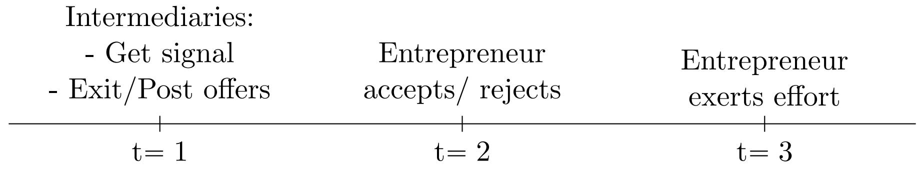
The timing of the game is as follows: at the beginning of the game, the entrepreneurs learn their types and apply for a loan to both intermediaries. The financial intermediaries then observe the screening signal, update their priors and simultaneously decide whether to extend an offer to the borrower and if so, in which terms. The entrepreneur compares the offers and contracts with the intermediary whose offer gives her the highest utility. [12] Finally, the entrepreneur decides how much effort she puts in the project.

The order of moves described above is summarized by the following timeline:

[10] For the signal to be completely uninformative about the borrower type, the required assumption would be $\sigma^B = 0$, so that low-ability entrepreneurs always send uninformative signals and therefore the posterior of the lenders would be equal to the prior. The assumption that $\sigma^j \geqslant 1/2$ considers each technology to identify the type separately, so that the technology identifying a low-ability entrepreneur is on average more right than wrong. Compared to He et al., 2022, its akin to bounding the different screening accuracies to $\Delta = 1/2$.

[11] Notice that the trade-off arises because borrowers will prefer lenders that monitor less (banks), but also prefer lenders that can offer a lower interest rate (tech-lenders). Therefore, the case of $m^T < m^B$ is not only unrealistic but also uninteresting, as it creates no trade-off.

[12] If the borrower is indifferent between two offers, she picks one at random. In equilibrium, however, ties do not occur, so the tie-breaking rule is not used.



3 Equilibrium characterization

This section is organized in two parts: first, I conduct some preliminary analysis deriving the optimal effort, the possible signal realizations and the strategies that are available to the lenders. I conclude the preliminary analysis using these building blocks to derive lender's ex-ante expected profits. In a second part, I derive the candidate equilibria of this model and provide parameter bounds for when they appear.

3.1 Preliminary analysis

This section calculates the necessary steps to derive the credit market equilibria. It discusses the calculations of borrowers' optimal effort choices and how they connect to the possible signal scenarios. Finally, it discusses the strategies that the lenders will employ and builds the expected payoff functions.

3.1.1 Borrowers' optimal effort choices

Proceeding by backward induction, we first need to calculate the optimal level of effort the entrepreneur chooses at $t = 3$. Formally, it is derived as the effort that maximizes the expected utility given monitoring. From this condition, we get an *incentive compatible* level of effort that we carry through all the programs in this paper.

The incentive compatible level of effort corresponds to:

$$e_i^{j\star}(R) \equiv \arg\max_e e(A_i - R) + A_i \frac{1-e^2}{2m^j}, \qquad e_i^{j\star}(R) = m^j \left(1 - \frac{R}{A_i}\right) \tag{3}$$

From Equation (3) the optimal level of effort increases with the monitoring rate. For the same repayment, a high-ability entrepreneur will exert more effort if it contracts with the tech-lender than with the traditional bank.

$$e_h^{T\star}(R) > e_h^{B\star}(R) \tag{4}$$

Equation (3) further implies that if both intermediaries offer the same rate, the high-ability entrepreneur prefers to contract with the traditional bank than with the tech-lender, since the cost of misbehaving is lower.

Furthermore, from Equation (3) and the normalization of $A_l = 1$, the low-ability entrepreneur will never exert any effort for $R \geqslant 1$. Anticipating that the low-ability entrepreneur never repays, a lender observing a low signal will always refrain from offering credit. From Equation (1), the optimal utility for the low-ability entrepreneur from getting a loan collapses to $u_l^j = A_l/2m^j$, and so does not depend on R. This means that, whenever the low-ability entrepreneur gets two offers, she will always prefer an offer from the traditional bank to an offer from the tech-lender.

$$u_l^B > u_l^T \qquad \forall R \geqslant 1$$

The incentive compatible level of effort is anticipated by lenders and entrepreneurs, so that the objective functions for granting a loan to the high-ability entrepreneur in Equations (1) and (2) become: [13]

$$u_h^j(R) = \frac{1}{2}\left[\frac{A_h}{m^j} + \frac{m^j}{A_h}(A_h - R)^2\right] \tag{5}$$

$$\pi_h^j(R) = m^j\left(1 - \frac{R}{A_h}\right)R - 1 \tag{6}$$

Notice that, following Equation (6), the profit maximizing interest rate would be $R^\star = A_h/2$. For the lenders, increasing the interest rate has two effects: a direct, positive effect, as a higher R means higher profits; and an indirect, negative effect, as increasing R decreases the effort the borrower puts in the project and hence decreases the probability of repayment. For any $R < R^\star$, the direct effect dominates and profits increase as the interest rate increases; while for $R > R^\star$, the indirect effect dominates and profits decrease as the interest rate increases. [14]

3.1.2 Possible scenarios

Denote by p_{xy} the probability of the scenario in which the tech-lender observes signal $s^T = x$ and the traditional bank observes the signal $s^B = y$. The ex-ante probabilities of each combination of signals are:

$$\begin{aligned} p_{ll} &= (1-\theta)\sigma^T\sigma^B \\ p_{l\varnothing} &= (1-\theta)\sigma^T(1-\sigma^B) \\ p_{\varnothing l} &= (1-\theta)(1-\sigma^T)\sigma^B \\ p_{\varnothing\varnothing} &= \theta + (1-\theta)(1-\sigma^T)(1-\sigma^B) \end{aligned} \tag{7}$$

We can additionally calculate the probabilities of success, and hence of repayment, associated with each scenario in Equations (7). The probabilities of success when either of the lenders receives a low signal ($p_{ll}, p_{l\varnothing}, p_{\varnothing l}$) are zero (only low-ability entrepreneurs send low signals, and they never pay back). When both receive an uninformative signal, the probabilities of success will differ between intermediaries, because they induce different levels of effort. In particular, the probability of success for a given repayment for each intermediary, when both observe an uninformative signal:

$$\Pr(\text{success}^j | s_\varnothing^B \wedge s_\varnothing^T) = \frac{\Pr(s_\varnothing^B \wedge s_\varnothing^T|\text{success}^j)\Pr(\text{success}^j)}{p_{\varnothing\varnothing}} = \frac{\theta}{p_{\varnothing\varnothing}}e^j \quad \forall j = \{B, T\} \tag{8}$$

3.1.3 Strategies

In this game, each lender has two information sets: one where it receives a empty signal and one where it receives a low signal. A strategy for each lender is the collection of actions for each information set: whether it offers credit, and conditional on making an offer, the repayment it requires form the entrepreneur.

In the information set where a lender receives a low signal, it refrains from offering credit. Recall that this is driven by a signal structure that perfectly identifies low-ability borrowers and

[13] As argued above, the utility of accepting a loan for the low-ability entrepreneur is $u_l^j = A_l/2m^j$; and the profits derived by the lenders from offering such loan are: $\pi_l^j = -1$.

[14] Denote by $u^{\min j}$ the profit-maximizing utility that a borrower gets from accepting an offer by lender j at $R^\star$. The exact expression denoted in Equation 28.

by Equation (3) (the low-ability entrepreneur will not exert effort, yielding a project that never succeeds).

When a lender receives an empty signal, it internalizes the relation in Equation (4): the high-ability entrepreneurs will gauge the repayment rate and the monitoring intensity together when assessing an offer, and decide with whom to contract on the basis of which lender offers a higher utility. This suggests that the competition in this market is better expressed in terms of utilities offered (competition-in-utilities as in de Cornière and Taylor, 2021 or in Villas-Boas and Schmidt-Mohr, 1999), rather than simply in repayments. Although equivalent, describing the competition in terms of utilities simplifies the exposition considerably. Therefore, for the remainder of the paper, I will assume that the lenders compete in the space of utilities instead of in repayments R. Appendix B.1 discusses this change of variable from repayments R to utilities in more detail.

Let $u^j \in [\underline{u}, \overline{u}]$ be the utility level that lender j offers in pure strategies in the information set where it receives an empty signal. If lenders play mixed strategies, a strategy specifies a probability of making an offer z^j and a distribution over utilities. Let G^j on $[\underline{u}, \overline{u})$ denote the distribution of entrepreneurial utility that lender j offers when it observes an empty signal.

Definition 1. A mixed strategy is a mapping from signal realizations $s^j = \{s^j_\varnothing, s^j_l\}$ to decisions of making an offer z^j and, conditional on making an offer, the probability distribution over acceptable utilities $G^j(u)$.

$$\begin{aligned}\text{Strategy}^j : \{s^j_\varnothing, s^j_l\} &\to [0,1] \times \Delta(u)\\ s^j &\mapsto \left(z^j, G^j(u)\right)\end{aligned}$$

Notice that, for lender $k \neq j$, $G^j(u^k)$ represents the probability that the utility offered by lender j is below the utility offered by lender k: $G^j(u^k) = \Pr(u^j \leqslant u^k)$. Therefore, we interpret it as the probability that lender k wins the high-ability borrower.

3.1.4 Payoffs

In this section, I derive the ex-ante expected profits of the lenders of making an offer u. [15]

Consider first the tech-lender's profits from offering a utility u. Both lenders observe an uninformative signal with probability $p_{\varnothing\varnothing}$. The expected profit the tech-lender will make from the borrower depends on whether the traditional bank makes an offer or not. This is because if the traditional bank makes an offer (which occurs with probability z^B), all the low-ability entrepreneurs prefer to contract with the traditional bank. In this case, the expected profit of the tech-lender is derived only from the high ability entrepreneurs, who are in updated proportion $\theta/p_{\varnothing\varnothing}$, and only if the tech-lender wins them (which happens with probability $G^B(u)$). On the other hand, if the traditional bank does not make an offer $(1-z^B)$, the tech-lender will win all the borrowers, with an updated success probability of $\theta \times e^T(u)/p_{\varnothing\varnothing}$. In the cases where the traditional bank instead observed a low signal $(p_{\varnothing l})$, the tech-lender will make losses on the borrowers it wins, as these are low-ability entrepreneurs for sure. The tech-lender's ex-ante expected profits are expressed below.

$$\mathbb{E}\left[\Pi^T(u)\right] = p_{\varnothing\varnothing}\left[(1-z^B)\left(\frac{\theta}{p_{\varnothing\varnothing}}e^T(u)R^T(u)-1\right) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(u)\left(e^T(u)R^T(u)-1\right)\right)\right] - p_{\varnothing l}$$

We can derive the expected profit of the traditional bank from making an offer in an analogous way. As is the case with the tech-lender's profits, if the rival does not make an offer when both lenders

[15] Using ex-ante expected profits before receiving a signal is analogous to using the expected profits conditional on receiving a good signal, because the case when the intermediary receives a low signal is trivial (the lender never extends an offer and so makes zero profits).

observe an uninformative signal (which happens with probability $1 - z^T$), the traditional bank will win all the borrowers in the market, who will have an updated success probability of $\theta \times e^B(u)/p_{\varnothing\varnothing}$. If instead the tech-lender makes an offer (an event with probability z^T), the traditional bank is sure to capture all the low ability entrepreneurs, the proportion of whom is $(1 - \theta/p_{\varnothing\varnothing})$. In this case, it will win the proportion of high-ability entrepreneurs whenever it makes a better offer than the traditional bank, which happens with probability $G^T(u)$.

$$\mathbb{E}\left[\Pi^B(u)\right] = p_{\varnothing\varnothing}\Bigg[(1 - z^T)\left(\frac{\theta}{p_{\varnothing\varnothing}}e^B(u)R^B(u) - 1\right) + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}G^T(u)\left(e^B(u)R^B(u) - 1\right) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\Bigg] - p_{l\varnothing}$$

To simplify notation, call the profits when the rival intermediary does not make an offer $\rho^j(u)$, and the profits derived exclusively from the high-ability entrepreneur when the rival makes an offer as $\tau^j(u)$.

$$\tau^j(u) = e^j(u)R^j(u) - 1 \tag{9}$$

$$\rho^j(u) = \frac{\theta}{p_{\varnothing\varnothing}}e^j(u)R^j(u) - 1 \tag{10}$$

Therefore:

$$\mathbb{E}\left[\Pi^T(u)\right] = p_{\varnothing\varnothing}\left[(1 - z^B)\rho^T(u) + z^B\left(\frac{\theta G^B(u)}{p_{\varnothing\varnothing}}\tau^T(u)\right)\right] - p_{\varnothing l} \tag{11}$$

$$\mathbb{E}\left[\Pi^B(u)\right] = p_{\varnothing\varnothing}\left[(1 - z^T)\rho^B(u) + z^T\left(\frac{\theta G^T(u)}{p_{\varnothing\varnothing}}\tau^B(u) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing} \tag{12}$$

3.2 Equilibrium derivation

In this section I focus on the case where the intermediary obtains an uninformative signal, as the best response following a low signal is to not offer credit.

3.2.1 Monopolist: only the traditional bank is active

Consider first the case when the traditional bank is alone in the market. The traditional bank only extends an offer in case it observes an empty signal. The ex-ante expected profits are: [16]

$$\mathbb{E}[\Pi^B(u)] = \Pr\left(s^B_\varnothing\right)\left[\Pr\left(H|s^B_\varnothing\right)e^B(u)R^B(u) - 1\right]$$

The profits of the traditional bank when it acts as a monopolist are:

$$\mathbb{E}[\Pi^{\text{mon}B}] = \frac{1}{2}\left(\left(\frac{Am^B}{2} - 1\right)\theta - 1\right) \tag{13}$$

Assumption (A2) guarantees that these profits are above zero.

Assumption (A2): Minimum monitoring.
The monitoring intensity of the traditional bank is above n^B, where n^B is defined as: [17]

$$m^B > n^B = \frac{2}{A_h}\frac{1+\theta}{\theta} \tag{A2}$$

[16] We could derive the profit maximizing outcome here in terms of repayment since there is no competitor offering a different product. To allow for comparisons with the rest of the section, I derive the outcome directly in terms of entrepreneurial utility.

[17] Since we are normalizing m^T to one, we will require that the high entrepreneurial ability is at least 4. This condition comes from the full information profits $m^T \geqslant 4/A_h$.

3.2.2 Competition: both lenders are active in the market

When there are two lenders in the market, the credit market competition is characterized by a winner's curse, which implies that lenders will play in mixed strategies.

Proposition 1. There exist no pure strategy equilibrium in the lending game when two lenders are present in the market.

Proof. Proof B.2 in Appendix B. □

The intuition is as follows: suppose that the traditional bank contracts with a borrower whose creditworthiness test returned an empty signal. The borrower could have chosen the traditional bank either because the bank offered the entrepreneur a higher utility than the tech-lender or because the tech-lender identified the borrower as a low-ability entrepreneur and decided not to offer credit, in which case the traditional bank will incur in expected losses. Games with this feature tend not to have pure strategy equilibria (He et al., 2022, Marquez, 1997).

Definition 2. (Chu and Wei, 2021) An equilibrium is a strategy profile $\left(\left(z^B, G^B(u)\right); \left(z^T, G^T(u)\right)\right)$ such that, given $\left(z^T, G^T(u)\right)$, z^B and almost every $u \in \operatorname{supp} G^B(u)$ maximize $\mathbb{E}\left[\Pi^B(u)\right]$; and, given $\left(z^B, G^B(u)\right)$, z^T and almost every $u \in \operatorname{supp} G^T(u)$ maximize $\mathbb{E}\left[\Pi^T(u)\right]$.

Let $\underline{u}^j$ and $\overline{u}^j$ be the lower bound and upper bound of each of the utility distributions $G^j(u)$ $\forall j = \{B, T\}$:

$$\underline{u}^j = \inf\left\{u | G^j(u) > 0\right\} \qquad \overline{u}^j = \sup\left\{u | G^j(u) < 1\right\} \qquad \forall j = \{B, T\}$$

Proposition 2. In any mixed-strategy equilibrium, the two lenders' utility distributions have the following properties:

1. They share the same lower bound $\underline{u} = u^{\min B}$, where $u^{\min B} = u^B(R^\star)$, and the same upper bound $\overline{u}$ on their supports.
2. They are strictly increasing on their supports: they have no gaps and no mass points over the range $(\underline{u}, \overline{u})$.

Proof. Proof B.3 in Appendix B. □

From Proposition 2, the distribution functions are increasing on the utilities offered, and we know that profits decrease as utilities offered increase. Therefore, to make the rival lender indifferent along the support, the equilibrium profits of the two lenders must be constant along the support of their mixing distributions. Denote such constant equilibrium level of profits for each lender $j = \{B, T\}$ as K^j.

Equilibrium profits

The level of profits in equilibrium will depend on two different market forces. In the case of homogeneous products and information asymmetries, the lender with the information advantage tends to make positive expected profits (He et al., 2022). [18] The bank with the superior knowledge is generally able to better adjust its offers to make sure that it does not make expected losses, exposing the less informed bank to problems of adverse selection. The less informed bank hence breaks-even, while the informed bank can extract some rents (von Thadden, 2004). In this paper, however, lenders can be thought of as offering differentiated products, so the profits they will make

[18] Similarly, with homogeneous products and cost asymmetry, the lender with the lowest cost makes positive expected profits (Marquez, 1997) and the other lender breaks-even in expectations.

will non only depend on their information asymmetry but also on borrowers preferences: borrowers perceive the loans to be different, because each loan entails different monitoring.

In theory, therefore, we could have four different scenarios depending on the level of profits: two symmetric scenarios, where either both lenders make positive expected profits ($K^T > 0, K^B > 0$) or both lenders make zero expected profits ($K^T = K^B = 0$); and two asymmetric scenarios, where one of the lenders makes profits while the other one breaks even ($K^T = 0, K^B > 0$; $K^T > 0, K^B = 0$). Lemma 1 rules out the case where both lenders make positive expected profits.

Lemma 1. In any equilibrium of the lending game, competition will force at least one of the two lenders to make an expected profit of zero.

Proof. Proof B.4 in Appendix B. □

In what follows I will focus on the asymmetric candidate equilibria: either the traditional bank forces the tech-lender to break-even in expectations; or the tech-lender is stronger, forcing the traditional bank to break-even in expectations. [19] I first derive these equilibria and then derive conditions to distinguish which equilibrium prevails. As I will show below, which equilibrium arises will depend on the relative monitoring intensity of the traditional bank and the screening accuracy of the tech-lender.

Candidate equilibrium 1: the traditional bank makes positive expected profits

Consider first the candidate equilibrium where the traditional bank makes positive expected profits, so that $K^B > K^T = 0$.

Proposition 3. The unique mixed strategy equilibrium of the lending game when the traditional bank makes positive expected profits is characterized by:

1. Expected profits are zero for the tech-lender, while the traditional bank makes positive expected profits.

$$K^{B1} = p_{\varnothing\varnothing}\left[(1 - z^{T1})\rho^B(\underline{u}^B) - z^{T1}\left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right] - p_{l\varnothing} \tag{14}$$

2. The traditional bank always offers credit $z^{B1} = 1$, while the tech-lender offers credit with a probability $z^{T1} \in (0, 1)$

$$z^{T1} = \frac{\rho^B(\underline{u}^B) - \rho^B(\overline{u}^{T1})}{\rho^B(\underline{u}^B) - \rho^B(\overline{u}^{T1}) + \theta\tau^B(\overline{u}^{T1})/p_{\varnothing\varnothing}} \tag{15}$$

3. The tech-lender and the traditional bank play $G^{T1}(u)$ and $G^{B1}(u)$ respectively, over the common support $(\underline{u}^B, \overline{u}^{T1})$, where:

$$\tau^T(\overline{u}^{T1}) = \frac{p_{\varnothing l}}{\theta} \tag{16}$$

$$G^{B1}(u) = \frac{p_{\varnothing l}}{\theta\tau^T(u)} \tag{17}$$

$$G^{T1}(u) = \frac{K^B + p_{l\varnothing} - p_{\varnothing\varnothing}(1 - z^{T1})\rho^B(u) + z^{T1}(p_{\varnothing\varnothing} - \theta)}{\theta z^{T1}\tau^B(u)} \tag{18}$$

4. The distribution $G^{B1}(u)$ has a mass point at $\underline{u}^B$. The size of the mass point is given by $\mu^{B1}(\underline{u}^B)$.

[19] I do not focus on the equilibrium where both make zero profits because lenders are asymmetric.

Proof. Since the ex-ante profits for the traditional bank are strictly positive, it is a best response to always offer credit to the entrepreneur that returns an uninformative signal: $z^{B1} = 1$. In the case of the tech-lender, we can use the fact that profits are zero to back up the upper bound of the support.

$$\mathbb{E}\left[\Pi^T(\overline{u}^{T1})\right] = p_{\varnothing\varnothing}\left[\frac{\theta}{p_{\varnothing\varnothing}}\tau^T(\overline{u}^{T1})\right] - p_{\varnothing l} = 0$$

Therefore, the upper bound of the utility distributions is implicitly defined by the relation:

$$\tau^T(\overline{u}^{T1}) = \frac{p_{\varnothing l}}{\theta}$$

To find $G^{T1}(u)$, we can simply set the tech-lender's profits to their equilibrium level of zero.

$$G^{B1}(u) = \frac{p_{\varnothing l}}{\theta\tau^T(u)}$$

Notice that to make the zero profit condition hold for utilities close to the lower bound, the traditional bank needs to place a mass point at $\underline{u}^B$ of size $\mu^{B1}(\underline{u}^B)$:

$$\begin{aligned}
K^{T1} &= p_{\varnothing\varnothing}\left[\frac{\theta}{p_{\varnothing\varnothing}}G^{B1}(\underline{u}^B)\tau^T(\underline{u}^B)\right] - p_{\varnothing l} = 0 \\
\mu^{B1}(\underline{u}^B) = G^{B1}(\underline{u}^B) &= \frac{p_{\varnothing l}}{\theta\tau^T(\underline{u}^B)}
\end{aligned}$$

Employing that the profits of the lender need to be constant along the support, we can write a system of equations that define the profits of the traditional bank and the probability that the tech-lender makes an offer:

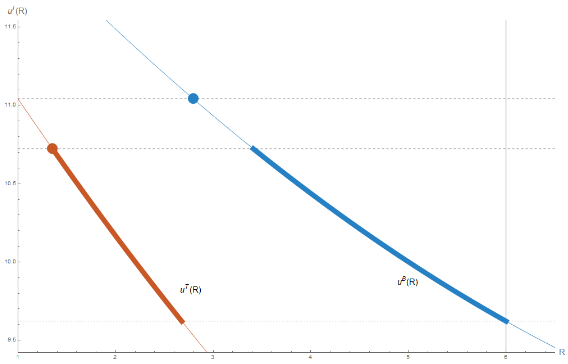
$$\begin{aligned}
K^{B1} &= \mathbb{E}\left[\Pi^B(\underline{u}^B)\right] = p_{\varnothing\varnothing}\left[(1 - z^{T1})\rho^B(\underline{u}^B) - z^{T1}\left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right] - p_{l\varnothing} \\
K^{B1} &= \mathbb{E}\left[\Pi^B(\overline{u}^{T1})\right] = p_{\varnothing\varnothing}\left[(1 - z^{T1})\rho^B(\overline{u}^{T1}) + z^{T1}\left(\frac{\theta}{p_{\varnothing\varnothing}}\tau^B(\overline{u}^{T1}) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}
\end{aligned}$$

From these two equations we can back up z^{T1} and K^{B1}, and thus employ Equation (12) to find the distribution $G^{T1}(u)$.

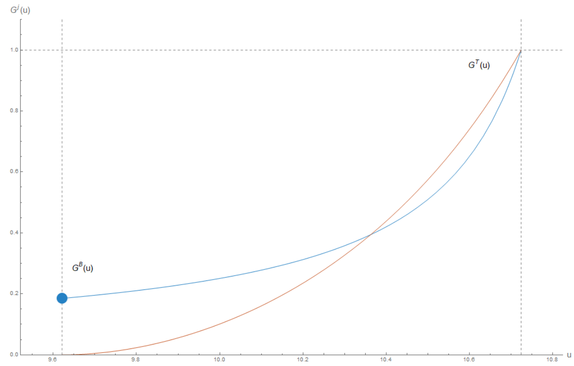
$$\begin{aligned}
z^{T1} &= \frac{\rho^B(\underline{u}^B) - \rho^B(\overline{u}^{T1})}{\rho^B(\underline{u}^B) - \rho^B(\overline{u}^{T1}) + \theta\tau^B(\overline{u}^{T1})/p_{\varnothing\varnothing}} \\
K^{B1} &= p_{\varnothing\varnothing}\left[(1 - z^{T1})\rho^B(\underline{u}^B) - z^{T1}\left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right] - p_{l\varnothing} \\
G^{T1}(u) &= \frac{K^{B1} + p_{l\varnothing} - p_{\varnothing\varnothing}(1 - z^{T1})\rho^B(u) + z^{T1}(p_{\varnothing\varnothing} - \theta)}{\theta z^{T1}\tau^B(u)}
\end{aligned}$$

□

The panels in Figure 1 illustrate the equilibrium results. Figure 1a displays the utility that the high-ability entrepreneur derives from contracting with the traditional bank (in blue) and the tech-lender (in orange). The dots in the figure represent the maximum utility each lender can offer to the entrepreneur without incurring in expected losses. As we can see, the maximum utility that the traditional bank can offer is above that the tech-lender can offer. This means that, by setting the upper bound of the utility distributions to the break even rate of the tech-lender, the traditional bank is making expected profits.



(a) Utilities as a function of repayment



(b) Distributions over utilities

Figure 1: Candidate equilibrium 1
Parameters: $A_h = 12, \theta = 0.5, m^B = 0.7, \sigma^T = 0.6$

Candidate equilibrium 2: the tech-lender makes positive expected profits

Consider now the candidate equilibrium where the tech-lender makes positive expected profits, so that $K^T > K^B = 0$.

Proposition 4. The unique mixed strategy equilibrium of the lending game when the tech-lender makes positive expected profits is characterized by:

1. Expected profits are zero for the traditional bank, while the tech-lender makes positive expected profits K^{T2}.

$$K^{T2} = p_{\varnothing\varnothing}(1 - z^{B2})\rho^T(\underline{u}^B) - p_{\varnothing l} \tag{19}$$

2. The tech-lender always offers credit $z^{T2} = 1$, while the traditional bank offers credit with a probability $z^{B2} \in (0, 1)$.

$$z^{B2} = \frac{\rho^T(\underline{u}^B) - \rho^T(\overline{u}^{B2})}{\rho^T(\underline{u}^B) - \rho^T(\overline{u}^{B2}) + \theta\tau^T(\overline{u}^{B2})/p_{\varnothing\varnothing}} \tag{20}$$

3. The tech-lender and the traditional bank play $G^{T2}(u)$ and $G^{B2}(u)$ respectively, over the common support $(\underline{u}^B, \overline{u}^{B2})$, where:

$$\tau^B(\overline{u}^{B2}) = (1-\theta)(1-\sigma^B)/\theta \tag{21}$$

$$G^{T2}(u) = \frac{p_{l\varnothing} + p_{\varnothing\varnothing} - \theta}{\theta\tau^B(u)} \tag{22}$$

$$G^{B2}(u) = \frac{K^{T2} + p_{\varnothing l} - p_{\varnothing\varnothing}\left(1 - z^{B2}\right)\rho^T(u)}{\theta z^{B2}\tau^T(u)} \tag{23}$$

4. The distribution $G^{T2}(u)$ has a mass point at $\underline{u}^B$. The size of the mass point is given by $\mu^{T2}(\underline{u}^B)$.

Proof. Since the expected profits for the tech-lender are strictly positive, it is a best response to always offer credit to the entrepreneur that returns an empty signal: $z^{T2} = 1$. In the case of the traditional bank, we can use the fact that equilibrium profits are zero to back up the upper bound of the utility distribution.

$$\mathbb{E}\left[\Pi^B(\overline{u}^{B2})\right] = p_{\varnothing\varnothing}\left[\frac{\theta}{p_{\varnothing\varnothing}}\tau^B(\overline{u}^{B2}) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right] - p_{l\varnothing} = 0$$

Therefore, the upper bound of the utility distribution is implicitly defined by the relation

$$\tau^B(\overline{u}^{B2}) = (p_{l\varnothing} + p_{\varnothing\varnothing} - \theta)/\theta = (1-\theta)(1-\sigma^B)/\theta \tag{24}$$

To find $G^{T2}(u)$, we can simply set the traditional bank's profits $\mathbb{E}\left[\Pi^B(u)\right]$ to its equilibrium level of zero.

$$G^{T2}(u) = \frac{p_{l\varnothing} + p_{\varnothing\varnothing} - \theta}{\theta\tau^B(u)}$$

Notice that to make the profits hold for utilities close to the lower bound, the tech-lender needs to have a mass point at $\underline{u}^B$ of size $\mu^{T2}(\underline{u}^B)$.

$$K^{B2} = p_{\varnothing\varnothing}\left[\frac{\theta}{p_{\varnothing\varnothing}}G^T(\underline{u}^B)\tau^B(\underline{u}^B) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right] - p_{l\varnothing} = 0$$
$$\mu^{T2}(\underline{u}^B) = G^{T2}(\underline{u}^B) = \frac{p_{l\varnothing} + p_{\varnothing\varnothing} - \theta}{\theta\tau^B(\underline{u}^B)}$$

Employing that the profits of the lender need to be constant along the support, we can write a system of equations that define the profits of the tech-lender and the probability that the traditional bank makes an offer:

$$K^{T2} = \mathbb{E}\left[\Pi^T(\underline{u}^B)\right] = p_{\varnothing\varnothing}\left[(1-z^{B2})\rho^T(\underline{u}^B)\right] - p_{\varnothing l}$$
$$K^{T2} = \mathbb{E}\left[\Pi^T(\overline{u}^{B2})\right] = p_{\varnothing\varnothing}\left[(1-z^{B2})\rho^T(\overline{u}^{B2}) + z^{B2}\left(\frac{\theta}{p_{\varnothing\varnothing}}\tau^T(\overline{u}^{B2})\right)\right] - p_{\varnothing l}$$

From these two equations we can back up z^{B2} and K^{T2}, and thus employ Equation (11) to find the distribution $G^B(u)$.

$$z^{B2} = \frac{\rho^T(\underline{u}^B) - \rho^T(\overline{u}^{B2})}{\rho^T(\underline{u}^B) - \rho^T(\overline{u}^{B2}) + \theta\tau^T(\overline{u}^{B2})/p_{\varnothing\varnothing}}$$
$$K^{T2} = p_{\varnothing\varnothing}(1-z^{B2})\rho^T(\underline{u}^B) - p_{\varnothing l}$$
$$G^{B2}(u) = \frac{K^{T2} + p_{\varnothing l} - p_{\varnothing\varnothing}\left(1-z^{B2}\right)\rho^T(u)}{\theta z^{B2}\tau^T(u)}$$

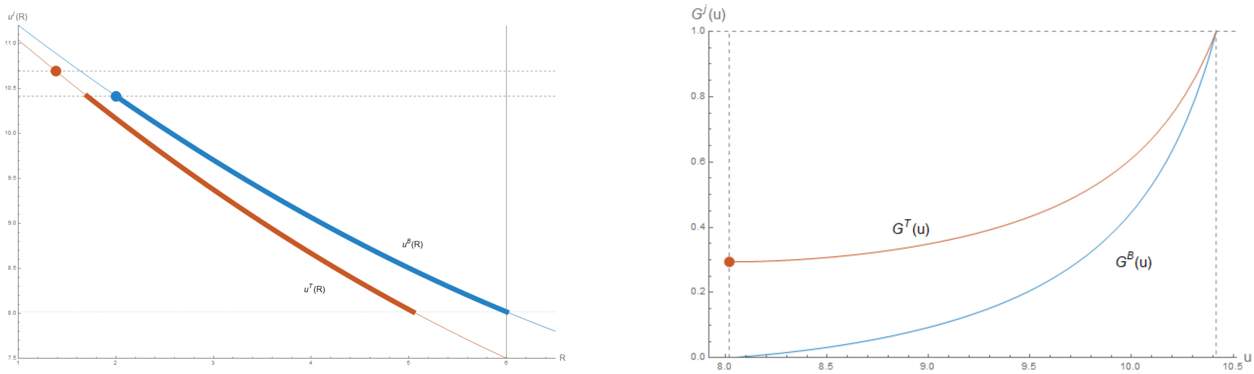
□

The two panels in Figure 2 illustrate the equilibrium results. In Figure 2a we can see the utilities of the high-ability entrepreneur when contracting with the traditional bank, in blue, and with the tech-lender, in orange. The maximum utility each lender can propose to the borrower without incurring in expected losses is depicted by the dots. The maximum utility that the tech-lender can propose is above the one that the traditional bank can propose. Therefore, as the upper bound of the utility distributions is defined by the one that makes the traditional bank break even, the tech-lender is making positive expected profits.

Figure 2b displays the distribution over utilities. The traditional bank offers a higher utility in the sense of first order stochastic dominance (FOSD). This means that, on average, the traditional bank offers higher utilities more often than the tech-lender.

3.3 Equilibrium bounds

Following the candidate equilibria in section 3.2, the central question is: for given parameter values, which of the equilibria arises? The main take-away from this section is that the monitoring intensity is the parameter that governs which equilibrium arises, and the better screening accuracy of the tech-lender plays only a secondary role. Furthermore, the aforementioned equilibria do not overlap.



(a) Utilities as a function of repayment

(b) Distributions over utilities

Figure 2: Candidate equilibrium 2
Parameters: $A_h = 12, \theta = 0.5, m^B = 0.9, \sigma^T = 0.6$

We will therefore derive thresholds for the traditional bank's monitoring intensity to differentiate between the relevant cases.

All the thresholds in this section depend on the value of the tech-lender's screening accuracy σ^T. To make the text clearer, I abuse notation and express the thresholds without their dependency on σ^T, and only include it when necessary.

3.3.1 Monopoly vs competition

The first step is to differentiate when the traditional bank is able to act as a monopolist in the market and completely crowd-out the tech-lender.

Proposition 5. For a given screening intensity of the tech-lender, there exists a threshold level of bank monitoring intensity $\underline{m}^B$ such that:

- If $m^B \in \left[n^B, \underline{m}^B\right)$, then the bank is relatively bad at reducing appropriation by the entrepreneur. This implies that the preference the entrepreneur has for the lower monitoring of the bank is so strong that she prefers it over the tech-lender, even when the bank offers the profit maximizing utility.
- If $m^B \geqslant \underline{m}^B$, then the traditional bank is relatively good at monitoring and hence the entrepreneur's preference for lower monitors is not too high. The tech-lender is hence able to exert competitive pressure.

Proof. Proof B.5 in Appendix B. □

Proposition 5 tells us that the traditional bank is able to act as a monopolist (charge $u^{\min B}$) when its monitoring intensity is relatively low (below $\underline{m}^B$). In the model, this translates into a high preference for a lower monitor, so that the entrepreneur never chooses to contract with the tech-lender whenever $m^B < \underline{m}^B$, even when it offers the maximum utility $\overline{u}^{T1}$.

3.3.2 Competition between the two lenders

When the monitoring intensity is not too low (above $\underline{m}^B$), borrowers consider the loans as competing products. In this section, I analyse the profits that lenders make when they play the equilibrium strategies prescribed in Section 3.2.2.

Proposition 6. For a given level of tech-lender screening accuracy, there exits a threshold level of monitoring of the traditional bank $\overline{m}^B \in \left(\underline{m}^B, 1\right)$ such that:

– If $m^B \in \left[\underline{m}^B, \overline{m}^B\right]$ the equilibrium profits for the traditional bank in candidate equilibrium 1 are non-negative: $K^{B1} \geqslant 0$.

– If $m^B \in \left(\overline{m}^B, 1\right)$ the equilibrium profits for the traditional bank in candidate equilibrium 1 are strictly negative: $K^{B1} < 0$.

Proof. Proof B.6 in Appendix B. □

The intuition behind Proposition 6 is as follows: when the traditional bank is sufficiently different to the tech-lender (ie, $m^B \in (\underline{m}^B, \overline{m}^B)$, it can exploit the preference the borrowers have for a weaker monitor. Although it is no longer acting as a monopolist ($m^B > \underline{m}^B$), the traditional bank can still make positive expected profits. To derive this threshold, we must compare the highest utilities that the lenders can offer before incurring in negative profits.

Proposition 7. For a given level of tech-lender screening accuracy, there exits a threshold level of monitoring of the traditional bank $\tilde{m}^B \in \left(\underline{m}^B, 1\right)$ such that:

– If $m^B \in \left[\underline{m}^B, \tilde{m}^B\right)$ the equilibrium level of profits for the tech-lender in candidate equilibrium 2 is strictly negative $K^{T2} < 0$.

– If $m^B \geqslant \left[\tilde{m}^B, 1\right)$ the equilibrium level of profits for the traditional bank is non-negative $K^{T2} \geqslant 0$.

Proof. By simulations in proof B.7 in Appendix B. □

The intuition behind Proposition 7 is as follows: when the traditional bank and the tech-lender are sufficiently similar (ie, $m^B \in (\tilde{m}^B), 1)$), borrowers regard the tech-lender and the traditional bank as closer substitutes. The tech-lender can therefore exploit its better screening accuracy and make positive expected profits.

To understand the ranking, notice that both $\underline{m}^B$ and $\overline{m}^B$ are derived using the tech-lender's maximum utility offered $\overline{u}^{T1}$, but $\underline{m}^B$ compares it to the bank's profit-maximizing utility $u^{\min B}$, while $\overline{m}^B$ compares it to the bank's break-even utility $\overline{u}^{B2}$. As $\overline{u}^{B2} > u^{\min B}$, we have that $\underline{m}^B < \overline{m}^B$. Additionally, the following relation follows from simulations: $\underline{m}^B < \overline{m}^B \leqslant \tilde{m}^B$.

The following figure summarizes all the thresholds gathered from Proposition 5 to 7, for a given level of σ^T.

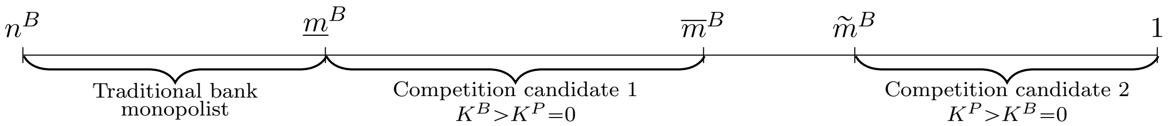


Figure 3 contains an example of the equilibrium level of profits in each of the cases as a function of the traditional bank's monitoring intensity. The vertical lines represent the threshold levels of monitoring. The green straight line is the traditional bank's monopoly profits, the blue parabola is the traditional bank's profits from candidate equilibrium 1, and the orange curve is the tech-lender's profits from candidate equilibrium 2.

A privacy interpretation

We can revisit the privacy interpretation provided at the beginning of the model, where the m stands for (the inverse of) borrowers' preference for safeguarding their privacy. In this model, this preference for privacy countervails tech-lender's superior screening. The results show that the more technologically-enabled player may not always have a market presence if its technology is too intrusive. Therefore, previous studies that only focus on technological advancements at the screening stage are missing an important component of the environment.

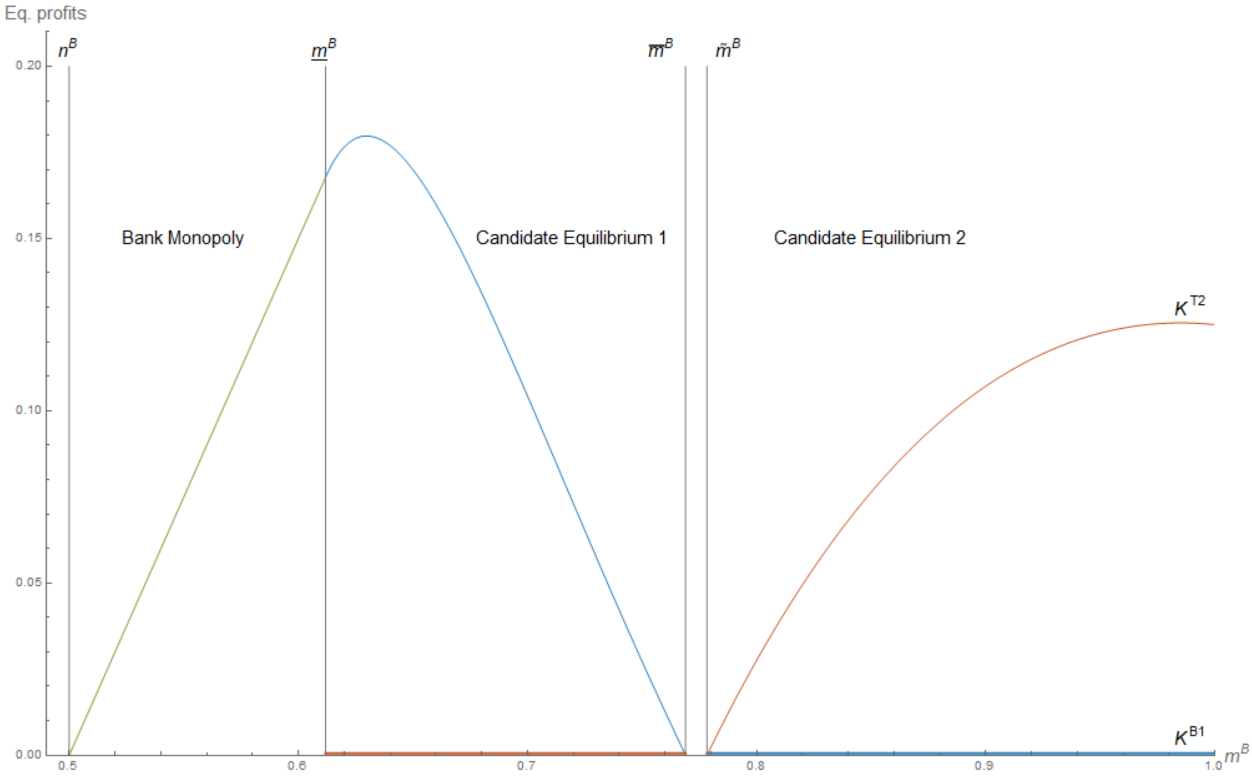


Figure 3: Equilibrium level of profits
Parameters: $A_h = 12, \theta = 0.5, \sigma^T = 0.6$

Market breakdown

As the line above and Figure 3 depict, there is an interval of the traditional bank's monitoring intensity between $\overline{m}^B$ and $\tilde{m}^B$ where neither of the proposed candidate equilibria arise. This is because, in this region, the equilibrium expected profits prescribed by the strategies above, for either the traditional bank or the tech-lender, are negative, a contradiction to equilibrium play. The lender making negative expected profits would rather stay out of the market, but then the rival would best-respond by offering the monopoly utility. This, in turn, means that the lender who decided to stay out would have an incentive to enter.

I refer to this situation as market breakdown. Appendix B.8 expands on the dynamics that arise in this region.

4 Comparative Statics

In this section I perform comparative statics exercises on the candidate equilibria to understand how the parameters affect the two forces in the market: the winner's curse and product competition. When relevant, I compare the resulting comparative statics with those of He et al., 2022. When the closed form solution does not offer an insight into the direction of the effects, I rely on simulations. The direction of the comparative statics will depend on the candidate equilibrium that we examine, so the implicit assumption in this section is that the changing parameters remain in the required range for each candidate equilibria.

4.1 Candidate equilibrium 1

Let us first focus on the case where the traditional bank makes profits, which happens when the monitoring intensity of the traditional bank is between $\underline{m}^B$ and $\overline{m}^B$. Corollaries 1 to 3 state the direction of the comparative statics for the probability that the tech-lender makes an offer, industry profits and the utility distributions respectively. I discuss the results of these corollaries together after Corollary 3.

Corollary 1. The probability that the tech-lender makes an offer upon reception of an uninformative signal in candidate equilibrium 1 moves as follows:

1. It increases with the proportion of high-ability entrepreneurs (θ).
2. It increases with the traditional bank's monitoring intensity (m^B).
3. It increases with the tech-lender's screening accuracy (σ^T).

Proof. Proof C.1 in Appendix C. □

Corollary 2. Traditional bank's profits constitute industry profits in candidate equilibrium 2, and move as follows:

1. They increase with the proportion of high-ability entrepreneurs (θ).
2. They increase with the traditional bank's monitoring intensity (m^B), provided that the monitoring intensity is not too high; otherwise, they are decreasing in the traditional bank's monitoring intensity.
3. They decrease with the tech-lender's screening accuracy (m^B).

Proof. Proof C.2 in Appendix C. □

Corollary 3. The lenders' utility distributions in candidate equilibrium 2 change as follows:

1. As the proportion of high-ability borrowers (θ) increases, both lenders offer a higher utility in the sense of FOSD.
2. The traditional bank's utility distribution is unaffected by its monitoring technology (m^B), while the bank's monitoring technology has an ambiguous effect on the tech-lender's distribution.
3. As the tech-lender's screening accuracy (σ^T) increases, both lenders offer a higher utility in the sense of FOSD.

Proof. Proof C.3 in Appendix C. □

A better screening accuracy increases the winner's curse, goes to the tech-lender's advantage so it makes an offer more often and the traditional bank's equilibrium profits decrease.

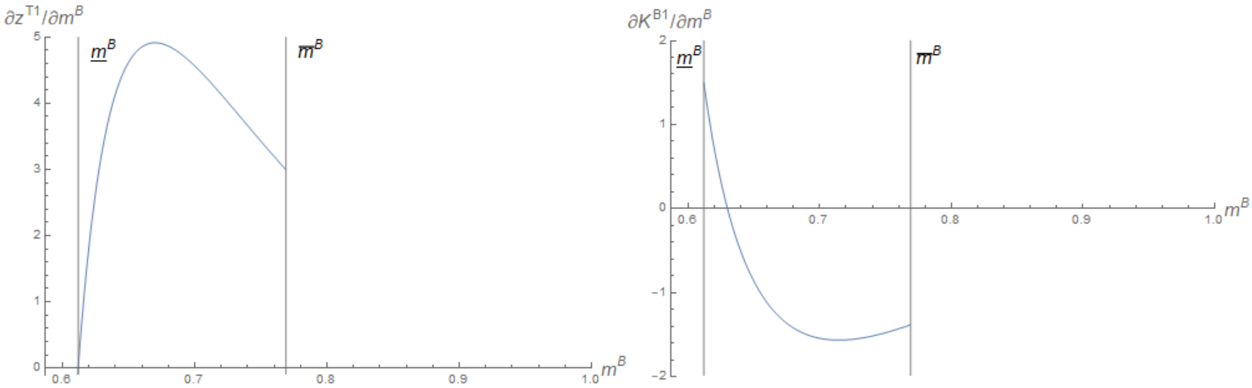
Lenders offer higher utilities in the sense of FOSD whenever there are more high-ability entrepreneurs or if the tech-lender's screening accuracy increases, and the highest possible level of utility $\overline{u}^{T1}$ also increases. With a better screening technology, the tech-lender can offer a higher utility and still break even.

Furthermore, with more high-ability borrowers, there is a decrease of the winner's curse, which raises traditional bank's profits. A higher proportion of high-ability borrowers encourages the tech-lender, which is breaking even, to make an offer more frequently.

The monitoring intensity of the traditional bank affects profits through two channels: on the one hand, greater monitoring increases effort and hence the probability of project success, increasing profits; on the other hand, greater monitoring makes the traditional bank more similar to the tech-lender. This intensifies competition between the two, and forces the tech-lender to make an offer more often, which diminishes industry profits. Which of these two forces dominate depends on the initial value of the monitoring intensity.

- For values of the monitoring intensity closer to $\underline{m}^B$), an increase in the monitoring intensity increases profits from the captured borrowers (from their higher effort) more than it increases the chances of tech-lender's entry. Therefore, overall it increases traditional bank's profits.
- For values of the monitoring intensity closer to $\overline{m}^B$, an increase in the monitoring intensity of the traditional bank decreases its profits. This happens because, as m^B increases, both lenders become more and more similar, increasing competition, tech-lender entry, and hence diminishing the traditional bank's equilibrium profits.

Figures 4a and 4b make explicit the sign of the comparative statics with respect to m^B.



(a) Tech-lender's probability of making an offer

(b) Traditional bank's profits

Figure 4: Comparative statics with respect to traditional bank's monitoring intensity
Parameters: $A_h = 12, \theta = 0.5, \sigma^T = 0.6$

The effect of an increase in the monitoring intensity of the traditional bank is ambiguous for the tech-lender's distribution. It pushes the lower bound of the distribution to the left, meaning that the borrower gets offered lower values of utility more often.

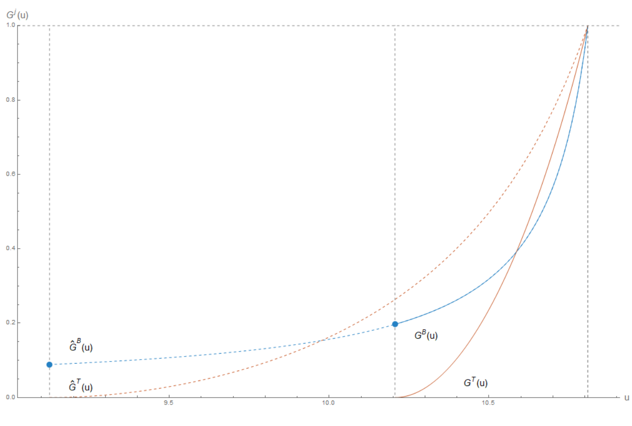


Figure 5: Comparative statics of utility distributions with respect to traditional bank's monitoring
Param: $A_h = 12$,$\theta = 0.5$, $\sigma^T = 0.75$, $m^B = 0.65$, $\hat{m}^B = 0.75$

4.2 Candidate equilibrium 2

We can now turn to the case where the tech-lender makes profits, which happens when the monitoring intensity of the traditional bank is between $\widetilde{m}^B$ and 1. Corollaries 4 to 6 state the direction of the comparative statics for the traditional bank's probability of making an offer, industry profits and the utility distributions respectively. I discuss the results of these corollaries together at the end.

Corollary 4. The probability that the traditional bank makes an offer upon reception of an uninformative signal in candidate equilibrium 2 moves as follows:

1. It increases with the proportion of high-ability entrepreneurs (θ).
2. It decreases with the monitoring intensity of the traditional bank (m^B), provided the monitoring intensity is not too high.
3. It is unaffected by changes in the tech-lender's screening accuracy (σ^T).

Proof. Proof C.4 in Appendix C. □

Corollary 5. The tech-lender's profits constitute industry profits in candidate equilibrium 2, and move as follows:

1. They decrease with the proportion of high-ability entrepreneurs (θ).
2. They increase with the traditional bank's monitoring ability (m^B), provided that the monitoring ability is not too high; otherwise, they are decreasing in the traditional bank's monitoring intensity.
3. They increase as the tech-lender has a better screening accuracy (σ^T).

Proof. Proof C.5 in Appendix C. □

Corollary 6. The distributions of utility offered by the lenders change as follows:

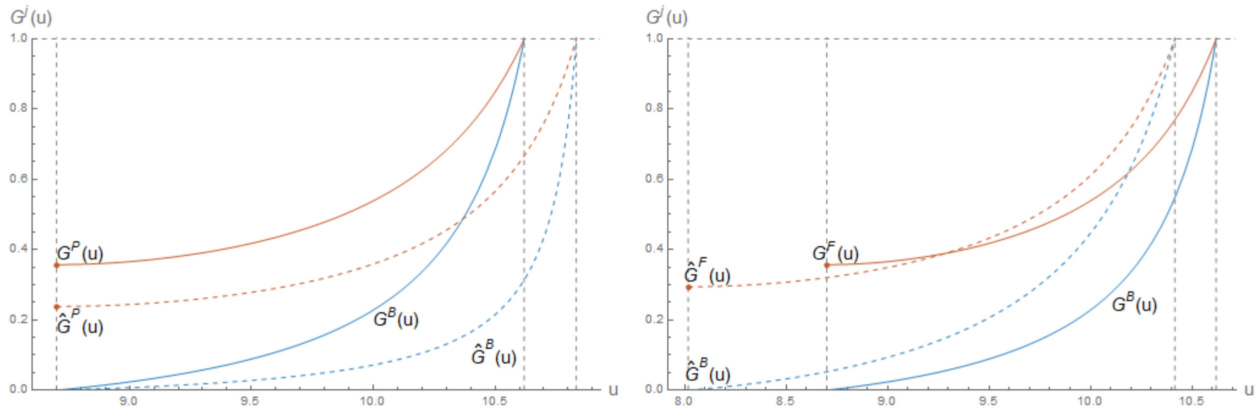
1. As the proportion of high-ability borrowers (θ) increases, both lenders offer a higher utility in the sense of first order stochastic dominance (FOSD) and the upper bound of their utility distributions increases.
2. The traditional bank's monitoring intensity (m^B) has an ambiguous effect on the utility offered by the lenders. As the monitoring intensity of the traditional bank increases, the lower bound of the utility distributions decreases.
3. They are unaffected by the tech-lender's screening accuracy (σ^T).

Proof. Proof C.6 in Appendix C. □

There are two forces at play in these comparative statics: the winner's curse, and lenders' differentiation.

As the proportion of high-ability entrepreneurs increases, the winner's curse becomes less severe, and hence the traditional bank makes an offer more frequently. This intensifies competition and hence decreases the tech-lender's equilibrium profits. This result is reminiscent of Corollary 1 in He et al., 2022. An increase in competition following an increase in the proportion of high-ability entrepreneurs moves both lenders' distributions towards offering higher utilities more often, as displayed in Figure 6a.

The tech-lender's screening ability only impacts positively its equilibrium profits. Opposed to He et al., 2022, the probability that the traditional bank makes an offer does not depend on the tech-lender's screening accuracy. The intuition for this result is as follows. Consider the case when the two intermediaries receive an uninformative signal from an entrepreneur. In this candidate equilibrium, the tech-lender will always make an offer upon reception of an uninformative signal. Whenever the traditional bank also makes an offer, its offer will attract all the low-ability entrepreneurs whose tests returned two uninformative signals. The winner's curse hence no longer plays a role, and attracting the low-ability entrepreneurs is independent of the screening ability of the tech-lender. In He et al., 2022, the non-creditworthy borrowers behave just like the creditworthy ones, so that the winner's curse dictates that the traditional bank makes an offer less often when the tech-lender becomes a better screener. In my model, however, this effect does not play a role as the low-ability entrepreneurs prefer to contract with the traditional bank anyway.



(a) Proportion of high-ability borrowers

(b) Traditional bank's monitoring intensity

Figure 6: Comparative statics on utility distributions
Parameters: $A_h = 12$, $\theta = 0.5$, $\sigma^T = 0.75$, $m^B = 0.8$, $\hat{\theta} = 0.6$, $\hat{m}^B = 0.9$

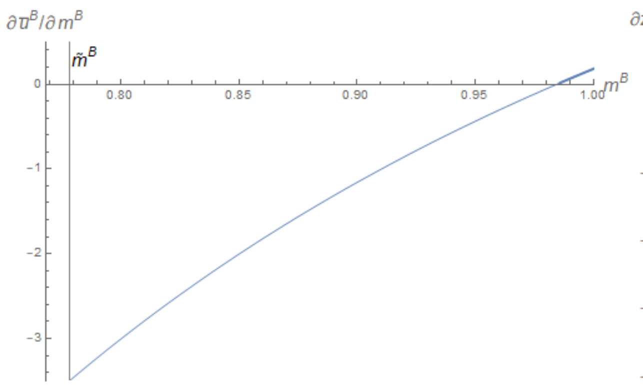
A higher monitoring intensity by the traditional bank means that the lenders can offer the entrepreneurs a lower minimum utility (higher repayment). Therefore, as m^B increases the lower bound of the utility distributions shifts to the left. The effect of changes in the monitoring intensity on the traditional bank's probability of making an offer and on the industry level of profits differ depending on the starting level of monitoring. They are summarized in Figure 7.

- When the traditional bank's monitoring intensity is very close to one, borrowers' preference for the traditional bank is not very strong. Following an increase in m^B, the two lenders will compete aggressively. Greater competition: increases the highest utility that lenders offer in equilibrium $\overline{u}^{B2}$ (Figure 7a), increases the probability that the traditional bank makes an offer (Figure 7b), and therefore decreases the tech-lender's equilibrium profits (Figure 7c).
- When the traditional bank's monitoring intensity is not too close to one, lenders are not too similar and so we have the opposite result. As the traditional bank becomes a better monitor, this has a negative effect on the entrepreneur's utility, as the borrower is required to put a higher level of effort. Consequently, the maximum utility that the entrepreneur can get decreases (Figure 7a). This also reduces the probability with which the traditional bank extends an offer (Figure 7b)). This result is similar to the one driven by the winner's curse in He et al., 2022. Finally, if the rival lender makes an offer less often, competition decreases, which has a positive impact in the tech-lender's equilibrium level of profits (Figure 7c).

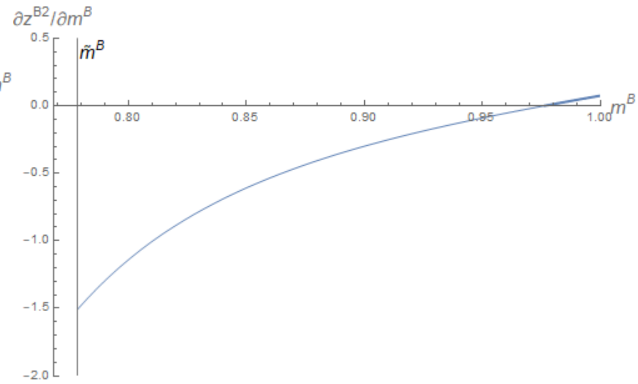
4.3 Traditional bank as a monopolist

Corollary 7. Traditional bank's profits constitute industry profits in the case when it acts as a monopolist (see Equation (13)). They move as follows:

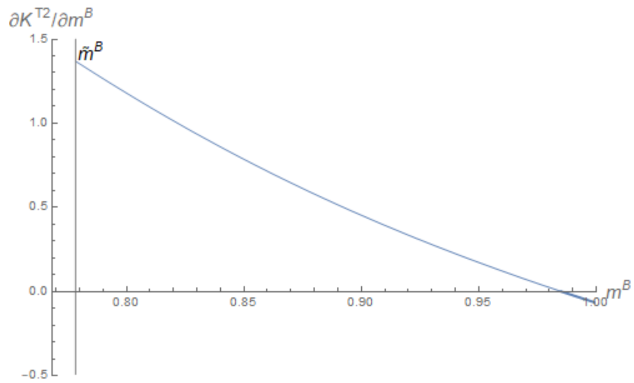
1. They increase with the proportion of high-ability entrepreneurs.



(a) Highest utility offered $\overline{u}^B$



(b) Prob. of making an offer z^{B2}



(c) Industry profits K^{T2}

Figure 7: Comparative statics with respect to traditional bank's monitoring
Parameters: $A_h = 12, \theta = 0.5, \sigma^T = 0.6$

2. They increase with the monitoring intensity of the traditional bank.

Furthermore, the utility that the high-ability entrepreneur obtains from contracting with the traditional bank in the monopolist case decreases with the traditional bank's monitoring intensity.

Proof. Proof C.7 in Appendix C. □

When the traditional bank is the only player in the market, an increase in the monitoring technology forces entrepreneurs to exert more effort, which decreases their level of utility and increases the traditional bank's profits. Profits also increase when the proportion of high-ability entrepreneurs raises, as it means that the overall market quality increases.

4.4 Discussion

The comparative statics in this section fill a gap in the existing literature that exclusively focuses on the better screening accuracy of more technologically oriented players. The previous literature misses the dynamics that arise when we also consider that these lenders monitor borrowers differently.

The two forces at play that are relevant here are product differentiation and the winner's curse. On the one hand, product differentiation benefits the traditional bank, as borrowers prefer lenders that monitor less. On the other hand, the winner's curse benefits the tech-lender, as it has a more accurate screening technology. Product differentiation governs the comparative statics with respect to the monitoring intensity, whereas the winner's curse dominate the comparative statics with respect to the proportion of high-ability entrepreneurs and the tech-lender's screening accuracy.

The screening accuracy, and hence the winner's curse, plays a greater role the lower the monitoring intensity: when product differentiation is higher, as in candidate equilibrium 1, changes in the screening accuracy can make the tech-lender more attractive to borrowers; however, when the two lenders are similar in terms of their monitoring intensity, the tech-lender will make profits as it is a better screener. Increasing its screening accuracy would not exacerbate the winner's curse, since the low-ability borrowers always prefer to contract with the traditional bank.

5 Conclusion

In this paper, I analyse how two lenders with different lending technologies shape the credit market equilibrium. My analysis is motivated by recent policy work and empirical evidence showing that tech-lenders are gaining importance in the lending sector, and that they have the potential to be both better at screening and at monitoring. I find that tech-lenders might not always be present in a market, and even if they do they need not make positive expected profits.

I present a theoretical framework of the lending market where lenders differ along two dimensions: their ability to identify a borrower's type before granting a loan and their ability to monitor borrowers' effort once a loan has been granted. As tech-lenders use sophisticated tools and big data to screen their borrowers, in my model they are the better screener, allowing good borrowers to get a better rate; furthermore, given the interconnectedness between lending and other activities carried out in the platforms, they are also the better monitor. A trade-off hence arises because borrowers prefer lower rates and also lower monitoring.

The main insight of my paper is that whether the tech-lender can have a market presence is largely driven by the preference for lower monitoring. If consumers' preference for lower monitoring is very high, then the tech-lender will be unable to exploit its better information technology to make profits, and in some cases will not even be able to have a market presence at all. I therefore differentiate between three possible equilibria in the lending market: i) the traditional bank acts as a monopoly, which arises when it is a very low monitor; ii) the traditional bank makes positive expected profits, while the tech-lender breaks-even in expectations, which happens when the bank's monitoring takes intermediate values; iii) the tech-lender makes positive expected profits, while the traditional bank breaks-even in expectation, which happens when the traditional bank and the tech-lender are sufficiently similar in terms of monitoring. As far as I know, this distinction is new in the literature, as previous studies exclusively focused on tech-lender's higher screening ability. By only considering differences in screening ability, they exclusively identified the cases when the better screener could make positive expected profits (or at least higher profits than the traditional bank).

The resulting comparative statics will differ depending on which equilibrium we consider, as these exist under non-overlapping sets of parameters. In general, they will be influenced by two forces: a winner's curse arising from the asymmetry of information in the pre-contracting stage; and product differentiation arising from borrowers' preference for a better monitor. Furthermore, my model predicts that lower-ability entrepreneurs will prefer to stay with the traditional banks, providing theoretical insights into whether we should expect tech-lenders to engage in cream-fishing.

This paper provides a first attempt at modeling tech-lenders and traditional banks as differentiated products, and sheds some light into why we observe lending by tech-lenders take-off in some countries/ sectors while not in others. More works should be devoted to understanding how preferences for monitoring and privacy affect the borrowers' choice of lenders.

A FinTechs and BigTecs

Technology has been at the core of financial intermediation for centuries, but recent developments in IT infrastructure, and the advancements in the gathering and processing of big data, have brought about new players in the financial markets. After a wave of consolidation in the 1990s and early 2000s, the sector experienced little entry of new players. High transaction costs are believed to be reason for this limited entry (Philippon, 2015, Philippon, 2016). FinTechs and BigTechs aim at reducing these frictions, as well as respond to an increasing demand for alternative sources of credit (Thakor, 2020, Vives, 2019).

The Financial Stability Board provides the most agreed definition of what constitutes a FinTech firm: technologically enabled innovation in financial services that could result in new business models, applications, processes or products. [20] FinTech firms act mostly online, use artificial intelligence and big data to price products and target customers, and many rely on market-based activities, keeping them in the realm of shadow banking. Just as traditional shadow banks, FinTech firms usually exploit regulatory loopholes when they operate.

BigTechs, instead, are large technology companies whose main line of business is not the provision of financial services. Recently, however, they have started to offer financial services or products to the users in their platforms. BigTechs' activities rely on high amounts of data, network externalities, and interwoven activities (Croxson et al., 2021). These elements create economies of scale and scope and foster monopolization tendencies (Vives, 2021).

The forces driving technological adoption in the banking sector are: on the supply side, the extensive use of technology by these players, in the form of APIs, cloud computing, digital currencies, and blockchain technology, is targeted towards reducing transaction costs: lowering the search costs of matching transacting parties; achieving economies of scale in gathering and using large data; achieving cheaper and more secure information transmission; and reducing verification costs (Thakor, 2020); on the demand side, there also exists greater technological literacy and smartphone penetration, greater service expectations, and drives for social responsibility (Vives, 2019).

Traditional banks have been slow to embrace the technology revolution to the same level as other players, possibly due to legacy costs (Navaretti et al., 2018). Banks usually provide a wide portfolio of services, which allows them to cross-subsidize across products and benefit from economies of scope. New players tend to operate exclusively in one element of the value chain (for example, payments or loans). Technological lenders are expanding into all the functions that were previously only covered by traditional banks: deposits, lending, payments or insurance (Thakor, 2020). I focus my analysis on the credit market, in particular lending to SMEs. [21] Technologically enabled lenders can improve lending market efficiency by effectively screening candidates via the use of big data. Information can act as a substitute for collateral (Gambacorta et al., 2022), allow for more targeted price discrimination and in some instances promote financial inclusion (Berg et al., 2021).

This digital disruption also has implications for financial stability. Although credit offered by FinTech and BigTech lenders has not reached a point of systemic importance, their combined lending volumes are growing worldwide (Cornelli et al., 2020). BigTech lending is more relevant in developing economies, while FinTechs have a higher presence in developed countries. While credit risk has not increased substantially, the adoption of these technologies also creates new systemic risks from the reliance on third-party services, like cloud computing (Vives, 2019).

[20] https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/fintech/

[21] For example, the share of unsecured personal loans granted by FinTechs in the United States rose from less than 5% in 2013 to almost 40% in 2018. FinTech lenders' origination activity in this sector mostly focuses on refinancing rather than new loans, probably due to a comparative advantage from online origination.

B Proofs for equilibrium calculations

B.1 From offering repayments to offering utilities

As explained in Section 3.1.3, the relation in Equation (4) hints that the entrepreneurs will gauge the repayment rate and the monitoring intensity together when assessing an offer, and decide on the basis of which one yields a higher utility. This suggests that the competition in this market is better expressed in terms of utilities offered (competition-in-utilities as in de Cornière and Taylor, 2021).

Example
Consider the example displayed in Figure 8, where utilities $u_h^j(R)$ are graphed as a function of the repayment amount R. The orange curve represents the utility of the high-ability entrepreneur for contracting with the tech-lender, while the blue line represents the utility for contracting with the traditional bank, for strictly positive effort levels. The top horizontal line represents the utility when the bank breaks-even. The vertical line corresponds to the profit maximizing rate $R^\star = A_h/2$, and the bottom horizontal line is the minimum utility associated to the traditional bank (the utility when it charges $R^\star$).

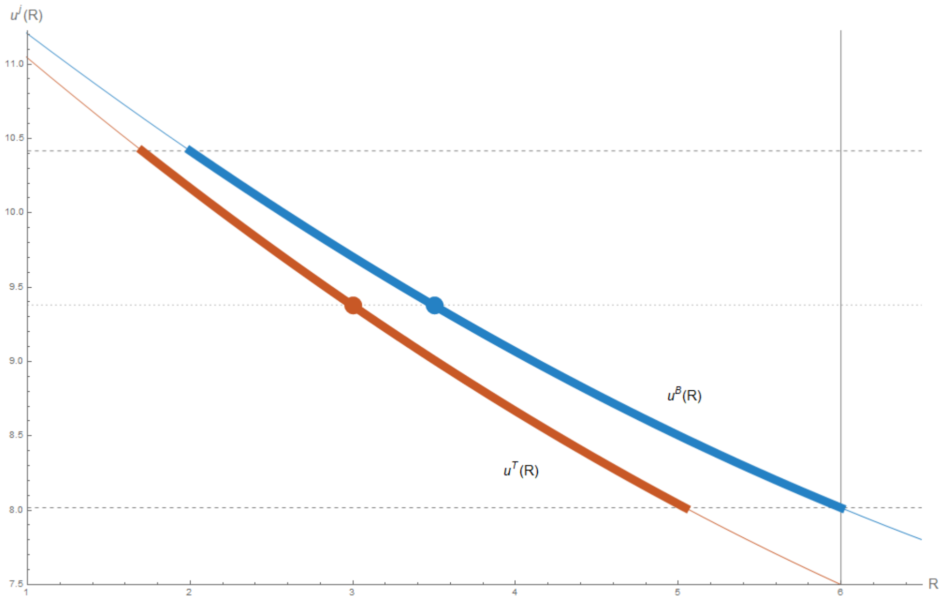


Figure 8: Utilities as a function of repayment
Parameters: $A_h = 12$, $\theta = 0.5$, $m^B = 0.9$, $\sigma^T = 0.6$

In this example, if the traditional bank offers a repayment of $R \approx 3.5$, then tech-lender needs to offer a repayment of $R \approx 3$ to match the utility that the high-ability entrepreneur gets from the competing offer. [22] Therefore, I express this problem in a competition-in-utilities approach (de Cornière and Taylor, 2021 or Villas-Boas and Schmidt-Mohr, 1999), where lenders compete offering utilities instead of offering repayments. The utility has a mapping to the repayment rate charged to the high-ability borrower.

[22] Furthermore, no lender would offer a utility above the one that allows it to break-even or below its profit maximizing level. In this example, I restrict attention to utilities between the lowest break-even utility (here, that of the traditional bank), and the minimum utility offered (the equivalent to the profit maximizing choice by the traditional bank).

Due to the imperfect information in this model lenders play in mixed strategies (Proposition 1). In mixed strategy equilibria lenders make their offers in a common interval. Expressing the problem in terms of utilities allows us to apply the traditional toolkit in deriving mixed-strategy equilibria (see the properties of the equilibrium at the beginning of section 3.2). From Figure 8 it is clear that the interval of feasible repayments (R) is not common to both lenders, but the interval of feasible utilities is.

We can transform Equations (1) and (2) to express the repayment and the profits as a function of the utility and effort level, respectively. This transformation yields:

$$R_h^j(u,e) = A_h - \frac{1}{e_h^j}\left[u - \frac{A_h}{2m^j}\left(1 - {e_h^j}^2\right)\right] \tag{25}$$

$$\pi_h^j(u,e) = e_h^j(u) R_h^j(u,e) - 1 \tag{26}$$

Using Equation (25), we can calculate the optimal level of effort as a function of utility instead of repayments in an analogous way to that of Equation (3).

$$e_h^{j\star}(u) = \sqrt{\frac{2m^j}{A_h}u - 1} \tag{27}$$

Again, more monitoring yields a higher level of effort, as does a higher level of utility. [23] Note that, since the lenders will not extend credit to entrepreneurs returning a low signal, we focus on the choice for the high-ability entrepreneur and from now on drop the subscript for clarity.

Finally, denote as $u^{\min j}$ the minimum level of utility, which corresponds to the one that a high-ability entrepreneur would get in a setting where lenders offer the profit maximizing utility. [24]

$$\max_u \quad e^j(u)R^j(u,e) - 1 \quad \text{st} \quad e^{j\star}(u) = \sqrt{\frac{2m^j}{A}u - 1}$$

$$u^{\min j} = A\frac{\left(4 + {m^j}^2\right)}{8m^j} \tag{28}$$

To allow for invertibility of the profit functions, I focus on the profit region where the winning profits are decreasing on the utility offered (increasing in the repayment). In my model, the profit functions are non-monotone, as the lenders trade-off higher effort with lower interest rates (see Equation (26)). [25] The moral hazard in the problem endogenously limits the minimum utility that each lender will offer to that in Equation (28). Notice that $u^{\min B} > u^{\min P}$. Hence, for the cap to cover the region where both lenders' profits are decreasing in utility offered, we set $u^{\min B} = \underline{u}^B$.

[23] This optimal level of effort as a function of the utility is anticipated by the lenders and by the entrepreneurs in their decisions.

$$R_h^j(u) = A_h - 2\left(u - \frac{A_h}{2m^j}\right)\left(\sqrt{\frac{2m^j}{A_h}u - 1}\right)^{-1} \qquad \pi_h^j(u) = A_h\sqrt{\frac{2m^j}{A_h}u - 1} - 2\left(u - \frac{A_h}{2m^j}\right)$$

[24] Recall that the profit maximizing repayment is equal to $R^\star = A_h/2$. This repayment in turn induces different utilities depending on which lender offers it.

[25] Kaplan and Wettstein, 2000 also focus their mixed strategy equilibrium in the region where profits are increasing on the interest rate, but on a different setting. They look at the possibility to sustain mixed-strategy equilibria that yield positive profits in the presence of constant-returns-to-scale technology and price competition.

B.2 Proof for Proposition 1

Proof. Suppose that each lender $j = \{B, T\}$ plays a pure strategy u^j following an empty signal. There can be three cases:

1. If $u^B < u^T$: all high-ability entrepreneurs go the tech-lender, so the traditional bank is making looses from the low-ability entrepreneurs. Therefore the traditional bank is better off not participating in the market, a contradiction to equilibrium play.
2. If $u^B > u^T$: all high-ability entrepreneurs that return an empty signal to both lenders decide to contract with the traditional bank. The tech-lender makes losses from the low ability entrepreneurs that returned a low signal to the traditional bank but a empty signal to the tech-lender. Therefore, the tech-lender is better off not participating in the market, a contradiction to equilibrium play.
3. If $u^B = u^T$: in this case, the two lenders share the high-ability entrepreneurs. The tech-lender could deviate to offering $\breve{u}^T = u^T + \varepsilon$ and capture all the high-ability entrepreneurs for a ε higher utility. For a small enough ε, this is a profitable deviation.

Therefore, there are no pure strategy equilibria in the game where both lenders are active in the market. □

B.3 Proof for Proposition 2

The properties of the two lenders' utility distributions in any mixed-strategy equilibrium are summarized by the following lemmata:

Lemma 2. The two distributions share the same lower bound $\underline{u}$ and the same upper bound $\overline{u}$ in their supports. [26]

Proof.

– Upper bound: Suppose the upper bounds are different, and denote $\overline{u}^j = \sup\left(\text{supp}(G^j)\right)$. Assume without loss of generality that $\overline{u}^{T1} > \overline{u}^B$. Take any $u' \in (\overline{u}^B, \overline{u}^{T1})$.

$$\mathbb{E}\left[\Pi^T(u')\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u') + z^B\left(\frac{\theta G^B(u')}{p_{\varnothing\varnothing}}\tau^T(u')\right)\right] - p_{\varnothing l}$$
$$\mathbb{E}\left[\Pi^T(\overline{u}^B)\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(\overline{u}^B) + z^B\left(\frac{\theta G^B(\overline{u}^B)}{p_{\varnothing\varnothing}}\tau^T(\overline{u}^B)\right)\right] - p_{\varnothing l}$$

Notice that $\Pr(u^B \leqslant u') = \Pr(u^B \leqslant \overline{u}^{T1}) = 1$. As lenders' profits are decreasing in the level of entrepreneurial utility offered, any $u' \in (\overline{u}^B, \overline{u}^{T1})$ is dominated by $\overline{u}^B$ for the tech-lender. This contradicts that $\overline{u}^{T1}$ is an equilibrium play of the tech-lender.

We can apply a similar reasoning for the traditional bank's strategy in the case $\overline{u}^B > \overline{u}^{T1}$. Hence, the upper bound of both utility distributions must be the same: $\overline{u}^{T1} = \overline{u}^B = \overline{u}$.

– Lower bound: Suppose the lower bounds are different, and denote $\underline{u}^j = \inf\left(\text{supp}(G^j)\right)$.

Suppose $\underline{u}^T > \underline{u}^B$. For any $u' \in (\underline{u}^B, \underline{u}^T)$:

$$\mathbb{E}\left[\Pi^B(\underline{u}^B)\right] = p_{\varnothing\varnothing}\left[(1-z^T)\rho^B(\underline{u}^B) + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}G^T(\underline{u}^B)\tau^B(\underline{u}^B) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}$$
$$\mathbb{E}\left[\Pi^B(u')\right] = p_{\varnothing\varnothing}\left[(1-z^T)\rho^B(u') + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}G^T(u')\tau^B(u') - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}$$

[26] In this part of the proof we assume that there are no ties. Lemma 4 shows that there are indeed no mass points in the mixing distribution, and therefore we can abstract from ties in the main analysis (Varian, 1980).

As $\Pr(u^T \leqslant \underline{u}^B) = \Pr(u^T \leqslant u') = 0$, $\mathbb{E}\left[\Pi^B(\underline{u}^B)\right] > \mathbb{E}\left[\Pi^B(u')\right]$ so that any $u' \in (\underline{u}^B, \underline{u}^T)$ is dominated by $\underline{u}^B$. Hence the bank places no probability on the interval $(\underline{u}^B, \underline{u}^T)$. Since demand is increasing in utility and the offers change continuously, there cannot be a discrete upward jump in profits as the utility offered decreases. We examine the tech-lender's profits on the neighbourhood of $\underline{u}^B$, ie, at $\underline{u}^B + \varepsilon$:

$$\mathbb{E}\left[\Pi^T(\underline{u}^T)\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(\underline{u}^T) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(\underline{u}^T)\tau^T(\underline{u}^T)\right)\right] - p_{\varnothing l}$$
$$\mathbb{E}\left[\Pi^T(\underline{u}^B+\varepsilon)\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(\underline{u}^B+\varepsilon) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(\underline{u}^B+\varepsilon)\tau^T(\underline{u}^B+\varepsilon)\right)\right] - p_{\varnothing l}$$

Note that, since for the bank any $u' \in (\underline{u}^B, \underline{u}^T)$ is dominated by $\underline{u}^B$, we have that $G^B(\underline{u}^B+\varepsilon) = G^B(\underline{u}^T)$, and hence $\mathbb{E}\left[\Pi^T(\underline{u}^B+\varepsilon)\right] > \mathbb{E}\left[\Pi^T(\underline{u}^T)\right]$. Hence, setting the lower bound of $\underline{u}^T$ for the tech-lender is not optimal and there is a profitable deviation.

Suppose instead that $\underline{u}^B > \underline{u}^T$. For any $u' \in (\underline{u}^T, \underline{u}^B)$, $\Pr(u^B \leqslant \underline{u}^T) = \Pr(u^B \leqslant u') = 0$.

$$\mathbb{E}\left[\Pi^T(\underline{u}^T)\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(\underline{u}^T) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(\underline{u}^T)\tau^T(\underline{u}^T)\right)\right] - p_{\varnothing l}$$
$$\mathbb{E}\left[\Pi^T(u')\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u') + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(u')\tau^T(u')\right)\right] - p_{\varnothing l}$$

As $\mathbb{E}\left[\Pi^T(\underline{u}^T)\right] > \mathbb{E}\left[\Pi^T(u')\right]$, the tech-lender does not place any probability on the interval $(\underline{u}^T, \underline{u}^B)$. Since demand is increasing in utility and the offers change continuously, there cannot be a discrete upward jump in profits as the utility offered decreases. We examine the traditional bank's profits on the neighbourhood of $\underline{u}^T$, ie, at $\underline{u}^T + \varepsilon$:

$$\mathbb{E}\left[\Pi^B(\underline{u}^B)\right] = p_{\varnothing\varnothing}\left[(1-z^T)\rho^B(\underline{u}^B) + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}G^T(\underline{u}^B)\tau^B(\underline{u}^B) - \left(1-\frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}$$
$$\mathbb{E}\left[\Pi^B(\underline{u}^T+\varepsilon)\right] = p_{\varnothing\varnothing}\left[(1-z^T)\rho^B(\underline{u}^T+\varepsilon) + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}G^T(\underline{u}^T+\varepsilon)\tau^B(\underline{u}^T+\varepsilon) - \left(1-\frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}$$

Note that as $G^T(\underline{u}^T+\varepsilon) = G^T(\underline{u}^B)$, we have $\mathbb{E}\left[\Pi^T(\underline{u}^B+\varepsilon)\right] > \mathbb{E}\left[\Pi^T(\underline{u}^T)\right]$. Hence, setting the lower bound at $\underline{u}^B$ for the traditional bank is not optimal and there is a profitable deviation.

Therefore, the two lower bounds are equal: $\underline{u} = \underline{u}^B = \underline{u}^T$.

□

Lemma 3. Their lower bound is at $\underline{u} = u^{\min B}$.

Proof. The moral hazard in the problem endogenously limits the minimum utility that each lender will offer to that obtained when borrowers are charged $R^\star$. [27] Recall that $u^{\min j}$ is the utility that a borrower gets from accepting an offer by lender j at $R^\star$. From Equation (4), when both

[27] In models of credit market competition, there is normally an exogenous cap on the interest rate that lenders can request. The rationale for such a restriction is that usury laws or exogenous outside options limit the ability of the lenders to set the interest rate (He et al., 2022). Following the profit function in Equation (6), it is clear that neither lender will offer an interest rate above $R^\star$. As we express competition in terms of the utilities offered to the borrowers, the cap needs to be set accordingly. A cap on the minimum level of utility $\underline{u}$ provides a holistic interpretation of the regulations protecting the borrowers beyond the interest rate caps, such as consumer protection and data privacy. For example, the FCA recently asked FinTech lenders active in the Buy-Now, Pay-Later environment to redraft their terms of use, covering termination, suspension or restriction of access to customer accounts for any reason without notice, as well as cancellation policy.
https://www.ft.com/content/ca428bc8-65c3-49ed-8ba6-0d6f206098aa

lenders offer the same rate, the high-ability borrower derives a higher utility by contracting with the traditional bank. Therefore, as Equation (28) also shows, $u^{\min B} > u^{\min P}$. Hence, for the cap to cover the region where both profits are decreasing on the utility offered (analogous to increasing on the repayment), [28] the lower bound will be at most at the highest of the two: $\underline{u} \geqslant u^{\min B}$. [29]

Suppose that the lower bound is at $\underline{u} > u^{\min B}$, and consider a deviation by the tech-lender to charge $u^{\min B}$.

$$\mathbb{E}\left[\Pi^T(\underline{u})\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(\underline{u}) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(\underline{u})\tau^T(\underline{u})\right)\right] - p_{\varnothing l}$$

$$\mathbb{E}\left[\Pi^T(u^{\min B})\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u^{\min B}) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(u^{\min B})\tau^T(u^{\min B})\right)\right] - p_{\varnothing l}$$

Since there are no mass points in the equilibrium distributions (Lemma 4 below), the tech-lender looses the high-ability customer almost surely at $\underline{u}$, so that $G^B(\underline{u}) = G^B(u^{\min B}) = 0$. But then $\mathbb{E}\left[\Pi^T(\underline{u})\right] < \mathbb{E}\left[\Pi^T(u^{\min B})\right]$, which contradicts the optimality of $\underline{u}$. □

Lemma 4. They are strictly increasing on their supports: they have no gaps and no mass points over the range $(\underline{u}, \overline{u})$.

Proof. Suppose there exits an atom at $u' \in (\underline{u}, \overline{u})$ in the traditional bank's distribution, and denote the size of this mass by $\mu^B(u')$. Recall that when two lenders offer the same utility, the high-ability entrepreneur randomizes between them. Hence, the tech-lender's probability of winning a high-ability entrepreneur if it also offers u' is $\Pr(u^B < u') + \mu^B(u')/2$. [30]

$$\mathbb{E}\left[\Pi^T(u')\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u') + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}\left(\Pr(u^B < u') + \frac{\mu^B(u')}{2}\right)\tau^T(u')\right)\right] - p_{\varnothing l}$$

The number of mass points in any probability distribution must be countable, so that we can find an arbitrarily small ε such that $u' \pm \varepsilon$ is offered with zero probability. We can write the profits of the tech-lender at both sides of the traditional bank's mass point as:

$$\mathbb{E}\left[\Pi^T(u'+\varepsilon)\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u'+\varepsilon) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}\Pr(u^B \leqslant u'+\varepsilon)\tau^T(u'+\varepsilon)\right)\right] - p_{\varnothing l}$$

$$\mathbb{E}\left[\Pi^T(u'-\varepsilon)\right] = p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u'-\varepsilon) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}\Pr(u^B \leqslant u'-\varepsilon)\tau^T(u'-\varepsilon)\right)\right] - p_{\varnothing l}$$

Taking limits, we have:

$$\begin{aligned}
\lim_{\varepsilon\to 0}\mathbb{E}\left[\Pi^T(u'+\varepsilon)\right] &= p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u') + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}\lim_{\varepsilon\to 0}\Pr(u^B \leqslant u'+\varepsilon)\tau^T(u')\right)\right] - p_{\varnothing l}\\
&= p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u') + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}\left(\Pr(u^B < u') + \mu^B(u')\right)\tau^T(u')\right)\right] - p_{\varnothing l} > \mathbb{E}\left[\Pi^T(u')\right]\\
\lim_{\varepsilon\to 0}\mathbb{E}\left[\Pi^T(u'-\varepsilon)\right] &= p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u') + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}\lim_{\varepsilon\to 0}\Pr(u^B \leqslant u'-\varepsilon)\tau^T(u')\right)\right] - p_{\varnothing l}\\
&= p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(u') + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}\Pr(u^B < u')\tau^T(u')\right)\right] - p_{\varnothing l} < \mathbb{E}\left[\Pi^T(u')\right]
\end{aligned}$$

[28] Lenders will compete in the region of repayment rates between where they make zero profits (break-even rate) and where they maximize profits ($R^\star$). In this region, profits are increasing in the repayments.

[29] An additional interpretation of this restriction could rely on a rigid status quo before tech-lender entry or an exogenous outside option available to borrowers.

[30] In this proof I use the definition of a CDF to explicitly signal where the mass point plays a role.

$$G^j(u) = \Pr(u^j \leqslant u) = \Pr(u^j < u) + \Pr(u^j = u) = \Pr(u^j < u) + \mu^j(u)$$

Therefore, the tech-lender has a profitable deviation to move the mass placed at u' to $u' + \varepsilon$, and it will not place any probability in the interval $(u' - \varepsilon, u')$. But this means that for the traditional bank it is no longer optimal to have a mass at u', as at $u' - \varepsilon$ it makes higher profits with the same probability as in u' of being the highest offer. This last reasoning also implies that the distributions have no gaps, as the rival lender would find it optimal to have a mass point, but these are ruled out.

We can apply a similar reasoning to the tech-lender's strategy. Suppose there exits an atom at $u' \in (\underline{u}, \overline{u})$ in the tech-lender's distribution, and denote the size of this mass by $\mu^T(u')$. The traditional bank's probability of winning a high ability entrepreneur if it also offers u' is $\Pr(u^T < u') + \mu^T(u')/2$. The associated profits are:

$$\mathbb{E}\left[\Pi^B(u')\right] = p_{\varnothing\varnothing}\left[(1 - z^T)\rho^B(u') + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}\Big(\Pr(u^T < u') + \mu^T(u')\Big)\tau^B(u') - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}$$

Just as before, the number of mass points in any probability distribution must be countable, so that we can find an arbitrarily small ε such that $u' \pm \varepsilon$ is offered with zero probability. We can write the profits of the traditional bank at both sides of the tech-lender's mass point as:

$$\mathbb{E}\left[\Pi^B(u' + \varepsilon)\right] = p_{\varnothing\varnothing}\left[(1 - z^T)\rho^B(u' + \varepsilon) + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}\Pr(u^T \leqslant u' + \varepsilon)\tau^B(u' + \varepsilon) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}$$
$$\mathbb{E}\left[\Pi^B(u' - \varepsilon)\right] = p_{\varnothing\varnothing}\left[(1 - z^T)\rho^B(u' - \varepsilon) + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}\Pr(u^T \leqslant u' - \varepsilon)\tau^B(u' - \varepsilon) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}$$

Taking limits, we have:

$$\begin{aligned}\lim_{\varepsilon \to 0}\mathbb{E}\left[\Pi^B(u' + \varepsilon)\right] &= p_{\varnothing\varnothing}\left[(1 - z^T)\rho^B(u') + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}\Big(\Pr(u^T < u') + \mu^T(u')\Big)\tau^B(u') - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}\\ &> \mathbb{E}\left[\Pi^B(u')\right]\\ \lim_{\varepsilon \to 0}\mathbb{E}\left[\Pi^B(u' - \varepsilon)\right] &= p_{\varnothing\varnothing}\left[(1 - z^T)\rho^B(u') + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}\Pr(u^T < u')\tau^B(u') - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}\\ &< \mathbb{E}\left[\Pi^B(u')\right]\end{aligned}$$

The traditional bank has a profitable deviation to move the mass placed at u' to $u' + \varepsilon$, and it will not place any probability in the interval $(u' - \varepsilon, u')$. But this means that for the tech-lender it is no longer optimal to have a mass at u', as at $u' - \varepsilon$ it makes higher profits with the same probability as in u' of being the highest offer. □

B.4 Proof for Lemma 1

Proof. Suppose otherwise and assume that the equilibrium profits for the two lenders are strictly positive. In this candidate equilibrium the two lenders will always offer credit upon seeing an empty signal, so that $z^B = z^T = 1$. Profits must be constant along the support of the utility distribution. Evaluating the profit for both lenders at the lower bound:

$$\mathbb{E}\left[\Pi^T(\underline{u})\right] = p_{\varnothing\varnothing}\left[\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(\underline{u})\tau^T(\underline{u})\right)\right] - p_{\varnothing l} \equiv K^T$$
$$\mathbb{E}\left[\Pi^B(\underline{u})\right] = p_{\varnothing\varnothing}\left[\left(\frac{\theta}{p_{\varnothing\varnothing}}G^T(\underline{u})\tau^B(\underline{u}) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing} \equiv K^B$$

By definition, $G^j(\underline{u}) = 0$ $j = \{B, T\}$, but to make this equation hold for u close to $\underline{u}$, both lenders need to place a mass point. However, both lenders cannot have an atom at the same point, as following the proof of Lemma 4 there would be a profitable deviation. This contradicts the players being in equilibrium, hence there cannot be an equilibrium where both players make positive expected profits. □

B.5 Proof for Proposition 5

Proof. Denote the upper bound of the utility distribution in candidate equilibrium 1 as $\overline{u}^{T1}$. The threshold level of monitoring intensity that separates monopoly from competition is the one that equates the utility that the entrepreneur gets when the traditional bank offers its profit maximizing utility with the maximum utility the tech-lender can offer. Therefore, we use $\overline{u}^{T1}$ and compare it against $u^{\min B}$:

$$\overline{u}^{T1} = u^{\min B}(\underline{m}^B)$$

For values $m^B < \underline{m}^T$, we get that $\overline{u}^{T1} < u^{\min B}$, while for values $m^B \geqslant \underline{m}^T$, we get that $\overline{u}^{T1} \geqslant u^{\min B}$. □

At the point $\underline{m}^B$, the traditional bank stops being a monopolist and starts competing with the tech-lender. Therefore, an alternative derivation of $\underline{m}^B$ is to look for the values of the bank's monitoring intensity where the traditional bank's monopoly profits and competition profits intersect. This can be seen in Figure 9 below. The green straight line represents the profits of the traditional bank when it is in a monopoly position. The blue parabola represents the equilibrium profits from candidate equilibrium 1. Both profits intersect at the point $\underline{m}^B$.

$$\mathbb{E}[\Pi^{\text{mon }B}](\underline{m}^B) = K^{B1}(\underline{m}^B)$$

$$\frac{1}{2}\left[\theta\left(A\frac{m^B}{2}-1\right)-1\right] = p_{\varnothing\varnothing}\left[(1-z^{T1}(\underline{m}^B))\rho^B(\underline{u}^B(\underline{m}^B),\underline{m}^B) - z^{T1}(\underline{m}^B)\left(1-\frac{\theta}{p_{\varnothing\varnothing}}\right)\right] - p_{l\varnothing}$$

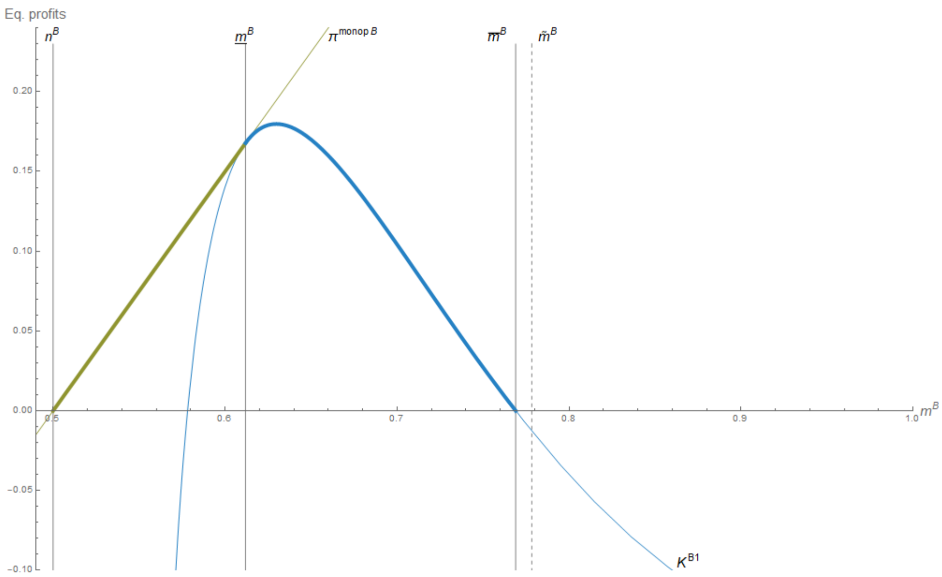


Figure 9: Traditional bank's equilibrium profits from candidate equilibrium 1
Parameters: $A_h = 12, \theta = 0.5, \sigma^T = 0.6$

B.6 Proof for Proposition 6

Proof. To find $\overline{m}^B$, I solve for the level of monitoring intensity of the traditional bank that makes the profits of the traditional bank from candidate equilibrium 2 equal to zero. $\overline{m}^B$ is the largest real root of:

$$K^{B1} = p_{\varnothing\varnothing}\left[(1-z^{T1}(\overline{m}^B))\rho^B(\underline{u}^B(\overline{m}^B),\overline{m}^B) - z^{T1}(\overline{m}^B)\left(1-\frac{\theta}{p_{\varnothing\varnothing}}\right)\right] - p_{l\varnothing} = 0$$

□

B.7 Proof for Proposition 7

Proof. To find $\tilde{m}^B$, I solve for the level of monitoring intensity of the traditional bank that makes the profits of the tech-lender from candidate equilibrium 1 equal to zero.

$$K^{T2} = p_{\varnothing\varnothing}(1 - z^{B2}(\tilde{m}^B))\rho^T(\underline{u}^B(\tilde{m}^B)) - p_{\varnothing l} = 0$$

The equation cannot be solved analytically. We can, however, perform numerical simulations. The root solver requires an initial guess. Given that when $\sigma^T = 1$, $\tilde{m}^B(\sigma^T = 1) = \overline{m}^B(\sigma^T = 1)$, I use $\overline{m}^B$ as the initial guess.

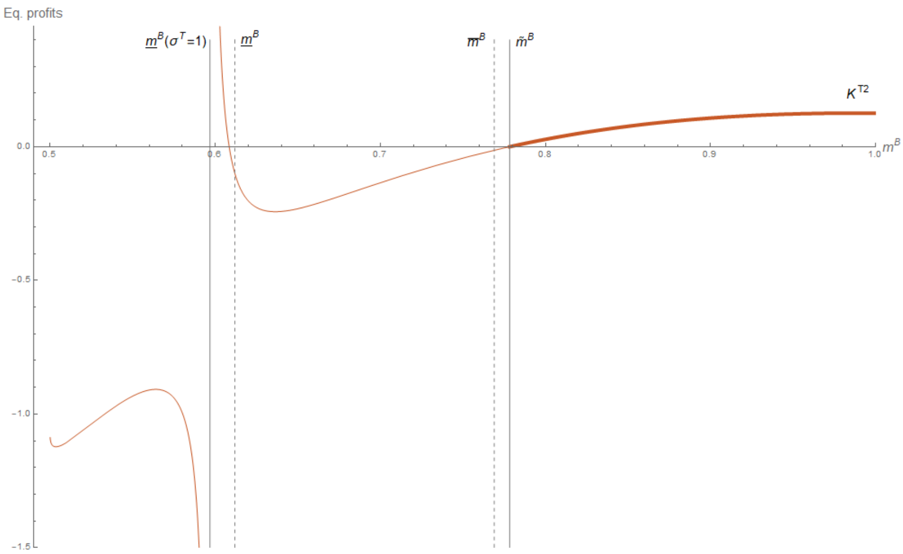


Figure 10: Tech-lender's equilibrium profits from candidate equilibrium2
Parameters: $A_h = 12, \theta = 0.5, \sigma^T = 0.6$

□

B.8 Market breakdown

As Figure 3 depicts, there is a region between $\overline{m}^B$ and $\tilde{m}^B$ where neither of the proposed candidate equilibria arise. To better understand the dynamics in this region, consider the profits that each intermediary derives at the upper bound of the utility distribution:

$$\begin{aligned}
\mathbb{E}\left[\Pi^T(\overline{u})\right] &= p_{\varnothing\varnothing}\left[(1-z^B)\rho^T(\overline{u}) + z^B\left(\frac{\theta}{p_{\varnothing\varnothing}}G^B(\overline{u})\tau^T(\overline{u})\right)\right] - p_{\varnothing l} \\
\mathbb{E}\left[\Pi^B(\overline{u})\right] &= p_{\varnothing\varnothing}\left[(1-z^T)\rho^B(\overline{u}) + z^T\left(\frac{\theta}{p_{\varnothing\varnothing}}G^T(\overline{u})\tau^B(\overline{u}) - \left(1 - \frac{\theta}{p_{\varnothing\varnothing}}\right)\right)\right] - p_{l\varnothing}
\end{aligned}$$

Using the definitions in Equations (9) and (10), as well as $G^j(\overline{u}) = 1$, we can re-arrange the terms to find the following expressions:

$$\mathbb{E}\left[\Pi^T(\overline{u}^T)\right] = \theta\tau^T(\overline{u}^{T1}) - p_{\varnothing\ell} - (1-z^B)p_{\varnothing\ell} \geqslant 0 \tag{29}$$

$$\mathbb{E}\left[\Pi^B(\overline{u}^B)\right] = \theta\tau^B(\overline{u}^B) + \theta - p_{\varnothing\varnothing} - p_{\varnothing\ell} \geqslant 0 \tag{30}$$

Equations (29) and (30) provide some insight as to why there may exist a region where competition results in market breakdown. Equation (30) represents the minimum profits that the traditional bank can make. These profits are independent of the strategy that the tech-lender plays (they do not depend on the probability z^T). The reason is that, since the traditional bank will always attract the low-ability borrowers, the strategy of the tech-lender does not play a role in calculating the traditional bank's break-even utility. Therefore, the break-even utility is the same for the traditional bank both in candidate equilibria 1 and 2.

Equation (29) represents the profits that the tech-lender makes when it offers the highest utility possible. In this case, the probability that the traditional bank makes an offer does impact the utility at which the tech-lender breaks-even. Therefore, in candidate equilibrium 1 (where the traditional bank makes profits so it always makes an offer, $z^{B1} = 1$), the maximum utility that the tech-lender can offer is higher than that it could offer if the traditional bank did not participate. The reason is that when the traditional bank makes an offer, the tech-lender is sure to only capture high-ability entrepreneurs, so it can make more attractive offers to the borrowers (higher $\bar{u}^T$).

Denote the tech-lender's break-even rate in candidate equilibrium 1 as $\bar{u}^{T1}$ and in candidate equilibrium 2 as $\bar{u}^{T2}$. From Equation (29), since $z^B \in [0,1]$, we can see that $\bar{u}^{T1} \leqslant \bar{u}^{T2}$.

$$\begin{aligned}
\mathbb{E}\left[\Pi^T(\bar{u}^{T1})\right] &= \theta\tau^T(\bar{u}^{T1}) - p_{\varnothing\ell} && \geqslant 0 \\
\mathbb{E}\left[\Pi^T(\bar{u}^{T2})\right] &= \theta\tau^T(\bar{u}^{T2}) - p_{\varnothing\ell} - (1 - z^{B2})p_{\varnothing\ell} && \geqslant 0
\end{aligned}$$

The last part of Equation (29), namely $(1-z^B) \times p_{\varnothing\ell}$, drives any difference between $\bar{u}^{T1}$ and $\bar{u}^{T2}$. [31] It represents the joint probability of the traditional bank not making an offer when the tech-lender makes an offer, which can happen either because the traditional bank is randomizing when it sees an uninformative signal $(1 - z^B)$, or because it observes a low signal when the tech-lender observes an uninformative signal $(p_{\varnothing\ell})$.

If we analyze the role of m^B in each of these break-even utilities, we can see that:

- Low monitoring $m^B \in \left(n^B, \bar{m}^B\right)$: $\bar{u}^{T1} = \bar{u}^{T2} < \bar{u}^B$. The traditional bank can offer a higher utility while breaking-even, so the relevant comparison is that between $\bar{u}^{T1}$ and $\bar{u}^B$.
- High monitoring $m^B \in \left(\tilde{m}^B, 1\right)$: $\bar{u}^B < \bar{u}^{T2} < \bar{u}^{T1}$. The tech-lender can offer a higher utility while breaking-even, so the relevant comparison is that between $\bar{u}^{T2}$ and $\bar{u}^B$.
- Intermediate monitoring $m^B \in \left(\bar{m}^B, \tilde{m}^B\right)$: $\bar{u}^{T2} < \bar{u}^B < \bar{u}^{T1}$. By randomizing when it makes an offer, the traditional bank is able to offer a higher break-even utility than the tech-lender $\bar{u}^B > \bar{u}^{T2} > \bar{u}^{T1}$, but then the traditional bank will make positive expected profits and randomizing would no longer be a best response. In such a case, when the traditional bank always makes an offer, and so the tech-lender will never face the low-ability entrepreneurs, so that the relevant comparison is between $\bar{u}^B < \bar{u}^{T1}$, which signals that the traditional bank can no longer make positive expected profits, as the tech-lender is able to offer higher break-even utility.

The two asymmetries in this model contribute to generate the market break-down.

1. To better understand the role of competition in creating this market break-down, we can compare the outcome with other market structures.
   - For example, as shown in Corollary 7, in the case when the traditional bank acts as a monopolist, equilibrium profits monotonically increases with the monitoring technology. In case the tech-lender is a monopoly, its profits are are independent of m^B.

[31] The utility that makes the tech-lender break-even in candidate equilibrium 1 does not depend on monitoring.

– Alternatively, consider the case of a duopoly where both lenders are identical in their monitoring intensity. In this case, the low-ability entrepreneur no longer has a preference for the traditional bank, and the expected profit functions are:

$$\mathbb{E}\left[\Pi^T(u)\right] = p_{\varnothing\varnothing}\left[1 - z^B + z^B G^B(u)\right]\rho^T(u) - p_{\varnothing\ell}$$
$$\mathbb{E}\left[\Pi^B(u)\right] = p_{\varnothing\varnothing}\left[1 - z^T + z^T G^T(u)\right]\rho^B(u) - p_{\ell\varnothing}$$

This case is analogous to He et al., 2022, where the winner's curse manifests itself as a higher cost of lending. Therefore, the lender with the lower costs will make positive expected profits, while the lender with the higher costs will break-even in expectations.

2. Furthermore, imperfect information also plays a role in this market break-down. In particular, when $\sigma^T = 1$, the interval of market break-down disappears. This is because, by having perfect information on the type of borrower, the tech-lender is no longer exposed to winner's curse, so that it no longer needs to randomize to hedge against it.

C Proofs for the comparative statics results

C.1 Proof to Corollary 1

Recall that:

$$z^{T1} = \frac{\rho^B(u^{\min B}) - \rho^B(\overline{u}^T)}{\rho^B(u^{\min B}) - \rho^B(\overline{u}^T) + \theta\tau^B(\overline{u}^T)/p_{\varnothing\varnothing}} = \frac{e^B(u^{\min B})R^B(u^{\min B}) - e^B((\overline{u}^T)R^B((\overline{u}^T)}{e^B(u^{\min B})R^B(u^{\min B}) - 1}$$

Let us first focus on the comparative statics for the proportion of high-ability types and the tech-lender's screening technology, as these parameters do not enter the effort or repayment functions directly.

$$\begin{aligned}\frac{\partial z^{T1}}{\partial x} =& \frac{1}{\tau^B(u^{\min B})^2}\left[\frac{\partial u^{\min B}}{\partial x}\left(\frac{\partial e^B(u^{\min B})}{\partial u^{\min B}}R^B(u^{\min B}) + \frac{\partial R^B(u^{\min B})}{\partial u^{\min B}}e^B(u^{\min B})\right)\left(e^B(\overline{u}^T)R^B(\overline{u}^T) - 1\right)\right.\\ &\left. - \frac{\partial \overline{u}^T}{\partial x}\left(\frac{\partial e^B(\overline{u}^T)}{\partial \overline{u}^T}R^B(\overline{u}^T) + \frac{\partial R^B(\overline{u}^T)}{\partial \overline{u}^T}e^B(\overline{u}^T)\right)\left(e^B(u^{\min B})R^B(u^{\min B}) - 1\right)\right]\end{aligned}$$

The comparative statics with respect to the probability of making an offer rely on the following identity:

$$\frac{\partial e^B(u)}{\partial u}R^B(u) + \frac{\partial R^B(u)}{\partial u}e^B(u) = \frac{\partial R^B(u)}{\partial u}\left(-\frac{m^B}{A}R^B(u) + e^B(u)\right) = \frac{\partial R^B(u)}{\partial u}\left(2\sqrt{\frac{2m^B}{A}u - 1} - m^B\right)$$

Where the element inside the parenthesis is zero when $u = u^{\min B}$ and positive in $u \in (u^{\min B}, \overline{u}^T)$. This means that the sign of the comparative statics reduce to the sign of the derivative of $\partial \overline{u}^T/\partial x$:

$$\frac{\partial z^{T1}}{\partial x} = -\underbrace{\frac{1}{\tau^B(u^{\min B})}}_{+}\frac{\partial \overline{u}^T}{\partial x}\underbrace{\frac{\partial R^B(\overline{u}^T)}{\partial \overline{u}^T}}_{-}\left(\underbrace{e^B(\overline{u}^T) - \frac{m^B}{A}R^B(\overline{u}^T)}_{+}\right)$$

$$\text{sign}\left\{\frac{\partial z^{T1}}{\partial \theta}\right\} = \text{sign}\left\{\frac{\partial \overline{u}^T}{\partial \theta}\right\} > 0$$

$$\text{sign}\left\{\frac{\partial z^{T1}}{\partial \sigma^T}\right\} = \text{sign}\left\{\frac{\partial \overline{u}^T}{\partial \sigma^T}\right\} > 0$$

The comparative statics for the monitoring intensity are as follows:

$$\begin{aligned}
\frac{\partial z^{T1}}{\partial m^B} &= \frac{1}{\tau^B(u^{\min B})^2}\times \\
&\Bigg[\tau^B(\overline{u}^T)\Bigg[\left(\frac{\partial e^B(u^{\min B})}{\partial u^{\min B}}\frac{\partial u^{\min B}}{\partial m^B}+\frac{\partial e^B(u)}{\partial m^B}|_{u^{\min B}}\right)R^B(u^{\min B}) \\
&\quad+\left(\frac{\partial R^B(u^{\min B})}{\partial u^{\min B}}\frac{\partial u^{\min B}}{\partial m^B}+\frac{\partial R^B(u)}{\partial m^B}|_{u^{\min B}}\right)e^B(u^{\min B})\Bigg] \\
&-\tau^B(u^{\min B})\Bigg[\left(\frac{\partial e^B(\overline{u}^T)}{\partial \overline{u}^T}\frac{\partial \overline{u}^T}{\partial m^B}+\frac{\partial e^B(u)}{\partial m^B}|_{\overline{u}^T}\right)R^B(\overline{u}^T)+\left(\frac{\partial R^B(\overline{u}^T)}{\partial \overline{u}^T}\frac{\partial \overline{u}^T}{\partial m^B}+\frac{\partial R^B(u)}{\partial m^B}|_{\overline{u}^T}\right)e^B(\overline{u}^T)\Bigg]\Bigg] \\
&= \frac{1}{\tau^B(u^{\min B})^2}\left[\tau^B(\overline{u}^T)\frac{\partial e^B(u^{\min B})}{\partial m^B}R^B(u^{\min B})-\tau^B(u^{\min B})\left(\frac{\partial e^B(\overline{u}^T)}{\partial m^B}R^B(\overline{u}^T)+\frac{\partial R^B(\overline{u}^T)}{\partial m^B}e^B(\overline{u}^T)\right)\right]
\end{aligned}$$

From simulations, we can say that the sign of the derivative is positive. An example can be seen in Figure 4a.

C.2 Proof to Corollary 2

Industry profits in candidate equilibrium 1 are traditional bank's profits. We can rewrite them so that:

$$\begin{aligned}
K^{B1} &= p_{\varnothing\varnothing}\left[(1-z^{T1})\rho^B(u^{\min B})-z^{T1}\left(1-\frac{\theta}{p_{\varnothing\varnothing}}\right)\right]-p_{l\varnothing} \\
&= \theta e^B(u^{\min B})R^B(u^{\min B})-z^{T1}\theta\tau^B(u^{\min B})-\frac{1+\theta}{2}
\end{aligned}$$

The comparative statics for the screening accuracy and the proportion of high-ability types are as follows:

$$\begin{aligned}
\frac{\partial K^{B1}}{\partial \theta} &= \tau^B(u^{\min B})\left(1-z^{T1}-\frac{\partial z^{T1}}{\partial \theta}\theta\right)+\frac{1}{2}>0 \\
\frac{\partial K^{B1}}{\partial \sigma^T} &= -\frac{\partial z^{T1}}{\partial \sigma^T}\theta\tau^B(u^{\min B})<0
\end{aligned}$$

From simulations, we can see that the sign of the comparative statics with respect to the proportion of high-ability entrepreneurs is positive.

The direction of the comparative statics of profits with respect to the monitoring intensity is as follows:

$$\begin{aligned}
\frac{\partial K^{B1}}{\partial m^B} &= \theta\frac{\partial e^B(u^{\min B})R^B(u^{\min B})}{\partial m^B}-\theta\frac{\partial z^{T1}}{\partial m^B}\tau^B(u^{\min B})-\theta z^{T1}\frac{\partial e^B(u^{\min B})R^B(u^{\min B})}{\partial m^B} \\
&= \theta\left[R^B(u^{\min B})\frac{\partial e^B(u^{\min B})}{\partial m^B}(1-z^{T1})-\tau^B(u^{\min B})\frac{\partial z^{T1}}{\partial m^B}\right] \\
&= \frac{\theta}{4}\left[A(1-z^{T1})-\frac{\partial z^{T1}}{\partial m^B}(Am^B-4)\right]\gtrless 0
\end{aligned}$$

For values of the monitoring intensity close to $\underline{m}^B(\sigma^T)$ the sign of this derivative is positive: an increase in the monitoring intensity increases traditional bank's profits. However, for higher values the sign turns negative: an increase in the monitoring intensity of the traditional bank decreases its profits. These dynamics are depicted in Figure 4b.

C.3 Proof to Corollary 3

$$
\begin{aligned}
G^{B1}(u) &= \frac{p_{\varnothing l}}{\theta\tau^T(u)} = \frac{1}{2\tau^T(u)}\frac{1-\theta}{\theta(1-\sigma^T)} \\
G^{T1}(u) &= \frac{K^B + p_{l\varnothing} - p_{\varnothing\varnothing}(1-z^{T1})\rho^B(u) + z^{T1}(p_{\varnothing\varnothing}-\theta)}{\theta z^{T1}\tau^B(u)} \\
&= \frac{K^B - \theta(1-z^{T1})\tau^B(u) + (1-\theta)/2}{\theta z^{T1}\tau^B(u)}
\end{aligned}
$$

The comparative statics for $G^{B1}(u)$ are straightforward:

$$
\begin{aligned}
\frac{\partial G^{B1}}{\partial\theta} &= -\frac{1-\sigma^T}{2\theta^2\tau^T(u)} < 0 \\
\frac{\partial G^{B1}}{\partial m^B} &= 0 \\
\frac{\partial G^{B1}}{\partial\sigma^T} &= -\frac{1-\theta}{2\theta\tau^T(u)} < 0
\end{aligned}
$$

For the tech-lender's distribution $G^{T1}(u)$ the comparative statics are more elaborate:

$$
\begin{aligned}
\frac{\partial G^{T1}(u)}{\partial\theta} &= \frac{1}{\tau^B(u)\big(\theta z^{T1}\big)^2}\Bigg[\left(\frac{\partial K^{B1}}{\partial\theta} - \tau^B(u)\left(1 - z^{T1} - \theta\frac{\partial z^{T1}}{\partial\theta}\right) - \frac{1}{2}\right)\theta z^{T1} \\
&\quad - \big(K^{B1} - \theta(1-z^{T1})\tau^B(u) + (1-\theta)/2\big)\left(z^{T1} + \theta\frac{\partial z^{T1}}{\partial\theta}\right)\Bigg] \\
&= -\underbrace{\frac{1}{\tau^B\big(z^{T1}\big)^2}}_{+}\underbrace{\frac{\partial z^{T1}}{\partial\theta}}_{+}\Bigg(\underbrace{\tau^B(u^{\min B}) - \tau^B(u)}_{+}\Bigg) < 0 \\
\frac{\partial G^{T1}(u)}{\partial\sigma^T} &= \frac{1}{\theta\tau^B(u)\big(z^{T1}\big)^2}\left[\left(\frac{\partial K^{B1}}{\partial\sigma^T} + \frac{\partial z^{T1}}{\partial\sigma^T}\theta\tau^B(u)\right)z^{T1} - \big(K^{B1} - \theta(1-z^{T1})\tau^B(u) + (1-\theta)/2\big)\frac{\partial z^{T1}}{\partial\sigma^T}\right] \\
&= \underbrace{\frac{\partial z^{T1}/\partial\sigma^T}{\theta\tau^B(u)\big(z^{T1}\big)^2}}_{+}\Bigg[\underbrace{z^{T1}\theta}_{+}\Bigg(\underbrace{\tau^B(u) - \tau^B(u^{\min B})}_{-}\Bigg) - \Bigg(\underbrace{K^{B1} - \theta(1-z^{T1})\tau^B(u) + (1-\theta)/2}_{+}\Bigg)\Bigg] < 0
\end{aligned}
$$

The comparative statics for $G^{T1}(u)$ rely on the previous comparative statics for z^{T1} and K^{B1}.

$$
\begin{aligned}
\frac{\partial G^{T1}(u)}{\partial m^B} &= \frac{1}{\theta\big(\tau^B(u)z^{T1}\big)^2}\Bigg[\left(\frac{\partial K^{B1}}{\partial m^B} - \theta\left(\frac{\partial\tau^B(u)}{\partial m^B}(1-z^{T1}) - \tau^B(u)\frac{\partial z^T}{\partial m^B}\right)\right)z^{T1}\tau^B(u) \\
&\quad - \big(K^B - \theta(1-z^{T1})\tau^B(u) + (1-\theta)/2\big)\left(\frac{\partial\tau^B(u)}{\partial m^B}z^{T1} + \tau^B(u)\frac{\partial z^T}{\partial m^B}\right)\Bigg] \\
&= \frac{1}{\theta\big(\tau^B(u)z^{T1}\big)^2}\left[\tau^B(u)\left(z^{T1}\frac{\partial K^{B1}}{\partial m^B} + \theta\tau^B(u)\frac{\partial z^{T1}}{m^B}\right) - \left(K^{B1} + \frac{1-\theta}{2}\right)\left(z^{T1}\frac{\partial\tau^B(u)}{\partial m^B} + \tau^B(u)\frac{\partial z^{T1}}{m^B}\right)\right]
\end{aligned}
$$

The sign of the comparative statics for $G^{T1}(u)$ depend on the level of utility. An example can be seen in Figure 5.

C.4 Proof to Corollary 4

To expand and give intuition on Corollary 4, recall that Equation (20) can be rewritten as:

$$\begin{aligned} z^{B2} &= \frac{p_{\varnothing\varnothing}\rho^T(u^{\min B}) - p_{\varnothing\varnothing}\rho^T(\overline{u}^B)}{p_{\varnothing\varnothing}\rho^T(u^{\min B}) - p_{\varnothing\varnothing}\rho^T(\overline{u}^B) + \theta\tau^T(\overline{u}^B)} \\ &= \frac{\theta}{\theta}\frac{e^T(u^{\min B})R^T(u^{\min B}) - e^T(\overline{u}^B)R^T(\overline{u}^B)}{e^T(u^{\min B})R^T(u^{\min B}) - 1} \end{aligned}$$

Here we can see that the traditional bank's probability of making an offer is not affected by changes in the tech-lender's screening accuracy. [32]

Let x denote the parameter with respect to which we want to calculate the comparative statics.

$$\frac{\partial z^{B2}}{\partial x} = \frac{\frac{\partial\left[e^T(u^{\min B})R^T(u^{\min B})\right]}{\partial x}\left(e^T(\overline{u}^B)R^T(\overline{u}^B) - 1\right) - \frac{\partial\left[e^T(\overline{u}^B)R^T(\overline{u}^B)\right]}{\partial x}\left(e^T(u^{\min B})R^T(u^{\min B}) - 1\right)}{\left(e^T(u^{\min B})R^T(u^{\min B}) - 1\right)^2}$$

Let us first focus on the effect of an increase in the proportion of high-ability entrepreneurs θ, which only enters through the second term of the numerator $e^T(\overline{u}^B)R^T(\overline{u}^B)$.

$$\text{sign}\left\{\frac{\partial z^{B2}}{\partial\theta}\right\} = \text{sign}\left\{-\frac{\partial[e^T(\overline{u}^B)R^T(\overline{u}^B)]}{\partial\theta}\right\} = \text{sign}\left\{-\underbrace{\frac{\partial\overline{u}^B}{\partial\theta}}_{+}\left(\underbrace{\frac{\partial e^T(\overline{u}^B)}{\partial\overline{u}^B}}_{+}\underbrace{R^T(\overline{u}^B)}_{+} + \underbrace{\frac{\partial R^T(\overline{u}^B)}{\partial\overline{u}^B}}_{-}\underbrace{e^T(\overline{u}^B)}_{+}\right)\right\}$$

Every term in the derivative is positive except for $\partial R^T(\overline{u}^B)/\partial\overline{u}^B$: when there are more high-ability entrepreneurs, the utility at which the traditional bank makes zero profits is higher, and the higher utility raises the level of effort. However, a higher utility offered to the entrepreneur implies a lower repayment rate for the lender. This second effect dominates the previous two. Hence, overall a higher proportion of high-ability entrepreneurs increases the probability with which the traditional bank makes an offer.

For the comparative static with respect to the monitoring intensity, we can adapt the formula for $\partial z^{B2}/\partial x$.

$$\begin{aligned} \text{sign}\left\{\frac{\partial z^{B2}}{\partial m^B}\right\} &= \left\{\frac{\partial(e^T(u^{\min B})R^T(u^{\min B}))}{\partial m^B} - \frac{\partial(e^T(\overline{u}^B)R^T(\overline{u}^B))}{\partial m^B}\right\} \\ &= \left\{\underbrace{\frac{\partial u^{\min B}}{\partial m^B}}_{-}\left(\underbrace{\frac{\partial e^T(u^{\min B})}{\partial u^{\min B}}R^T(u^{\min B}) + \frac{\partial R^T(u^{\min B})}{\partial u^{\min B}}e^T(u^{\min B})}_{-}\right)\right. \\ &\quad \left. - \underbrace{\frac{\partial\overline{u}^B}{\partial m^B}}_{\pm}\left(\underbrace{\frac{\partial e^T(\overline{u}^B)}{\partial\overline{u}^B}R^T(\overline{u}^B) + \frac{\partial R^T(\overline{u}^B)}{\partial\overline{u}^B}e^T(\overline{u}^B)}_{-}\right)\right\} \end{aligned}$$

The second term dominates the effect for most of the values of m^B, and the key is the direction of change of the upper bound $\overline{u}^B$ as the monitoring intensity changes. For most values of the traditional bank's monitoring intensity, this effect is negative: as the traditional bank becomes a

[32] Recall that the screening accuracy does not directly impact the level of effort or the repayment amount, and from Equation (24) it does not impact the upper bound of the distribution either.

better monitor, this has a negative effect on the entrepreneur's utility. Consequently, the maximum utility that the entrepreneur can get decreases. However, for values of the monitoring intensity very close to one, the traditional bank and the tech-lender are very similar, which intensifies competition and forces the traditional bank to offer a higher upper bound $\overline{u}^B$. Consequently, the derivative of $\partial \overline{u}^B / \partial m^B$ turns positive. Figure 7b provides an example of this situation.

C.5 Proof to Corollary 5

Recall that:

$$K^{T2} = p_{\emptyset\emptyset}(1 - z^{B2})\rho^T(u^{\min B}) - p_{\emptyset l}$$

To expand and give intuition on Corollary 5, let x be the variable against which the comparative statics of Equation (19) will be calculated:

$$\frac{\partial K^{T2}}{\partial x} = \frac{\partial p_{\emptyset\emptyset}}{\partial x}(1 - z^{B2})\rho^T(u^{\min B}) - \frac{\partial z^{B2}}{\partial x} p_{\emptyset\emptyset}\rho^T(u^{\min B}) + \frac{\partial \rho^T(u^{\min B})}{\partial x} p_{\emptyset\emptyset}(1 - z^{B2}) - \frac{\partial p_{\emptyset l}}{\partial x}$$

Let us first focus on the impact of the screening accuracy on tech-lender's equilibrium profits. In what follows we will use that, $\partial z^{B2}/\partial \sigma^T = 0$ and from Equations (7), the following is true $\partial p_{\emptyset\emptyset}/\partial \sigma^T = \partial p_{\emptyset l}/\partial \sigma^T = -(1-\theta)/2$.

$$\begin{aligned}
\frac{\partial K^{T2}}{\partial \sigma^T} &= \frac{\partial p_{\emptyset\emptyset}}{\partial \sigma^T}(1 - z^{B2})\rho^T(u^{\min B}) + \frac{\partial \left(\theta e^T(u^{\min B})R^T(u^{\min B})/p_{\emptyset\emptyset} - 1\right)}{\partial \sigma^T} p_{\emptyset\emptyset}(1 - z^{B2}) - \frac{\partial p_{\emptyset l}}{\partial \sigma^T} \\
&= \frac{\partial p_{\emptyset\emptyset}}{\partial \sigma^T}\left[(1 - z^{B2})\rho^T(u^{\min B}) - 1\right] + \frac{\partial \left(\theta e^T(u^{\min B})R^T(u^{\min B})/p_{\emptyset\emptyset} - 1\right)}{\partial \sigma^T} p_{\emptyset\emptyset}(1 - z^{B2}) \\
&= \frac{\partial p_{\emptyset\emptyset}}{\partial \sigma^T}\left[(1 - z^{B2})\rho^T(u^{\min B}) - 1\right] + \frac{\partial (1/p_{\emptyset\emptyset})}{\partial \sigma^T}\theta\left(e^T(u^{\min B})R^T(u^{\min B})\right) p_{\emptyset\emptyset}(1 - z^{B2}) \\
&= \frac{\partial p_{\emptyset\emptyset}}{\partial \sigma^T}\left[(1 - z^{B2})\left(\theta e^T(u^{\min B})R^T(u^{\min B})/p_{\emptyset\emptyset} - 1\right) - 1 - (1 - z^{B2})\theta e^T(u^{\min B})R^T(u^{\min B})/p_{\emptyset\emptyset}\right]
\end{aligned}$$

$$\frac{\partial K^{T2}}{\partial \sigma^T} = \frac{\partial p_{\emptyset\emptyset}}{\partial \sigma^T}(z^{B2} - 2) > 0$$

For the impact from the proportion of high-ability entrepreneurs, the effect seems ambiguous:

$$\frac{\partial K^{T2}}{\partial \theta} = \underbrace{\frac{\partial p_{\emptyset\emptyset}}{\partial \theta}(1 - z^{B2})\rho^T(u^{\min B})}_{+} - \underbrace{\frac{\partial z^{B2}}{\partial \theta} p_{\emptyset\emptyset}\rho^T(u^{\min B})}_{+} + \underbrace{\frac{\partial \rho^T(u^{\min B})}{\partial \theta} p_{\emptyset\emptyset}(1 - z^{B2})}_{+} - \underbrace{\frac{\partial p_{\emptyset l}}{\partial \theta}}_{-}$$

However, from simulations we can see that the negative term of the equation dominates: an increase in the proportion of high-ability entrepreneurs decreases the tech-lender's profits. This is due to a decrease of the winner's curse: there are more high-ability entrepreneurs, which weakens the winner's curse and hence increases competition, impacting the tech-lender's profits negatively.

For the impact from the traditional bank's monitoring intensity, we develop the equations as follows:

$$\frac{\partial K^{T2}}{\partial m^B} = \underbrace{\frac{\partial \rho^T(u^{\min B})}{\partial m^B}}_{+} \underbrace{p_{\emptyset\emptyset}(1 - z^{B2})}_{+} - \underbrace{\frac{\partial z^{B2}}{\partial m^B}}_{\pm} \underbrace{p_{\emptyset\emptyset}\rho^T(u^{\min B})}_{+}$$

We can refer to the calculations of the comparative statics of the traditional bank's probability to make an offer with respect to the monitoring intensity to retrieve the value of the elements in the equation. We know that $\partial \rho^T(u^{\min B})/\partial m^B > 0$, which means that the direction of this comparative static depends on the traditional bank's probability of making an offer: for lower values of the traditional bank's monitoring intensity, the probability of the traditional bank making an offer decreases with the monitoring intensity, which in turn means that the tech-lender's profits increase; on the other hand, for higher levels of the monitoring technology, the probability that the traditional bank makes an offer increases, which has a negative effect on the tech-lender's profits. This is depicted in Figure 7c.

C.6 Proof to Corollary 6

Recall from Equation (22) and Equation (23).

$$\begin{aligned} G^{T2}(u) &= \frac{p_{l\varnothing} + p_{\varnothing\varnothing} - \theta}{\theta \tau^B(u)} = \frac{1-\theta}{2\theta} \frac{1}{e^B(u) R^B(u) - 1} \\ G^{B2}(u) &= \frac{K^{T2} + p_{\varnothing l} - p_{\varnothing\varnothing}\left(1 - z^{B2}\right)\rho^T(u)}{\theta z^{B2} \tau^T(u)} \end{aligned}$$

Let us first focus on the comparative statics of $G^{T2}(u)$.

$$\begin{aligned} \frac{\partial G^{T2}(u)}{\partial \sigma^T} &= 0 \\ \frac{\partial G^{T2}(u)}{\partial \theta} &= -\frac{1}{2\theta^2 \tau^B(u)} < 0 \\ \frac{\partial G^{T2}(u)}{\partial m^B} &= -\frac{1-\theta}{\tau^B(u)^2} \frac{\partial \tau^B(u)}{\partial m^B} \gtrless 0 \end{aligned}$$

The effect of the monitoring intensity on the tech-lender's utility distribution will depend on the level of utility it offers.

The comparative statics for $G^{B2}(u)$ are more complex and use the results from Corollary 4 and Corollary 5 and that $\partial p_{\varnothing\varnothing}/\partial\sigma^T = \partial p_{\varnothing l}/\partial\sigma^T < 0$:

$$\begin{aligned} \frac{\partial G^{B2}(u)}{\partial \sigma^T} &= \frac{1}{\theta z^{B2}\tau^T(u)} \left[\frac{\partial K^{T2}}{\partial \sigma^T} + \frac{\partial p_{\varnothing l}}{\partial \sigma^T} - \left(\frac{\partial p_{\varnothing\varnothing}}{\partial \sigma^T}(1 - z^{B2})\rho^T(u) + \frac{\partial \rho^T(u)}{\partial \sigma^T} p_{\varnothing\varnothing}(1 - z^{B2}) \right) \right] \\ &= \frac{1}{\theta z^{B2}\tau^T(u)} \left[\frac{\partial p_{\varnothing\varnothing}}{\partial \sigma^T}(z^{B2} - 2) + \frac{\partial p_{\varnothing\varnothing}}{\partial \sigma^T} - \left(\frac{\partial p_{\varnothing\varnothing}}{\partial \sigma^T}(1 - z^{B2})\rho^T(u) + \frac{\partial \rho^T(u)}{\partial \sigma^T} p_{\varnothing\varnothing}(1 - z^{B2}) \right) \right] \\ &= \frac{1}{\theta z^{B2}\tau^T(u)} \left[\frac{\partial p_{\varnothing\varnothing}}{\partial \sigma^T}(z^{B2} - 2) + \frac{\partial p_{\varnothing\varnothing}}{\partial \sigma^T} - \frac{\partial p_{\varnothing\varnothing}}{\partial \sigma^T} \left((1 - z^{B2})\rho^T(u) - (1 - z^{B2}) \frac{\theta e^T(u) R^T(u)}{p_{\varnothing\varnothing}} \right) \right] \\ \frac{\partial G^{B2}(u)}{\partial \sigma^T} &= 0 \end{aligned}$$

The comparative statics with respect to the proportion of high-ability entrepreneurs and the traditional bank's monitoring intensity depend on both the utility offered and on the level of m^B.

$$\begin{aligned} \frac{\partial G^{B2}(u)}{\partial \theta} =& \frac{1}{\tau^T(u)(\theta z^{B2})^2} \times \\ & \left[\left(\underbrace{\frac{\partial K^{T2}}{\partial \theta}}_{-} + \underbrace{\frac{\partial p_{\varnothing l}}{\partial \theta}}_{-} - \left(\underbrace{\frac{\partial p_{\varnothing\varnothing}}{\partial \theta}(1 - z^{B2})\rho^T(u)}_{-} - \underbrace{\frac{\partial z^{B2}}{\partial \theta} p_{\varnothing\varnothing}\rho^T(u)}_{+} + \underbrace{\frac{\partial \rho^T(u)}{\partial \theta} p_{\varnothing\varnothing}(1 - z^{B2})}_{\pm} \right) \right) \underbrace{\theta z^{B2}}_{+} \right. \\ & \left. - \left(\underbrace{z^{B2} + \theta \frac{\partial z^{B2}}{\partial \theta}}_{+} \right) \left(\underbrace{K^{T2} + p_{\varnothing l} - p_{\varnothing\varnothing}\left(1 - z^{B2}\right)\rho^T(u)}_{+} \right) \right] < 0 \end{aligned}$$

The sign of the first term in the square brackets is negative, meaning that the overall effect is negative.

$$\frac{\partial G^{B2}}{\partial m^B} = \frac{1}{\theta\tau^T(u)(z^{B2})^2}\left[\left(\frac{\partial K^{T2}}{\partial m^B} + p_{\varnothing\varnothing}\rho^T(u)\frac{\partial z^{B2}}{\partial m^B}\right)z^{B2} - \left(K^{T2} + p_{\varnothing l} - p_{\varnothing\varnothing}\left(1 - z^{B2}\right)\rho^T(u)\right)\frac{\partial z^{B2}}{\partial m^B}\right]$$
$$= \underbrace{\frac{1}{\theta\tau^T(u)(z^{B2})^2}}_{+}\left[z^{B2}\frac{\partial K^{T2}}{\partial m^B} - \frac{\partial z^{B2}}{\partial m^B}\left(K^{T2} + p_{\varnothing l} - p_{\varnothing\varnothing}\rho^T(u)\right)\right] \gtrless 0$$

C.7 Proof to Corollary 7

Recall:

$$\mathbb{E}[\Pi^{\text{mon}B}] = \frac{1}{2}\left(\left(\frac{Am^B}{2} - 1\right)\theta - 1\right)$$
$$u^{\min B} = A\frac{4 + m^{B2}}{8m^B}$$

The comparative statics are calculated as follows:

$$\frac{\partial\,\mathbb{E}[\Pi^{\text{mon}B}]}{\partial m^B} = \frac{A\theta}{4} > 0$$
$$\frac{\partial\,\mathbb{E}[\Pi^{\text{mon}B}]}{\partial\theta} = \frac{Am^B - 2}{4} > 0$$
$$\frac{\partial u^{\min B}}{\partial m^B} = \frac{A}{8}\left(1 - \frac{4}{m^{B2}}\right) < 0$$

C.8 Summary of comparative statics results

Tables 2 and 1 summarize the results of the comparative statics. Table 2 refers to the results from Corollaries 1 to 3. Table 1 summarizes the results from Corollaries 4 to 6 using the same notation as 2.

The comparative statics are of the form $\partial X/\partial\alpha$, so that the endogenous variables X are placed at the rows, and the changing parameter α in the columns. The table shows "+", "−" or "±" depending on whether the comparative static is always positive, negative, or if the sign depends on parameter values. Where an asterisk is placed, it indicates that the sign comes from an analytical solution and not from simulations.

	θ	Low m^B / High m^B	σ^T
z^{T1}	$+^\star$	$+$	$+^\star$
K^{B1}	$+^\star$	+ / -	$-^\star$
$G^{T1}(u)$	$-^\star$	$\pm$	$-^\star$
$G^{B1}(u)$	$-^\star$		$-^\star$

Table 1: Summary of comparative statics for candidate equilibrium 1
An asterisk * denotes an analytical solution.

	θ	Low m^B / High m^B	σ^T
z^{B2}	$+^\star$	- / $+$	
K^{T2}	-	$+$ / -	$+^\star$
$G^{T2}(u)$	$-^\star$	$\pm$	
$G^{B2}(u)$	$-^\star$	$\pm$	

Table 2: Summary of comparative statics for candidate equilibrium 2
An asterisk * denotes an analytical solution.

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