Bank-Platform Competition in the Credit Market

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Abstract

The paper analyzes the equilibrium on the credit market when a bank and a platform compete to offer credit to borrowers. The platform does not manage deposit accounts, but acts as an intermediary between the borrower and the investor, offering a risky contract such that the investor is only reimbursed if the borrower is successful. We first characterize the optimal contracts proposed by the platform, depending on the two-sided structure of the market. Then, we study the impact of bank-platform competition on the average risk of bank loans and the relative level of interest rates.

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

JEL Codes: L1, L5, G2.

1 Introduction

Over the last ten years, the entry of non-banks in the retail credit market has impacted the volume of credit offered to retail borrowers and the risks faced by financial intermediaries. Non-banks such as online P2P lenders, payday lenders or balance sheet lenders often rely on business models that differ from the traditional organization of banks. Among these new players, lending platforms such as Prosper, Lending Club or Zopa have managed to attract a significant share of the retail lending market in specific market segments.[1]

Several empirical papers have started to study how the entry of lending platforms impacts the availability of credit for retail consumers and the average risk on the retail lending market.

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[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.

However, very little is known from a theoretical perspective about the impact of entry of lending platforms on the equilibrium in the retail credit market. In particular, we are not aware of any paper analyzing how competition between a bank and an alternative finance provider organized as a platform impacts the repayments made by borrowers, the investors' behavior and the profitability of platforms. This paper aims at answering these research questions.

Lending platforms are part of the wider FinTech movement that is reshaping competition in the banking industry.[2] Like banks, lending platforms create value by matching borrowers with investors and by pricing credit risk with credit scoring techniques. In other words, they perform the traditional brokerage function of financial intermediaries (see Havrylchyk and Verdier, 2018). However, platforms offer innovative services both on the borrower side and the investor side. On the borrower side, platforms allow consumers to make a credit application online, which reduces the cost of access to credit. Furthermore, they may use alternative data sources to screen borrowers, thereby serving specific groups of consumers (e.g., students, small businesses) without requiring any collateral nor credit history. On the investor side, platforms offer risky contracts to investors, as the latter are only paid back if the borrower is successful.

This innovative business model enables platforms to differentiate themselves from traditional banks. Banks make profits on the net interest margin between the interest rate received from borrowers and the interest rate paid to depositors. A bank typically offers to investors-depositors a demandable debt contract. Depositors do not have any knowledge of the underlying loans which are selected by the bank and do not participate in the screening process. Moreover, they may withdraw their funds at any time provided the bank is solvent. In case the bank fails, they benefit from deposit guarantee schemes up to a certain limit. Since loans and funding sources may differ in terms of risk and maturity, the business model of banks relies on the management of maturity transformation.[3] A direct consequence of this organization is the vulnerability of banks to credit and liquidity risk, which justifies the need

[2]Over the last ten years, banks have started to compete with alternative finance providers. Those companies use different business models to supply all the services that are traditionally offered by financial intermediaries (e.g., payments, financial advice, lending, asset management...).

[3]See Diamond and Dybvig, 1983, Gorton and Pennacchi, 1990.

for their regulation (See Rochet, 2008).

Unlike banks, platforms neither perform risk nor maturity transformation. If an investor decides to fund a loan, the loan repayment is directly paid by the borrower to the investor. A platform makes profit on the servicing fees paid the investor and the origination fees paid by the borrower. Furthermore, investors face a liquidity risk when they fund a loan on the platform, because they cannot withdraw their investment before maturity. Therefore, platforms transfer a share of the credit risk and the liquidity risk to investors.[4] This explains why lending platforms often benefit from a specific regulatory regime in various countries.[5] Several regulators do not allow platforms to manage deposit accounts, forcing them to rely on banks to serve their consumers.

Whether competition between banks and platforms enables a more efficient allocation of credit in specific market segments is an opened research question. On the one hand, platforms may be more efficient than banks at offering credit to borrowers either because their cost of processing a credit application online is lower, or because they are able to gather alternative data sources on a targeted groups of consumers. Moreover, banks incur high costs of serving borrowers who are not able to pledge collateral because of existing regulations.[6] Therefore, platforms could help smaller borrowers who are underserved by banks to have access to credit, relieving the problem of credit rationing that may be more severe for this population. On the other hand, several regulators (as the Financial Conduct Authority in the United-Kingdom) have expressed concerns that platforms could overcharge borrowers for their services. Because of crossed-network externalities, platform need to attract both borrowers and investors to take-off, which, as we shall demonstrate, may not reduce the cost of credit for SMEs. Moreover, the co-existence of various regulatory regimes may decrease the efficiency of financial regulations by allowing financial intermediaries to benefit from regulatory arbitrage opportunities.

We build a model to study the equilibrium on the retail credit market when a bank competes with an alternative finance provider organized as a platform. Financial intermediaries

[4] In case the borrower defaults, the platform does not receive the servicing fee from the investor. Therefore, even if the investor bears all the risks, the platform's revenues are risky. Some alternative finance providers called balance sheet lenders fund the loans with their own funds and take on all the risks.

[5] See OECD (2018) for examples of different regulatory frameworks for crowdfunding platforms.

[6] See the OECD Report: Enhancing SME access to diversified financing instruments, February 2018.

have no informational advantage over each other. Ex ante, the financial intermediaries and the investor do not observe the borrower's probability of success. The financial intermediaries and the borrower do not know the investor's taste for liquidity. The borrower and the investor first open an account in a bank. Then, they may borrow or lend respectively at the bank or through a lending platform.

The market is two-sided and the bank and the platform act as intermediaries between the investor and the borrower. On the borrower side, the bank offers a standard debt contract, in which all firms are asked to provide the same amount of collateral. The collateral enables the bank to select a borrower of better quality, while the platform does not ask for a collateral. On the investor side, the bank guarantees the return on deposits to the investor, while, on the platform, the lender bears all the risk, being reimbursed only in case of success. 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 the higher expected return, while the others are served by the lending platform. We analyze the impact of the characteristics of the return on deposits and the borrower repayment to the bank on investor and borrower participation in the platform. 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. Interestingly, we show that investor participation in the platform may vary non-monotonically with the borrower repayment to the bank, which determines the average quality of borrowers on the platform. In some cases, investor participation in the platform may even be reduced when the platform attracts borrowers of better quality. On the one hand, the investor values a higher average quality of borrowers on the platform. On the other hand, the platform may extract more surplus from the investor by decreasing the return on investment offered to the investor when the average quality of borrowers increases. The result of these two effects on investor participation depends both on borrower and investor heterogeneity.

Similarly, the borrower repayment to the bank has an ambiguous impact on borrower participation in the platform. Competition between the bank and the platform may not reduce the borrower repayment. Depending on borrower heterogeneity, the platform may choose to raise the borrower repayment when the bank offers a more attractive interest rate to borrowers. This is due to the negative externality that the bank exerts on the quality of the platform's loans. Hence, the platform may choose to raise the return offered to investors, which implies that the borrower repayment increases because the platform needs to balance its revenues from both sides of the market. We identify the conditions under which the platform adjusts the price structure in favor of investors, to the detriments of borrowers.

At the first stage of the game, the bank has to decide whether or not to accomodate platform entry. If the bank accomodates platform entry, it chooses the return on deposits so as to equalize the marginal cost and the marginal benefit that the investor funds a loan on the platform. The marginal borrower is set such that the marginal benefits on in-house lending activities are equal to the marginal profits of outsourcing loans to the platform. Then we derive the equilibrium of the game. We show that the bank offers a return on deposits that is equal to the return on the risk-free asset plus a premimum that depends on the attractiveness of the platform to investors in terms of liquidity. The bank reduces the marginal borrower compared to the monopoly case and renounces to profits on lending transactions to extract surplus from the additional depositors who borrow from the platform. We discuss how bank-platform competition could impact the transmission of the monetary policy.

The reminder of the paper is as follows. In Section 2, we describe the main features of the market. In Section 3, we present the literature that is related to our study. In Section 4, we build a model to study the equilibrium on the credit market when a bank competes with a platform. In Section 5, we analyze a benchmark in which the bank is a monopoly on the market. In Section 6, we solve for the equilibrium of the game. In Section 7, we discuss the implications of our model for the transmission of the monetary policy. Finally, we conclude.

2 Market description

Banks and platforms match lenders and borrowers with different financial needs. Both types of financial intermediaries collect some information on borrowers and assess their credit risk. However, their business models are very different both on the investor side and on the borrower side.

On the investor side, unlike depositors, lenders on platforms have access to online information on the borrower's project and the platform's ratings. Therefore, they are able to screen borrowers and assess their probability of being reimbursed. Using their own information and the platform's analysis, investors choose to invest in one or several projects.[7] If the borrower is successful, the lender receives directly the interest rate from the platform, after the deduction of servicing fees. If the borrower defaults, the lender loses all his investment. Therefore, the investor's ability to take on some risks and observe the platform's rating of projects is a key difference between the deposit contract and the platform contract. Another fundamental difference between banks and platforms is that platforms do not perform maturity transformation so that, in general, investors cannot withdraw their funds before maturity. Several platforms (e.g., Prosper, Lending Club) have started to organize secondary markets to enable investors to resell their loans. However, the volume of transactions on these markets is so low that investments in online loans are considered as particularly illiquid. This differentiates also crowdlending from other innovative funding mechanisms such as ICOs.

On the borrower side, as mentioned, bank loans typically require a collateral. On the contrary, several platforms offer credit without requiring any collateral from their borrowers (see Galema, 2019, for evidence). For instance, the French platform LendiX (renamed October) compares different credit contracts offered by banks and platforms. The platform may provide credit without any collateral at a higher interest rate than the bank and with a quicker reply. There are several other platforms in France offering credit contracts without collateral (e.g., Prexem). Galema (2019) documents a lower use of collateral in P2P lending than in bank lending to SMEs and analyzes whether substitutes such as personal or third-party guarantees can fulfill a similar role as collateral. According other authors (e.g., Gambacorta et al., 2020) big tech platforms, especially in China, use consumer data as collateral. Note also that the borrower repayment includes the fees paid to the platform. The website lendingmemo.com explains to borrowers that they should take the sum of the origination fee and the interest rate into account when comparing credit offers.

While allowing to borrow without a collateral, platforms might induce specific cost to

[7] Diversification is often recommended by platforms. However, we do not study this aspect of investors' behavior in our model.

potential borrowers. The cost of seeking credit on the platform includes the cost of registering on the platform's website, the cost of gathering all the information demanded by the platform (such as the proof of citizenship, the legal residence, the proof of bank account ownership etc...). This cost may also include the cost of finding the relevant platform to apply for a credit. For example, Adams et al. (2017) use survey data to show that only 25% of consumers are aware of online lenders. The cost of seeking credit from a bank includes the transportation cost of going to the nearest bank branch. Havrylcky et al. (2018) show that an increase in one standard deviation in the density of bank branches at the county level in the United-States reduces the volume of P2P loans funded by Lending Club and Prosper by 29%. To capture these differences in search costs for the consumers, we assume in our model that borrowers bear a fixed search cost to seek credit, both from the bank and from the platform. We also assume that this cost is lower for the platform, aiming to reflect the fact that platforms may simplify the access to credit, being able to provide a loan more quickly online, with an easier application process.

As a consequence, the profits of banks and platforms differ. Banks earn profits from the net-interest margin, whereas platforms are usually compensated with origination and on-going fees on the borrower side (typically from 1 to 6% of the loan amount) and servicing fees on the investor side (around 1% of principal plus interest).[8]

Moreover, platforms are often not subject to the same regulations and authorizations as banks. The ability to manage deposit accounts is a key difference between both types of intermediaries in various countries and jurisdictions (e.g., Austria, Belgium, Finland, France, European Union). For example, in the United-States, Prosper and Lending Club are not allowed by regulation to originate loans. They rely on the origination services offered by WebBank, a FDIC-insured, Utah-chartered industrial bank that originates all loans sold through their marketplaces. After originating the loan, WebBank sells it back to the platform and charges a fee for this operation. Borrowers who seek credit from Lending Club or Prosper need to prove that they have a valid bank account. To capture these stylized facts, we assume in our model that only the bank can manage deposit accounts and extracts a rent from this activity.

[8] As argued by Wang (2019), several FinTech lenders tend to earn net interest margins as banks.

Since online lenders face lighter regulation as banks, it is often argued that their funding cost is lower than the banks' cost of capital. On the other hand, one could argue that banks have a large stock of intangible capital that entrants do not possess, namely data on their customer base. An interesting comparison is the entry of shadow banks. Begenau and Landvoigt (2017) show that shadow banks capture a larger share of banking activity due to regulatory arbitrage. Buchak et al. (2017) find that non-banks enter more in US counties with more exposure to fair-lending lawsuits. To describe in a parsimonious way these differences in the costs of banks and platforms, we simply assume in our model that the platform marginal cost is lower than the one of the bank.

3 Related literature

Our paper contributes to the burgeoning literature on P2P lending platforms (See Morse, 2015, Belleflamme et al., 2016, and Havrylchyk and Verdier, 2018 for surveys).[9]

A strand of this literature focuses on the supply side by analyzing how platforms select borrowers and price credit risk. Several papers study the determinants of borrower funding on platforms (Butler et al., 2016, Siegel and Young, 2012, Hertzberg et al., 2018, Lin et al., 2013), or try to quantify the impact of borrowers' soft information on lending outcomes (Duarte et al., 2012, Iyer et al., 2015). Other papers analyze the platform's incentives to offer information to investors. Using data from Lending Robot, Vallée and Zeng (2018) show that sophisticated investors select loans differently and tend to outperform less sophisticated ones. However, the outperformance shrinks when the platform reduces the information provision to investors. Several papers 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., 2016, Liskovich and Shaton, 2017). Cong et al. (2019) provide evidence of crossed-network externalities between investors and borrowers and show that their magnitude depends on the maturity of the platform.

Our paper is also related to an emerging empirical literature that aims at analyzing

[9] Several papers rely on the analysis of micro-data coming from the two main platforms in the United-States, Prosper and Lending Club.

competition between banks and platforms. The main research question is whether platform credit is a complement or a substitute to bank credit. In this context, several papers provide empirical evidence that P2P lenders complement banks by offering credit to high-risk borrowers that are usually excluded from the retail credit market (see De Roure et al., 2016, Butler et al., 2016). In particular, Butler et al. show that borrowers who are located in more competitive markets demand lower reservation rates on P2P platforms. Using data from the platforms Prosper and Lending Club in the United-States, Havrylckyk et al. (2018) show that P2P platforms have made in-roads in counties characterized by a smaller density of bank branches and a lower HHI index.

Several papers concentrate on specific market segments, such as personal loans or revolving accounts and try to measure whether P2P credit is a substitute to bank credit. Balyuk (2018) provides evidence that banks rely on certification by P2P lenders when deciding to increase the amount of credit available on revolving accounts. This increase is larger for borrowers who are more credit constrained. Wolfe and Yoo (2017) analyze the substitution between bank credit and P2P platforms on the personal loan segment in the United-States. They show that the substitution effect occurs most strongly among poor credit borrowers. On the contrary, P2P platforms may complement banks by offering better credit facilities to higher quality credit borrowers. Their study reveals that the intensity of competition between P2P platforms and banks depends on the bank's size and the degree of competition in banking retail markets. Small commercial banks may lose up to 1.8% of their personal loan volume following an increase in one standard deviation of P2P lending activity. Furthermore, banks are more affected by entry in less competitive markets. Focusing also on personal credit, using individual borrower data, Di Maggio and Yao (2018) show that P2P platforms select borrowers who have ex ante good credit scores but who are more likely to default ex post. They show that platforms do not target borrowers who are credit-rationed by banks, but who tend to be more present-biased and who borrow over their means. Tang (2019) exploits a change in bank lending standards to show that P2P lending is a substitute to bank credit in terms of serving infra-marginal borrowers. At the same time, it complements bank credit with respect to smaller loans.

There is also a scarce emerging theoretical literature on competition between Fintech and banks. Parlour, Rajan and Zhu (2020) study the impact of competition between Fintech and banks on the disruption of information flows stemming from payments. They show that Fintech competition benefits consumers with weak bank affinity. However, they do not study competition between banks and platforms. Moreover, their paper is focused on the informational advantage of banks over Fintech firms as regards the management of consumers' payment data.

Our paper is also related to a wider strand of the literature that studies SMEs access to finance. An important research question is why SMEs choose to substitute bank credit with alternative funding souces. A literature studies why SMEs resort to Venture Capital (See Gompers and Lerner, 2011 for a survey). Berger and Schaeck (2011) show that SMEs substitute venture capital for multiple banking relationships and test whether firms use VC to avoid rent extraction from their main banks. In the FinTech environment, Chod and Lyandres (2018) develop a theoretical model to analyze the trade-off of risk-averse entrepreneurs between ICO financing and VC. They derive the conditions under which entrepreneurs prefer VC to ICO financing.[10]

4 The model

We build a model to study the equilibrium on the credit market when a bank competes with an alternative finance provider organized as a platform. The platform is differentiated from the bank on the borrower side and on the investor side. On the borrower side, the platform offers a credit contract with no collateral and a quicker access to credit. On the investor side, the platform enables the investor to choose whether or not to invest in an illiquid debt contract.[11] Our model enables us to study how competition impacts repayment rates on the credit market and investor participation in the platform.

[10] On the one hand, ICO financing creates an agency conflict between the entrepreneur and investors, because the level of investment in the project is chosen after funds have been secured. On the other hand, ICO financing enables a risk-averse entrepreneur to transfer part of the venture risk to diversified investors, without diluting his control rights.

[11] We do not model any information advantage of the bank over the platform and choose to leave this issue for future research.

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, the 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.[12] Neither the bank nor the platform has an informational advantage on its competitor as regards to the observation of the borrower's probability of success.[13]

Before asking for a loan, the borrower needs to open an account in the bank, for which the bank charges him a fixed fee F_B. When he opens an account, the borrower does not know his probability of success, that is revealed to him at the second stage. However, the ex-ante the distribution of θ is common knowledge (i.e., it is also known to the financial intermediaries and the investor). The probability of success θ is distributed on $[0, 1]$ according to the probability density h and the cumulative H.[14]

At the following stage, the borrower may choose to borrow from the bank or from an alternative provider, a platform, that offers a different lending contract. The bank contract involves a fixed repayment R_B^b in case of success and the payment of the collateral C in case of failure. The platform contract involves a fixed repayment R_B^p in case of success, but no collateral in case of failure. In both contracts, the borrower is protected by limited liability in case of failure.

If the borrower seeks credit from the bank (resp., the platform), he incurs a fixed search cost $s_b \geq 0$ (resp., s_p). We normalize s_p to $s_p = 0$.[15]

[12] In our paper, the bank's decision to ask for a collateral is exogenous. Our model follows the theories on the ex ante role of collateral (i.e., before the observation of the borrower's risk). Conversely, according to the ex post theories on the role of collateral, a bank is more likely to require riskier borrowers to pledge collateral once it has observed the borrower's risk.

[13] 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. According to Gambacorta et al. (2020), big tech companies use data as collateral, which enables them to supply credit which a much lower amount of collateral than banks.

[14] 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 riks.

[15] This does not impact any of the results that we obtain in the paper as long as we assume that the cost of seeking credit from the bank is higher for the borrower, that is, that $s_b - s_p > 0$. If $s_p > 0$, the indifferent borrower between taking a loan on the platform and in the bank depends on the difference in search costs $s_b - s_p$.

If the borrower only seeks credit from the bank, he is funded with certainty provided he is able to supply the collateral. If the borrower seeks credit from the platform, he is not funded with certainty. The borrower forms passive expectations on the probability p_e of being funded on the platform, because he cannot observe the contract offered by the platform to its investor.[16] We assume that the borrower may not obtain a credit from the bank if he is not funded by the platform. Therefore, the borrower obtains an expected utility

$$u_B^b(\theta) = \theta(y - R_B^b) - (1-\theta)C - s_b \tag{1}$$

if he seeks credit from the bank and an expected utility

$$u_B^p(\theta) = p_e\theta(y - R_B^p) - s_p \tag{2}$$

if he seeks credit from the platform. The borrower's reservation utility is equal to zero if he does not borrow. We denote by θ_0 the marginal borrower, i.e., the borrower who is indifferent between borrowing from the bank or the platform.

Investor A risk-neutral investor wants to invest \$1 in a project. The investor is characterized by his private taste for liquidity $v \in [\underline{v}, \overline{v}]$, which is unobservable by the financial intermediaries and the borrower.[17]

Before investing either in the bank or in the platform, the investor needs to open an account in the bank, for which the bank charges him a fixed fee F_I. The investor's outside option is to invest in the risk-free asset, which yields a return of $R_f \geq 1$. Deposits in the bank are perfectly insured.

When he opens an account, the investor is unaware of his private taste for liquidity that is revealed to him at the second stage. However, he knows the distribution of v, which is

[16] This implies that the borrower has fixed expectations on the investor's decision to particpate 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.

[17] We do not make any assumption on the type of investor that is funding the loans on the platform. Over the years, institutional investors have taken an increasing share of the platforms' funding sources (see Zhang et al., 2015). Moreover, we do not consider that the investor may invest both in the bank and the platform. The project is indivisible in our setting.

also known to the financial intermediaries. The taste for liquidity v is distributed on $[\underline{v}, \overline{v}]$ according to the probability density g and the cumulative G.

At the following stage, the investor observes whether the borrower seeks credit from the bank or the platform and decides whether or not to lend. The bank and the platform offer different types of contracts in terms of insurance and returns on investment. If the investor lends through the bank, he obtains the return on deposits R_d and does not take any risk because deposits are perfectly insured. If the investor lends through the platform, he receives the return offered by the platform R_I^p if the borrower is successful and 0 otherwise.[18] Therefore, the investor shares some risk with the platform. The investor is able to observe the contract offered by the financial intermediaries to the borrower and is therefore able to form responsive expectations on his probability of being reimbursed. He anticipates that he will be reimbursed with the average probability of success $p_M(\theta_0)$ of the borrowers that the platform is able to attract.[19] Furthermore, the investor incurs some disutility v of investing in the platform rather than in the bank because investments in the platform are more illiquid. Therefore, the investor's utility of lending through the bank is

$$u_I^b(R_d) = R_d - 1, \tag{3}$$

whereas the investor's utility of lending through the platform is

$$u_I^p(v, R_I^p, \theta_0) = p_M(\theta_0) R_I^p - v - 1. \tag{4}$$

If he observes that the borrower seeks credit from the bank, the investor agrees to lend if the return on deposits exceeds the return on the risk-free asset. If the borrower seeks credit from the platform, the investor agrees to fund the loan if he expects a higher utility of doing so than leaving its funds in a bank account or investing in the risk-free asset.[20] The

[18] The return corresponds to the sum of the principal of the loan, the interest rate, net of the servicing fee.

[19] We do not model screening efforts of investors and leave this aspect of the market for future research. Murphy (2016) makes 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 to 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 (Davis and Murphy, 2016).

[20] As there is a single investor in our framework, we focus on modelling an externality between the borrower

marginal investor, i.e., the investor who is indifferent between lending through the bank or the platform, is denoted by v_0.[21]

The bank The bank offers deposit contracts to borrowers and investors, in exchange for fixed fees denoted by F_B and F_I, respectively. Opening a deposit account is necessary to borrow from the platform or invest in the platform. If the investor keeps its money in the bank instead of lending on the platform, the bank pays him the return on deposits R_d. Because of regulatory constraints, we assume that the return on deposits cannot exceed $\rho > R_f$.

The bank offers a lending contract to the borrower that involves the fixed repayment R_B^b in case of success and the payment of the collateral C in case of failure. The costs of proposing the lending contract to its clients is equal to $c_b \geq 0$. We assume that the bank does not price discriminate between borrowers by offering them a different type of contract that does not require a collateral.[22]

The bank chooses the terms of the deposit contracts and the borrower repayment before platform entry.[23] The platform is not allowed by regulation to issue loans, nor to manage deposit accounts. It has to rely on the bank to serve its borrowers and may pay an issuing fee for it. In that case, the platform and the bank are organized as the notary model (see Kirby and Worner, 2015). Without loss of generality, we normalize the net revenue of the bank on outsourced loans to zero.[24]

The bank's profit is π^b and it is the sum of the profit made on home borrowers π_h^b (i.e.,

and the investor. We leave for future research the issue of externalities between investors or between borrowers that are surveyed in Belleflamme et al. (2016).

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

[22] This assumption can be motivated by the existence of regulatory constraints such as capital requirements. Degryse et al. (2019) show that higher capital requirements imply that banks require loans to be collateralized more often.

[23] Such an assumption could be justified by the fact that large banks do not modify their contracts frequently, whereas platforms may have the opportunity of changing their prices more rapidly because they operate online with lighter internal constraints.

[24] This normalization does not impact our results if this amount is exogenous (e.g., if the issuing fee is regulated or cost-based). Adding an issuing fee a paid by the platform to the bank and an issuing cost k_b for the bank would modify the results only marginally. In practice, this would impact the opportunity cost for the bank of issuing a credit to the platform from R_f, the forgiven risk-free return, to $R_f - (a - k_b)$. In contrast, the costs of the platform to finance a loan are increased by a. When including this modifications, all the qualitative results of the paper are unaffected.

the borrowers who choose to remain in the bank) and the profit made on loans that are outsourced to the platform π_o^b if the bank issues them.

The platform The platform may offer credit to the borrower if it attracts funds from the investor.[25] The platform offers a lending contract to the borrower that involves the fixed repayment R_B^p in case of success and no collateral in case of failure. The platform shares some risk with the investor who is offered R_I^p if the borrower is successful and zero otherwise.[26] Serving the borrower costs c_p to the platform, where the marginal cost c_p is lower than the bank's marginal cost c_b. The platform's profit is π^p. The platform is not allowed by regulation to manage deposit accounts.[27]

Assumptions:

(A1) The credit market is covered under duopoly.

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

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

Assumption (A2) ensures that there is an interior solution in our benchmark when the bank maximizes its profit under monopoly. 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 $\overline{E}(\theta_0) = \int_{\theta_0}^{1} \theta h(\theta) d\theta$,
- $\underline{V}(v_0) = \int_{\underline{v}}^{v_0} v g(v) dv$ and $\overline{V}(v_0) = \int_{v_0}^{\overline{v}} v g(v) dv$.

[25] In our framework, we focus on the entry of a monopoly platform. In several markets, there are many P2P lending platforms. However, because of network effects and the need to reach a critical mass of users, there is often one dominant platform in the market that captures a large share of borrowers.

[26] In our framework, the net-interest margin and the sum of servicing and on-going fees are equivalent because the loan amount is fixed. We do not model the fixed fee that the platform receives for originating the loan.

[27] 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.

Example: Along the paper, we present a simple example in which θ and v are both uniformly distributed on the interval $[0, 1]$.

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.
- Stage 2: The borrower and the investor decide on whether or not to open an account in the bank.
- Stage 3: 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. He observes whether the borrower seeks credit from the bank or the platform and decides whether or not to lend to the borrower.
- 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.

5 A benchmark: a monopolistic bank

In this section, we study the equilibrium on the credit market if a monopolistic bank offers a contract to the borrower that requires the supply of a collateral.

The credit contract without price discrimination The bank chooses the interest rate that maximizes its profit subject to the participation constraint of the borrower and the investor. A borrower asks a credit from the bank if and only if $u_B^b(\theta) \geq 0$, where $u_B^b(\theta)$ is given by (1). From the participation constraint of the borrower, we denote by

$$\theta_{0B} \equiv (C + s_b)/(y - R_B^b + C) \tag{5}$$

the indifferent consumer between borrowing and not borrowing. The bank lends to borrowers who have a high probability of success and uses the collateral as a selection device. The participation constraints of the borrower and the investor on the deposit market are respectively given by

$$F_B \leq \int_{\theta_{0B}}^{1} u_B^b(\theta) h(\theta) d\theta, \tag{6}$$

and

$$R_f \leq R_d - F_I. \tag{7}$$

The borrower opens an account if and only if his expected utility of borrowing exceeds the cost of the deposit fee (See Eq. (6)). The investor opens an account if and only if he expects to earn at least the return on the risk-free asset (See Eq. (7)).

The bank's profit under monopoly is given by

$$\pi^b = F_B + F_I + \int_{\theta_{0B}}^{1} (\theta R_B^b + (1-\theta)C - R_d - c_b) h(\theta) d\theta + \int_{0}^{\theta_{0B}} (R_f - R_d) h(\theta) d\theta. \tag{8}$$

The bank's profit in Eq. (8) is the sum of the deposit fees and the bank's net return on investment. If the borrower seeks credit from the bank, the bank obtains a random return that depends on the probability of success of the project. If the borrower does not seek credit from the bank, the bank invests in the risk-free asset and obtains the return R_f. In all cases, the bank pays the return R_d to depositors.

In Lemma 1, we give the profit-maximizing marginal borrower θ_{0B} chosen by a monopolistic bank and the corresponding profit-maximizing repayment $(R_B^b)^m$.

Lemma 1 *A monopolistic bank chooses a repayment given by*

$$(R_B^b)^m = y + C - \frac{y(C + s_b)}{s_b + c_b + R_f}. \tag{9}$$

The bank is indifferent on the choice of the deposit rate $R_d \in (R_f, \rho)$ and extracts completely the surplus of the marginal borrower, the latter being given by

$$\theta_{0B} = (s_b + c_b + R_f)/y. \tag{10}$$

It makes a profit given by $(\pi^b)^m = y\overline{E}(\theta_{0B}) - (s_b + c_b + R_f)(1 - H(\theta_{0B}))$.

Proof. See Appendix A. ■

The bank extracts completely the surplus of the marginal borrower through the deposit fee and chooses the marginal borrower such that the marginal benefits of granting a loan are equal to the marginal costs for the bank and the borrower. The marginal benefits correspond to the expected return for the borrower $y\theta_{0B}$ and the marginal costs correspond to the cost of searching credit for the borrower s_b, the opportunity cost of renouncing to invest in the risk-free asset for the bank R_f, and the bank's marginal cost of serving the borrower c_b.

There is an infinity of credit contracts defined by a collateral and an interest rate that yield the same level of risk and the same profit for the bank. Moreover, there is an infinity of combinations of deposit fees and returns on deposits that leave the investor indifferent between leaving his money in a bank account and investing in the risk-free asset.

6 Competition between the bank and the platform

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

6.1 The investor's decision to fund a credit on the platform

At stage 4, the investor decides whether or not to lend to the borrower. If he observes that the borrower seeks credit from the bank, the investor always agrees to leave its fund in the bank if he obtains at least the return on the safe asset (i.e., if $R_d \geq R_f$). In what follows, we focus on an equilibrium in which the bank offers at least the return on the risk-free asset to the investor, otherwise, the bank does not make any profit.

If he observes that the borrower seeks credit from the platform, the investor prefers to lend through the platform if and only if

$$u_I^p(v) \geq u_I^b(v) \equiv R_d - 1. \tag{11}$$

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 loan on the platform. From (11), the taste for liquidity of the marginal investor is implicitly defined by $u_I^p(v_0(R_I^p, \theta_0, R_d)) = R_d - 1$. Therefore, from (4), if $p_M(\theta_0)R_I^p - R_d$ belongs to $(\underline{v}, \overline{v})$, the marginal investor is given by

$$v_0(R_I^p, \theta_0, R_d) \equiv p_M(\theta_0)R_I^p - R_d. \tag{12}$$

If $R_d \geq p_M(\theta_0)R_I^p - \underline{v}$, the marginal investor is given by $v_0(R_I^p, \theta_0, R_d) = \underline{v}$. If $R_d \leq p_M(\theta_0)R_I^p - \overline{v}$, the marginal investor is given by $v_0(R_I^p, \theta_0, R_d) = \overline{v}$.

Investor participation in the platform depends on the return offered by the platform R_I^p. Moreover, it also depends on the marginal 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.[28] If $p_M(\theta_0)R_I^p - R_d$ belongs to $(\underline{v}, \overline{v})$, 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 its funds in the bank. If the deposit rate is high enough (i.e., if $R_d \geq p_M(\theta_0)R_I^p - \underline{v}$), the investor never lends on the platform. If the deposit rate is low enough (i.e., if $R_d \leq p_M(\theta_0)R_I^p - \overline{v}$), the investor always prefers to lend on the platform. Since v is distributed according to the probability density g with cumulative G, the probability that the investor wishes to lend on the platform is $G(v_0(R_I^p, \theta_0, R_d))$.

[28] In France, in 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 on their expected probability to receive the return on their investment.

6.2 The borrower's decision to seek credit from the bank or the platform

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 (i.e., if $R_B^p < y$ and $p_e > 0$). For this purpose, he compares his expected utility of seeking credit from the bank and from the platform, by taking into account the probabilities of being funded by each financial intermediary. If the borrower only seeks credit from the bank, he is funded with certainty if he is able to supply the collateral required by the bank. If he seeks credit from the platform, he is funded with probability p_e. Therefore, the borrower seeks credit from the bank if and only if he obtains a higher expected utility of doing so, that is if and only if

$$u_B^b(\theta) \geq u_B^p(\theta). \tag{13}$$

Suppose that neither the bank nor the platform captures the entire market and that the borrower anticipates that he is funded with probability $p_e > 0$ on the platform. Replacing for $u_B^b(\theta)$ and $u_B^p(\theta)$ into Eq. (13) gives the indifferent consumer θ_0 between the bank and the platform, that is,

$$\theta_0 = \frac{C + s_b}{y(1 - p_e) + C - R_B^b + p_e R_B^p}. \tag{14}$$

The marginal borrower depends on the differentiation between the contracts offered by both financial intermediaries (through the collateral), the differentiation in quality (in terms of search costs) and the respective probabilities of being funded by the bank and the platform. Finally, note that either the bank or the platform can capture the entire lending market depending on the amount of collateral for the bank loan.[29]

If $\theta_0 \in (0, 1)$, the platform attracts the infra-marginal borrowers (i.e., such that $\theta \leq \theta_0$) and the bank attracts the borrowers such that $\theta \geq \theta_0$. Since θ is distributed according to the probability density h with cumulative H, if the market is covered, the demand for credit on the platform is given by $H(\theta_0)$ and the demand for credit at the bank's is given by $1 - H(\theta_0)$.

From (14), the platform obtains a higher share of consumers when the amount of collateral

[29] The bank captures the entire market if $y < R_B^p$. The platform captures the entire market if $C + s_b \geq y(1 - p_e) + (C - R_B^b) + p_e R_B^p$.

demanded by the bank increases, when the quality advantage of the platform (in terms of search costs) increases, when the difference in repayment rates decreases or when consumers anticipate a higher probability of being funded.

If the borrower anticipates that he is not funded on the platform (i.e., $p_e = 0$), he does not get any utility of taking a loan on the platform. Therefore, the borrower trades off between taking a loan from the bank and not borrowing. The indifferent borrower is then identical to θ_{0B} given by Eq. (5) in Section 5, when the bank is a monopoly.

In our model, platform credit may both be a complement and a substitute to bank credit. If $\theta_0 \geq \theta_{0B}$, for given repayments charged by the bank and the platform, some borrowers who seek credit from the bank under monopoly prefer to seek credit from the platform under duopoly. Hence, those borrowers (characterized by an intermediate probability of success) substitute platform credit for bank credit. However, the platform serves the borrowers who have a low probability of success and who are not served under monopoly. Hence, for borrowers of lower quality, the platform complements bank credit.[30]

6.3 Stage 2: platform prices

We consider a situation in which the platform enters the market (that is, entry is not blockaded). The bank chooses a borrower repayment such that the borrower may wish to borrow from the platform (i.e., $\theta_0 \in (0, 1)$), and a return on deposits such that the investor may wish to fund a loan on the platform (i.e., the return on deposits R_d belongs to $(p_M(\theta_0)R_I^p - \overline{v}, p_M(\theta_0)R_I^p - \underline{v})$).

At stage 2, the platform chooses the return R_I^p given to investors and the borrower repayment R_B^p that maximize its expected profit given by

$$\pi^p = G(v_0(R_I^p, \theta_0, R_d)) \int_0^{\theta_0} (\theta(R_B^p - R_I^p) - c_p)h(\theta)d\theta. \tag{15}$$

If the platform offers the return R_I^p to investors, for a given marginal borrower is θ_0, there is

[30] Since borrowers borrow a constant amount from one financial intermediary (but not both), we do not capture in our framework the complementarities generated by higher volume of credit obtained from both intermediaries (as in Balyuk, 2018). Furthermore, we do not model the role of adverse selection caused by the fact that banks may be better informed on their borrowers due to their long-term relationships.

a probability $G(v_0(R_I^p, \theta_0, R_d))$ that an investor wishes to lend on the platform. The platform attracts the infra-marginal borrowers (i.e., such that $\theta \leq \theta_0$). In case of success, with probability θ the platform obtains the loan repayment R_B^p and offers the return R_I^p to investors.[31] The platform's margin $R_B^p - R_I^p$ correponds to the sum of the fees paid by the borrower and the investor each time a borrower repays a loan (servicing+on-going fees). In all cases, the platform incurs the cost c_p of serving borrowers.

Replacing for the average probability of success $p_M(\theta_0) = (\int_0^{\theta_0} \theta h(\theta) d\theta)/H(\theta_0)$ into (15), the platform's profit is given by

$$\pi^p = G(v_0(R_I^p, \theta_0, R_d))H(\theta_0)((R_B^p - R_I^p)p_M(\theta_0) - c_p).$$

In Proposition 1, we give the platform's best-responses $\widehat{R_B^p}$ and $\widehat{R_I^p}$ to the marginal borrower θ_0 chosen by the bank if there is an interior solution to the platform's profit-maximization problem.[32] For this purpose, we use the following notations:

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

We assume that the second-order conditions of profit-maximization hold. In Appendix B-2, we show that this is the case with our uniform distributions.

Proposition 1 *Suppose that there exists an equilibrium in which the platform enters the market and shares the lending market with the bank. For a given marginal borrower θ_0 and a deposit rate R_d chosen by the bank, if there is an interior solution to the platform's profit-maximization problem, the platform chooses a return for investors such that*

$$\frac{(\widehat{R_B^p} - \widehat{R_I^p})p_M(\theta_0) - c_p}{p_M(\theta_0)\widehat{R_I^p}} = \frac{1}{\varepsilon_I}, \tag{16}$$

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

[32] 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. See Appendix B-1 for the details.

and the price structure such that

$$\frac{\widehat{R_I^p}}{\widehat{R_B^p}} = \frac{\mu_P \varepsilon_I}{\varepsilon_B}. \tag{17}$$

Proof. See Appendix B-1. ■

On the investor side, the platform trades off between increasing the return offered to investors, which generates a higher volume of transactions, and lowering it to increase its margin in 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 borrowers 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 Lemma 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 of demand elasticities between both sides. However, our model differs from Rochet and Tirole (2003) because the platform's revenue is uncertain. This explains why the price structure is weighted by μ_P, the elasticity of the platform's expected revenue to the borrower repayment.

Remark that for an equilibrium in which the platform enters the market to exist, it must be that, at the 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. We shall discuss later in the next section how the bank can impact platform entry by its strategy and whether such an equilibrium may exist given the market conditions.

In pratice, 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 has expressed the concern that platforms may overcharge borrowers on the mortgage residential market, showing that in some cases investors would only receive 3% of return while borrowers pay 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.

An example: If there is an interior solution, in our example, we find that

$$\widehat{R_B^p}(\theta_0, R_d) = 2(C + s_b + p_e(c_p + R_d))/(3\theta_0 p_e), \tag{18}$$

and

$$\widehat{R_I^p}(\theta_0, R_d) = (C + s_b - 2p_e(c_p - 2R_d))/(3\theta_0 p_e). \tag{19}$$

In the special case of a uniform distribution, the price structure $\widehat{R_I^p}/\widehat{R_B^p}$ is independent of θ_0.

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 both on 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 case of success. Therefore, the investor internalizes a share of the risk borne by the platform in its decision to fund a loan on the platform. Moreover, investor participation depends on the deposit rate chosen by the bank.

In Corollary 1, we give the implicit definition of the marginal investor $\widehat{v}_0$ as a function of the marginal borrower θ_0 and the deposit rate R_d when the platform chooses the prices that maximize its profit. We define $\widehat{v}_0$ as $\widehat{v}_0(\theta_0, R_d) \equiv v_0(\widehat{R_I^p}, \theta_0, R_d)$. For this purpose, let $\eta(\theta_0) \equiv p_M(\theta_0) R_B^p / \underline{\varepsilon}(\theta_0, R_B^p)$, where $\underline{\varepsilon}(\theta_0, R_B^p) = -(R_B^p/\underline{E}(\theta_0))(d\underline{E}(\theta_0)/dR_B^p)$ denotes the elasticity of the expected probability of success $\underline{E}(\theta_0)$ to the repayment R_B^p. In Appendix

B-3, we prove that $\underline{\varepsilon}(\theta_0, R_B^p) = \theta_0^3 h(\theta_0) R_B^p / (\beta \underline{E}(\theta_0))$, where, if $p_e > 0$,

$$\beta \equiv (C + s_b)/p_e. \tag{20}$$

Therefore, we have

$$\eta(\theta_0) = \beta p_M(\theta_0) \underline{E}(\theta_0) / \theta_0^3 h(\theta_0). \tag{21}$$

Corollary 1 *Suppose that $p_e > 0$. If $R_d \geq \overline{R_d}(\theta_0) \equiv \theta_0 \eta(\theta_0)/(\theta_0 - p_M(\theta_0)) - (c_p + \underline{v})$, the investor never lends on the platform and the marginal investor is given by $\widehat{v}_0(\theta_0, R_d) = \underline{v}$.*
If $R_d \leq \underline{R_d}(\theta_0) \equiv \theta_0 \eta(\theta_0) - 1/g(\overline{v}))/(\theta_0 - p_M(\theta_0)) - (c_p + \overline{v})$, the investor always lends on the platform and the marginal investor is given by $\widehat{v}_0(\theta_0, R_d) = \overline{v}$.
If $R_d \in (\underline{R_d}(\theta_0), \overline{R_d}(\theta_0))$, the marginal investor on the platform $\widehat{v}_0(\theta_0, R_d)$ is implicitly defined by

$$\widehat{v}_0(\theta_0, R_d) = \frac{\theta_0}{(\theta_0 - p_M(\theta_0))} \left(\eta\theta_0 - \frac{G(\widehat{v}_0(\theta_0, R_d))}{g(\widehat{v}_0(\theta_0, R_d))} \right) - (c_p + R_d).$$

Proof. See Appendix B-3. ■

If the average probability of success is very elastic to the choice of the marginal borrower (i.e., if $\eta(\theta_0)$ given in Eq. (21) is low), there is a higher probability that no investor wishes to fund a loan on the platform, reflecting the fact that loans on the platforms are riskier than deposit accounts.

In Corollary 2, we express the platform's profit at the profit-maximizing prices as a function of the marginal borrower θ_0 chosen by the bank and the return on deposits R_d.

Corollary 2 *For a given marginal borrower θ_0 and a return on deposits R_d chosen by the bank, the platform makes a profit*

$$\pi^p(\theta_0, R_d) = H(\theta_0) \frac{G^2(\widehat{v}_0(\theta_0, R_d))}{g(\widehat{v}_0(\theta_0, R_d))}.$$

An example - uniform distributions: If v and θ are uniformly distributed on $[0, 1]$, we have $\eta(\theta_0) = \beta/4$ and $\beta = (C + s_b)/p_e$. If $R_d \in (\beta/2 - c_p - 3, \beta/2 - c_p)$, the marginal investor is given by $\widehat{v}_0(\theta_0, R_d) = (\theta_0/2)\widehat{R_I^p}(\theta_0, R_d) - R_d$, that is, we have

$$\widehat{v}_0(\theta_0, R_d) = \frac{C + s_b - 2p_e(R_d + c_p)}{6p_e}. \tag{22}$$

In the uniform distribution case, the marginal investor does not depend on θ_0.

From Corollary 2, the platform's profit is given by $\pi^p(\theta_0, R_d) = \theta_0(\widehat{v}_0(\theta_0, R_d))^2$. Replacing for $\widehat{v}_0(\theta_0, R_d)$ given in Eq. (22), we find that

$$\pi^p(\theta_0, R_d) = \frac{\theta_0(C + s_b - 2p_e(R_d + c_p))^2}{36(p_e)^2}. \tag{23}$$

The impact of bank prices on investor participation: We analyze how bank prices (i.e., R_d and R_B^b) impact the investor's decision to fund a loan on the platform (i.e., $\widehat{v}_0$). Investor participation in the platform decreases with the return on deposits. Logically, if the return on deposits becomes more attractive, the investor chooses not to fund a loan on the lending platform. More interestingly, investor participation in the platform may vary non-monotonically with the borrower repayment to the bank, or equivalently, the quality of the marginal borrower θ_0. In some cases, investor participation may even decrease when the platform attracts a marginal borrower of better quality. This ambiguous impact of the borrower repayment to the bank on investor participation is caused by two effects. On the one hand, the investor values a higher average quality of borrowers on the platform when the borrower repayment to the bank increases. On the other hand, in some cases, the platform may decrease the return offered to the investor when the average quality of borrowers increases, as the platform may decide to extract more surplus from the investor. This second effect depends on the distribution of the probability of success and the distribution of the investor's taste for liquidity. In Appendix B-4, we show that $\partial\widehat{v}_0/\partial\theta_0$ has the sign of

$$\theta_0(\theta_0 - p_M(\theta_0))\eta'(\theta_0) + (\theta_0 p_M^{'}(\theta_0) - p_M(\theta_0))\left(\eta\theta_0 - \frac{G(\widehat{v}_0)}{g(\widehat{v}_0)}\right).$$

We have that $\theta_0 - p_M(\theta_0) \geq 0$ and $\eta(\theta_0) - \dfrac{G(v_0)}{g(v_0)} \geq 0$. The sign of $\theta_0 p_M^{'}(\theta_0) - p_M\theta_0$ and the sign of η' are ambiguous and depend on the distribution of the probability of success. In our uniform distribution case, since $p_M(\theta_0) = \theta_0/2$ and $\eta(\theta_0) = \beta/4$, $\widehat{v}_0$ is independent of θ_0. In the general case, $\widehat{v}_0$ depends on θ_0 and its variation with θ_0 reflects the platform's trade-off between increasing the repayment for borrowers to make more profit and lowering the repayment to increase investor and borrower participation to the platform. It can be either positive or negative depending on the shape of the distribution of θ on the interval $[0,1]$. We give in Appendix B-5 examples of distributions such that investor participation in the platform becomes lower when the platform attracts borrowers of better quality.

The impact of bank prices on plaform prices and borrower participation: In Lemma 2, we analyze how changes in the marginal borrower and the return on deposits impact the borrower repayment, the return offered to the investor and the price structure.

Lemma 2 *Assume that* $(\underline{v}+\rho)(G/g)'(\underline{v}) \leq c_p$. *The borrower repayment* $\widehat{R_B^p}$, *the return offered to the investor* $\widehat{R_I^p}$ *and the price structure* $\widehat{R_I^p}/\widehat{R_B^p}$ *increase with the return on deposits* R_d.
If $\partial\widehat{v}_0/\partial\theta_0 \leq 0$, *the borrower repayment* $\widehat{R_B^p}$, *the return offered to the investor* $\widehat{R_I^p}$ *and the price structure* $\widehat{R_I^p}/\widehat{R_B^p}$ *decrease with* θ_0. *If* $\partial\widehat{v}_0/\partial\theta_0 \geq 0$, $\widehat{R_I^p}$ *and* $\widehat{R_B^p}$ *may either increase or decrease with* θ_0 *and the price structure* $\widehat{R_I^p}/\widehat{R_B^p}$ *increase with* θ_0.

Proof. See Appendix B-5. ■

When the bank increases the return on deposits, the platform raises the return offered to the investor and the borrower repayment. Therefore, borrower participation in the platform is reduced. Moreover, the platform increases relatively more the return offered to the investor than the repayment asked to the borrower.

The variations of the marginal borrower have a non-monotonic impact on the return offered to the investor and the platform's borrower repayment (and therefore, on borrower participation). They also have an ambiguous impact on the price structure that depends on the relationship between the marginal investor and the marginal borrower. Therefore, if the bank lowers the borrower repayment (or equivalently reduces θ_0), the platform may react by increasing the borrower repayment. Hence, competition between the bank and the platform may not lower repayment rates on the borrower side of the platform.

In Appendix B-7, we analyze how the platform's profit varies with the return on deposits, the marginal borrower and the level of collateral for a given expected probability that the investor participates in the platform.

6.4 Stage 2: the borrower's and the investor's decision to open an account

The borrower (resp., the investor) decides to open an account in the bank if his expected surplus of borrowing (resp., investing) exceed the deposit fee charged by the bank. We denote by $ES_B(R_B^b, R_d, \widehat{R_I^p}, \widehat{R_B^p})$ (resp., $ES_I(R_B^b, R_d, \widehat{R_I^p}, \widehat{R_B^p})$) the borrower's (resp., the investor's) expected surplus of leaving his money in a bank account. The borrower's participation constraint is given by

$$F_B \leq ES_B(R_B^b, R_d, \widehat{R_I^p}, \widehat{R_B^p}), \tag{24}$$

where

$$ES_B(R_B^b, R_d, \widehat{R_I^p}, \widehat{R_B^p}) = \int_0^{\theta_0} u_B^p(\theta)h(\theta)d\theta + \int_{\theta_0}^1 u_B^b(\theta)h(\theta)d\theta.$$

The borrower obtains the surplus $u_B^p(\theta)$ if he borrows from the platform (i.e., if $\theta \leq \theta_0$) and the surplus $u_B^b(\theta)$ if he borrows from the bank (i.e., if $\theta \geq \theta_0$). The investor's participation constraint is given by

$$F_I \leq ES_I(R_B^b, R_d, \widehat{R_I^p}, \widehat{R_B^p}), \tag{25}$$

where

$$\begin{aligned} ES_I(R_B^b, R_d, \widehat{R_I^p}, \widehat{R_B^p}) &= H(\theta_0)\left(\int_{\underline{v}}^{\widehat{v_0}} (u_I^p(v) - (R_f - 1))g(v)dv + (1 - G(\widehat{v_0}))(R_d - R_f)\right) \\ &\quad +(1 - H(\theta_0))(R_d - R_f). \end{aligned}$$

With probability $H(\theta_0)$, the borrower seeks credit from the platform. If the investor wishes to fund the loan (that is, if $v \leq \widehat{v_0}$), he obtains a surplus of $u_I^p(v) - (R_f - 1)$. If the investor does not wish to fund the loan (i.e., if $v > \widehat{v_0}$), he keeps his money in his bank account and obtains a surplus $R_d - R_f$. With probability $1 - H(\theta_0)$, the borrower does not seek credit from the platform and the investor also obtains a surplus $R_d - R_f$.

6.5 Stage 1: bank prices and platform entry

At the first stage, the bank chooses the deposit fees, the loan repayment and the return on deposits that maximize its profit. We start by determining the bank's profit-maximizing strategy if it accomodates platform entry. Then we determine whether the bank prefers to accomodate or to deter platform entry.

6.5.1 Bank prices

Suppose that there exists an equilibrium in which the platforms enters the market.[33] The bank's profit is given by $\pi^b = F_B + F_I + \pi_h^l + \pi_o^l$, where π_h^l corresponds to the profit on in-house lending activities and π_o^l to the profit on lending activities that are outsourced to the platform. 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 neither funded by the bank nor by the platform.

As shown in Appendix C-ii, the bank can extract the maximum surplus from depositors through the deposit fees F_I and F_B. The total profit $\pi_h = \pi_h^d + \pi_h^l$ that the bank obtains from in-house lending activities is given by

$$\pi_h(\theta_0) = \int_{\theta_0}^{1} (\theta y - s_b - c_b - R_f) h(\theta) d\theta. \tag{26}$$

The total profit $\pi_o = \pi_o^d$ that the bank obtains from outsourcing loans to the platform is given by

$$\pi_o(\theta_0, R_d) = \int_0^{\theta_0} \widehat{u}_B^p(\theta, \theta_0, R_d) h(\theta) d\theta + H(\theta_0) \int_{\underline{v}}^{\widehat{v}_0} (u_I^p(v) - (R_f - 1)) g(v) dv, \tag{27}$$

where $\widehat{u}_B^p(\theta, \theta_0, R_d) = p_e \theta(y - \widehat{R_B^p}(\theta_0, R_d))$ is the borrower's utility of taking a loan on the platform and $u_I^p(v) = p_M(\theta_0)\widehat{R_I^p}(\theta_0, R_d) - v - 1$ is the investor's utility of lending through the platform. The total bank's profit is therefore given by

$$\pi^b(\theta_0, R_d) = \pi_h(\theta_0) + \pi_o(\theta_0, R_d). \tag{28}$$

The bank's profit depends on the interest rate R_B^b only through the choice of the indifferent borrower θ_0. Therefore, it is equivalent for the bank to maximize its profit with respect

[33] Such an equilibrium may not exist as we shall discuss in the following sub-section, where we determine whether the bank prefers to accommodate platform entry, in case entry is not blockaded.

to R_B^b or θ_0. We assume that the second-order conditions hold when the bank maximizes its profit with respect to θ_0 and R_d.[34] We denote the profit-maximizing marginal borrower and return on deposits by $\widehat{\theta}$ and $\widehat{R}_d$, respectively. We also denote by:

- $F_I^p(\theta_0, R_d) \equiv \int_{\underline{v}}^{\widehat{v_0}} (u_I^p(v) - (R_f - 1))g(v)dv$ the expected surplus of investors who fund a loan on the platform,
- $\widehat{u}_B^p(\theta, \theta_0, R_d) = p_e\theta(y - \widehat{R_B^p}(\theta_0, R_d))$ the borrower's utility of taking a loan on the platform.

In Proposition 2, we explain how the bank chooses the return on deposits $\widehat{R}_d$ and the profit-maximizing marginal borrower $\widehat{\theta}$, if it accomodates platform entry.

Proposition 2 *Suppose that there exists an equilibrium with platform entry. If there is an interior solution, the bank chooses the deposit rate so as to equalize the marginal cost and the marginal benefit that the investor funds a loan on the platform, that is, we have*

$$\widehat{R}_d = R_f + \frac{(\widehat{\theta} G(\overline{v_0}) - p_M(\widehat{\theta}) p_e)(G/g)'(\overline{v_0})}{(\widehat{\theta} - p_M(\widehat{\theta}))g(\overline{v_0})}, \tag{29}$$

where $\overline{v_0} = v_0(\widehat{R_I^p}, \widehat{\theta}, \widehat{R}_d)$. *The bank chooses the marginal borrower such that the marginal profits on in-house lending activities are equal to the marginal profits of outsourcing loans to the platform, that is, at* $R_d = \widehat{R}_d$ *and* $\theta_0 = \widehat{\theta}$, *we have*

$$\widehat{\theta} = \frac{(c_b + s_b + R_f)}{y} + \frac{\overline{u}_B^p + \overline{F}_I^p}{y} + \frac{\dfrac{\partial \pi_o}{\partial v_0}\dfrac{\partial \widehat{v}_0}{\partial \theta_0} - p_e \underline{E}(\widehat{\theta})\dfrac{\partial \widehat{R_B^p}}{\partial \theta_0}}{yh(\theta_0)}, \tag{30}$$

where $\overline{u}_B^p = \widehat{u}_B^p(\widehat{\theta}, \widehat{\theta}, \widehat{R}_d)$ *and* $\overline{F}_I^p = F_I^p(\widehat{\theta}, \widehat{R}_d)$.

Proof. See Appendix C. ■

At an equilibrium with platform entry, the bank chooses the return on deposits so as to equalize the marginal cost and the marginal benefit of increasing the probability that

[34] In the Appendix, we show that the second-order conditions hold in our example with uniform distributions.

the investor funds a loan on the platform (See Eq. (29)). If the bank raises the return on deposits, the investor is less likely to fund a loan on the platform because the return offered by the platform becomes less attractive. The bank gains the net cost of outsourcing lending activies to the platform (i.e., R_f). The bank also takes into account the impact of its choice on the platform's prices at the next stage of the game. As shown in Lemma 2, a higher return on deposits increases the borrower repayment on the platform and the return offered by the platform to the investor. If the borrower repayment is higher on the platform, the bank extracts a lower surplus from the borrower-depositor who takes a loan from the platform.[35] If the return offered to the investor is higher on the platform, the bank extracts a higher surplus from the investor-depositor who lends through the platform (See the last two terms of Eq. (29)).

We now analyze the choice of the marginal borrower in Eq. (30). An increase in the marginal borrower has two effects on the bank's profit. First, it reduces the probability that a borrower seeks credit from the bank. The bank loses marginally the rents that it extracts from the marginal lender (see the left-hand side of Eq. (30)). Second, the probability that a borrower seeks credit from the platform increases. The bank gains the marginal revenues that it extracts from the marginal borrower and the investor who funds a loan on the platform through the deposit fees (see the right-hand side of Eq. (30)). The expected utility of the marginal borrower who seeks credit on the platform increases and investor participation to the platform becomes higher. Therefore, the bank extracts higher rents from lending transactions on the platform (i.e., $\overline{u}_B^p$) and higher rents from the deposits of investors who fund a loan on the platform (i.e., $\overline{F}_I^p$). The bank also takes into account the impact of its choice on the platform's prices, which is reflected by the last term of Eq. (30). However, as shown in Corollary 1, the marginal investor and the platform's prices may vary non monotonically with the marginal borrower, and therefore, this effect is ambiguous.

The equilibrium if the platform enters the market: If there exists an equilibrium in which the platform enters the market, this equilibrium is characterized by the marginal borrower θ^*, the return on deposits R_d^*, the borrower repayment on the platform $(R_B^p)^*$

[35] The bank loses $-(p_M(\widehat{\theta})p_e)(G/g)'(\overline{v_0})/((\widehat{\theta} - p_M(\widehat{\theta}))g(\overline{v_0}))$. This term corresponds to the marginal loss of surplus from the borrower-depositor.

and the return offered to the investor on the platform $(R_I^p)^*$ such that the consumer makes rational expectations on the probability of being funded. Since the consumer makes rational expectations on the probability of being funded, at the equilibrium, we have $p_e = G(\overline{v_0})$ if $\overline{v_0} \in (\underline{v}, \overline{v})$. We denote by $\overline{v_0}^* = v_0((R_I^p)^*, \theta^*, R_d^*)$. From Proposition 2, at the equilibrium, the return on deposits is implicitly defined by

$$R_d^* = R_f + (G/g)(\overline{v_0}^*)(G/g)'(\overline{v_0}^*). \tag{31}$$

The bank offers a return on deposits that is equal to the return on the risk-free asset plus a premium that depends on the attractiveness of the platform for the investor. From Proposition 2, we show in Appendix C-vi) that the marginal borrower is implicitly defined by

$$\theta^* = \theta_{0B} + \frac{G(\overline{v_0}^*)}{y}\left(\overline{u}_B^p + \overline{F}_I^p + (\theta^* - p_M(\theta^*))(R_B^p)^*\right). \tag{32}$$

From Proposition 1, the borrower repayment on the platform $(R_B^p)^*$ and the return offered to the investor on the platform $(R_I^p)^*$ are implicitly defined by Eq. (16) and (17) evaluated at $\theta = \theta^*$ and $R_d = R_d^*$. This completes the characterization of the equilibrium with platform entry, provided that such an equilibrium exists. Remark that, since $\theta^* \geq p_M(\theta^*)$, the average quality of the bank's lending portfolio increases following platform entry, that is, we have $\theta^* \geq \theta_{0B}$.

At the equilibrium of the game, if the platform enters the market, the bank makes a profit given by

$$\pi^b(\theta^*, R_d^*) = \pi_h(\theta^*) + \pi_o(\theta^*, R_d^*). \tag{33}$$

There is an equilibrium in which the platform enters the market if borrowers obtain a positive utility of taking a loan on the platform, that is, if

$$y > \widehat{R_B^p}(\theta^*, R_d^*),$$

and if the investor obtains a positive utility of funding a loan on the platform, that is, if

$$\widehat{v}_0(\theta^*, R_d) \geq \underline{v}.$$

Moreover, the bank should obtain a higher profit if the platform enters the market than if it does not under monopoly.[36]

An example: In our uniform distributions example, if there is an equilibrium in which there is platform entry, rational expectations imply that the consumer anticipates to be funded with probability $p_e^* = \overline{v_0}^*$, where

$$\overline{v_0}^* = \frac{1}{8}(\sqrt{(R_f + c_p)^2 + 48(C + s_b)} - (R_f + c_p)). \tag{34}$$

The equilibrium is implicitly defined by

$$R_d^* = R_f + \overline{v_0}^*.$$

$$\theta^* = \theta_{0B} + \frac{\overline{v_0}^*}{y}\left(\overline{u}_B^p + \overline{F}_I^p + (\theta^*/2)(R_B^p)^*\right)$$

$$(R_I^p)^* = \frac{(C + s_b) + 2p_e^*(2p_e^* + 2R_f - c_p)}{3p_e^*\theta^*},$$

and

$$(R_B^p)^* = \frac{2(C + s_b + p_e^*(c_p + R_f + p_e^*))}{3p_e^*\theta^*}.$$

For this solution to be compatible with platform entry, it must be that, in equilibrium, the repayment asked by the platform is lower than the value of the project, that is, that $(R_B^p)^* < y$, otherwise the borrower has no incentives to seek credit on the platform.[37] Moreover, the investor wishes to fund a loan on the platform if

$$\frac{1}{8}(\sqrt{(R_f + c_p)^2 + 48(C + s_b)} - (R_f + c_p)) \geq \underline{v}.$$

[36] We have assumed so far that entry is not blockaded in our setting. If the return on deposits offered by the bank exceeds a certain threshold, the investor never funds a loan on the platform. Similarly, if the return on deposits exceeds another given threshold, the borrower does not wish to borrow from the platform. Therefore, entry is not blockaded if these thresholds exceed the return on the risk-free asset. Then, it is possible that the bank chooses a return on deposits that allows the platform to enter and the bank may increase its profit when the platform enters the market. The bank increases its profit under duopoly if if extracts more surplus from the additional depositors than it loses revenues from lending transactions when it competes with the platform.

[37] If $0 < C < 1$, $R_f = 1$ and $0 \leq s_b < 1$, a necessary condition for this equilibrium to exist is that $c_b > (15 - 36C - 100s_b + 49\sqrt{1 + 8(C + s_b)})/64$.

7 Policy implications

Our model enables to analyze several policy issues. We choose to focus on one interesting question, that is, the impact of platform entry on the transmission of monetary policy (i.e., through the variations of the risk-free asset). In principle, an increase in the risk-free interest rate should be passed-through by banks and platforms to borrowers into higher repayment rates. Our model shows that this conclusion is not straightforward.

An increase in the return on the risk-free asset implies that the bank raises the return on deposits to secure the participation of the depositors. As shown in Proposition 2, there is also a direct positive effect on the marginal borrower (see the first term in Eq. (30)), which implies that the bank may reduce its credit supply.[38] The platform's best-response is indirectly related to the return on the risk-free asset through the return on deposits and the marginal borrower. We have shown in Lemma 2 that the borrower repayment on the platform increases with the return on deposits, which is positively related to the return on the risk-free asset. Hence, we obtain the standard effect that a higher return on the risk-free asset raises the borrower repayment on the platform. However, the effect that goes through the marginal borrower is less obvious, because we have shown in Lemma 2 that the borrower repayment on the platform may be reduced when the bank increases its interest rate on loans. This implies that an increase in the return on the risk-free asset could also lead paradoxically to lower repayments on the platform. Our model shows that financial intermediaries organized as platforms may respond in unexpected ways to changes in the monetary policy, depending on the magnitude of externalities between borrowers and investors (modelled by investor and borrower heterogeneity in our setting).

At the equilibrium, the transmission of the monetary policy by banks could also be affected. Indeed, we see in Proposition 2 that when it chooses the marginal borrower, the bank takes into account its impact on the platform's strategy at the next stage. Knowing that the platform might become more competitive if it increases the marginal borrower (following an increase in the return on the risk-free asset), the bank might decide not to tighten as much its credit supply as it would do without the platform. One implication of our model

[38] At the equilibrium, this is not necessarily the case because of the indirect effect of the bank's choice of the borrower repayment on the platform's price.

is that Central Banks should carefully try to measure whether competition between banks and alternative finance providers may impact the transmission mechanisms of the monetary policy.

8 Conclusion

Competition between banks and 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. If platforms need to rely on banks for their activities, banks have incentives to open the retail credit market to competition, as long as the rents that it extracts from depositors compensate for lower revenues from lending transactions. In the future, our work could be extended by taking into account the impact of platform competition on borrower repayments.

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Appendix

Appendix A: Proof of Lemma 1 Since the participation constraints are satiated, the bank's profit is given by

$$\pi^b = \int_{\theta_{0B}}^{1} (y\theta - s_b - c_b - R_f)h(\theta)d\theta.$$

The bank is able to extract the expected surplus that the borrower and the investor obtain from the lending transaction through the deposit fees. It is equivalent for the bank to choose its interest rate on loans R_B^b and the indifferent borrower θ_{0B}. Solving for the first-order condition of profit-maximization, we find that

$$\frac{d\pi^b}{d\theta_{0B}} = (R_f + s_b + c_b - y\theta_0)h(\theta_{0B}).$$

Therefore, the bank extracts completely the rents of the lending transaction made by the marginal borrower, which is given by $\theta_{0B} = (s_b + c_b + R_f)/y$.

Appendix B -1: Proof of Proposition 1 Assume that the marginal borrower θ_0 belongs to $(0, 1)$ and that the bank chooses a return on deposits R_d such that the investor may wish to fund a loan on the platform. We denote the platform's margin by $m_p = (R_B^p - R_I^p)p_M(\theta_0) - c_p$. Solving for the first-order conditions of profit-maximization gives

$$\frac{\partial \pi^p}{\partial R_I^p} = p_M(\theta_0)g(v_0(R_I^p, \theta_0, R_d))H(\theta_0)m_P - G(v_0(R_I^p, \theta_0, R_d))p_M(\theta_0)H(\theta_0), \quad \text{(FOC-PF1)}$$

and

$$\frac{\partial \pi^p}{\partial R_B^p} = \frac{d\theta_0}{dR_B^p}(g(v_0)p_M^{'}(\theta_0)R_I^p H(\theta_0)m_P + G(v_0)H(\theta_0)(R_B^p - R_I^p)p_M^{'}(\theta_0) + m_P h(\theta_0)G(v_0)) + p_M(\theta_0)H(\theta_0)G(v_0). \quad \text{(FOC-PF2)}$$

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. The first equation yields

$$m_P = G(v_0(R_I^p, \theta_0, R_d))/g(v_0(R_I^p, \theta_0, R_d)). \quad \text{(FOC-PF1-Bis)}$$

Replacing for this equation into (FOC-PF2), since $g(v_0)m_P = G(v_0(R_I^p, \theta_0, R_d))$, we find that (FOC-PF2) can be rewritten as

$$G(v_0)\left[\frac{d\theta_0}{dR_B^p}(H(\theta_0)R_B^p p_M^{'}(\theta_0) + m_P h(\theta_0)) + p_M(\theta_0)H(\theta_0)\right] = 0. \quad \text{(FOC-PF2-Bis)}$$

Replacing for the elasticity of investor demand to the interest rate R_I^p given by $\varepsilon_I = (dG(v_0(R_I^p, \theta_0, R_d))/dR_I^p)(R_I^p/G(v_0(R_I^p, \theta_0, R_d)))$ into (FOC-PF1-Bis), we find that

$$\frac{m_P}{p_M(\theta_0)R_I^p} = \frac{1}{\varepsilon_I}.$$

Therefore, we have

$$\frac{(R_B^p - R_I^p)p_M(\theta_0) - c_p}{p_M(\theta_0)R_I^p} = \frac{1}{\varepsilon_I}.$$

This equation corresponds to the Lerner formula.

Dividing Eq. (FOC-PF2-Bis) by $H(\theta_0)G(v_0) > 0$, we find that

$$\frac{d\theta_0}{dR_B^p}(p_M^{'}(\theta_0)R_B^p + \frac{h(\theta_0)}{H(\theta_0)}m_P) + p_M(\theta_0) = 0.$$

Therefore, multiplying this equation by $(R_B^p/p_M(\theta_0))$ gives

$$\frac{R_B^p}{p_M(\theta_0)}\frac{d(p_M(\theta_0)R_B^p)}{dR_B^p} + \frac{R_B^p}{p_M(\theta_0)}\frac{d\theta_0}{dR_B^p}\frac{h(\theta_0)}{H(\theta_0)}m_P = 0.$$

Replacing for $\varepsilon_B = -(h(\theta_0)R_B^p/H(\theta_0))(d\theta_0/dR_B^p)$ and $\mu_P = (d(R_B^p p_M(\theta_0))/dR_B^p)(R_B^p/p_M(\theta_0)R_B^p)$, we find that

$$R_B^p\mu_P - \frac{\varepsilon_B}{p_M(\theta_0)}m_P = 0.$$

This implies that we have

$$\frac{m_P}{p_M(\theta_0)R_B^p} = \frac{\mu_P}{\varepsilon_B},$$

that is,

$$\frac{(R_B^p - R_I^p)p_M(\theta_0) - c_p}{p_M(\theta_0)R_B^p} = \frac{\mu_P}{\varepsilon_B}.$$

Dividing this equation by the first equation of the FOC gives the price structure, that is,

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

This completes the proof of Proposition 1.

Appendix B-2: Second-Order conditions in the uniform case 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

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

In our uniform distribution example, we have

$$\frac{\partial^2 \pi^p}{\partial^2 R_I^p}\bigg|_{(\widehat{R_I^p},\widehat{R_B^p})} = -\frac{\theta_0^3}{2} < 0,$$

and

$$\frac{\partial^2 \pi^p}{\partial R_I^p \partial R_B^p}\bigg|^2_{(\widehat{R_I^p},\widehat{R_B^p})} - \frac{\partial^2 \pi^p}{\partial^2 R_I^p}\bigg|_{(\widehat{R_I^p},\widehat{R_B^p})} \frac{\partial^2 \pi^p}{\partial^2 R_B^p}\bigg|_{(\widehat{R_I^p},\widehat{R_B^p})} = \frac{-\theta_0^6(C+s_b-2p_e(c_p+R_d))^2}{48(C+s_b)^2} < 0.$$

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

Appendix B-3: the platform's best-responses in the general case: From (FOC-PF1), we have that $m_P = G/g$. Therefore, given θ_0, R_d and R_I^p, the repayment of the borrower is given by

$$R_B^p = R_I^p + (1/p_M(\theta_0))(c_p + G(v_0(R_I^p,\theta_0,R_d))/g(v_0(R_I^p,\theta_0,R_d)) \tag{35}$$

Replacing for $p_M^{'}(\theta_0)H(\theta_0) = h(\theta_0)(\theta_0 - p_M(\theta_0))$ into (Eq. FOC-PF2), we find that at an interior solution

$$\frac{d\theta_0}{dR_B^p}h(\theta_0)(R_B^p(\theta_0 - p_M(\theta_0)) + p_M(\theta_0)(R_B^p - R_I^p) - c_p) + p_M(\theta_0)H(\theta_0) = 0.$$

Replacing for $\underline{E}(\theta_0) = p_M(\theta_0)H(\theta_0)$ and rearranging the terms, we obtain

$$\underline{E}(\theta_0) + \frac{d\theta_0}{dR_B^p}h(\theta_0)(\theta_0(R_B^p - R_I^p) - c_p + (\theta_0 - p_M(\theta_0))R_I^p) = 0.$$

Since $d\theta_0/dR_B^p = -(\theta_0)^2/\beta$, where $\beta = (C+s_b)/p_e$, replacing for R_B^p given by the (Eq-

RBp), we have that

$$(\theta_0 - p_M(\theta_0))R_I^p = (c_p) + \frac{\beta \underline{E}(\theta_0)}{h(\theta_0)(\theta_0)^2} - (\theta_0/p_M(\theta_0))(c_p + (G/g)(v_0(R_I^p, \theta_0, R_d))).$$

We denote by $\underline{\varepsilon}(\theta_0, R_B^p) = -(R_B^p/\underline{E}(\theta_0))(d\underline{E}(\theta_0)/dR_B^p)$ the elasticity of the expected probability of success to the borrower repayment. We have

$$\frac{d\underline{E}(\theta_0)}{dR_B^p} = \theta_0 h(\theta_0)\frac{d\theta_0}{dR_B^p}.$$

Since $d\theta_0/dR_B^p = -\theta_0^2/\beta$, we have

$$\underline{\varepsilon}(\theta_0, R_B^p) = \frac{-R_B^p d\underline{E}(\theta_0)}{\underline{E}(\theta_0)dR_B^p} = \frac{\theta_0^3 h(\theta_0)R_B^p}{\beta \underline{E}(\theta_0)}.$$

Since $\eta(\theta_0) = p_M(\theta_0)R_B^p/\underline{\varepsilon}(\theta_0, R_B^p)$ and $\underline{\varepsilon}(\theta_0, R_B^p) = \theta_0^3 h(\theta_0)R_B^p/(\beta \underline{E}(\theta_0))$, the return chosen for investors $\widehat{R_I^p}$ is implicitly defined by

$$\widehat{R_I^p} = \frac{\theta_0}{p_M(\theta_0)(\theta_0 - p_M(\theta_0))}\left[\eta(\theta_0) - (G/g)(v_0(\widehat{R_I^p}, \theta_0, R_d))\right] - \frac{c_p}{p_M(\theta_0)}. \tag{36}$$

Since $\widehat{v}_0(\theta_0, R_d) = v_0(\widehat{R_I^p}, \theta_0, R_d)$ and $v_0(\widehat{R_I^p}, \theta_0, R_d) = p_M(\theta_0)\widehat{R_I^p} - R_d$, the marginal investor is implicitely defined by

$$\widehat{v}_0(\theta_0, R_d) = \frac{\theta_0}{(\theta_0 - p_M(\theta_0))}\left(\eta(\theta_0) - \frac{G(\widehat{v}_0(\theta_0, R_d))}{g(\widehat{v}_0(\theta_0, R_d))}\right) - c_p - R_d. \tag{37}$$

We now derive the necessary conditions such that there is an interior solution (i.e., the marginal investor $\widehat{v}_0(\theta_0, R_d) \in (\underline{v}, \overline{v})$). Let

$$Z(v) \equiv v - \frac{\theta_0}{(\theta_0 - p_M(\theta_0))}(\eta(\theta_0) - (G/g)(v)) + c_p + R_d. \tag{38}$$

The function Z is twice differentiable on the segment $[\underline{v}, \overline{v}]$. For all $v \in [\underline{v}, \overline{v}]$, we have

$$Z'(v) = 1 + \frac{\theta_0}{(\theta_0 - p_M(\theta_0))}(G/g)'(v).$$

Since G/g is increasing in v, for all $v \in [\underline{v}, \overline{v}]$, we have that $Z'(v) \geq 0$. Therefore, Z is increasing in v. If $Z(\overline{v}) \leq 0$, for all $v \in [\underline{v}, \overline{v}]$, we have $Z(v) \leq 0$ and the investor always lends on the platform. If $Z(\underline{v}) \geq 0$, for all $v \in [\underline{v}, \overline{v}]$, we have $Z(v) \geq 0$ and the investor never lends on the platform. If $Z(\overline{v}) > 0$ and $Z(\underline{v}) < 0$, there exists a unique $\widehat{v}_0(\theta_0, R_d) \in (\underline{v}, \overline{v})$ such that $Z(\widehat{v}_0(\theta_0, R_d)) = 0$. Replacing for $Z(\overline{v})$ and $Z(\underline{v})$ given by Eq. (38) gives the result of Corollary 1.

Appendix B-4: Variations of the marginal investor, the borrower repayment on the platform and the return offered to the investor with bank prices:

- Variation of the marginal investor with θ_0:

Taking the derivative of (37) given in Appendix B-3 with respect to θ_0, we find that

$$\frac{\partial \widehat{v}_0}{\partial \theta_0}(1 + \frac{\theta_0 (G/g)'(\widehat{v}_0)}{(\theta_0 - p_M(\theta_0))}) = \frac{\theta_0 \eta'(\theta_0)}{(\theta_0 - p_M(\theta_0))} + \frac{\theta_0 p_M^{'}(\theta_0) - p_M(\theta_0)}{(\theta_0 - p_M(\theta_0))^2} \left(\eta(\theta_0) - \frac{G(\widehat{v}_0)}{g(\widehat{v}_0)} \right).$$

Since $(G/g)'(\widehat{v}_0) \geq 0$ and $\theta_0 - p_M(\theta_0) \geq 0$, $\partial \widehat{v}_0 / \partial \theta_0$ has the sign of

$$\theta_0(\theta_0 - p_M(\theta_0))\eta'(\theta_0) + (\theta_0 p_M^{'}(\theta_0) - p_M(\theta_0)) \left(\eta(\theta_0) - \frac{G(\widehat{v}_0)}{g(\widehat{v}_0)} \right).$$

As $\widehat{v}_0 \geq 0$, it must be that $\eta(\theta_0) - \dfrac{G(\widehat{v}_0)}{g(\widehat{v}_0)} \geq 0$. Moreover, we have that

$$-p_M(\theta_0) + \theta_0 p_M^{'}(\theta_0) = \frac{-\underline{E}(\theta_0) + \theta_0 h(\theta_0)(\theta_0 - p_M(\theta_0))}{H(\theta_0)}.$$

We also have that $\theta_0 - p_M(\theta_0) \geq 0$. If $-p_M(\theta_0) + \theta_0 p_M^{'}(\theta_0) \geq 0$ and $\eta'(\theta_0) \geq 0$, the sign of $\partial \widehat{v}_0 / \partial R_d$ is positive. Hence, a higher probability of success of the marginal borrower increases the marginal investor. However, in the general case, it is impossible to conclude that $\partial \widehat{v}_0 / \partial \theta_0 \geq 0$.

- Variation of the borrower repayment and the return offered to investors with θ_0:

As for $\partial \widehat{v}_0 / \partial \theta_0$, it is impossible to conclude that $\partial \widehat{R_I^p} / \partial \theta_0$ and $\partial \widehat{R_B^p} / \partial \theta_0$ have a constant sign in the general case. Since $\widehat{R_I^p} = (\widehat{v}_0 + R_d)/p_M(\theta_0)$, we have

$$\frac{\partial \widehat{R_I^p}}{\partial \theta_0} = \frac{1}{p_M(\theta_0)} \frac{\partial \widehat{v}_0}{\partial \theta_0} - \frac{p'_M(\theta_0)}{p_M(\theta_0)} \widehat{R_I^p}. \tag{39}$$

From (35), since $\widehat{R_I^p} = (\widehat{v}_0 + R_d)/p_M(\theta_0)$, we have

$$\frac{\partial \widehat{R_B^p}}{\partial \theta_0} = \frac{1}{p_M(\theta_0)} \frac{\partial \widehat{v}_0}{\partial \theta_0}(1 + (G/g)'(\widehat{v}_0)) - \frac{p'_M(\theta_0)}{p_M(\theta_0)} \widehat{R_B^p}. \tag{40}$$

Since $p_M^{'}(\theta_0) \geq 0$ and $(G/g)'(\widehat{v}_0)$, if $\partial \widehat{v}_0 / \partial \theta_0 \leq 0$, $\widehat{R_I^p}$ and $\widehat{R_B^p}$ are decreasing with θ_0. If $\partial \widehat{v}_0 / \partial \theta_0 \geq 0$, $\widehat{R_I^p}$ and $\widehat{R_B^p}$ may either increase or decrease with θ_0.

In our uniform distribution example, from Eq. (18) and (19), the borrower repayment and the return offered to investors are both decreasing with θ_0 because the marginal investor is independent of θ_0.

- Variation of the marginal investor with R_d:

Taking the derivative of (37) given in Appendix B-3 with respect to R_d, we find that

$$\frac{\partial \widehat{v}_0}{\partial R_d}(1 + \frac{\theta_0 (G/g)^{'}(\widehat{v}_0)}{(\theta_0 - p_M(\theta_0))}) = -1.$$

Therefore, we have that

$$\frac{\partial \widehat{v}_0}{\partial R_d} = \frac{-(\theta_0 - p_M(\theta_0))}{\theta_0 - p_M(\theta_0) + \theta_0 (G/g)'(\widehat{v}_0)}.$$

Since $\theta_0 - p_M(\theta_0) \geq 0$ and $(G/g)^{'} \geq 0$, the marginal investor is decreasing with the deposit rate.

- Variation of the return offered to investors $\widehat{R_I^p}$ with the deposit rate:

Taking the derivative of (36) with respect to R_d, we find that

$$\frac{\partial \widehat{R_I^p}}{\partial R_d} = -\frac{\partial \widehat{v}_0}{\partial R_d} \frac{\theta_0 (G/g)^{'}(\widehat{v}_0)}{p_M(\theta_0)(\theta_0 - p_M(\theta_0))}. \tag{41}$$

Since $\partial\widehat{v}_0/\partial R_d \leq 0$, $(G/g)' \geq 0$ and $\theta_0 - p_M(\theta_0) \geq 0$, the return offered to investors is increasing with the deposit rate.

- Variation of the borrower repayment rate offered $\widehat{R_B^p}$ with the deposit rate:

  Taking the derivative of (35) with respect to R_d, we find that

$$\frac{\partial\widehat{R_B^p}}{\partial R_d} = \frac{\partial\widehat{R_I^p}}{\partial R_d} + \frac{\partial\widehat{v}_0}{\partial R_d}\frac{(G/g)'(\widehat{v}_0)}{p_M(\theta_0)}.$$

Replacing for $\partial\widehat{R_I^p}/\partial R_d$, we find that

$$\frac{\partial\widehat{R_B^p}}{\partial R_d} = -\frac{\partial\widehat{v}_0}{\partial R_d}\frac{(G/g)'(\widehat{v}_0)}{(\theta_0 - p_M(\theta_0))}. \tag{42}$$

Since $\partial\widehat{v}_0/\partial R_d \leq 0$, $(G/g)' \geq 0$ and $\theta_0 - p_M(\theta_0) \geq 0$, the borrower repayment rate is increasing with the deposit rate.

- Variation of the marginal investor with the level of collateral C:

  We have

$$\frac{d\widehat{v}_0(\theta_0, R_d)}{dC} = \frac{\theta_0}{(\theta_0 - p_M(\theta_0))}\frac{d\beta}{dC}\frac{\underline{E}(\theta_0)}{h(\theta_0)(\theta_0)^2} + \frac{\partial\widehat{v}_0(\theta_0, R_d)}{\partial\theta_0}\frac{d\theta_0}{dC}.$$

An increase in the level of collateral has two effects on the marginal investor. Since $d\beta/dC \geq 0$, a higher level of collateral increases the elasticity of the probability of success to the borrower repayment, which raises the marginal investor. Since $d\theta_0/dC \geq 0$, a higher level of collateral increases the probability of success of the marginal borrower. If $\partial\widehat{v}_0(\theta_0, R_d)/\partial\theta_0 \geq 0$, this implies that investor participation in the platform increases and therefore, that the overall effect is to increase the marginal investor. If $\partial\widehat{v}_0(\theta_0, R_d)/\partial\theta_0 \leq 0$, investor participation in the platform decreases, and the overall effect is ambiguous.

Appendix B-5: examples of distributions In our supplementary online Appendix we have considered the family of beta distributions, to provide illustrate the impact of different distributions of θ. As well known, the shape of the beta distribution varies with the two characteristic parameters and many common distributions can be obtained as special cases. For example, if the two parameters of the beta distributions are equal to one, the beta corresponds to the uniform distribution and the marginal investor is independent of the marginal borrower. By varying the parameters of the beta distribution we provide examples in which the $h(\theta)$ can be increasing, decreasing or non monotone. In these examples we find the following. If the distribution of θ is increasing on the interval $[0, 1]$ or U-shaped, then the marginal investor is decreasing on the marginal borrower. This happens for instance if both parameters are equal to $1/2$ and the beta distribution coincides with the arcsin distribution. If instead the beta distribution is decreasing on the interval $[0, 1]$ or unimodal, then the marginal investor is increasing with the marginal borrower.

Appendix B-6: Variations of the price structure with bank prices: From (Eq-RBp), we have

$$\frac{\widehat{R_B^p}}{\widehat{R_I^p}} = 1 + \frac{1}{p_M(\theta_0) R_I^p} \left(c_p + \frac{G(\widehat{v}_0)}{g(\widehat{v}_0)} \right).$$

Since $\widehat{v}_0 = p_M(\theta_0)\widehat{R_I^p} - R_d$, we have

$$\frac{\widehat{R_B^p}}{\widehat{R_I^p}} = 1 + \frac{1}{\widehat{v}_0 + R_d} \left(c_p + \frac{G(\widehat{v}_0)}{g(\widehat{v}_0)} \right).$$

Taking the derivative of this equation with respect to θ_0, we find that

$$\left(\frac{\widehat{R_B^p}}{\widehat{R_I^p}} \right)' (\theta_0) = \frac{1}{(\widehat{v}_0 + R_d)^2} \frac{d\widehat{v}_0}{d\theta_0} \left(-(c_p + \frac{G(\widehat{v}_0)}{g(\widehat{v}_0)}) + (\widehat{v}_0 + R_d) \left(\frac{G}{g} \right)' (\widehat{v}_0) \right).$$

To determine the sign of the parenthesis, we study the function

$$T(x) = -(c_p + \frac{G(x)}{g(x)}) + (x + R_d) \left(\frac{G}{g} \right)' (x)$$

for $x \in (\underline{v}, \overline{v})$. We have $T'(x) = (x + R_d)(G/g)''(x)$. Since G/g is concave, $(G/g)''$ is negative. This implies that $T'(x) \leq 0$ and that T is decreasing on $(\underline{v}, \overline{v})$. Since $G(\underline{v}) = 0$, we have $T(\underline{v}) = -c_p + (\underline{v} + R_d)(G/g)'(\underline{v})$. Since $(\underline{v} + R_d)(G/g)'(\underline{v}) \leq c_p$ from (A4), we have $T(\underline{v}) \leq 0$. Therefore, for any $x \in (\underline{v}, \overline{v})$, we have $T(x) \leq 0$. This implies that $\left(\widehat{R_B^p}/\widehat{R_I^p}\right)' (\theta_0)$ has the same sign as $-\partial\widehat{v}_0/\partial\partial\theta_0$. If the marginal investor $\widehat{v}_0$ decreases (resp., increases) with the marginal borrower θ_0, the ratio $\widehat{R_B^p}/\widehat{R_I^p}$ increases (resp., decreases) with the marginal borrower. The price structure $\widehat{R_I^p}/\widehat{R_B^p}$ increases (resp., decreases) with the marginal borrower when the marginal investor increases (resp., decreases with the marginal borrower).

Finally, as $\widehat{v}_0 + R_d$ is independent of R_d, the variation of the price structure with the deposit rate as the same sign as $(G/g)'(\widehat{v}_0)(\partial\widehat{v}_0/\partial R_d)$. Since $(G/g)' \geq 0$ and $(\partial\widehat{v}_0/\partial R_d) \leq 0$, the ratio $\widehat{R_B^p}/\widehat{R_I^p}$ is decreasing with the deposit rate. The price structure $\widehat{R_I^p}/\widehat{R_B^p}$ is increasing with the marginal borrower.

Appendix B-7: Comparative statics - platform profit:

- Variation of the platform's profit with the marginal borrower:

  We have

$$\frac{d\pi_P}{d\theta_0} = h(\theta_0)\frac{G^2(\widehat{v}_0(\theta_0, R_d))}{g(\widehat{v}_0(\theta_0, R_d))} + H(\theta_0)G(\widehat{v}_0(\theta_0, R_d))\left(\frac{\partial\widehat{v}_0}{\partial\theta_0}\right)\left(\frac{2g^2 - Gg^{'}}{g^2}\right).$$

Since (G/g) is increasing, we have $2g^2 - Gg^{'} \geq 0$. Therefore, if $\partial\widehat{v}_0/\partial\theta_0 \geq 0$, the platform's profit is increasing with the marginal borrower.

- Variation of the platform's profit with the deposit rate:

$$\frac{d\pi_P}{dR_d} = H(\theta_0)G(\widehat{v}_0(\theta_0, R_d))\left(\frac{\partial\widehat{v}_0}{\partial R_d}\right)\left(\frac{2g^2 - Gg^{'}}{g^2}\right).$$

Since $\partial\widehat{v}_0/\partial R_d \leq 0$, the platform's profit is decreasing with the deposit rate.

- Variation of the platform's profit with the level of collateral:

  We have

$$\frac{d\pi^p}{dC} = \frac{d\pi^p}{d\theta_0}\frac{d\theta_0}{dC} + \frac{d\widehat{v}_0}{dC}H(\theta_0)G(\widehat{v}_0)\left(\frac{2g - Gg'}{g}\right)(\widehat{v}_0).$$

Appendix C: the bank's profit-maximizing prices i) The participation constraints of depositors:

We denote by π_h^d the maximum surplus that the bank may extract from depositors thanks to its in-house lending activities. We have

$$\pi_h^d = \int_{\theta_0}^{1} u_B^b(\theta)h(\theta)d\theta + (1 - H(\theta_0))(R_d - R_f) + (1 - G(v_0))H(\theta_0)(R_d - R_f). \tag{43}$$

The first term of Eq. (43) corresponds to the expected utility of the borrower if he takes a loan from the bank. The second term of Eq. (43) corresponds to the revenues that the bank extracts from the investor if the latter does not lend on the platform.

We denote by π_o^d the maximum surplus that the bank may extract from depositors who decide to invest to the platform. We have

$$\pi_o^d = \int_{0}^{\theta_0} \widehat{u}_B^p(\theta, \theta_0, R_d)h(\theta)d\theta + H(\theta_0)\int_{\underline{v}}^{\widehat{v}_0} (u_I^p(v) - (R_f - 1))g(v)dv. \tag{44}$$

where $\widehat{u}_B^p(\theta, \theta_0, R_d) = p_e\theta(y - \widehat{R_B^p}(\theta_0, R_d))$ and $u_I^p(v) = p_M(\theta_0)\widehat{R_I^p}(\theta_0, R_d) - v - 1$. The first term of Eq. (44) corresponds to the expected utility of the borrower if he takes a loan from the platform. The second term of Eq. (44) corresponds to the expected surplus of the investor if the latter funds a loan on the platform.

From (24), (25), (43) and (44), the sum of the participation constraints of depositors can be rewritten as

$$F_I + F_B \leq \pi_h^d + \pi_o^d.$$

ii) The bank's profit from lending activities:

If a consumer of type $\theta \geq \theta_0$ borrows from the bank, the bank always funds it and obtains an expected revenue equal to $\theta R_B^b + (1-\theta)C$. The bank also incurs the cost of funding the loan by deposits at a rate R_d and the marginal cost c_b. Since $u_B^b(\theta) = \theta y - (\theta R_B^b + (1-\theta)C) - s_b$, the bank's expected margin of lending to a consumer of type θ is given by $\theta y - u_B^b(\theta) - s_b - c_b - R_d$. If a borrower of type $\theta \leq \theta_0$ wishes to borrow from the platform, there is a probability $1 - G(\widehat{v}_0)$ that the investor refuses to fund the loan. In that case, the bank refuses to fund the loan and invests instead in the risk-free asset. The bank obtains a return $R_f - R_d$. Since there is a probability $H(\theta_0)$ that the borrower is of type $\theta \leq \theta_0$ and a probability $1 - G(\widehat{v_0})$ that the loan is not funded, the bank's expected return from investment in the risk-free asset is given by $(1 - G(\widehat{v_0}))H(\theta_0)(R_f - R_d)$. Therefore, the bank's profit on in-house lending activities is given by

$$\pi_h^l = \int_{\theta_0}^{1} (\theta y - u_B^b(\theta) - s_b - c_b - R_d)h(\theta)d\theta + (1 - G(\widehat{v_0}))H(\theta_0)(R_f - R_d). \tag{45}$$

iii) The bank's profit:

The bank has a monopoly on deposits and can therefore extract the maximum surplus of depositors through the deposit fees. Therefore, the participation constraints of depositors are binding and we have $F_I + F_B = \pi_h^d + \pi_o^d$. Since $\pi^b = \pi_h^l + \pi_o^l + F_I + F_B$, we have

$$\pi^b = \pi_h^l + \pi_o^l + \pi_h^d + \pi_o^d.$$

We denote by $\pi_h = \pi_h^l + \pi_h^d$ the total profit that the bank obtains from in-house lending activities, and by $\pi_o = \pi_o^d$ the total profit that the bank obtains from depositors financing loans on the platform.

Since $\pi_h = \pi_h^d + \pi_h^l$, from Eq. (43) and Eq. (45), we have

$$\pi_h(\theta_0) = \int_{\theta_0}^{1} (\theta y - s_b - c_b - R_f)h(\theta)d\theta. \tag{46}$$

Since $\pi_o = \pi_o^d$, from Eq. (44), we have

$$\pi_o(\theta_0, R_d) = \int_{0}^{\theta_0} \widehat{u}_B^p(\theta, \theta_0, R_d)h(\theta)d\theta + H(\theta_0) \int_{\underline{v}}^{\widehat{v_0}} (u_I^p(v) - R_f)g(v)dv). \tag{47}$$

The bank's profit depends on the interest rate R_B^b only through the choice of the indifferent borrower θ_0. Therefore, it is equivalent for the bank to maximize its profit with respect to R_B^b or through θ_0.

iv) Solving for the first-order condition of profit-maximization, we find that

$$\frac{\partial \pi^b}{\partial \theta_0} = \frac{\partial \pi_h}{\partial \theta_0} + \frac{\partial \pi_o}{\partial \theta_0} + \frac{\partial \pi^b}{\partial R_I^p}\frac{\partial \widehat{R_I^p}}{\partial \theta_0} + \frac{\partial \pi^b}{\partial R_B^p}\frac{\partial \widehat{R_B^p}}{\partial \theta_0}, \tag{FOC-B-ThetaTild}$$

and

$$\frac{\partial \pi^b}{\partial R_d} = \frac{\partial \pi_h}{\partial R_d} + \frac{\partial \pi_o}{\partial R_d} + \frac{\partial \pi^b}{\partial R_I^p}\frac{\partial \widehat{R_I^p}}{\partial R_d} + \frac{\partial \pi^b}{\partial R_B^p}\frac{\partial \widehat{R_B^p}}{\partial R_d}. \qquad \text{(FOC-B-DepositRate)}$$

We start by solving (FOC-B-DepositRate). From (46), we have $\partial \pi_h/\partial R_d = 0$. The bank's profit on depositors financing loans on the platform depends on $\widehat{R_B^p}$ only through $\widehat{u}_B^p$ (see Eq. (47)). Since $\widehat{u}_B^p(\theta, \theta_0, R_d) = p_e\theta(y - \widehat{R_B^p})$, we have $\partial \pi^b/\partial R_B^p = -p_e\underline{E}(\theta_0)$. From (47), since $u_I^p(v) = p_M(\theta_0)\widehat{R_I^p} - v - 1$, we have

$$\frac{\partial \pi^b}{\partial R_d} = \frac{\partial \widehat{v}_o}{\partial R_d}H(\theta_0)g(\widehat{v}_o)(u_I^p(\widehat{v}_o) - (R_f - 1)) + p_M(\theta_0)H(\theta_0)G(\widehat{v}_o)\frac{\partial \widehat{R_I^p}}{\partial R_d} - p_e\underline{E}(\theta_0)\frac{\partial \widehat{R_B^p}}{\partial R_d}.$$

Since $u_I^p(\widehat{v}_o) = R_d - 1$ and $\underline{E}(\theta_0) = p_M(\theta_0)H(\theta_0)$, we have

$$\frac{\partial \pi^b}{\partial R_d} = H(\theta_0)(\frac{\partial \widehat{v}_o}{\partial R_d}g(\widehat{v}_o)(R_d - R_f) + p_M(\theta_0)(G(\widehat{v}_o)\frac{\partial \widehat{R_I^p}}{\partial R_d} - p_e\frac{\partial \widehat{R_B^p}}{\partial R_d})).$$

Therefore, there are three cases. In the first case, there is an interior solution such that $H(\theta_0) > 0$. If $H(\theta_0) > 0$ and $\partial \widehat{v}_o/\partial R_d \neq 0$, the profit-maximizing deposit rate is implicitely defined by

$$\widehat{R}_d = R_f + \frac{p_M(\theta_0)(-G(\widehat{v}_o)(\partial \widehat{R_I^p}/\partial R_d) + p_e(\partial \widehat{R_B^p}/\partial R_d))}{(\partial \widehat{v}_o/\partial R_d)g(\widehat{v}_o)}.$$

Replacing for $(\partial \widehat{R_I^p}/\partial R_d)$ and $(\partial \widehat{R_B^p}/\partial R_d)$ given respectively by Eq. (41) and Eq. (42), since $p_M(\theta_0) = \underline{E}(\theta_0)/H(\theta_0)$, the deposit rate is implicitely defined by

$$\widehat{R}_d = R_f + \frac{1}{(\theta_0 - p_M(\theta_0))g(\widehat{v}_o)}(\theta_0 G(\widehat{v}_o) - p_e p_M(\theta_0))(G/g)'(\widehat{v}_o). \qquad (48)$$

In the second case, there is a corner solution such that the bank covers the market and chooses θ_0 such that no investor wishes to lend on the platform or no borrower wishes to borrow from the platform. We study this solution in section 6-5-2. The third and last possibility is that the bank chooses the deposit rate that minimizes the value of the marginal investor on the platform, that is, if there exists such a solution, we have $\partial \widehat{v}_o/\partial R_d = 0$. From Appendix B-4, we have $\partial \widehat{v}_o/\partial R_d = 0$ if and only if $\theta_0 = p_M(\theta_0)$, which is impossible.

If there is an interior solution, when the bank increases the deposit rate, there is a lower probability that the investor funds a loan on the platform. The bank gains at the margin the return on the risk-free asset R_f.

The bank also internalizes the impact of the deposit rate on the return offered by the platform to the investor and the borrower repayment chosen by the platform. Since the return offered by the platform to the investor increases with the deposit rate, this raises the surplus of the marginal investor on the platform. Therefore, the bank loses revenues from the marginal borrower who has a higher probability of being funded by the platform. However, at the same time, a countervailing effect arises because the borrower repayment chosen by the platform also increases with the deposit rate. This decreases the marginal borrower's utility of taking a loan on the platform. Hence, there is a higher probability that the bank funds the loan, which increases the bank's revenues.

We turn to the resolution of (FOC-B-ThetaTild). We have

$$\frac{d\pi^b}{d\theta_0} = \frac{\partial \pi_h}{\partial \theta_0} + \frac{\partial \pi_o}{\partial \theta_0} + \frac{\partial \pi^b}{\partial R_I^p}\frac{\partial \widehat{R_I^p}}{\partial \theta_0} + \frac{\partial \pi^b}{\partial R_B^p}\frac{\partial \widehat{R_B^p}}{\partial \theta_0}. \tag{49}$$

Taking the derivative of Eq. (46) with respect to θ_0, we find that

$$\frac{\partial \pi_h}{\partial \theta_0} = -h(\theta_0)(\theta_0 y - s_b - c_b - R_f). \tag{50}$$

Since $F_I^p(\theta_0, R_d) = \int_{\underline{v}}^{\widehat{v_0}} (u_I^p(v) - (R_f - 1))g(v)dv$, $F_I^p(\theta_0, R_d)$ only depends on θ_0 through $\widehat{v_0}$. Moreover, Eq. (47) only depends on $\widehat{R_I^p}$ through the choice of $\widehat{v_0}$. Taking the derivative of Eq. (47) with respect to θ_0, we find that

$$\frac{\partial \pi_o}{\partial \theta_0} = h(\theta_0)(\widehat{u}_B^p(\theta_0, \theta_0, R_d) + F_I^p(\theta_0, R_d)) + \frac{\partial \pi_o}{\partial v_0}\frac{\partial \widehat{v_0}}{\partial \theta_0} - p_e \underline{E}(\theta_0)\frac{\partial \widehat{R_B^p}}{\partial \theta_0}. \tag{51}$$

Replacing for Eq. (50) and (51) into (49) gives

$$\begin{aligned}\frac{\partial \pi^b}{\partial \theta_0} &= h(\theta_0)(-(\theta_0 y - s_b - c_b - R_f) + \overline{u}_B^p + \overline{F}_I^p) \\ &\quad + \frac{\partial \pi_o}{\partial v_0}\frac{\partial \widehat{v_0}}{\partial \theta_0} - p_e \underline{E}(\theta_0)\frac{\partial \widehat{R_B^p}}{\partial \theta_0}.\end{aligned}$$

Therefore, if there is an interior solution $\widehat{\theta}$ to the bank's profit-maximization, it is chosen such that

$$y\widehat{\theta} - c_b - s_b - R_f = \overline{u}_B^p + \overline{F}_I^p + (\frac{\partial \pi_o}{\partial v_0}\frac{\partial \widehat{v_0}}{\partial \theta_0} - p_e \underline{E}(\widehat{\theta})\frac{\partial \widehat{R_B^p}}{\partial \theta_0})/h(\widehat{\theta}) = 0. \tag{52}$$

This completes the proof of Proposition 2.

v) Second-order conditions

The bank's profit admits a local maximum at $(\theta_0, \widehat{R_d})$ if

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

and

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

In our uniform distribution example, we have

$$\left.\frac{\partial^2 \pi^b}{\partial \theta_0^2}\right|_{(\theta_0,\widehat{R_d})} = -\frac{5}{9}\theta_0 < 0,$$

and

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

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.

vi) The marginal borrower when consumers make rational expectations on the probability of being funded:

We have

$$\left.\frac{\partial \pi_o}{\partial v_0}\right|_{R_d=\widehat{R}_d} = H(\theta_0)(g(\widehat{v_0})(\widehat{R}_d - R_f) + G(\widehat{v_0})).$$

We have already shown that if consumers make rational expectations on the probability of being funded, we have

$$\widehat{R}_d = R_f + (G/g)(\widehat{v}_o))(G/g)'(\widehat{v}_o).$$

Therefore, we have

$$\left.\frac{\partial \pi_o}{\partial v_0}\right|_{R_d=\widehat{R}_d} = H(\theta_0)G(\widehat{v}_0)(1 + (G/g)'(\widehat{v}_o)).$$

Since $p_e = G(\widehat{v}_0)$, $\underline{E}(\widehat{\theta})/p_M(\theta_0) = H(\theta_0)$ and

$$\frac{\partial \widehat{R_B^p}}{\partial \theta_0} = \frac{1}{p_M(\theta_0)}\frac{\partial \widehat{v}_0}{\partial \theta_0}(1 + (G/g)'(\widehat{v}_0)) - \frac{p_M'(\theta_0)}{p_M(\theta_0)}\widehat{R_B^p},$$

at $R_d = \widehat{R}_d$, we have

$$\frac{\partial \pi_o}{\partial v_0}\frac{\partial \widehat{v}_0}{\partial \theta_0} - p_e\underline{E}(\widehat{\theta})\frac{\partial \widehat{R_B^p}}{\partial \theta_0} = \frac{\partial \pi_o}{\partial v_0}\frac{\partial \widehat{v}_0}{\partial \theta_0} - G(\widehat{v}_0)H(\theta_0)\left[\frac{\partial \widehat{v}_0}{\partial \theta_0}(1 + (G/g)'(\widehat{v}_0)) - p_M'(\theta_0)\widehat{R_B^p}\right].$$

This implies that at $R_d = \widehat{R}_d$ and $\theta_0 = \widehat{\theta}$, we have

$$\frac{\partial \pi_o}{\partial v_0}\frac{\partial \widehat{v}_0}{\partial \theta_0} - p_e\underline{E}(\widehat{\theta})\frac{\partial \widehat{R_B^p}}{\partial \theta_0} = G(\widehat{v}_0)H(\widehat{\theta})p_M'(\widehat{\theta})\widehat{R_B^p}.$$

Replacing for this expression into Eq. (52) gives

$$y\widehat{\theta} - c_b - s_b - R_f = \overline{u}_B^p + \overline{F}_I^p + G(\widehat{v}_0)H(\widehat{\theta})p_M'(\widehat{\theta})\widehat{R_B^p}/h(\widehat{\theta}).$$

Since $p_M'(\theta_0)H(\theta_0) = h(\theta_0)(\theta_0 - p_M(\theta_0))$ and replacing for the marginal borrower under monopoly given by Eq. (10), we have

$$\widehat{\theta} = \theta_{0B} + \frac{\overline{u}_B^p + \overline{F}_I^p}{y} + \frac{(\widehat{\theta} - p_M(\widehat{\theta}))G(\widehat{v}_0)\widehat{R_B^p}}{y}.$$