Bank-Platform Competition in the Credit Market*

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Abstract

We analyze the equilibrium in the credit market when a bank and a lending platform compete to offer credit to borrowers. The platform does not manage deposit accounts, but acts as an intermediary between the borrower and investor, offering a risky contract such that the investor is only reimbursed if the borrower is successful. We show that the platform business model of financial intermediation may generate unexpected effects in the credit market. In particular, investor participation in the platform sometimes decreases when the platform attracts better-quality borrowers. When it competes with the platform, depending on the respective distributions of borrower and investor types, the bank may expand the supply of credit to low-quality borrowers, or restrict it to high-quality borrowers. Bank-platform competition expands the total supply of credit, but has an ambiguous impact on borrower surplus, because some borrowers may have higher repayments.

Keywords: Bank, Lending Platform, Credit Market, Credit Rationing.

JEL Codes: L1, L5, G2.

1 Introduction

Digital platforms are offering their intermediation services in several sectors of the economy, ranging from the transportation industry (e.g., Uber) to hotel reservations (e.g., Booking, Expedia, and other OTAs), or e-commerce (e.g., Amazon). The financial industry is not an exception. In the retail credit market, since 2006 lending platforms (such as Prosper, the Lending Club or Zopa) have been acting as intermediaries between borrowers and investors.

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In several countries, such platforms have managed to attract a significant share of the lending market in specific market segments, by both expanding the credit supply to underserved borrowers and competing with banks for their existing customer base.[1] More broadly, lending platforms are part of the FinTech movement that is reshaping competition in the banking industry.

Many empirical papers have started to study how the entry of lending platforms impacts the availability of credit for retail consumers and the average risk in the retail lending market. However, very little is known, from a theoretical perspective, about how competition between banks and lending platforms affects the repayments made by borrowers, the investor behavior, and the platform profitability. In this paper, we identify the conditions of entry when a traditional bank is competing with a platform, and show that platform entry may reduce borrower surplus.

Banks are defined in both the economic literature and the legislation as entities that take deposits and engage in credit activities. The function of a bank is to transform liquid deposits into long-term investments, which helps to ensure an efficient allocation of resources in the economy (Diamond and Dybvig, 1983). To overcome information frictions (moral hazard and adverse selection), banks screen their borrowers and decide whether or not to fund loans on behalf of their depositors (Diamond, 1984).

Lending platforms rely on a different business model of financial intermediation. The latter focus on offering credit intermediation services to borrowers and lenders. To do so, they often rely on banks for the upstream provision of deposit services.[2] The investors need to decide whether or not to fund projects that are posted online on the platform's website. If a project is funded, the borrower repays the principal and the interest rates directly to the investor, who cannot withdraw its funds before maturity. Therefore, unlike banks, lending platforms do not perform maturity transformation (see Havrylchyk and Verdier, 2018, OECD, 2018). Moreover, they often tend to offer unsecured lending (see Galema,

[1] See Claessens et al. (2018) for figures. In the United Kingdom, the Cambridge Center for Alternative Finance estimated that marketplace lending contributed to 15% of the lending flow of comparable bank credit to consumers and SMEs.

[2] The ability to manage deposit accounts is another key difference between both types of intermediaries in various countries and jurisdictions (e.g., Austria, Belgium, Finland, France, European Union). See the BIS annual report (2019) for examples of business models for online credit platforms (chapter on Big tech in finance, opportunities and risks).

2019, for evidence).[3]

In terms of pricing, platforms are usually compensated with origination and ongoing fees on the borrower side (between 1 and 6% of the loan amount) and servicing fees on the investor side (around 1% of the principal plus interest). The platform uses asymmetric pricing on both sides to attract both investors and borrowers, who exert externalities on each other. On the one hand, the borrower takes into account the probability of being funded by an investor in its decision to demand a credit on the platform. On the other hand, the investor takes into account the probability of being reimbursed in its choice to fund a loan application.

Given their specificities, whether competition between banks and lending platforms enables a more efficient allocation of credit in specific market segments is an open research question. Platforms could offer smaller borrowers, who are underserved by banks, access to credit, relieving the problem of credit rationing that may be more severe for this population. However, several regulators (such as the Financial Conduct Authority in the United Kingdom) have expressed concerns that platforms could overcharge borrowers for their services. Due to cross-side externalities, platforms need to attract both borrowers and investors in order to take off, which, as we shall demonstrate, might not reduce borrower repayments.

We build a two-sided market model of competition between a bank and a lending platform. The bank acts as an upstream provider of deposit services and competes with the platform for credit intermediation if there is platform entry. To focus on the role of externalities between the borrower and the investor, we assume that financial intermediaries have no informational advantage over each other. They observe neither the borrower's probability of success nor the investor's taste for liquidity.

On the borrowing side, the consumer trades off between taking a loan from the bank or from the platform, which is less efficient than the bank at monetizing a collateral. The bank is more advantageous for borrowers who have a higher likelihood of success: the latter have lower chances of losing the value of their collateral and a higher probability of being funded.

[3]Examples of platforms that do not require any collateral from borrowers include October and Prexem in the French market. Galema (2019) documents a lower use of collateral in P2P lending than in bank lending to SMEs. According to other authors (e.g., Gambacorta et al., 2020) big tech platforms, especially in China, use consumer data as collateral. In practice, banks also engage in unsecured lending. However, with the exception of credit cards, in most market segments in which banks compete with platforms, collateral requirements are a source of differentiation between financial intermediaries.

On the lending side, the investor trades off between leaving his funds in a perfectly liquid deposit account, and investing in an illiquid platform loan. If he invests in a platform loan, the investor is able to form expectations on the probability of the loan being reimbursed. Our simplified assumptions capture the main differences between the bank and the platform business model of financial intermediation in terms of externalities.

In this context, we characterize the optimal repayment rates chosen by the bank and the platform and the deriving market structure. If the platform enters the market, the bank attracts the projects with higher expected returns, while the others are served by the lending platform. We analyze how the return on deposits and the borrower repayment to the bank impact investor and borrower participation in the platform. If the investor's decision to fund a platform loan depends on the borrower repayment to the bank, we say that there is a Borrower to Investor externality (B2I). If the borrower's decision to take a loan from the platform depends on the return on deposits, we say that there is an Investor to Borrower (I2B) externality.

If there is no B2I externality, the bank lends to borrowers of better quality when it increases the borrower repayment. In this case, the deposit rate has no impact on the quality of borrowers attracted by the platform and by the bank, respectively. Logically, we show that investor participation in the platform decreases with the return on deposits, that is, if investing in the bank becomes more attractive.

If there is a B2I externality, the bank may lend to borrowers of either quality when it increases the borrower repayment and the deposit rate. This depends on the magnitude and the sign of the B2I externality and the I2B externality, respectively. In that case, bank prices have a non-trivial impact on investor participation in the platform. On the one hand, the investor values a higher average quality of investors on the platform. On the other hand, in some cases the platform may decrease the return offered to the investor when the average quality of borrowers increases. Whether the second effect dominates the first depends on both borrower and investor heterogeneity. This implies that even if the platform attracts better-quality borrowers, investor participation in the platform may be reduced.

At the first stage of the game, if it anticipates platform entry, the bank chooses the return on deposits so as to equalize the marginal cost and the marginal benefit from investor participation in the platform. The marginal borrower is set such that the marginal benefits of credit intermediation activities are equal to the marginal rents that the bank extracts from the deposit market thanks to the presence of the platform. We are also able to identify cases in which platform entry generates an unbundling of the upstream provision of deposit services and the downstream credit intermediation services.

We show that the bank may charge either a higher or a lower repayment to the borrower if the platform enters the market. This is due to the bank's trade-off between extracting surplus from the higher borrower types and competing with the platform for the riskier borrower types. Though platform entry enables riskier borrower types to access credit, it may reduce the surplus of borrowers of better quality when the borrower repayments increase. It follows that platform entry may reduce the average borrower surplus. This analysis explains why the welfare effects of platform entry are non-trivial. We also show that the bank changes its selection of borrowers when it competes with the platform and we identify cases in which the bank expands the supply of credit to borrowers of lower quality, or lends to borrowers of better quality, respectively.

The remainder of the paper is as follows. In Section 2, we position our paper in the literature on financial intermediation, lending platforms and platform competition. In Section 3, we build a model to study the equilibrium in the credit market when a bank competes with a platform. In Section 4, we solve for the equilibrium of the game and discuss our results in the context of the digital transformation of financial intermediaries. Finally, we conclude.

2 Related literature

Our paper analyzes competition between two different business models of financial intermediation. To our knowledge, this is the first theoretical attempt at understanding the effects on loan prices and investor behavior when a bank and a lending platform compete.

The theoretical literature on competition between financial intermediaries already takes into account the externalities between the lending and the deposit market (Bracoud, 2002 and 2007, Boyd and De Nicolo, 2005, Yanelle, 1989 and 1997). Our paper differs from the above contributions in that we consider simultaneous competition for deposits and loans, and cross-side externalities. Another strand of the literature unbundles the determination of deposit remuneration from the cost of funding via capital for traditional banks (see Allen, Carletti and Marquez, 2011). Unlike this literature, we focus on asymmetric financial intermediaries, differing in their selection technologies. An emerging theoretical literature analyzes competition between FinTech and banks. However, in most papers of this literature, FinTech entrants are not explicitly modeled as platforms (see Parlour, Rajan, and Zhu, 2020, He, Huang and Zhou, 2023, Fong, Liu, Meng and Tam, 2021, Verdier, 2021, Begenau and Landvoigt, 2022).

Our work is connected to a strand of the literature that studies why financial intermediaries give the economy an advantage (Diamond, 1984, Diamond and Dybvig, 1983, Kaplan, 2006, Dang et al., 2017), and the effect of the design of the financial system on financial innovation and welfare (Boot and Thakor, 1997). By contrast, we do not address the rationale for the existence of different business models of financial intermediation. Moreover, to zero in on the role of externalities between borrowers and investors, we assume that neither of the financial intermediaries has access to a technology that offers better information on the borrower's probability of success.

We formalize the borrower's trade-off between taking a secured loan from the bank and an unsecured loan from the platform. We do not study why the bank and the platform differ in their ability to monetize the borrower's collateral. This might depend on the existence of exogenous regulatory constraints, such as capital requirements (see Degryse et al., 2019).[4] Our assumption is confirmed by the empirical work of Galema (2019) who shows that lending platforms engage more in unsecured lending in specific market segments than banks do.[5] Big tech platforms, however, may have access to a superior enforcement technology than banks thanks to their business partnership with borrowers (see Boualam and Yoo, 2022, Bouvard, Casamatta and Xiong, 2022, or Li and Pegoraro, 2022).

Our paper contributes to the recent empirical literature on P2P lending platforms (see

[4]In the literature, several papers have studied why collateral can emerge as a solution to either ex-ante asymmetric information problems (Stiglitz and Weiss, 1981) or ex-post incentive problems between borrowers and lenders (Bester, 1994, Berger et al., 2011).

[5]In practice, banks also engage in unsecured lending. However, apart from credit cards, in most market segments in which banks compete with platforms, collateral requirements are a source of differentiation between financial intermediaries.

Morse, 2015, Belleflamme et al., 2016, and Havrylchyk and Verdier, 2018, for surveys).

A strand of the literature analyzes the platform business model: how platforms select borrowers and price credit risk (Butler et al., 2016, Hertzberg et al., 2018, Lin et al., 2013), their use of the borrower information (Duarte et al., 2012, Iyer et al., 2016), their incentives to offer information to investors (Vallée and Zeng, 2019), and the role of cross-side externalities (Cong et al., 2019). Some contributions study the market design of platforms and, in particular, the efficiency of an auction process compared to a system with posted prices (e.g., Franks et al., 2021, Liskovich and Shaton, 2017).

Another strand of the literature analyzes competition between banks and platforms, or Fintech lenders. There is empirical evidence that platform and Fintech lenders entry depends on the intensity of competition in local banking retail markets (Havrylchyk et al., 2021, Wolfe and Yoo, 2018), the credit conditions on platforms (Butler et al., 2016), the burden of financial regulations for banks (Buchak et al., 2018), the technological advantage of entrants (Fuster et al., 2019), and the scope of banks on the asset side (Benetton et al., 2022). Other papers measure whether P2P credit is a substitute for bank credit in specific market niches: revolving accounts (Balyuk, 2018), personal loans or credit (Wolfe and Yoo, 2018, Di Maggio and Yao, 2018). The central message of this literature is that P2P credit may both complement and substitute bank credit. The supply of credit may be expanded to the borrowers who are usually excluded from the retail credit market (see De Roure et al., 2018, Butler et al., 2016, Erel and Lieberson, 2022), or those who already have access to bank credit (Tang, 2019). Our theoretical paper complements this empirical literature by showing that the respective elasticities of borrower and investor demand for platform loans impact the substitution between bank credit and platform credit. Our paper also contributes to the literature on competition between asymmetric platforms, with a specific focus on the lending market (see Belleflamme, Peitz and Toulemonde, 2022, for a survey). Our setting includes two specific features that have not been investigated in this literature-to the best of our knowledge-that is, differentiation between intermediaries in terms of risks and endogenous cross-side externalities.

3 The model

We build a model of competition between asymmetric platforms: a bank and a lending platform. On the borrower side, the platform offers the borrower a credit contract that requires a lower amount of collateral, with fewer chances of being funded. On the lender side, the platform offers the investor a riskier and illiquid investment opportunity.

Borrower A risk-neutral borrower needs \$1 of funding to invest in a risky project that yields $y > 1$ with probability $\theta \in [0, 1]$ and 0 otherwise. Initially, a borrower has no monetary wealth and owns a collateral of value $C < 1$. His probability of success θ is private and unobservable by the financial intermediaries and the investor. The returns of the project cannot be modified, so there is no moral hazard. Neither the bank nor the platform has an informational advantage over its competitor as regards the observation of the borrower's probability of success.[6]

Before asking for a loan, the borrower is required to open a bank account and pay the fixed fee F_B. When he opens an account, the borrower does not know his probability of success θ. At the beginning of the game, all players (including the intermediaries) are aware that θ is distributed on $[0, 1]$ according to the probability density h and the cumulative H.[7]

After he has opened a bank account, the borrower may choose to borrow either from the bank or from the platform (i.e., single-homes). The utility of taking a loan from intermediary $i = b, p$ for a borrower of type θ is

$$u_B^i(\theta, R_B^i) = \theta p_B^i(y - R_B^i) - (1 - \theta)\tau^i C, \tag{1}$$

where p_B^i is the borrower's expected probability of being funded by intermediary i, R_B^i is the repayment to intermediary i in case of success, and τ^i is the share of the collateral seized by intermediary i in case of failure. The borrower's reservation utility is equal to zero if he

[6]We do not model any information advantage of the bank over the platform. It can be argued that the bank has better information on the borrower's payment account. On the other hand, the platform has better information on other characteristics of the borrower that may come from alternative data sources.

[7]As in the model of de Meza (2002), we assume that borrowers differ in terms of expected returns. De Meza (2002) explains why this view is more consistent with stylized aspects of SME financing than the model of Stiglitz and Weiss (1981), who assume that borrowers differ in terms of risk.

does not borrow.

The bank and the platform offer differentiated contracts. First, the borrower expects to be funded with certainty when he applies to the bank, whereas he is funded only with probability $p_B \in [0, 1]$ on the platform because the platform may fail to attract investors (i.e., we have $p^b_B = 1$ and $p^p_B = p_B$). The borrower cannot observe the contract offered by the platform to the investor and forms passive expectations of the probability p_B of being funded on the platform.[8] This assumption corresponds to the organization of most platforms in the market and enables us to simplify the model. Second, the bank and the platform differ in their abilities to seize the borrower's collateral in case of failure, such that the bank obtains a share $\tau^b > 0$ of the collateral C, whereas the platform obtains a share $\tau^p = 0$ (see Tirole, 2010).[9] This implies that the borrower prefers to take a loan from the bank when his probability of success is sufficiently high, and from the platform otherwise. We set the borrower's cost of applying for credit to zero and the share of collateral seized by the bank to $\tau^b = 1$ without loss of generality.

Finally, we denote by θ_0 the marginal borrower, i.e., the probability of the success of the borrower who is indifferent between borrowing from the bank or the platform. Given our setting, if both intermediaries are active and the market is covered, when he opens a bank account, the borrower expects to prefer the platform with probability $H(\theta_0)$ and the bank with probability $1 - H(\theta_0)$.

Investor A risk-neutral investor has \$1 of funds and may choose between opening a bank account and paying a fixed fee F_I or investing in the risk-free asset, which yields a return of $R_f \geq 1$.[10]

Opening a bank account gives the investor two options, which differ in terms of risk, return, and liquidity. The investor may either leave his money in the bank as a deposit (i.e.,

[8] This implies that the borrower has fixed expectations of the investor's decision to participate in the platform (see Hagiu and Halaburda, 2014). Therefore, he cannot adjust his expectation regarding investor participation in response to any changes in bank and platform prices. In turn, the bank and the platform treat the borrower's expectations as fixed when they set their prices. Expectations are fulfilled in equilibrium.

[9] Faia and Paiella (2018) also make the assumption that borrowers choosing the lending platform have lower collateral and little reputation.

[10] As there is a single investor in our framework, we focus on modeling an externality between the borrower and the investor. The types of externalities between investors or between borrowers are surveyed in Belleflamme et al. (2016).

invest in intermediary $i = b$) or fund a platform loan (i.e., invest in intermediary $i = p$). The investor discovers his taste for liquidity $v \in [0, \overline{v}]$ after he has opened a bank account. At the beginning of the game, all players (including the intermediaries) are aware that v is distributed on the interval $[0, \overline{v}]$ according to the probability density g and the cumulative G. We further assume that G/g is increasing and concave, which is a necessary condition to hold when the platform maximizes its profit.[11]

The investor's utility of investing in intermediary $i = b, p$ is

$$u_I^i(v, R_I^i, \theta_0) = p_I^i(\theta_0) R_I^i - \lambda^i v - 1, \tag{2}$$

where $p_I^i(\theta_0)$ is the average probability of success of the projects intermediated by i, and R_I^i is the return on investment in intermediary i. The investor incurs the disutility $\lambda^i v$ when he invests in intermediary $i = b, p$, where the parameter $\lambda^i \geq 0$ measures the illiquidity of the investment opportunity, with $\lambda^i = 0$ standing for a perfectly liquid investment.

The bank and the platform offer differentiated contracts in terms of risk, return, and liquidity. Bank deposits are less risky than platform loans. We simplify the paper by assuming that the investor is always reimbursed by the bank when he invests in bank deposits, that is, we have $p_I^b(\theta_0) = 1$. On the platform, the investor is reimbursed with the average probability of borrower success, conditional on the borrower taking a platform loan $p_I^p(\theta_0) = p_I(\theta_0) \in [0, 1]$.[12] The results of our paper hold as long as the probability that the investor will be reimbursed by the platform is much more sensitive to the marginal borrower than the probability that the investor is reiumbursed by the bank.[13]

The bank offers the investor the return on deposits $R_I^b = R_d$ and the platform offers the return $R_I^p \geq R_d$. The return offered by the platform corresponds to the sum of the

[11] In standard settings in which consumers differ across their valuation x for a product, the usual regularity assumption is that the hazard rate of the distribution of x is monotone and non-increasing (Barlow et al., 1963). In our setting, since the return offered to the investor is a cost for the platform, the usual regularity assumption is written differently.

[12] We do not model the screening efforts of investors and leave this aspect of the market for future research. Davis and Murphy (2016) make a distinction between the passive and the active investor model. In the active mode, investors select loans which are posted on the platform and participate in the selection process. In the passive model, investors decide to invest according to the average characteristics of the borrower and the maturity of the loan rather than specific loan characteristics.

[13] The development of the general model with a risky bank contract is available upon request.

principal of the loan, the interest rate, net of the servicing fee. Bank deposits are more liquid than platform loans. Therefore, to simplify the model, without loss of generality (as long as $\lambda^p > \lambda^b$), we assume that $\lambda^p = 1$ and $\lambda^b = 0$. If there is no financial crisis, bank deposits are very liquid, unlike platform loans, which cannot be withdrawn before maturity. This implies that if the investor's taste for liquidity v is low, he may prefer to fund a platform loan, whereas if his taste for liquidity is higher, he may prefer to leave his funds as deposits in the bank.

The marginal investor, i.e., the investor who is indifferent between lending through the bank or the platform, is denoted by v_0.[14] Given our setting, if both intermediaries are active and the market is covered, the investor expects to prefer the platform with probability $G(v_0)$ and the bank with probability $1 - G(v_0)$.

The bank The bank offers deposit services in the upstream market and credit intermediation services in the downstream market. Opening a deposit account is required to obtain a credit from either the bank or the platform. This assumption is in line with our understanding of the development of the Fintech sector and is discussed in Boot et al. (2021). Therefore, the bank makes a profit given by

$$\pi^b = \pi_L + F_B + F_I, \tag{3}$$

where π_L corresponds to the profit in the downstream market of lending activities and F_k for $k = I, B$ are the fixed deposit fees charged to the borrower ($k = B$) and the investor ($k = I$), respectively.[15]

In the downstream market of credit intermediation, if a borrower of type $\theta \geq \theta_0$ wishes to take a bank credit, the bank always funds it and obtains an expected margin given by

$$\theta y - c_b - R_d - u_B^b(\theta, R_B^b),$$

[14] We do not model the risk of platform failure that could also impact the investor's incentives to participate in the platform.

[15] Note that we include in the profit on in-house lending activities the profit that the bank makes from investing in the risk-free asset if the borrower is funded neither by the bank nor by the platform.

where c_b is the marginal cost of a lending transaction, R_d the return on deposits and $u_B^b(\theta, R_B^b)$ is the consumer utility of borrowing from the bank. If a borrower of type $\theta \leq \theta_0$ wishes to borrow from the platform, there is a probability $1 - G(v_0)$ that the investor will refuse to fund the loan. In that case, the bank will refuse to fund the loan and will obtain the return $R_f - R_d$ of investing in the risk-free asset. Therefore, the bank makes a profit from lending activities given by

$$\pi_L = \int_{\theta_0}^{1} (\theta y - c_b - R_d - u_B^b(\theta, R_B^b))h(\theta)d\theta + H(\theta_0)(1 - G(v_0))(R_f - R_d). \tag{4}$$

Note that this profit function encompasses the monopoly situation, when no investor funds a platform loan (i.e., $v_0 = 0$) and borrowers with lower probabilities of success do not borrow (i.e., if $\theta \leq \theta_0$).

The terms of the deposit contracts and the borrower repayment are decided by the bank before platform entry. Such a timing could be justified by the fact that large banks do not modify their contracts frequently, whereas platforms may have the opportunity to change their prices more rapidly because they operate online with lighter internal constraints. We also explored the possibility that competition is simultaneous and this does not affect the qualitative shape of the results.

A consumer of side $k = I, B$ opens a bank account if and only if the expected surplus of opening a bank account $ES_k(R_B^b, R_d)$ exceeds the fixed deposit fee F_k for $k = B, I$. The two-part tariff structure of the bank contract implies that the bank is able to extract the depositors' option value of making a credit transaction, intermediated either by the bank, or by the platform. This assumption simplifies the model and allows for a presentation of a closed form solution. With linear tariffs (i.e., with $F_k = 0$ for $k = I, B$), the structure of the repayment rates is qualitatively the same.

The platform The platform is only active in the downstream market of credit intermediation.[16] If a credit is intermediated by the platform, the investor receives R_I^p when he funds

[16] We assume that the platform and the bank are distinct financial intermediaries in our paper. However, both players could be integrated. For example, the FinTech lending platform Marcus is owned by Goldman Sachs. The Lending Club has recently acquired the bank Radius.

a platform loan and the borrower repays R_B^p. As the loan amount is fixed, the platform's net interest margin in case of success $R_B^p - R_I^p$ is equivalent to the sum of servicing and ongoing fees paid by the borrower and the investor each time a borrower repays a loan. The platform obtains zero profit when the borrower defaults. The platform incurs no credit intermediation cost and its expected profit is

$$\pi^p = G(v_0)H(\theta_0)p_I(\theta_0)(R_B^p - R_I^p). \tag{5}$$

In Eq. (5), if the platform offers the return R_I^p to the investor and asks for a repayment R_B^p from the borrower, the investor (resp., the borrower) prefers the platform with probability $G(v_0)$ (resp., $H(\theta_0)$). The platform's average net interest margin is $m_p = p_I(\theta_0)(R_B^p - R_I^p)$.[17]

Assumptions:

(A1) The credit market is covered under duopoly.

To be satisfied, Assumption (A1) implies that at the equilibrium, all borrower types derive a positive utility of taking a loan.

(A2) $y \geq c_b + R_f$.

Assumption (A2) ensures that there is an interior solution if no investor wishes to fund a loan on the platform. It means that the social value of the project is higher than its costs if the project is riskless.

In the paper, we will use the notations:

- $\underline{E}(\theta_0) = \int_0^{\theta_0} \theta h(\theta) d\theta$ and $\overline{E}(\theta_0) = \int_{\theta_0}^1 \theta h(\theta) d\theta$,
- $\underline{V}(v_0) = \int_0^{v_0} v g(v) dv$ and $\overline{V}(v_0) = \int_{v_0}^{\overline{v}} v g(v) dv$.

Timing of the game: The timing of the game is as follows:

- Stage 1: The bank sets the deposit fees for the investor and the borrower, F_I and F_B, respectively. It chooses the repayment of the lending contract R_B^b and the return on deposits R_d.

[17] This is equivalent to a direct repayment from the borrower to the investor.

- Stage 2: The borrower and the investor decide whether or not to open an account at the bank.
- Stage 3: If it enters the market, the platform chooses the repayment of the lending contract R_B^p and the return offered to investors R_I^p.
- Stage 4: The borrower learns his private probability of success θ and decides whether or not to borrow from the bank or the platform. The investor learns his private taste for liquidity v and decides to lend to the borrower via the bank or via the platform.
- Stage 5: The project payoffs materialize. If the project is successful, the borrower pays the interest rate to the investor (resp., the bank) if he has borrowed from the platform (resp., the bank). The bank pays the deposit rate to the investor in any case. If the project is not successful, the borrower defaults and the bank seizes the collateral.

4 Competition between the bank and the platform

In this section, we study the equilibrium when a bank competes with a lending platform in the credit market.

4.1 Stage 4: The investor and borrower decisions

Solving the game backwards, we first study the choices of the investor and the borrower at stage 4, following the realizations of parameters v and θ.

4.1.1 The investor's funding decision

At stage 4, the investor decides whether or not to lend to the borrower. We focus on an equilibrium in which the bank offers at least the return on the risk-free asset to the depositor (i.e., if $R_d \geq R_f$), otherwise, the bank does not make any profit. If he observes that the borrower is seeking credit from the platform, the investor prefers to lend through the platform if and only if

$$u_I^p(v, R_I^p, \theta_0) \geq u_I^b(v, R_d, \theta_0) \equiv R_d - 1. \tag{6}$$

Since $R_d \geq R_f$, this implies that, if the investor prefers to lend through the platform, this option is also better than investing in the risk-free asset.

We denote by $v_0(R_I^p, \theta_0, R_d)$ the taste for liquidity that leaves the investor indifferent between leaving his funds in the bank or funding a platform loan. From (6), the marginal investor's taste for liquidity is implicitly defined by $u_I^p(v_0, R_I^p, \theta_0) = R_d - 1$. Therefore, from (2), if $p_I(\theta_0)R_I^p - R_d$ belongs to $(0, \overline{v})$, the marginal investor is given by

$$v_0(R_I^p, \theta_0, R_d) \equiv p_I(\theta_0)R_I^p - R_d. \tag{7}$$

If the return on deposits is too high (i.e., if $R_d \geq p_I(\theta_0)R_I^p$), no investor funds a platform loan and we have $v_0(R_I^p, \theta_0, R_d) = 0$. If the return on deposits is too low (i.e., if $R_d \leq p_I(\theta_0)R_I^p - \overline{v}$), all investors prefer to fund a platform loan and we have $v_0(R_I^p, \theta_0, R_d) = \overline{v}$.

Investor participation in the platform depends on the return offered by the platform R_I^p. Moreover, it also depends on the marginal type of borrower θ_0 and the deposit rate R_d. Hence, the bank exerts an externality on the platform in its choice of the borrower repayment and the deposit rate.[18] If $p_I(\theta_0)R_I^p - R_d$ belongs to $(0, \overline{v})$, the investor lends through the platform if and only if the expected return offered by the platform is sufficiently high with respect to the deposit rate and if the investor's taste for liquidity is low enough (i.e., if $v \leq v_0(R_I^p, \theta_0, R_d)$). Otherwise, the investor prefers to leave his funds in the bank. Since v is distributed according to the probability density g with cumulative G, the probability that the investor will want to lend on the platform is $G(v_0(R_I^p, \theta_0, R_d))$.

4.1.2 The borrower's demand for credit

At stage 4, the borrower decides whether or not to seek credit from the bank or the platform, if his expected utility of taking a loan on the platform is positive. The borrower prefers to

[18] In France, February 2017, the consumer association UFC Que Choisir argued that despite high advertised returns, the realized net returns for investors on French platforms could be lower than the return on the risk-free bank deposit asset after taxation and default. This view has been challenged by French platforms. In our model, we consider that investors are able to make rational expectations of their expected probability of receiving the return on their investment.

take a credit from the bank if and only if

$$u_B^b(\theta, R_B^b) \geq u_B^p(\theta, R_B^p). \tag{8}$$

Suppose that neither the bank nor the platform captures the entire market and that the borrower anticipates being funded with probability $p_B > 0$ on the platform. Replacing $u_B^b(\theta, R_B^b)$ and $u_B^p(\theta, R_B^p)$ in Eq. (8) gives the indifferent borrower θ_0 between the bank and the platform, that is,

$$\theta_0(R_B^b, R_B^p) \equiv \frac{C}{y(1-p_B) + C - R_B^b + p_B R_B^p}. \tag{9}$$

The marginal borrower's type depends on the differentiation between the contracts offered by both financial intermediaries (through the collateral), and the respective probabilities of being funded by the bank and the platform.

A higher repayment R_B^b charged by the bank increases the marginal borrower's type. That is, we have $\partial\theta_0/\partial R_B^b = \theta_0^2/C \geq 0$. If $p_B > 0$, a higher borrower repayment charged by the platform decreases the marginal borrower's type, that is, we have $\partial\theta_0/\partial R_B^p = -\theta_0^2/\beta$, where

$$\beta \equiv C/p_B \tag{10}$$

is a measure of the sensitivity of the marginal borrower to the repayment charged by the platform. If $\theta_0 \in (0, 1)$, the platform attracts the infra-marginal borrower's types (i.e., such that $\theta \leq \theta_0$) and the bank attracts the borrowers, such that $\theta \geq \theta_0$. From (9), the platform attracts a higher share of the market when the amount of collateral demanded by the bank increases, when the difference in repayment rates decreases or when consumers anticipate a higher probability of being funded.

If $p_B = 0$, the borrower never takes a loan from the platform and the marginal borrower's type is given by θ^M, corresponding to the one that would be chosen by a monopolistic bank in the absence of a platform, as shown in Appendix A, where[19]

[19]We detail in Appendix A the bank's behavior if the platform does not enter the market. If the borrower anticipates that he will not be funded on the platform (i.e., $p_B = 0$), there is no utility from taking a loan on the platform. Therefore, he trades off between taking a loan from the bank and not borrowing.

$$\theta^M = \frac{C}{y + C - R_B^b}. \tag{11}$$

4.2 Stage 3: Platform prices

Let us denote the platform best responses $\widehat{R_B^p}(R_B^b, R_d)$ and $\widehat{R_I^p}(R_B^b, R_d)$, such that the profit function Eq. (5) is maximized. The marginal borrower at the profit-maximizing prices chosen by the platform is given by

$$\theta_P(R_B^b, R_d) \equiv \theta_0(R_B^b, \widehat{R_B^p}(R_B^b, R_d)), \tag{12}$$

and the marginal investor at the profit-maximizing prices chosen by the platform is given by

$$v_P(R_B^b, R_d) \equiv v_0(\widehat{R_I^p}(R_B^b, R_d), \theta_P(R_B^b, R_d), R_d). \tag{13}$$

In Proposition 1, we give the platform best responses $\widehat{R_B^p}$ and $\widehat{R_I^p}$ if there is an interior solution to the platform's profit-maximization problem.[20] To proceed, we formalize additional notations first. At the platform's profit-maximizing prices, we denote by:

- ε_I^p the elasticity of investor demand to the return R_I^p,
- ε_B^p the elasticity of borrower demand to the repayment R_B^p,
- μ_P the elasticity of the platform's expected revenue $p_I(\theta_0)R_B^p$ to the repayment R_B^p.

We assume that the second-order conditions of profit-maximization hold.[21]

Proposition 1 *Suppose that there exists an equilibrium in which the platform enters the market and serves the borrower with positive probability. For a given borrower repayment* R_B^b *and a deposit rate* R_d *chosen by the bank, if there is an interior solution to the platform's*

[20]There is a corner solution if either i) the investor never funds a loan on the platform, ii) the investor always funds a loan on the platform, iii) the borrower always prefers to borrow from the platform, iv) the borrower never borrows from the platform.

[21] In Appendix D-2, we show that this is the case with uniform distributions for v and θ.

profit-maximization problem, the platform chooses a return for investors, such that

$$\frac{(\widehat{R_B^p} - \widehat{R_I^p})p_I(\theta_P)}{p_I(\theta_P)\widehat{R_I^p}} = \frac{1}{\varepsilon_I^p}, \tag{14}$$

and a price structure, such that

$$\frac{\widehat{R_I^p}}{\widehat{R_B^p}} = \frac{\mu_P \varepsilon_I^p}{\varepsilon_B^p}. \tag{15}$$

Proof. See Appendix B-1. ■

On the investor side, the platform trades off between increasing the return offered to the investor, which generates a higher volume of transactions, and lowering it to increase its margin in the case of success. For a given quality of the bank's lending portfolio (represented by the marginal borrower), the platform chooses its mark-up on its marginal cost according to the Lerner formula. All else being equal, the higher the elasticity of investor demand to the return R_I^p, the lower the platform's mark-up on its marginal cost.

On the borrower side, the platform trades off between increasing the loan repayment, as it increases its margin, and lowering the loan repayment, to increase the quality of borrower types who seek credit on the platform. A higher average quality has a positive marginal impact on investor demand. The platform chooses the repayment on the borrower side, such that the marginal gain from a higher repayment exactly compensates the marginal loss from the surplus that is extracted from the marginal borrower and the marginal investor.

In Proposition 1, the ratio $\widehat{R_I^p}/\widehat{R_B^p}$ corresponds to the price structure mentioned in the literature on platform markets (see Rochet and Tirole, 2003). The price structure is equal to the ratio of the elasticity of the investor demand to the return R_I^p, divided by the elasticity of the marginal borrower to the repayment R_B^p, weighted by the elasticity of the platform's revenue to the repayment. Since the platform earns revenues from both sides of the market, it adjusts the price structure to account for the differences in demand elasticities between both sides. However, our model differs from Rochet and Tirole (2003) because the platform's revenue is uncertain. This explains why, in Proposition 1, the price structure is weighted by μ_P, the elasticity of the platform's expected revenue to the borrower repayment.[22] If the

[22]Note that for an equilibrium in which the platform enters the market to exist, it must be that, at the

probability p_I^p that the investor is reimbursed when he funds a platform loan is a constant, we have $\mu_P = 1$ and Proposition 1 is identical to Rochet and Tirole (2003).

In practice, lending platforms often charge asymmetric rates on both sides of the market. In particular, there is empirical evidence that platforms may exert their market power by increasing the interest rates charged to borrowers, without paying high interest rates to investors. For example, in July 2018 the Financial Conduct Authority in the United Kingdom expressed the concern that platforms may overcharge borrowers in the mortgage residential market, showing that in some cases investors would only receive a 3% return while borrowers paid an interest rate exceeding 30%. De Roure et al. (2018) document for a German P2P lender that P2P loans have higher interest rates, while being riskier and less profitable.

Investor participation in the platform: Competition between the bank and the platform impacts the investor's decision to fund a loan on the platform. Investor participation in the platform depends on both the average probability of success of borrowers who demand a credit on the platform (i.e., the quality of borrowers) and the return offered by the platform in the case of success. Therefore, the investor internalizes a share of the risk borne by the platform in his decision to fund a loan. The quality of platform loans is endogenous and depends on bank prices. Moreover, investor participation depends on the deposit rate chosen by the bank.

For this purpose, let $\eta(\theta_0) \equiv p_I(\theta_0) R_B^p / \phi_P(\theta_0, R_B^p)$, where

$$\phi_P(\theta_0, R_B^p) = -\frac{R_B^p}{\underline{E}(\theta_0)} \frac{d\underline{E}(\theta_0)}{dR_B^p}$$

denotes the elasticity of the expected probability of success $\underline{E}(\theta_0)$ to the repayment R_B^p chosen by the platform. Replacing for ϕ_P into $\eta(\theta_0)$ gives

$$\eta(\theta_0) = \frac{\beta p_I(\theta_0) \underline{E}(\theta_0)}{\theta_0^3 h(\theta_0)}, \tag{16}$$

where β given by (10) measures the sensitivity of the marginal borrower to the repayment

platform's best-responses $\widehat{R_B^p}$ and $\widehat{R_I^p}$ the marginal borrower obtains a positive utility of taking a loan on the platform and the marginal investor obtains a positive utility of funding a loan on the platform.

chosen by the platform.[23]

In Corollary 1, we give the implicit definition of the marginal investor at the platform's profit-maximizing prices as a function of the marginal borrower.

Corollary 1 *Suppose that* $p_B > 0$ *and* $\theta_P \equiv \theta_P(R_B^b, R_d)$*. If the bank chooses its prices* R_B^b *and* R_d *such that*

$$R_d \geq \overline{R_d}(\theta_P) \equiv \frac{\theta_P \eta(\theta_P)}{(\theta_P - p_I(\theta_P))},$$

the investor never lends on the platform, that is, we have $v_P(R_B^b, R_d) = 0$*.*
If the bank chooses its prices R_B^b *and* R_d *such that*

$$R_d \leq \underline{R_d}(\theta_P) \equiv \frac{1}{(\theta_P - p_I(\theta_P))} \left(\theta_P \eta(\theta_P) - \frac{1}{g(\overline{v})} \right) - \overline{v},$$

the investor always lends on the platform, that is, we have $v_P(R_B^b, R_d) = \overline{v}$*.*
If the bank chooses its prices R_B^b *and* R_d *such that* $R_d \in (\underline{R_d}(\theta_P), \overline{R_d}(\theta_P))$*, the marginal investor on the platform* $v_P \equiv v_P(R_B^b, R_d)$ *is implicitly defined by*

$$v_P = \frac{\theta_P}{(\theta_P - p_I(\theta_P))} \left(\eta(\theta_P) - \frac{G(v_P)}{g(v_P)} \right) - R_d. \tag{17}$$

Proof. See Appendix B-3. ■

If the average probability of success is very elastic to the choice of the marginal borrower (i.e., if $\eta(\theta_P)$ given in Eq. (16) is low), there is a higher probability that no investor will want to fund a loan on the platform, reflecting the fact that loans on the platforms are riskier than deposit accounts.

It is not obvious that investor participation in the platform will increase with the quality of platform loans: the sign of $\partial v_P / \partial \theta_P$ in Eq. (17) is either positive or negative. This result is caused by the platform business model. On the one hand, the investor values a higher average quality of borrowers on the platform. On the other hand, in some cases, the platform may adjust the price structure in favor of the borrower and to the detriment of the investor when the average quality of borrowers increases. This second effect depends on the distribution of the probability of success and the distribution of the investor's taste for

[23] If θ is uniformly distributed, η is a constant.

liquidity.

The quality of platform loans is determined by bank prices. We therefore proceed by analyzing how the choice of the borrower repayment R_B^b and the deposit rate R_d impact investor participation in the platform and the marginal borrower.

Impact of bank prices on the marginal borrower and the investor participation in the platform:

Examples of distributions: To provide as many explicit solutions as possible, in the rest of the paper we present results under the assumption that v is uniformly distributed on the $[0, 1]$ interval and θ belongs to the beta family, so that $\theta \sim \text{Beta}[a, b]$, where a and b are positive and real parameters.[24]

Bank prices impact the cross-side externalities between borrowers and investors. We define the I2B (Investor to Borrower) and the B2I (Borrower to Investor) externalities as follows:

Definition 1 *There is a B2I externality if a higher borrower repayment R_B^b changes the marginal investor, that is, if $\partial v_P/\partial R_B^b \neq 0$.*
There is an I2B externality if a higher deposit rate R_d changes the marginal borrower, that is, if $\partial\theta_P/\partial R_d \neq 0$.

For given bank prices, the sign and the magnitude of the B2I externality depends on

$$\alpha_I = \frac{\theta_P}{(\theta_P - p_I(\theta_P))}\eta'(\theta_P) + \frac{\theta_P p_I'(\theta_P) - p_I(\theta_P)}{(\theta_P - p_I(\theta_P))^2}\left(\eta(\theta_P) - v_P\right), \tag{18}$$

and the magnitude of the I2B externality depends on

$$\alpha_B = -\left.\frac{\partial\theta_0}{\partial R_B^p}\right|_{\theta_P} = \theta_P^2/\beta > 0. \tag{19}$$

[24]As known, the shape of the beta distribution varies with these two parameters and many common distributions can be obtained as special cases. For example, if the two parameters are equal to one, the beta corresponds to the uniform distribution. The probability density of θ can be increasing, decreasing or non-monotone depending on the parameters a and b.

The I2B and the B2I externalities are endogenously determined by the choice of bank prices, according to borrower and investor heterogeneity, respectively.

The term α_I has the sign of $\partial v_P/\partial\theta_P$ (see Eq. (17)) and reflects how small changes in the marginal borrower impact investor participation in the platform.[25] It is a measure of the B2I externality. The sign of α_I can be either positive or negative depending on the shape of the Beta distribution for θ (See appendix D-1).[26] If α_I is positive, the marginal investor increases when the platform attracts borrowers of better quality, whereas the reverse is true otherwise. A high α_I in absolute value implies that the marginal investor is very sensitive to the marginal borrower.

The sign of α_B is always positive. This term captures the I2B externality, which is related to the intensity of bank-platform competition for borrowers. A lower value for the bank collateral C, a higher project value y or a higher probability that the investor funds a loan on the platform p_B decrease the value of β, and therefore raise the magnitude of the I2B externality. If α_B is low, a higher deposit rate R_d has no significant impact on the marginal borrower θ_P (no I2B externality).

Depending on the values of α_B and α_I, there may be either an I2B externality, a B2I externality or both. The presence of cross-side externalities implies that bank prices have a non-trivial impact on both the quality of platform loans and investor participation in the platform. Lemma 1 gives the variation of the marginal borrower with bank prices.

Lemma 1 *If the B2I externality α_I is positive, or if it is negative and the product of the externalities $\alpha_B\alpha_I$ is low in absolute value, the bank lends to borrowers of better quality when it increases the borrower repayment or when it reduces the return on deposits, that is, we have $\partial\theta_P/\partial R_B^b > 0$ and $\partial\theta_P/\partial R_d < 0$.*

Proof. See Appendix B-4. ■

A higher borrower repayment chosen by the bank has two effects on the marginal borrower: a direct positive effect and an indirect effect that depends on its effect on the platform's best response on the borrower side (i.e., $\widehat{R_B^p}$). If the B2I externality is positive, or for

[25]The coefficient α_I is obtained by taking the derivative of Eq. (17) with respect to θ_P.

[26]If $h(\theta)$ is linear (as in $\theta \sim$ Beta[2, 1] or $\theta \sim$ Beta[1, 1]), we have $\alpha_I = 0$. If $h(\theta)$ is decreasing (as in in $\theta \sim$ Beta[1, 2]), we have $\alpha_I > 0$. On the contrary, when the density of θ is increasing and convex (like, for instance when $\theta \sim$ Beta[2, 1/2]), we have $\alpha_I < 0$.

low values of the product of the externalities $\alpha_B\alpha_I$ in absolute value, the direct effect always dominates the indirect effect.[27] Therefore, the bank lends to borrowers of better quality when it increases its borrower repayment. In that case, if the bank lowers the return of deposits, it also selects borrowers of better quality. Consequently, the bank is able to increase its margin on both sides (by lowering R_d and increasing R_B^b), and lend to borrowers of better quality.

In other cases, if the B2I externality is negative, and for large values of the product $\alpha_B\alpha_I$ in absolute value, the bank may lend to borrowers of lower quality when it increases its borrower repayment. This may happen when the externalities are of strong magnitude. The platform increases its borrower repayment when the bank increases the borrower repayment, which reduces the marginal borrower, and this indirect effect may dominate the direct effect. In that case, if the bank lowers the deposit rate, the bank lending supply expands.

In the rest of the paper, to limit the number of cases, we choose to analyze a market in which the indirect effect of the platform best response on the marginal borrower is not too strong with respect to the direct effect. This assumption is consistent with the fact that the quality of the bank lending portfolio responds more to the bank's choice of a borrower repayment than to the platform prices. Therefore, we make the assumption:

(A3) $\partial\theta_P/\partial R_B^b > 0$ and $\partial\theta_P/\partial R_d < 0$.

As shown in Lemma 1, (A3) holds if $\alpha_I > 0$ or if $\alpha_I < 0$ and $\alpha_B\alpha_I$ relatively low in absolute value. This is the case in particular if θ is uniformly distributed on $[0, 1]$, and in all other simulations with different shapes of the Beta distribution, except for negligible intervals of the parameters around the shutdown threshold of the platform. Given assumption (A3), Lemma 2 gives the impact of bank prices on investor participation in the platform.

Lemma 2 *If the B2I externality is positive ($\alpha_I \geq 0$), investor participation in the platform is increasing with R_B^b and decreasing with R_d. If there is no B2I externality ($\alpha_I = 0$), investor participation in the platform is not sensitive to R_B^b.*

If the B2I externality α_I is strictly negative ($\alpha_I < 0$), investor participation in the platform is decreasing with R_B^b, and may vary non-monotonically with R_d.

[27] The platform may sometimes react by increasing its borrower repayment when the bank increases it, which reduces the marginal borrower. However, the direct effect dominates the indirect effect when it is negative.

Proof. See Appendix B-4.

We show that under (A3), $\partial v_P/\partial R_B^b$ has the sign of the B2I externality α_I, whereas $\partial v_P/\partial R_d$ has the sign of $-p_I + \alpha_B\rho_B - \alpha_B\alpha_I$, with $\rho_B = p_I'(\theta_P)\widehat{R_B^p}$, $p_I = p_I(\theta_P)$. If $\alpha_I > 0$, since $-p_I + \alpha_B\rho_B < 0$ from the first-order condition of platform profit-maximization, we have $-p_I + \alpha_B\rho_B - \alpha_B\alpha_I < 0$. ■

If there is no B2I externality ($\alpha_I = 0$), the marginal investor is not sensitive to the choice of the bank's borrower repayment. Thus, investor participation in the platform only depends on the direct negative effect of the return on deposits chosen by the bank. If there is a B2I externality, the marginal investor depends both on the return on deposits and on the impact of bank prices on the marginal borrower. From (A3), if the bank increases the return on deposits, the marginal borrower is reduced. If the B2I externality is positive ($\alpha_I \geq 0$), investor participation in the platform decreases. By contrast, if the B2I externality is negative ($\alpha_I < 0$), the return offered to the investor may offset the increase in the deposit rate, such that investor participation may increase.

In Appendix D-1, we provide illustrations of Lemma 2 for different parameters of the Beta$[a, b]$. In these examples, we show that investor participation may increase or decrease with the borrower repayment asked by the bank, according to the shape of the Beta distribution. In particular, if $a = b = 1$ (θ uniformly distributed, $\alpha_I = 0$), we have that $\partial v_P/\partial R_B^b = 0$. If $a = 2, b = 1$ so that the density $h(\theta)$ is decreasing, then $\partial v_P/\partial R_B^b > 0$. Finally, if $a = 1, b = 1/2$ so that the density $h(\theta)$ is increasing and convex, then $\partial v_P/\partial R_B^b < 0$.[28] When $h(\theta)$ is linearly increasing as in $a = 2, b = 1$, v_P is constant in θ_P so that $\partial v_P/\partial R_B^b = 0$ as in the case of a uniform distribution of θ.

4.3 Stage 2: Bank accounts

A consumer of side $k = I, B$ opens a bank account if and only if his option value of opening a bank account is higher than the fixed deposit fee, that is, if and only if $ES_k(R_B^b, R_d) \geq F_k$. The option value of opening a bank account is the sum of the expected surplus of making

[28]Simulations show that the results obtained for $a = 1, b = 1/2$ are preserved when testing many other values of a and b such that the $h(\theta)$ is increasing and convex. Similarly, the results obtained for $a = 1, b = 2$ are preserved for values of a and b such that the $h(\theta)$ is decreasing.

a lending transaction with either the bank or the platform, respectively. Therefore, on the borrower side, the option value of opening a bank account is

$$ES_B(R_B^b, R_d) = \int_0^{\theta_P} u_B^p(\theta, \widehat{R_B^p})h(\theta)d\theta + \int_{\theta_P}^1 u_B^b(\theta, R_B^b)h(\theta)d\theta,$$

and on the investor side the option value of opening a bank account is

$$\begin{aligned} ES_I(R_B^b, R_d) &= H(\theta_P)\int_0^{v_P}(v_P + R_d - v - 1)g(v)dv + \\ &\quad (R_d - R_f)(H(\theta_P)(1 - G(v_P)) + (1 - H(\theta_P))). \end{aligned}$$

The first term in ES_I represents the average investor surplus of funding a platform loan. With probability $H(\theta_P)$, the borrower seeks credit from the platform. If the investor wishes to fund the loan (that is, if $v \leq v_P$), he obtains a surplus of $u_I^p(v, \widehat{R_I^p}) - (R_f - 1)$, or else $v_P + R_d - v - 1$. The second term in ES_I represents the average investor surplus of leaving his money in a bank account. If the investor does not wish to fund a platform loan (i.e., if $v > v_P$), he keeps his money in the bank and obtains a surplus $R_d - R_f$. With probability $1 - H(\theta_P)$, the borrower does not seek credit from the platform and the investor also obtains a surplus $R_d - R_f$.

4.4 Stage 1: Bank prices

At the first stage, the bank chooses the deposit fees F_B and F_I, the loan repayment R_B^b, and the return on deposits R_d that maximize its profit. We consider an interior equilibrium in which the platform enters the market.[29]

4.4.1 The bank profit

Since the bank has a monopoly on deposits, the two-part tariff structure of its contract implies that it extracts all the surplus of depositors through the fixed deposit fees. Replacing

[29] Such an equilibrium may not exist as we discuss in the following subsection, where we determine whether the bank prefers to accommodate platform entry, if entry is not blocked.

$F_k = ES_k(R_B^b, R_d)$ for $k = I, B$ in Eq. (3) gives

$$\pi^b = \pi_m + \pi_e, \tag{20}$$

where π_e is the total profit on the investor and borrower types who make a transaction through the "entrant" platform, and π_m is the total profit made on the other investor and borrower types. The profit π_e is the sum of the option values of making transactions through the platform for the borrower and the investor. We include in π_m the profit that the bank makes from lending, π_L, and from the extracting the consumer option value of opening a bank account, when the consumer does not make a transaction through the platform.

To facilitate the analysis, we rewrite each part of the bank profit as a function of θ_P, v_P, R_B^b and R_d. The bank makes an additional profit from entry given by:

$$\pi_e = \int_0^{\theta_P} u_B^p(\theta, \widehat{R_B^p})h(\theta)d\theta + H(\theta_P)\int_0^{v_P}(v_P + R_d - v - R_f)g(v)dv, \tag{21}$$

where the platform best response is given by:

$$\widehat{R_B^p} = ((C/\theta_P) - (y(1-p_B) + C - R_B^b))/p_B. \tag{22}$$

Since $g(v_P) = 1$, we have $\pi_e = p_B(y - \widehat{R_B^p})\underline{E}(\theta_P) + H(\theta_P)(v_P(R_d - R_f) + v_P^2/2)$.

The profit π_m from consumers who do not use the platform is given by:

$$\pi_m = \pi_L + \int_{\theta_P}^1 u_B^b(\theta, R_B^b)h(\theta)d\theta + (R_d - R_f)(H(\theta_P)(1 - G(v_P)) + (1 - H(\theta_P))),$$

where the last term of π_m represents the surplus that the bank extracts from the investors who do not fund a platform loan. Replacing π_L given in Eq. (4) in π_m gives

$$\pi_m = \int_{\theta_P}^1 (\theta y - c_b - R_f)h(\theta)d\theta. \tag{23}$$

The profit function π_m is exactly identical to the bank profit under monopoly, except that the marginal borrower θ_P is determined according to the platform competition.[30]

[30] The marginal borrower under monopoly is determined comparing the consumer utility of taking a bank

Replacing π_m and π_e in Eq. (20) gives the bank profit as a function of θ_P, v_P, R_B^b and R_d:

$$\pi^b = \int_{\theta_P}^{1} (\theta y - c_b - R_f)h(\theta)d\theta + p_B(y - \widehat{R_B^p})\underline{E}(\theta_P) + H(\theta_P)(v_P(R_d - R_f) + \frac{v_P^2}{2}), \quad (24)$$

where the platform best response $\widehat{R_B^p}$ is given by Eq. (22).

4.4.2 The profit-maximizing prices and the selection of borrowers

Competition with the platform implies that the bank trades off between making some profits from the downstream lending market and extracting some surplus from the upstream deposit market. When the bank increases the quality of its lending portfolio, this affects the marginal revenues that it obtains from the lending market and the deposit fees, respectively. The marginal revenues from a higher quality of loans are equal to $\widetilde{\pi}^b h(\theta_P)$, where

$$\widetilde{\pi}^b = y((\theta^M)^* - \theta_P) + \widetilde{\pi}^e, \quad (25)$$

$(\theta^M)^*$ being the profit-maximizing marginal borrower under monopoly, and $\partial \pi_e / \partial \theta_P = \widetilde{\pi}^e h(\theta_P)$ representing the additional marginal surplus from the deposit fees paid by the borrower and the investor, respectively, where $\widetilde{\pi}^e = \widetilde{\pi}_B^e + \widetilde{\pi}_I^e$,

$$\widetilde{\pi}_B^e = u_B^p(\theta_P, \widehat{R_B^p}) + (C\underline{E}(\theta_P))/(\theta_P^2 h(\theta_P)), \quad (26)$$

and

$$\widetilde{\pi}_I^e = (R_d - R_f)v_P + v_P^2/2. \quad (27)$$

Competition with the platform introduces a complementarity between the bank deposit-taking activity and the platform credit activity, that is not present in the monopoly benchmark. All else being equal, by selecting better quality borrowers, the bank obtains a higher marginal benefit of increasing the deposit rate, as it extracts a higher surplus from the investor types who fund platform loans. This complementarity between the credit and deposit-

loan and the outside option of no loan.

taking activities is standard in the literature on financial intermediation (see Freixas and Rochet, 2008).[31] In our setting, it is caused by the borrowers and investors' need to open a bank account to use the platform.

The profit-maximizing prices: To analyze the bank's optimal prices, we formalize additional notations and denote by:

- $\varepsilon_B^d = (\partial H(\theta_P)/\partial R_d)(R_d/\theta_P)$ the elasticity of the borrower demand for platform loans to the return on deposits R_d (resp., $\varepsilon_B^b > 0$ the elasticity of the borrower repayment chosen by the bank R_B^b),
- $\varepsilon_I^d = (\partial v_P/\partial R_d)(R_d/\theta_P)$ the elasticity of investor participation in the platform v_P to the return on deposits R_d (resp., ε_I^b the elasticity of the borrower repayment chosen by the bank R_B^b).

The sign of the elasticities depend on the externalities. From (A3), we have $\varepsilon_B^d < 0$ and $\varepsilon_B^b > 0$. From Lemma 2, if the B2I externality is strictly positive, we have $\varepsilon_I^b > 0$ and $\varepsilon_I^d < 0$. If the B2I externality is strictly negative, we have $\varepsilon_I^b \leq 0$ and ε_I^d is either positive or negative. If there is no B2I externality, we have $\varepsilon_I^b = 0$.

We are now able to determine the bank profit-maximizing prices. If there is an interior solution, the first-order conditions of bank profit-maximization are given by

$$\frac{\partial \pi^b}{\partial R_B^b} = \widetilde{\pi}^b h(\theta_P)\frac{\partial \theta_P}{\partial R_B^b} - \underline{E}(\theta_P) + \frac{\varepsilon_I^b v_P}{R_B^b}\frac{\partial \pi^b}{\partial v_P} = 0, \tag{28}$$

and

$$\frac{\partial \pi^b}{\partial R_d} = \widetilde{\pi}^b h(\theta_P)\frac{\partial \theta_P}{\partial R_d} + H(\theta_P)v_P + \frac{\varepsilon_I^d v_P}{R_d}\frac{\partial \pi^b}{\partial v_P} = 0, \tag{29}$$

where, if $R_d > R_f$, we have $\partial \pi^b/\partial v_P = \partial \pi^e/\partial v_P = (R_d - R_f + v_P)H(\theta_P) > 0$. We assume that the second-order conditions hold, which is the case if v and θ are uniformly distributed (see Appendix D-4).

[31] The cross-derivative of π_e with respect to θ_P and R_d differs from zero. In the literature on financial intermediation, the prices of loans and deposits may be interrelated to the bank cost function (see Freixas and Rochet, 2008). If there are economies of scope, a higher return on deposits decreases the marginal cost of lending.

We proceed by analyzing how competition with the platform impacts the choice of bank prices. The first terms in Eq. (28) and (29), respectively, represent the marginal impact of bank prices on the selection of borrowers. Under monopoly, the bank chooses the marginal borrower that equalizes the marginal benefits and the marginal costs of lending for the bank and the borrower ($\widetilde{\pi}^b = y((\theta^M)^* - \theta) = 0$). The marginal benefits and costs differ with platform competition because the bank takes into account how a higher quality of its lending portfolio impacts the marginal revenues from the depositors who use the platform (i.e, $\widetilde{\pi}^b = y((\theta^M)^* - \theta) + \widetilde{\pi}^e$). The second and the third terms in Eq. (28) and (29), respectively, represent the impact of bank prices on the additional profit that the bank extracts from the depositors who use the platform, if the selection of borrowers is not sensitive to prices. The sign and the magnitude of the last terms of Eq. (28) and (29), respectively, depend on the B2I externality, as bank prices affect investor participation in the platform for a given quality of loans. For example, if the B2I externality is negative, which implies that $\varepsilon_I^b \leq 0$, the bank incurs a higher marginal cost of increasing the borrower repayment, because it extracts a lower surplus from the investors who fund platform loans.

In Proposition 2, we give the profit-maximizing prices $(R_B^b)^*$ and R_d^* if there is an interior solution to the bank's profit-maximization problem. The equilibrium values of the marginal borrower and the marginal investor are denoted by θ^* and v^*, respectively.

Proposition 2 *Suppose that there exists an equilibrium with platform entry. The bank chooses the marginal borrower such that the marginal profits from in-house lending activities are equal to the marginal profits of allowing the platform to serve borrowers, that is, at R_d^* and θ^*, we have*

$$\widetilde{\pi}^b = \frac{p_I(\theta^*)(R_B^b)^*}{\varepsilon_B^b} - v^* \frac{\varepsilon_I^b}{\varepsilon_B^b}(R_d^* - R_f + v^*). \tag{30}$$

The bank chooses the deposit rate so as to equalize the marginal cost and the marginal benefit obtained when the investor funds a loan on the platform, that is, we have

$$R_d^* - R_f + v^* = -\frac{\widetilde{\pi}^b}{v^*}\frac{\varepsilon_B^d}{\varepsilon_I^d} - \frac{R_d^*}{\varepsilon_I^d}. \tag{31}$$

Proof. See Appendix C. ■

When the bank competes with the platform, the profit-maximizing deposit rate and the borrower repayments depend on the relative elasticities of investor demand and borrower demand for platform loans. These elasticities impact the rents that the bank extracts from the deposit market. The formula obtained in Proposition 2 resembles the one obtained with a platform business model of intermediation, in which the price structure $(R_B^b)^*/R_d^*$ and the ratio of demand elasticities on each side play a determinant role. The implicit definition of prices is more complex because financial intermediaries compete with asymmetric business models.

The bank chooses the return on deposits so as to equalize the marginal benefit of serving its borrowers and extracting rent from the depositors who use the platform (see Eq. (31)). A higher return on deposits expands the bank lending supply, because the bank lends to lower-quality borrowers (see (A3)). The average quality of platform loans is also reduced, which impacts investor participation in the platform, according to the B2I externality. If the B2I externality is positive, investor participation is reduced, which decreases the bank profit (i.e., $\varepsilon_I^d < 0$). If the B2I externality is negative, investor participation may either increase or decrease.

The bank chooses the borrower repayment according to the same trade off between the profits of loans and deposits. A higher borrower repayment decreases the bank lending supply, because the bank lends to higher-quality borrowers (see (A3)). On the other hand, the bank extracts a lower surplus from the borrower types who take a platform loan. The impact of the borrower repayment on the surplus that the bank extracts from the investors who fund the platform depends on the B2I externality. If it is negative (i.e., $\varepsilon_I^b < 0$), investor participation in the platform is reduced, which decreases the bank's profit.

The impact of competition on the selection of borrowers: A consequence of Proposition 2 is that the bank changes its selection of borrowers when it competes with the platform, according to the sign and magnitude of the B2I externality (see Appendix C-2). If there is no B2I externality ($\alpha_I = 0$), the bank always lends to higher-quality borrowers when it competes with the platform (i.e., we have $(\theta^M)^* \leq \theta^*$). In that case, the bank prefers not to compete with the platform for the riskier borrower types, in order to extract higher rents from the borrower and the investor through the deposit fees. Thus, the platform complements bank credit for the lower borrower types and substitutes bank credit for the intermediary borrower types.[32]

If the B2I externality differs from zero, the bank trades off between extracting a higher marginal surplus from the borrower and the investor, respectively. The result of this trade-off depends on the relative elasticities of borrower and investor demand to prices.

If the B2I externality is strictly positive ($\alpha_I > 0$), the bank tends to lower the quality of its lending portfolio to extract a higher marginal surplus from the investor. However, this effect may be offset by the extraction of a lower marginal surplus from the borrower. When investor demand is relatively more sensitive to prices than borrower demand, the bank may sometimes select borrowers of lower quality when it competes with the platform (i.e., we may have $(\theta^M)^* > \theta^*$). In that case, the platform expands the lending supply to lower borrower types when it enters the market, but does not substitute for bank credit.

If the B2I externality is strictly negative ($\alpha_I < 0$), the bank tends to increase the quality of its lending portfolio to extract a higher marginal surplus from the borrower. However, this effect may be offset by the extraction of a lower marginal surplus from the investor. If borrower demand is relatively more sensitive to prices than investor demand, the bank selects higher-quality borrowers when competing with the platform.

We thus conclude that if the B2I externality differs from zero, the bank may select borrowers of higher or lower quality when it competes with the platform.[33] The impact of competition with the platform depends on the bank's trade-off between extracting rents from the borrower and the investor, and the distribution of the probabilities of success in the credit market.

The equilibrium with uniform distributions: To fully characterize the equilibrium, we first restrict attention to the case in which both borrower and investor types are uniformly distributed on the $[0, 1]$ interval (a special case of the Beta distribution). In this case, there

[32] A family of distributions such that $h(\theta) = (a+1)\theta\hat{}(1/a)/a$, with $a > 0$, is such that there is no B2I externality.

[33] This result is caused by the B2I externality. If the bank could not extract any rents from the investor (with $R_d = R_f$), the bank would still have the incentives to increase the quality of its lending portfolio when the B2I externality is negative, and would sometimes lower the quality of its lending portfolio with a positive B2I externality.

is no B2I externality ($\alpha_I = 0$). If the platform enters the market, as shown in Appendix D-3, at the interior equilibrium we have

$$R_d^* = \frac{3p_B^*(R_f - p_B^*) + C}{5p_B^*}, \tag{32}$$

$$(R_B^b)^* = y(1 - p_B^*) + C - \frac{C}{5\theta^*} + \frac{2p_B^*(R_f - p_B^*)}{5\theta^*}, \tag{33}$$

where the marginal borrower and the marginal investor are respectively:

$$\theta^* = \frac{R_f + c_B}{(1 - p_B^*)y} + \frac{C - 2p_B^*(R_f - p_B^*)^2}{40(1 - p_B^*)(p_B^*)^2 y} - \frac{C/2}{(1 - p_B^*)y}, \tag{34}$$

$$v^* = \frac{C + 2p_B^*(p_B^* - R_f)}{10p_B^*}. \tag{35}$$

Rational expectations imply that the consumer anticipates being funded with probability v^*, so that $p_B^* = v^* = (\sqrt{R_f^2 + 8C} - R_f)/8$.

For instance, if $R_f = 1$, all the conditions for an interior solution hold for intermediate values of the cost of the bank c_b.[34] If c_b is too small, then the bank monopolizes the investor side and $v^* = 0$. On the other hand, if c_b is too large, the platform monopolizes the market and $\theta^* = 1$. Simulations show that if there is an interior solution, the bank's profit is higher under duopoly, so the bank would not deter entry. It is worth noting that these corner solutions imply that competition between financial intermediaries may cause a vertical reorganization of the sector, banks serving as upstream managers of deposits, and FinTech platforms supplying loans to consumers. This happens when the value of projects y is relatively small, or the bank's ability to monetize the collateral C is large or finally if the return on the risk-free asset R_f is large.

4.4.3 The effects of platform entry on borrower surplus:

Platform entry may have non-trivial effects on borrower surplus. On the one hand, the supply of credit is expanded to lower borrower types, but on the other hand, bank-platform competition might not always reduce borrower repayments. Indeed, the difference between

[34] The relevant thresholds are $c_b \geq \frac{1}{64}\left(-8y\left(\sqrt{1+8C} - 9\right) + 5\sqrt{1+8C} + 12C - 69\right)$ and $c_b \leq \frac{1}{64}(15 - 36C + 49\sqrt{1+8C})$.

borrower repayments with competition and under monopoly equals:

$$(R_B^b)^* - (R_B^M)^* = C(\frac{1}{(\theta^M)^*} - \frac{1}{\theta^*}) - p_B^*(y - (R_B^p)^*). \quad (36)$$

The first term captures the change in borrower quality with platform competition. It is positive if the bank selects borrowers of higher quality when it competes with the platform and negative otherwise. The second term captures the more standard price-reducing effect of competition. This negative effect is larger when the probability p_B^* that the borrower will find an investor on the platform increases, and when the reimbursement $(R_B^p)^*$ asked by the platform decreases. If the bank selects lower-quality borrowers than in the case of a monopoly, the borrower repayment is unambiguously lower with platform competition (that is, we have $(R_B^b)^* \leq (R_B^M)^*$). If the bank selects borrowers of higher quality, the borrower repayment may either be higher or lower than than in the case of a monopoly.

If there is no B2I externality, with uniform distributions of v and θ, the repayment rates may either increase or decrease. As shown in Appendix C-2, the bank lends to higher-quality borrowers if there is no B2I externality. For relatively large values of R_f, we have that $(R_B^b)^* > (R_B^M)^*$, which implies that high-quality borrower types pay higher repayments to the bank if the latter competes with the platform. The same happens when C is relatively large. Indeed, when C is larger, the market size of the platform is larger, but competition does not reduce the repayments paid by borrowers of higher quality. Hence, the surplus of high-quality borrower types may be reduced because of platform entry. Moreover, the repayment charged by the platform $(R_B^p)^*$ is in general higher than the repayment charged by the bank under monopoly $(R_B^M)^*$. Therefore, intermediary types of borrowers also lose surplus when the bank competes with the platform.[35]

If the B2I externality α_I differs from 0, the marginal investor v_P is sensitive to the borrower repayment chosen by the bank. The existence of a B2I externality affects the magnitude of the variation of the borrower repayment with respect to the monopoly case. From Eq. (30) of Proposition 2, the sign of the difference between repayment rates is given

[35]For instance, if c_b is fixed in the middle of the admissible values given in Appendix C-5, for $R_f = 1$ and $C = 0.3$, $(R_B^b)^* > (R_B^M)^*$ for all $y \leq 3$, and $(R_B^p)^* > (R_B^M)^*$ for all $y \leq 2.7$. Similar admissible threshold values of y are obtained varying the model parameters.

by:

$$p_I(\theta^*)((R_B^b)^* - (R_B^M)^*) = \varepsilon_B^b \widetilde{\pi}^b - p_I(\theta^*)(R_B^M)^* + \varepsilon_I^b (R_d^* - R_f + v^*)v^*.$$

Since $R_d^* - R_f + v^* > 0$ and since ε_I^b has the same sign as the B2I externality α_I, a higher sensitivity of the marginal investor v_P to the borrower repayment chosen by the bank increases $(R_B^b)^* - (R_B^M)^*$ if $\alpha_I > 0$ (resp., decreases $(R_B^b)^* - (R_B^M)^*$ if $\alpha_I < 0$). The relative elasticities of borrower demand and investor participation (ε_B^b and ε_I^b) impact the bank's incentives to increase the borrower repayment. For example, if the B2I externality is negative, ε_I^b is much higher than ε_B^b (in absolute value), the bank tends to reduce the borrower repayment more compared to the monopoly case when the magnitude of the B2I externality is increasing.

Unfortunately, our model does not allow us to similarly analyze the effect of platform entry on investor surplus, as the profit-maximizing deposit rate chosen by a monopolistic bank is not uniquely defined (see Appendix A). However, we note that platform entry has an impact on the level of risk supported by the investor. In the absence of the platform, all types of investors choose the (less-risky) bank contract, whereas if the platform enters the market, the inframarginal investors choose to fund a risky loan on the platform. This has no particular welfare impact in our framework in which all agents are risk neutral.

We thus conclude that the welfare effects of platform entry are not trivial. Though the profit of financial intermediaries increases, the average surplus of borrowers may be reduced if platform entry causes an increase in borrower repayments. The surplus of investors could increase if platforms offered higher returns to the investor than the bank does under monopoly, but investors could also bear higher risks.

4.5 Empirical implications

Our model offers some empirical predictions related to the impact of bank-platform competition on market outcomes. First, starting with the simplified case in which B2I externalities are not relevant, our model predicts that entry of the platform is more likely when the value of projects y is relatively small, or the bank's ability to monetize a collateral C is large, or finally if the return on the risk-free asset R_f is large. We thus expect entry of lending platforms to be more likely (and their market share larger upon entry) in relatively less profitable segments of the borrower market, when bank regulation is stricter (which could be captured by a larger C in the model) and finally in periods of high interest rates. Moreover, we also find that when the risk-free interest rate R_f is relatively large, high-quality borrowers generally pay higher repayments upon platform entry, with respect to the monopoly case. The same happens for high values of C, i.e., when banks monetize a higher share of the borrower's collateral. These findings could guide empirical explorations of the impact of platforms on bank prices.

More importantly, our model concentrates on the role of endogenous cross-side network externalities. Starting from the results stated above, we show how these externalities can amplify or mitigate the effects on platform entry and on bank tariffs depending on the sign of B2I externalities. This is related to the shape of the distribution of borrower types $h(\theta)$, and, in particular, to whether the density function is increasing or decreasing: this implies that markets with a larger mass of probability for relatively profitable projects will behave differently than markets in which a large number of projects have small expected rentability. Empirical work could try to assess what the relevant characteristics are of markets and/or technologies which match theses findings (for example, by comparing the outcomes observed in new markets as opposed to declining markets, in riskier markets, or in markets with low rentability but high social impact). Also, depending on the nature and size of cross-side network externalities, our model shows that lending platforms may either substitute or complement bank credit for intermediary borrower types, depending on the respective elasticities of borrower and investor demand for platform loans and on the sign and size of B2I and I2B externalities.

In addition, our model can be seen as a conceptual framework to interpret some existing empirical results which try to determine if and to what extent platform entry concentrates in regions with weaker access to traditional banks (Havrylchyk et al., 2021, Fuster et al., 2019). We also show that in some cases, platform entry may generate an expansion of bank credit to intermediary borrower types. Finally, our theoretical results could be useful to further explore the role of economy of scopes in shaping the credit market. In particular, our model is related to the findings of Benetton et al. (2022), who provide evidence that banks use the complementarity of their products on the asset side to compete with non-bank lenders. We explain how bank borrower repayments and returns on deposits depend on the attractiveness of platforms for investors and the quality of platforms' lending portfolios. This specific property could be tested in the market niches where banks compete with lending platforms.

5 Conclusion

Competition between banks and lending platforms with asymmetric business models is likely to generate non-trivial effects in the retail credit market. The resulting impact on repayment rates for borrowers and returns for investors depends on the degree of heterogeneity between borrowers and investors. We show that platform entry may generate unexpected effects in the credit market. Investor participation in the platform may be reduced when the platform attracts borrowers of better quality. Moreover, platform repayments charged to borrowers could be decreasing in bank repayments. In addition, we show that the welfare effects of platform entry are complex, and platform entry may reduce the average expected surplus of borrowers.

In the future, our work could be extended in a more general framework with several competing banks and platforms, and with the endogenous possibility for an entrant platform to choose its business model of financial intermediation.

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Appendix

Appendix A: Monopolistic Bank If the bank monopolizes the market, a borrower asks for credit from the bank if and only if $u_B^b(\theta, R_B^b)$ given in Eq.(1) is positive. The marginal borrower is given by $\theta_0^M \equiv C/(y - R_B^b + C)$. The bank chooses the return on deposits R_d and the borrower repayment R_B^b to maximize its profit π^b given in Eq. (20) with $\theta_0 = \theta_0^M$, subject to the participation constraints of the borrower, that is,

$$F_B \leq \int_{\theta_0^M}^1 u_B^b(\theta) h(\theta) d\theta, \tag{37}$$

and the participation constraint of the investor, that is, $F_I \leq R_d - R_f$. Since the participation constraints are satiated, the bank's problem is equivalent to maximizing

$$\pi^b = \int_{\theta_0^M}^{1} (y\theta - c_b - R_f)h(\theta)d\theta.$$

The bank completely extracts the surplus of the marginal borrower through the deposit fee and chooses the repayment R_B^M that the marginal benefits of granting a loan are equal to the marginal costs for the bank and the borrower. Solving for the first-order condition gives the profit-maximizing loan repayment

$$(R_B^M)^* = y + C - \frac{yC}{c_b + R_f}, \tag{38}$$

and the profit-maximizing marginal borrower

$$(\theta^M)^* = (c_b + R_f)/y. \tag{39}$$

The bank is indifferent to the choice of the deposit rate $R_d \geq R_f$ and its maximum profit is given by $(\pi^b)^m = y\overline{E}((\theta_0^M)^*) - (c_b + R_f)(1 - H((\theta^M)^*))$.

Appendix B-1: Proof of Proposition 1 We characterize the profit-maximizing platform prices $\widehat{R_B^p}$ and $\widehat{R_I^p}$ if there is an equilibrium with platform entry. We assume that the second-order conditions hold (i.e., the Hessian matrix is semi-definite negative) such that there is an interior solution to the platform's profit-maximization problem. These conditions are satisfied, for instance, in the case of uniform distributions (see Appendix D-4). We denote by $m_P = (\widehat{R_B^p} - \widehat{R_I^p})p_I(\theta_P)$ the platform's margin. Solving for the first-order conditions of profit-maximization gives

$$p_I(\theta_P)H(\theta_P)m_P g(v_P) - p_I(\theta_P)H(\theta_P)G(v_P) = 0 \tag{FOC-PF1}$$

and

$$\frac{d\theta_0}{dR_B^p}\left[(g(v_P)\widehat{R_I^p}m_P+G(v_P)(\widehat{R_B^p}-\widehat{R_I^p}))H(\theta_P)p_I^{'}(\theta_P)+m_Ph(\theta_P)G(v_P)\right]+p_I(\theta_P)H(\theta_P)G(v_P)=0. \tag{FOC-PF2}$$

Since $p_I(\theta_P)H(\theta_P) > 0$ and $g(v_P) > 0$, the first equation yields

$$m_P = G(v_P)/g(v_P). \tag{FOC-PF1-Bis}$$

Replacing this equation in (FOC-PF2), we find that (FOC-PF2) can be rewritten as

$$G(v_P)\left[\left.\frac{d\theta_0}{dR_B^p}\right|_{\widehat{R_B^p}}(H(\theta_P)\widehat{R_B^p}p_I^{'}(\theta_P)+m_Ph(\theta_P))+p_I(\theta_P)H(\theta_P)\right]=0. \tag{FOC-PF2-Bis}$$

Replacing for the elasticity of investor demand with respect to R_I^p evaluated at the platform's profit-maximizing prices

$$\varepsilon_I^p=\frac{p_I(\theta_P)g(v_P)\widehat{R_I^p}}{G(v_P)},$$

the elasticity of borrower demand with respect to R_B^p at the platform's profit-maximiming prices

$$\varepsilon_B^p=-\left.\frac{d\theta_0}{dR_B^p}\right|_{\widehat{R_B^p}}\frac{h(\theta_P)\widehat{R_B^p}}{H(\theta_P)},$$

and the elasticity of the platform's expected revenue with respect to R_B^p at the platform's profit-maximizing prices

$$\mu_P=1+\frac{p_I^{'}(\theta_P)\widehat{R_B^p}}{p_I(\theta_P)}\left.\frac{d\theta_0}{dR_B^p}\right|_{\widehat{R_B^p}}$$

into Eq. (FOC-PF2-Bis) and Eq. (FOC-PF1-Bis), respectively, gives

$$\frac{(\widehat{R_B^p}-\widehat{R_I^p})p_I(\theta_P)}{p_I(\theta_P)\widehat{R_B^p}}=\frac{\mu_P}{\varepsilon_B^p},$$

and

$$\frac{(\widehat{R_B^p}-\widehat{R_I^p})p_I(\theta_P)}{p_I(\theta_P)\widehat{R_I^p}}=\frac{1}{\varepsilon_I^p}.$$

Dividing the first equation above by the second equation, we find that the price structure is given by

$$\frac{\widehat{R_I^p}}{\widehat{R_B^p}} = \frac{\mu_P \varepsilon_I^p}{\varepsilon_B^p}.$$

This completes the proof of Proposition 1.

Appendix B-3: The marginal investor at the profit-maximizing prices chosen by the platform: The platform's best responses are implicitely defined by (FOC-PF1) and (FOC-PF2). From (FOC-PF1), at the platform's profit-maximizing prices, we have that $m_P = G(v_P)/g(v_P)$. Replacing for $m_P = p_I(\theta_P)(\widehat{R_B^p} - \widehat{R_I^p})$, after multiplication by $\theta_P - p_I(\theta_P)$ and division by $p_I(\theta_P) > 0$, we obtain that

$$(\theta_P - p_I(\theta_P))(\widehat{R_B^p} - \widehat{R_I^p}) = \frac{(\theta_P - p_I(\theta_P))G(v_P)}{p_I(\theta_P)g(v_P)}. \tag{40}$$

This implies that

$$(\theta_P - p_I(\theta_P))\widehat{R_I^p} = (\theta_P - p_I(\theta_P))\widehat{R_B^p} - \frac{(\theta_P - p_I(\theta_P))G(v_P)}{p_I(\theta_P)g(v_P)}. \tag{Eq-B3-1}$$

Replacing $p_I'(\theta_0)H(\theta_0) = h(\theta_0)(\theta_0 - p_I(\theta_0))$ in (Eq. FOC-PF2-Bis), since $m_P = G(v_P)/g(v_P)$ at an interior solution, we find that

$$\left.\frac{d\theta_0}{dR_B^p}\right|_{\widehat{R_B^p}} h(\theta_P)((\theta_P - p_I(\theta_P))\widehat{R_B^p} + \frac{G(v_P)}{g(v_P)}) + p_I(\theta_P)H(\theta_P) = 0.$$

This implies that

$$(\theta_P - p_I(\theta_P))\widehat{R_B^p} + \frac{G(v_P)}{g(v_P)} = \frac{-p_I(\theta_P)H(\theta_P)}{\left.\frac{d\theta_0}{dR_B^p}\right|_{\widehat{R_B^p}} h(\theta_P)}.$$

Replacing this equation in (Eq-B3-1), we obtain

$$(\theta_P - p_I(\theta_P))\widehat{R_I^p} = \frac{-p_I(\theta_P)H(\theta_P)}{\left.\frac{d\theta_0}{dR_B^p}\right|_{\widehat{R_B^p}} h(\theta_P)} - \frac{\theta_P}{p_I(\theta_P)}\frac{G(v_P)}{g(v_P)}$$

Since $d\theta_0/dR_B^p = -(\theta_0)^2/\beta$ with $\beta = C/p_B$, and since $p_I(\theta_P)H(\theta_P) = \underline{E}(\theta_0)$, we have

$$(\theta_P - p_I(\theta_P))\widehat{R_I^p} = \frac{\beta\underline{E}(\theta_P)}{h(\theta_P)(\theta_P)^2} - \frac{\theta_P}{p_I(\theta_P)}\frac{G(v_P)}{g(v_P)}. \quad \text{(Eq-B3-2)}$$

We denote by $\phi_P(\theta_0, R_B^p) = -(R_B^p/\underline{E}(\theta_0))(d\underline{E}(\theta_0)/dR_B^p)$ the elasticity of the expected probability of success of the borrower repayment. Since $d\theta_0/dR_B^p = -\theta_0^2/\beta$ and $d\underline{E}(\theta_0)/dR_B^p = \theta_0 h(\theta_0)(d\theta_0/dR_B^p)$, we have

$$\phi_P(\theta_0, R_B^p) = \frac{\theta_0^3 h(\theta_0) R_B^p}{\beta\underline{E}(\theta_0)}.$$

Since $\eta(\theta_0) = p_I(\theta_0)R_B^p/\phi_P(\theta_0, R_B^p)$ and $\phi_P(\theta_0, R_B^p) = \theta_0^3 h(\theta_0)R_B^p/(\beta\underline{E}(\theta_0))$, we have

$$\eta(\theta_0) = p_I(\theta_0)\beta\underline{E}(\theta_0)/(\theta_0^3 h(\theta_0)).$$

Replacing for $\eta(\theta_P)$ into (Eq-B3-2), the return chosen for investors is implicitly defined by

$$(\theta_P - p_I(\theta_P))\widehat{R_I^p} = \frac{\theta_P\eta(\theta_P)}{p_I(\theta_P)} - \frac{\theta_P}{p_I(\theta_P)}\frac{G(v_P)}{g(v_P)}$$

Therefore, the return chosen for investors $\widehat{R_I^p}$ is implicitly defined by

$$\widehat{R_I^p} = \frac{\theta_P}{p_I(\theta_P)(\theta_P - p_I(\theta_P))}\left[\eta(\theta_P) - (G/g)(v_P)\right]. \quad (41)$$

Since $v_P = p_I(\theta_P)\widehat{R_I^p} - R_d$, the marginal investor is implicitely defined by

$$v_P = \frac{\theta_P}{(\theta_P - p_I(\theta_P))}\left(\eta(\theta_P) - \frac{G(v_P)}{g(v_P)}\right) - R_d. \quad (42)$$

We now derive the necessary conditions such that there is an interior solution (i.e., the marginal investor $v_P \in (0, \overline{v})$). Let

$$Z(v) \equiv v - \frac{\theta_P}{(\theta_P - p_I(\theta_P))}\left(\eta(\theta_P) - (G/g)(v)\right) + R_d. \quad (43)$$

The function Z is twice differentiable on the segment $[0, \overline{v}]$. Since G/g is increasing in v, for all $v \in [0, \overline{v}]$, we have that $Z'(v) \geq 0$. Therefore, Z is increasing in v. If $Z(\overline{v}) \leq 0$, for all

$v \in [0, \overline{v}]$, we have $Z(v) \leq 0$ and the investor always lends on the platform. If $Z(0) \geq 0$, for all $v \in [0, \overline{v}]$, we have $Z(v) \geq 0$ and the investor never lends on the platform. If $Z(\overline{v}) > 0$ and $Z(0) < 0$, there exists a unique $v_P \in (0, \overline{v})$ such that $Z(v_P) = 0$. Replacing $Z(\overline{v})$ and $Z(0)$ given by Eq. (43) gives the result of Corollary 1.

Appendix B-4: Variations of the best responses, the marginal investor and the marginal borrower with bank prices The platform best responses are implicitly defined by a system of four equations and four unknowns, that is, v_P, θ_P, $\widehat{R_I^p}$ and $\widehat{R_B^p}$. The first two equations are given by (FOC-PF1) and (FOC-PF2). The last two equations are given by Eq. (9) and Eq. (7). To simplify the exposure of the results, we assume that v is uniformly distributed on $[0, 1]$. Replacing $p_I(\theta_P)\widehat{R_I^p} = v_P + R_d$ in the first equation (FOC-PF1) of Appendix B-1 gives

$$p_I(\theta_P)\widehat{R_B^p} - 2v_P = R_d. \tag{E-PF1}$$

From Appendix B-3, the second equation (FOC-PF2) is equivalent to

$$v_P - \frac{\theta_P}{(\theta_P - p_I(\theta_P))} \left(\eta(\theta_P) - v_P\right) = -R_d. \tag{E-PF2}$$

The last two equations are given by the definition of the marginal borrower

$$\theta_P - \frac{C}{y(1 - p_B) + C - R_B^b + p_B\widehat{R_B^p}} = 0. \tag{E-PF3}$$

from Eq. (9) and the marginal investor

$$v_P - p_I(\theta_P)\widehat{R_I^p} = -R_d \tag{E-PF4}$$

from Eq. (7), respectively.

We analyze the variation of the platform's best responses, the marginal borrower θ_P and the marginal investor v_P using the implicit function theorem. Taking the derivative of each equation (E-PF1, E-PF2, E-PF3, and E-PF4) with respect to R_d and R_B^b, we obtain that

$$M_0 \begin{pmatrix} \frac{\partial \theta_P}{\partial R_d} \\ \frac{\partial v_P}{\partial R_d} \\ \frac{\partial \widehat{R_I^p}}{\partial R_d} \\ \frac{\partial \widehat{R_B^p}}{\partial R_d} \end{pmatrix} = \begin{pmatrix} 1 \\ -1 \\ 0 \\ -1 \end{pmatrix},$$

and

$$M_0 \begin{pmatrix} \frac{\partial \theta_P}{\partial R_B^b} \\ \frac{\partial v_P}{\partial R_B^b} \\ \frac{\partial \widehat{R_I^p}}{\partial R_B^b} \\ \frac{\partial \widehat{R_B^p}}{\partial R_B^b} \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ \frac{\theta_P^2}{C+s_b} \\ 0 \end{pmatrix}$$

where

$$M_0 = \begin{pmatrix} \rho_B & -2 & 0 & p_M \\ -\alpha_I & \gamma_I & 0 & 0 \\ 1 & 0 & 0 & \alpha_B \\ -\rho_I & 1 & -p_I & 0 \end{pmatrix}.$$

The coefficients of M_0 at the platform's profit-maximizing prices are given by $\alpha_B = \theta_P^2/\beta > 0$, $\rho_I = p_I'(\theta_P)\widehat{R_I^p} > 0$, $p_I = p_I(\theta_P)$, $\rho_B = p_I^{'}(\theta_P)\widehat{R_B^p} > 0$, $\gamma_B = \left.\frac{2g^2 - Gg^{'}}{g^2}\right|_{v_P} = 2 > 0$,

$$\alpha_I = \frac{\theta_P}{(\theta_P - p_I(\theta_P))}\eta'(\theta_P) + \frac{\theta_P p_I'(\theta_P) - p_I(\theta_P)}{(\theta_P - p_I(\theta_P))^2}\left(\eta(\theta_P) - v_P\right),$$

and $\gamma_I = \frac{2\theta_P - p_I(\theta_P)}{\theta_P - p_I(\theta_P)} > 0$. We also denote by $\Delta = (p_I - \alpha_B \rho_B)\gamma_I + \alpha_B \alpha_I \gamma_B$ the determinant of the matrix M_0.

- **Signs of the coefficients of the matrix M_0:**

Since $\theta_P \geq 0$ and $\beta \geq 0$, we have $\alpha_B \geq 0$. Since $p_I'(\theta_P) \geq 0$, we have $\rho_I \geq 0$ and $\rho_B \geq 0$. Moreover, we have $\gamma_I - \gamma_B = \gamma_I - 2 = p_I(\theta_P)/(\theta_P - p_I(\theta_P)) \geq 0$. In our example with the distribution Beta for θ, we find that the sign of α_I may be either positive or negative.

- **Sign of $\Delta = (p_I - \alpha_B \rho_B)\gamma_I + \alpha_I \alpha_B \gamma_B$:**

From (FOC2), in an interior solution, it must be that $p_I - \alpha_B \rho_B > 0$. Since $\gamma_I > 0$, we have $\gamma_I(p_I - \alpha_B \rho_B) > 0$. Since $\alpha_B \geq 0$, $\gamma_I > 0$ and $\gamma_B \geq 0$, if $\alpha_I \geq 0$ or if $\alpha_B \alpha_I$ is small in absolute value, we have $\Delta > 0$. This is the case in all our simulations with the Beta distribution, except for negligible intervals around the shutdown threshold for the platform.

- **Inverse of the matrix M_0:**

The matrix M_0 is invertible if and only if $\Delta \neq 0$. In that case, we have (with $\gamma_B = 2$)

$$M_0^{-1} = \frac{1}{\Delta} \begin{pmatrix} -\alpha_B \gamma_I & -\alpha_B \gamma_B & p_I \gamma_I & 0 \\ -\alpha_B \alpha_I & p_I - \alpha_B \rho_B & p_I \alpha_I & 0 \\ \frac{\alpha_B(\rho_I \gamma_I - \alpha_I)}{p_I} & \frac{p_I + \alpha_B(\rho_I \gamma_B - \rho_B)}{p_I} & \alpha_I - \rho_I \gamma_I & -\frac{\Delta}{p_I} \\ \gamma_I & \gamma_B & \gamma_B \alpha_I - \rho_B \gamma_I & 0 \end{pmatrix}.$$

- **The variations of the best responses, the marginal borrower and the marginal investor with respect to the borrower repayment R_B^b:**

If M_0 is invertible, we have

$$\begin{pmatrix} \frac{\partial \theta_P}{\partial R_B^b} \\ \frac{\partial v_P}{\partial R_B^b} \\ \frac{\partial \widetilde{R_I^p}}{\partial R_B^b} \\ \frac{\partial \widetilde{R_B^p}}{\partial R_B^b} \end{pmatrix} = \frac{\theta_P^2}{C\Delta} \begin{pmatrix} p_I \gamma_I \\ p_I \alpha_I \\ \alpha_I - \rho_I \gamma_I \\ \gamma_B \alpha_I - \rho_B \gamma_I \end{pmatrix}.$$

Since $p_I \gamma_I > 0$, we note that $\partial \theta_P / \partial R_B^b$ has the sign of Δ which is positive under (A3). We can therefore conclude that $\partial v_P / \partial R_B^b$ has the sign of α_I, which completes the first part of the proof of Lemma 2.

- **The variations of the best responses, the marginal borrower and the marginal investor with respect to the deposit rate R_d:**

If M_0 is invertible, we have

$$\begin{pmatrix} \frac{\partial \theta_P}{\partial R_d} \\ \frac{\partial v_P}{\partial R_d} \\ \frac{\partial \widehat{R_I^p}}{\partial R_d} \\ \frac{\partial \widehat{R_B^p}}{\partial R_d} \end{pmatrix} = M_0^{-1} \begin{pmatrix} 1 \\ -1 \\ 0 \\ -1 \end{pmatrix}.$$

This implies that

$$\begin{pmatrix} \frac{\partial \theta_P}{\partial R_d} \\ \frac{\partial v_P}{\partial R_d} \\ \frac{\partial \widehat{R_I^p}}{\partial R_d} \\ \frac{\partial \widehat{R_B^p}}{\partial R_d} \end{pmatrix} = \frac{1}{\Delta} \begin{pmatrix} -\alpha_B(\gamma_I - 2) \\ -p_I - \alpha_B \alpha_I + \alpha_B \rho_B \\ (\alpha_B(\rho_I \gamma_I - \alpha_I) - p_I - \alpha_B(2\rho_I - \rho_B) + \Delta)/p_I \\ \gamma_I - 2 \end{pmatrix}.$$

Since $\Delta > 0$ under (A3), $\alpha_B \geq 0$ and $\gamma_I - 2 \geq 0$, we have $\partial \theta_P / \partial R_d \leq 0$. The sign of $\partial v_P / \partial R_d$ is ambiguous. It is however possible to conclude that if $\alpha_I > 0$, the sign of $\partial v_P / \partial R_d$ is negative because $-p_I + \alpha_B \rho_B < 0$ from the (FOC2). This completes the second part of the proof of Lemma 2.

Appendix C: The bank profit-maximizing prices and the selection of borrowers:

Appendix C-1: The profit-maximizing prices: We have expressed $\pi^b = \pi_m + \pi_e$ as a function of θ_P, v_P, R_B^b and R_d in section 4.4.1. From Eq. (23), taking the derivative of π_m with respect to θ_P gives:

$$\frac{\partial \pi_m}{\partial \theta_P} = (y(-\theta_P + (\theta^M)^*))h(\theta_P).$$

From Eq. (21), taking the derivative of π_e with respect to θ_P gives

$$\frac{\partial \pi_e}{\partial \theta_P} = u_B^p(\theta_P, \widehat{R_B^p})h(\theta_P) + \frac{C}{\theta_P^2}\underline{E}(\theta_P) + h(\theta_P)((R_d - R_f)v_P + \frac{v_P^2}{2}),$$

because $u_B^p(\theta, \widehat{R_B^p}) = \theta p_B(y - \widehat{R_B^p})$ and $\partial \widehat{R_B^p} / \partial \theta_P = -C/(p_B \theta_P^2)$. Therefore, the derivative of π^b with respect to θ_P is given by

$$\frac{\partial \pi^b}{\partial \theta_P} = \frac{\partial(\pi_m + \pi_e)}{\partial \theta_P} = \widetilde{\pi}^b h(\theta_P),$$

with $\widetilde{\pi}^b = y(-\theta_P + (\theta^M)^*) + \widetilde{\pi}^e$, and

$$\widetilde{\pi}^e = u_B^p(\theta_P, \widehat{R_B^p}) + \frac{C}{\theta_P^2}\frac{\underline{E}(\theta_P)}{h(\theta_P)} + (R_d - R_f)v_P + \frac{v_P^2}{2}.$$

The first-order conditions of profit-maximization with respect to R_B^b and R_d are given by:

$$\frac{\partial \pi^b}{\partial R_B^b} = \widetilde{\pi}^b h(\theta_P)\frac{\partial \theta_P}{\partial R_B^b} - \underline{E}(\theta_P) + \frac{\varepsilon_I^b v_P}{R_B^b}\frac{\partial \pi^b}{\partial v_P} = 0, \qquad \text{(FOC-B1)}$$

and

$$\frac{\partial \pi^b}{\partial R_d} = \widetilde{\pi}^b h(\theta_P)\frac{\partial \theta_P}{\partial R_d} + H(\theta_P)v_P + \frac{\varepsilon_I^d v_P}{R_d}\frac{\partial \pi^b}{\partial v_P} = 0. \qquad \text{(FOC-B2)}$$

Replacing $\varepsilon_B^b = (h(\theta_P)/H(\theta_P))(\partial\theta_P/\partial R_B^b)R_B^b$, $\varepsilon_B^d = (h(\theta_P)/H(\theta_P))(\partial\theta_P/\partial R_d)R_d$, $\underline{E}(\theta_P) = H(\theta_P)p_I(\theta_P)$ and

$$\frac{\partial \pi^b}{\partial v_P} = \frac{\partial \pi^e}{\partial v_P} = H(\theta_P)(R_d - R_f + v_P)$$

in the first-order conditions, gives:

$$\varepsilon_I^d v^*(R_d^* - R_f + v^*) = -\varepsilon_B^d \widetilde{\pi}^b - R_d^* v^*,$$

and

$$\varepsilon_B^b \widetilde{\pi}^b = p_I(\theta^*)(R_B^b)^* - v^* \varepsilon_I^b (v^* + R_d^* - R_f).$$

A division of the first equation by $\varepsilon_I^d v^*$ and the second equation by ε_B^b, respectively, gives the result of Proposition 2.

Appendix C-2: The impact of competition on the selection of borrowers: Using equation (FOC-B1) of the first-order condition, at $\theta = \theta^*$, we have

$$\widetilde{\pi}^b = \frac{\underline{E}(\theta^*)}{h(\theta^*)\frac{\partial \theta_P}{\partial R_B^b}} - \frac{v^* \varepsilon_I^b}{\varepsilon_B^b}(v^* + R_d^* - R_f).$$

From equation (25), we have $\widetilde{\pi}^b = y((\theta^M)^* - \theta^*) + \widetilde{\pi}^e_B + \widetilde{\pi}^e_I$ (see equation), so that:

$$y((\theta^M)^* - \theta^*) = \delta_B + \delta_I,$$

where

$$\delta_B = \frac{\underline{E}(\theta^*)}{h(\theta^*)\frac{\partial\theta_P}{\partial R^b_B}} - \widetilde{\pi}^e_B,$$

and

$$\delta_I = -\frac{v^*\varepsilon^b_I}{\varepsilon^b_B}(v^* + R^*_d - R_f) - \widetilde{\pi}^e_I.$$

From Appendix B-4, we have $\partial\theta_P/\partial R^b_B = (\theta_P)^2\gamma_I p_I/(C\Delta)$. Replacing for $\widetilde{\pi}^e_B = u^p_B(\theta_P, \widehat{R^p_B}) + (C\underline{E}(\theta_P))/(\theta_P^2 h(\theta_P))$ given by (26) into δ_B gives

$$\delta_B = \frac{C\underline{E}(\theta^*)}{h(\theta^*)(\theta^*)^2}\frac{\alpha_B(-\rho_B\gamma_I + \alpha_I\gamma_B)}{\gamma_I p_I} - u^p_B(\theta^*, \widehat{R^p_B}).$$

Replacing $\alpha_B = p_B(\theta^*)^2/C$, $\gamma_B = 2$, $\rho_B = p'_I(\theta^*)\widehat{R^p_B}$, $\underline{E}(\theta^*) = p_I(\theta^*)H(\theta^*)$, $p'_I(\theta^*)H(\theta^*) = h(\theta^*)(\theta^* - p_I(\theta^*))$ and $u^p_B(\theta^*, \widehat{R^p_B}) = p_B\theta^*(y - \widehat{R^p_B})$, we find that

$$\delta_B = p_B(\frac{2\alpha_I H(\theta^*)}{\gamma_I h(\theta^*)} + p_I(\theta^*)\widehat{R^p_B} - \theta^* y).$$

From Appendix B-4, we have that

$$\frac{v^*\varepsilon^b_I}{\varepsilon^b_B} = \left(\frac{\partial\theta_P}{\partial R^b_B}\right)^{-1}\frac{\partial v_P}{\partial R^b_B}\frac{H(\theta^*)}{h(\theta^*)} = \frac{\alpha_I}{\gamma_I}\frac{H(\theta^*)}{h(\theta^*)}.$$

This implies that:

$$\delta_I = -\frac{H(\theta^*)\alpha_I}{h(\theta^*)\gamma_I}(v^* + R^*_d - R_f) - \widetilde{\pi}^e_I.$$

If $\alpha_I = 0$, since $p_I(\theta^*)\widehat{R^p_B} - \theta^* y < 0$ and $\widetilde{\pi}^e_I > 0$ from (27), we have $\delta_B = p_B(p_I(\theta^*)\widehat{R^p_B} - \theta^* y) < 0$ and $\delta_I = -\widetilde{\pi}^e_I < 0$. Therefore, we have $\delta_B + \delta_I = y((\theta^M)^* - \theta^*) < 0$. We thus conclude that if $\alpha_I = 0$, the bank lends to higher-quality borrowers when it competes with the platform.

If $\alpha_I < 0$, we have $\delta_B < 0$. However, the sign of δ_I is ambiguous, because the first term of

δ_I is positive, while the second is negative. Therefore, the bank tends to increase the quality of its lending portfolio to extract a higher marginal surplus from the borrower. However, this effect may be offset by the extraction of a lower marginal surplus from the investor because the B2I externality is negative.

If $\alpha_I > 0$, we have $\delta_I < 0$. However, the sign of δ_B is ambiguous, because the first term is positive, while the sum of the second and the third term is negative. Therefore, the bank tends to lower the quality of its lending portfolio to extract a higher marginal surplus from the investor. However, this effect may be offset by the extraction of a higher marginal surplus from the borrower.

Appendix D: Examples of distributions: We present here the case where v is uniformly distributed on $[0,1]$ interval, while θ is distributed following a Beta$[a,b]$ on the $[0,1]$ interval. In particular, we detail three cases:

- $a = b = 1$, which implies that θ is uniformly distributed on the $[0,1]$ interval;
- $a = 2, b = 1$, which implies that the density of θ, $h(\theta)$, is decreasing on the $[0,1]$ interval;
- $a = 2, b = 1/2$ which implies that the density of θ, $h(\theta)$, is increasing on the $[0,1]$ interval.

Appendix D-1: The platform's problem: We start considering the platform problem. In all our examples, we simply denote $\theta_P(R_B^b, R_d) = \theta_P$ for the sake of notation.

Uniformly distributed v and θ : We consider the case $a = b = 1$. Replacing $G(v_0) = v_0$, $h(\theta) = 1$ and $p_B = \theta/2$, from the first order conditions for the maximization of the profit of the platform (5), we obtain the platform's best responses at an interior solution:

$$\widehat{R_B^p}(R_B^b, R_d) = \frac{2(C + p_B R_d)}{3 p_B \theta_P}, \tag{44}$$

and

$$\widehat{R_I^p}(R_B^b, R_d) = \frac{(C + 4 p_B R_d)}{3 p_B \theta_P}, \tag{45}$$

with the marginal borrower at the profit-maximizing prices chosen by the platform given by

$$\theta_P(R_B^b, R_d) = \frac{C - 2p_B R_d}{3(C - R_B^b + y(1-p_B))}, \tag{46}$$

and the marginal investor given by

$$v_P(R_B^b, R_d) = \frac{C - 2p_B R_d}{6p_B}. \tag{47}$$

In this case, the marginal investor at the profit-maximizing prices chosen by the platform is independent of the borrower repayment chosen by the bank. To relate these results with the findings of Corollary 1, Lemma 1, and Lemma 2, we note that in the uniform case we have: $p_I(\theta_P) = \underline{E}(\theta_P) = \theta_P/2$. From (16), this implies that $\eta(\theta_P) = \beta/4$ and $\alpha_I = 0$. Using these results, it is straightforward to verify that in the uniform case we have $\partial\theta_P/\partial R_B^b > 0$, $\partial v_P/\partial R_B^b = 0$, $\partial\widehat{R_I^p}/\partial R_B^b < 0$ and $\partial\widehat{R_B^p}/\partial R_B^b < 0$.

Uniformly distributed v and decreasing $h(\theta)$: We consider now the case $a = 1$, $b = 2$. Replacing $G(v_0) = v_0$, $h(\theta) = 2(1-\theta)$ and $p_B = \theta(3-2\theta)/3(2-\theta)$, from the first-order conditions for the maximization of the profit of the platform (5), we obtain the platform's best responses at an interior solution:

$$\widehat{R_B^p}(R_B^b, R_d) = \frac{C(3-2\theta_P) + 3(1-\theta_P)(\theta_P-2)^2 p_B R_d}{(9-4\theta_P)(1-\theta_P)(2-\theta_P)\theta_P p_B} \tag{48}$$

and

$$\widehat{R_I^p}(R_B^b, R_d) = \frac{C(3-2\theta_P)^2 + 18(1-\theta_P)(2-\theta_P)^3 p_B R_d}{2\theta_P\left(8\theta_P^4 - 54\theta_P^3 + 133\theta_P^2 - 141\theta_P + 54\right)p_B}, \tag{49}$$

where we have simply denoted $\theta_P(R_B^b, R_d) = \theta_P$ for the sake of notation. From the above expressions we can derive:

$$v_P(R_B^b, R_d) = \frac{C(3-2\theta_P^2 - 6(1-\theta_P)(2-\theta_P)^2(3-\theta_P)p_B R_d}{6(1-\theta_P)(2-\theta_P)^2(4\theta_P-9)p_B}. \tag{50}$$

It can be verified that, for admissible values of the parameters, $v_P(R_B^b, R_d)$ given in (50) is an decreasing function of R_d and an increasing function of θ. Then, we have that:

$$\frac{\partial v_P}{\partial R_d} < 0,$$

and from (A3), we have:

$$\frac{\partial v_P}{\partial R_B^b} = \frac{\partial v_P}{\partial \theta_P}\frac{\partial \theta_P}{\partial R_B^b} > 0$$

We tested numerically many other distributions of θ such that $h(\theta)$ is decreasing with θ and we obtained the same results. We conclude that simulations show that in examples in which the density function $h(\theta)$ is increasing, the same results apply.

Uniformly distributed v and increasing $h(\theta)$: We now consider the case $a = 2$, $b = 1/2$. Replacing $G(v_0) = v_0$, $h(\theta) = 1/(2\sqrt{1-\theta})$ and $p_B = (2(1-\sqrt{1-\theta}) - \sqrt{1-\theta}\theta)/3(1-\sqrt{1-\theta})$, from the first-order conditions for the maximization of the profit of the platform (5), we obtain the platform's best responses at an interior solution:

$$\widehat{R_B^p}(R_B^b, R_d) = \frac{C\left(-4\theta_P + 8\sqrt{1-\theta_P} + 4\right) + 3\left(-\theta_P + 2\sqrt{1-\theta_P} + 2\right)p_B R_d}{\left(-5\theta_P + 9\sqrt{1-\theta_P} + 9\right)\theta_P p_B}, \tag{51}$$

and

$$\widehat{R_I^p}(R_B^b, R_d) = \frac{2C\left(\left(-\theta_P + 3\sqrt{1-\theta_P} + 2\right)\theta_P + \sqrt{1-\theta_P} - 1\right) + 9\left(2\left(\sqrt{1-\theta_P} + 1\right) - \theta_P\right)\theta_P p_B R_d}{\left(-5\theta_P + 14\sqrt{1-\theta_P} + 13\right)\theta_P^2 p_B}, \tag{52}$$

where we have once again denoted $\theta_P(R_B^b, R_d) = \theta_P$ for the sake of notation. From the above expression we can derive:

$$v_P(R_B^b, R_d) = \frac{2C\left(\sqrt{1-\theta_P} + 2\right)^2\sqrt{1-\theta_P} - 3\left(\sqrt{1-\theta_P} + 1\right)^2\left(2\sqrt{1-\theta_P} + 1\right)p_B R_d}{3\left(\sqrt{1-\theta_P} + 1\right)^2\left(5\sqrt{1-\theta_P} + 4\right)p_B}. \tag{53}$$

It can be verified that, for admissible values of the parameters, $v_P(R_B^b, R_d)$ given in (53) is an decreasing function of R_d and a decreasing function of θ_P. Then we have that:

$$\frac{\partial v_P}{\partial R_d} > 0,$$

and assuming (A3)

$$\frac{\partial v_P}{\partial R_B^b} = \frac{\partial v_P}{\partial \theta_P}\frac{\partial \theta_P}{\partial R_B^b} < 0$$

We tested numerically many other distributions of θ such that $h(\theta)$ is increasing with θ and convex and we obtained the same results. We conclude that simulations show that in examples in which the density function $h(\theta)$ is increasing and convex, the same results apply. If $h(\theta)$ is linearly increasing, v_P is constant in θ so that $\frac{\partial v_P}{\partial R_B^b} = 0$ as in the case of uniformly distributed θ described above.

Appendix D-2: Second-order conditions of the platform problem in the uniform case $a = b = 1$. We now fully solve the example with uniform distributions. In this case the model simplifies and we can derive the full analytical solution, including the second-order conditions and the solution of the bank's problem (see also next section D-3).

The platform's profit admits a local maximum at $(\widehat{R_I^p}, \widehat{R_B^p})$ if

$$\left.\frac{\partial^2 \pi^p}{\partial^2 R_I^p}\right|_{(\widehat{R_I^p}, \widehat{R_B^p})} < 0,$$

and

$$\left.\frac{\partial^2 \pi^p}{\partial R_I^p \partial R_B^p}\right|^2_{(\widehat{R_I^p}, \widehat{R_B^p})} - \left.\frac{\partial^2 \pi^p}{\partial^2 R_I^p}\right|_{(\widehat{R_I^p}, \widehat{R_B^p})}\left.\frac{\partial^2 \pi^p}{\partial^2 R_B^p}\right|_{(\widehat{R_I^p}, \widehat{R_B^p})} < 0.$$

If v and θ are uniformly distributed on $[0,1]$, we have

$$\left.\frac{\partial^2 \pi^p}{\partial^2 R_I^p}\right|_{(\widehat{R_I^p}, \widehat{R_B^p})} = -\frac{\theta_P^3}{2} < 0,$$

and

$$\left.\frac{\partial^2 \pi^p}{\partial R_I^p \partial R_B^p}\right|^2_{(\widehat{R_I^p}, \widehat{R_B^p})} - \left.\frac{\partial^2 \pi^p}{\partial^2 R_I^p}\right|_{(\widehat{R_I^p}, \widehat{R_B^p})}\left.\frac{\partial^2 \pi^p}{\partial^2 R_B^p}\right|_{(\widehat{R_I^p}, \widehat{R_B^p})} = \frac{-\theta_P^6(C - 2p_B(R_d))^2}{48C)^2} < 0.$$

Therefore, the second-order conditions are verified under the assumption of uniform distributions.

Appendix D-3: The bank's problem and equilibrium with uniform distributions, $a = b = 1$. To solve the bank's problem, we replace the values of $\widehat{R_B^p}$ and $\widehat{R_I^p}$ given in (44) and (45), respectively, in the profit function of the bank (24). Moreover, using (46) we can replace R_B^b in the profit function of the bank with:

$$R_B^b = y(1 - p_B) + \frac{2}{3}\left(\frac{p_B R_d + C}{\theta_P}\right) - \frac{(1 - \theta_P)C}{\theta_P} \tag{54}$$

Maximizing the bank's profit with respect to θ_P and R_d is equivalent to maximizing with respect to R_B^b and R_d after replacing (54). This simplifies the computations to obtain an explicit solution in this uniform example. Solving for the first-order condition with respect to θ_P and R_d we obtain that, at an interior solution, R_d^* and θ^* are given by the equations (32) and (34). Using equations (42), (44)-(45) and (54) we obtain the expressions for $(R_B^b)^*$ and v_0^* given in equations (33) and (35) respectively.

Appendix D-4: Second-order condition of the bank's problem with uniform distributions: The bank's profit admits a local maximum at (θ^*, R_d^*) if

$$\left.\frac{\partial^2 \pi^b}{\partial \theta_P^2}\right|_{(\theta^*, R_d^*)} < 0,$$

and

$$\left.\frac{\partial^2 \pi^b}{\partial \theta_P \partial R_d}\right|_{(\theta^*, R_d^*)}^2 - \left.\frac{\partial^2 \pi^b}{\partial \theta_0^2}\right|_{(\theta^*, R_d^*)} \left.\frac{\partial^2 \pi^b}{R_d^2}\right|_{(\theta^*, R_d^*)} < 0.$$

In our uniform distribution example, we have

$$\left.\frac{\partial^2 \pi^b}{\partial \theta_P^2}\right|_{(\theta^*, R_d^*)} = -\frac{5}{9}\theta^* < 0,$$

and

$$\left.\frac{\partial^2 \pi^b}{\partial \theta_P \partial R_d}\right|_{(\theta^*, R_d^*)}^2 - \left.\frac{\partial^2 \pi^b}{\partial \theta_0^2}\right|_{(\theta^*, R_d^*)} \left.\frac{\partial^2 \pi^b}{\partial R_d^2}\right|_{(\theta^*, R_d^*)} = -\frac{5}{9}\theta^*(1 - p_B)y < 0.$$

Therefore, if there is an interior solution, the conditions such that there is a local maximum at the profit-maximizing prices chosen by the bank are verified with our uniform distributions.