Fintech Entry, Lending Market Competition, and Welfare*

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Abstract

We study fintech entry and how it affects competition, investment, and welfare in a spatial model. We find that fintechs with inferior monitoring efficiency can successfully enter because of their superior flexibility in pricing. It follows that fintech borrowers are more likely to default than bank borrowers with similar characteristics. Higher bank concentration leads to higher fintech loan volume and quality. Fintech entry may induce banks' exit and reduce investment; however, it will increase investment if inter-fintech competition is intense enough. Fintech entry will improve welfare if fintechs have high monitoring efficiency and inter-fintech competition intensity is intermediate.

JEL Classification: G21, G23, I31

Keywords: digital technology, monitoring, credit, bank restructuring, Big Data, price discrimination

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1 Introduction

In recent years, FinTech and BigTech companies have played an increasingly significant role in the lending market. Already in 2019, FinTech and BigTech firms' lending volume reached nearly 800 billion USD globally (Cornelli et al., 2020). In emerging and developing markets, BigTech companies have made inroads in lending to small and medium enterprises. For example, in China, Ant Financial and WeBank provide lending to millions of small and medium firms (Frost et al., 2019). In developed economies, FinTech lenders have a relevant penetration. According to the US Federal Reserve's Small Business Credit Survey (2019), almost one-third of small and medium firms that sought financing applied with a FinTech firm or online lender, up from 19% in 2016. The annual growth rate of FinTech business lending volume in the US was over 40% from 2016 to 2020 (Berg et al., 2021). The COVID-19 pandemic likely accelerated the penetration of FinTech/BigTech firms ("fintech" hereafter for short) because of government support (e.g., cooperation with SBA to distribute PPP loans) and the surging demand for digital services (Demirgüç-Kunt et al., 2021).

What are the determinants of the entry of fintech lenders? How does fintech entry affect the competition in the lending market and, especially, the behavior of traditional banks? How does fintech entry affect entrepreneurs' investment? What are the welfare implications? To answer those questions and to help explain some facts about fintech lending, we build a model of spatial competition in which banks and fintechs compete to provide loans to entrepreneurs. In particular, our model will illuminate the following empirical results:

- Fintechs extend more loans in markets with a less competitive (or more concentrated) banking sector (Claessens et al., 2018; Jagtiani and Lemieux, 2018; Frost et al., 2019; Hau et al., 2021). Unanticipated/exogenous bank (branch) closures lead to an increase in the fintech market share and quality of their borrowers (Avramidis et al., 2021; Gisbert, 2021).

- Superior information technology by itself cannot explain the rise of fintech lending. Fintech borrowers are more likely to default than bank borrowers after controlling for observable characteristics (Di Maggio and Yao, 2021; Chava et al., 2021; Beaumont et al., 2021).

- Borrowers with better access to bank financing request loans at lower interest rates on a fintech platform (Butler et al., 2017). Bank specialization is associated with more favorable loan rates, especially when the threat of non-banks or other sources of credit is high (Blickle et al., 2021).

- Fintech credit can be a complement (Tang, 2019) or a substitute (Gopal and Schnabl, 2022; Eça et al., 2022) of bank credit.

We model the lending market as a circular city à la Salop (1979) where several banks, located equidistantly, and two potential fintechs located (virtually) at the center of the circle compete for entrepreneurs who are distributed along the city. By incurring opportunity costs, entrepreneurs can undertake risky investment projects, which may either succeed or fail. Entrepreneurs have no initial capital, so they require funding from lenders when undertaking investment projects. Lenders (banks and fintechs) have no direct access to investment projects, so their profits are derived from providing loans to entrepreneurs. In addition to financing entrepreneurs, another critical function of lenders is monitoring entrepreneurs in order to increase the probability of their projects' success (see, e.g., Carletti, 2004; Allen et al., 2011; Martinez-Miera and Repullo, 2017, 2019). Monitoring is more costly for a bank if there is more distance between the bank and the monitored entrepreneur. This distance can be physical[1] or in a characteristics space from the expertise of the bank on certain sectors or industries.[2] Fintechs, however, are equidistant from all entrepreneurs, which captures the idea that the use of digital technology by a fintech lender makes its monitoring efficiency independent of the physical lender-borrower distance or its expertise in certain sectors or industries.

Banks are incumbents in the lending market, while fintechs are new entrants. The incumbent banks post uniform loan rates first, and fintechs move second, posting discriminatory loan rate schedules based on entrepreneurs' locations. Fintechs can price more flexibly for two reasons: First, the customer-centric nature and more advanced digital technology of fintech lenders allow them to customize products and implement more effective price discrimination policies (Bofondi and Gobbi, 2017; Navaretti et al., 2018; Vives, 2019). For example, Fuster et al. (2022) find that the use of machine learning increases the loan rate disparity among borrowers.[3] In contrast, technology adoption and

[1]There is evidence that firm–bank *physical* distance matters for bank lending. See Petersen and Rajan (2002) and Brevoort and Wolken (2009).

[2]Blickle et al. (2021) find that a bank "specializes" by concentrating its lending disproportionately into one industry about which the bank has better knowledge. Paravisini et al. (2021) document that exporters to a given country are more likely to be financed by a bank that has better expertise in the country. Duquerroy et al. (2022) find that in local markets, there exist specialized bank branches that concentrate their SME lending on certain industries.

[3]Similarly, Chu et al. (2023) document that fintechs' use of machine learning algorithms can better de-

transformation to a customer-centric model are far from successful for banks because of their obsolete legacy systems, rigid internal processes, reliance on human-based decision-making, and the need to comply with a myriad of regulations (Stulz, 2019 and Carletti et al., 2020). Second, banks face tight regulations aimed at reducing discrimination. For example, US Courts have established that practices aimed at statistical discrimination by banks that go beyond credit risk assessment are not legal.[4] In our model, lenders have a profit motive but not a credit assessment motive to price-discriminate. That is, discrimination is based on firm characteristics that are not directly related to credit risk, which is not legal. Banks are tightly regulated and in compliance with the law. However, non-bank lenders can bypass such regulations with the help of new technology and non-traditional data.[5] We model this situation in a stark way by assuming that a bank can only offer a uniform loan rate to all entrepreneurs it lends to. We also analyze what would happen if banks could also discriminate in Internet Appendix D.

Under the setup just described, we study how the emergence of fintech lenders affects competition in the lending market and obtain results consistent with available empirical evidence.[6] We find that three types of equilibria may arise depending on the monitoring efficiency of fintechs: blockaded entry, potential entry, and actual entry. In the case with blockaded fintech entry, fintechs cannot make any difference to the lending market, so banks and entrepreneurs behave as if fintechs do not exist; such a case arises when fintech monitoring efficiency is low. If fintech monitoring efficiency is at an intermediate level, the equilibrium with potential fintech entry will arise, in which case banks decrease their loan rates to protect their market areas from fintech penetration. In this case, banks face effective competitive pressure from fintechs, although the latter do not serve any entrepreneur. Finally, if fintech monitoring efficiency is good enough, banks cannot fully

cipher differences in borrower preferences between female and male borrowers, thereby increasing gender-based price discrimination. In particular, this discrimination is driven by fintechs' profit-maximizing motive instead of their gender preference.

[4] "For lending, U.S. courts have been explicit in ruling that the target is credit risk assessment and that profit motives beyond credit risk are not legal reasons for statistical discrimination" (Morse and Pence, 2021).

[5] Existing legal rules are not so effective in reducing the discrimination of algorithm-based credit pricing adopted by fintech lenders. Gillis and Spiess (2019), using a simulation exercise based on real-world credit data, find that the existing legal rules are not so effective in reducing the discrimination of algorithm-based credit pricing because (a) these rules were developed to regulate human-based decision-making and (b) the complexity of machine learning hinders the application of existing law. For example, ECOA forbids race, religion, or age from being considered in credit terms; FHA prohibits discrimination based on race, color, and national origin. Those rules provide little guidance if lenders set credit terms based on machine learning and big data.

[6] Our model is best attuned to the SME lending market.

protect their market areas, so fintechs can lend to a positive mass of entrepreneurs, giving rise to the equilibrium with actual fintech entry.

When actual entry occurs, fintechs lend to entrepreneurs sufficiently far from all banks. A fintech borrower will receive a (weakly) lower fintech loan rate if she is closer to banks, which is in line with Butler et al. (2017) who document that borrowers with better access to bank financing request loans at lower interest rates on a fintech platform. Fintechs will have a higher competitive advantage if their monitoring efficiency improves relative to that of banks, in which case the market area served by fintechs will increase.

Increasing bank concentration enlarges fintechs' market area and lending volume because then there are more locations distant from all banks. This finding is consistent with the stylized fact that fintechs extend more loans in markets with a less competitive banking sector (Claessens et al., 2018; Jagtiani and Lemieux, 2018; Frost et al., 2019; Avramidis et al., 2021; Gisbert, 2021; Hau et al., 2021). Another consequence of a higher bank concentration is that a fintech faces less competitive pressure from banks, and so can serve more locations with higher loan rates, which on average increases the fintech's monitoring incentive and hence loan quality (proxied by the average success probability of the fintech's borrowers). This result is in line with Avramidis et al. (2021) who find that exogenous bank (branch) closures lead to an increase in the quality of fintech borrowers.

Fintechs' exclusive ability to price discriminate contributes to their competitive advantage over banks. When a bank competes with a fintech at a given location, the bank will worry that lowering its loan rate at this location will decrease its lending profits from all other locations. In contrast, the fintech does not have such concerns because of its ability to offer discriminatory loan rates based on locations. Consequently, actual fintech entry can occur even if fintechs have no advantage over banks in monitoring efficiency or funding cost. When a bank and a fintech have the same funding cost and serve borrowers of similar locations, the fintech will offer lower loan rates and hence exert less monitoring effort than the bank. As a result, fintech borrowers have lower success probabilities than bank borrowers who have similar characteristics. This is consistent with empirical evidence documenting that fintech borrowers are more likely to default than bank borrowers after controlling for other observable characteristics (Di Maggio and Yao, 2021; Chava et al., 2021; Beaumont et al., 2021).

Potential fintech entry forces banks to protect their market areas with a lower loan rate, which makes all entrepreneurs better off and thereby increases their total investment. However, actual fintech entry need not spur entrepreneurs' investment. On the one hand, the competitiveness of fintechs forces banks to provide higher utility to entrepreneurs, which incentivizes more entrepreneurs to undertake investment projects. On the other hand, actual fintech entry decreases banks' uniform loan rate, potentially making it unprofitable for banks to serve distant locations; at such locations, banks' competitive threat disappears, so a fintech can gain large market power, thereby hurting entrepreneurs and reducing their investment. Therefore, the net effect of actual fintech entry on investment is ambiguous. However, if competition among fintechs is sufficiently intense, actual fintech entry will increase entrepreneurs' investment because, in this case, fintechs will provide high utility to entrepreneurs no matter whether or not banks' competitive threat disappears.

Social welfare in our model equals the expected net value of all implemented investment projects, which is determined by (a) the mass of projects implemented by entrepreneurs (i.e., total investment), (b) the success probabilities of those projects and (c) the incurred social costs (including monitoring, funding, and opportunity costs). Fintech entry changes entrepreneurs' expected utility, thereby affecting the mass of projects implemented. It also changes lenders' loan rates and hence affects lenders' monitoring incentives, which determines the success probabilities of those projects. If a fintech has sufficiently good monitoring technology (compared with banks), then its actual entry will improve the monitoring efficiency of the entire market, thereby generating a cost-saving effect. In general, the welfare effect of fintech entry is ambiguous. Social welfare can either increase because of the cost-saving effect of actual entry or decrease if entrepreneurs' investment or lenders' monitoring incentive is reduced substantially. However, if the competition intensity among fintechs is at an intermediate level, actual entry with sufficiently good fintech monitoring efficiency will increase social welfare because, in this case, fintechs' pricing balances entrepreneurs' investment and lenders' monitoring incentives.

If banks can also discriminate, some results will change. First, actual fintech entry will not occur if fintechs have no advantage over banks in monitoring efficiency or funding cost. Second, the market area served by fintechs will be smaller because allowing banks to price discriminate increases banks' competitive advantage in the bank-fintech competition. Finally, potential or actual fintech entry always makes entrepreneurs better off and hence increases their investment. The reason is that banks' competitive threat will never disappear at any location if banks can break the uniform-pricing constraint; hence, fintech entry always increases the competition intensity among lenders.

In the long run, fintech entry can induce banks to leave the market and recover their salvage values, which reduces banks' competitive threat to fintechs. In the case with actual entry, if such a reduction in banks' threat substantially enlarges a fintech's market power, entrepreneurs' utility and investment will decrease. However, if the competition among fintechs is sufficiently intense, actual fintech entry will increase entrepreneurs' investment despite the reduction in banks' competitive threat. The welfare effect of fintech entry will also be a little different because an *option value effect* will arise when banks can exit. This effect means that banks can protect themselves by executing the option to exit and recover salvage values as fintech entry decreases their profitability. The option value effect is welfare-improving because fintech entry transfers bank profit to other parties (fintechs and/or entrepreneurs) and lets banks exit, which fulfills their option values.

Related literature. Our paper is related to several strands of the literature. First, our work belongs to the theoretical research on how a new entrant affects lending market competition. Gehrig (1998) builds a model studying how the entry of a new bank affects banks' screening efforts and loan quality. Different from our paper, the Gehrig model exogenously introduces a new bank into the lending market; in our paper, entry is endogenously determined. In addition, entrants in our model are fintechs, entities with distinct characteristics compared with banks.

Bouvard et al. (2022) study what drives a BigTech platform's entry into the lending market, where numerous competitive banks already exist. In their model, both banks and the bigtech can monitor entrepreneurs. The main difference between the bigtech and a bank is that, in addition to providing loans, the bigtech is also a monopolistic platform where entrepreneurs (i.e., merchants) can serve buyers, allowing the bigtech to charge transaction fees from merchants and buyers directly. Li and Pegoraro (2023) also model competition between banks and a bigtech, where the latter can control a borrower's access to revenues and enforce loan repayment. Our paper focuses on another difference between fin/bigtechs and banks: fin/bigtechs can price more flexibly and are less affected by the lending distance.

He et al. (2023) build a model studying the competition between a bank and a fintech. Their work focuses on how "open banking" – an information sharing mechanism that enables borrowers to share their customer data stored in a bank with a fintech lender – affects the lending competition between a bank that has consumer data and a fintech that does not have such data. In contrast, our model focuses on what drives fintech entry and what are its consequences. Parlour et al. (2022) study how a monopolistic bank competes with competitive fintechs for payment flows that contain borrowers' credit information; in that paper (a) the bank and fintechs do not directly compete in the loan market, and (b) fintechs cannot strategically set prices for their services because they do not have market power. In our model, banks and fintechs compete in the loan market, and all lenders can strategically choose their loan rates.[7]

A related work is Vives and Ye (2023), which analyzes the impact of information technology on lender competition and shows that the effects of an information technology improvement on competition, investment, and welfare depend on whether or not it weakens the influence of lender-borrower distance on monitoring efficiency. That paper, in contrast to the present one, does not study (a) what drives fintech entry into the credit market and (b) the effects of fintechs' superior flexibility in pricing. Vives and Ye (2023) models lender monitoring following Holmstrom and Tirole (1997) with monitoring reducing the private benefits entrepreneurs can derive by shirking. The present paper – building on Carletti (2004), Allen et al. (2011), and Martinez-Miera and Repullo (2017, 2019), assumes that lender monitoring can directly increase the success probability of entrepreneurs' projects.

Our paper is related to the thriving empirical literature on the rise of fintech in lending (see Vives, 2019 and Thakor, 2020 for surveys). To start with, there is considerable evidence showing that fintech lenders can use non-traditional data to participate in the lending market.[8] Philippon (2016) claims that the existing financial system's inefficiency can explain the emergence of new entrants that bring new technology to the sector. Buchak et al. (2018) find that regulation arbitrage can explain only a small proportion of the growth of fintechs and "shadow" banks in the US mortgage market, whereas technology improvement is responsible for approximately 90% of the gains of fintechs and for 30% of shadow bank growth overall. Jiang et al. (2022) document that digital disruption induces the entry of fintech-like financial intermediaries. Beaumont et al. (2021) find that superior information processing technology itself cannot explain the rise of fintech lending. Our model shows that fintech technology is indeed important in determining whether or not fintech entry is successful; however, fintechs do not need superior monitoring technology to penetrate the market as long as they can price more flexibly than incumbents.

[7]Building on He et al. (2023), Hu and Zryumov (2023) study bank-fintech competition and collaboration when banks can provide funding to fintechs. The main difference between a fintech and a bank is that the fintech has better screening ability, while the bank has access to cheaper funding. In a related work, Boualam and Yoo (2022) consider bank-fintech differences in monitoring ability, funding costs, and search costs. In Huang (2023), banks and fintechs differ in their lending technologies: fintechs learn from data, while banks rely on physical collateral.

[8]Such as soft information (Iyer et al., 2016), friendships and social networks (Lin et al., 2013), applicants' description text (Dorfleitner et al., 2016; Gao et al., 2018; Netzer et al., 2019), contract terms (Kawai et al., 2014; Hertzberg et al., 2018), digital footprints (Agarwal et al., 2020; Berg et al., 2020) and cashless payment information (Ghosh et al., 2021; Ouyang, 2021) – to assess the quality of borrowers.

Some empirical studies look at the relationship between bank lending and fintech credit. Tang (2019) finds that P2P lending is a substitute for bank lending in terms of serving infra-marginal bank borrowers, yet complements bank lending with respect to small loans. Gopal and Schnabl (2022) document that most of the increase in fintech credit substituted for a reduction in lending by banks. Eça et al. (2022) also find a substitute relationship between bank and fintech debts. Our model finds that actual fintech entry will erode the market area served by banks, indicating a substitution relation between fintechs and banks; however, if banks have local monopolies, then fintechs will complement banks by lending to those previously underserved borrowers.

Whether or not fintech loans are more risky is an important question in the literature on fintech lending. Fuster et al. (2019) find that there is no evidence indicating that fintech lenders target risky or marginal borrowers. However, Di Maggio and Yao (2021) find that fintech borrowers are more likely to default than bank borrowers after controlling for observable characteristics. Chava et al. (2021) provide similar evidence that consumers who borrow from marketplace lending platforms have higher default rates than those borrowing from traditional banks. Our findings are more consistent with the latter two papers.

The rest of our paper proceeds as follows: Section 2 presents the model set-up. In Section 3, we examine how fintech entry affects the type of equilibrium in the lending market. Section 4 characterizes the equilibria that may arise. In Section 5, we study how fintech entry affects entrepreneurs' investment. Section 6 provides a welfare analysis. Section 7 considers the case where banks can also price discriminate. In Section 8 we check the long-run effect of fintech entry by allowing banks to exit. We conclude in Section 9 with a summary of our findings. Appendix A presents all the proofs. Other appendices and internet appendices provide supplementary analyses and extensions.

2 The model

The economy and players. The economy is represented by a circular "city" of circumference 1, which is inhabited by entrepreneurs and lenders. A point on the circumference represents the characteristics of an entrepreneur (type of project, technology, geographical position, industry, . . .) at this location; two close points mean that the entrepreneurs in those locations are similar.

The economy has two types of lenders: $N \geq 2$ banks and two fintech firms (called "fintechs" hereafter). The $N \geq 2$ banks are located *equidistantly* around the city, so the arc-distance between two adjacent banks is $1/N$. This assumption means that a bank is closer to some entrepreneurs than to others. For example, banks are specialized in different sectors of the economy (see Paravisini et al., 2021 for export-related lending, Duquerroy et al., 2022 for SME lending and Giometti and Pietrosanti, 2022 for syndicated corporate loans). Throughout the paper, we use bank i to denote an arbitrary bank on the circle, and bank $i+1$ to represent the bank that is to the right of and adjacent to bank i. On the arc between banks i and $i+1$, we say that an entrepreneur is located at (location) z_i if the arc-distance between the entrepreneur and bank i is z_i. As a result, the arc-distance between location z_i and bank $i+1$ is $1/N - z_i$. From Sections 2 to 6 we take N as given, while in Section 8 banks may exit, and hence N is endogenous there.

Different from banks, the two fintechs (denoted by fintechs 1 and 2 respectively) are located at the center of the circle and thus equidistant from all entrepreneurs.[9] This assumption captures the idea that a fintech has a uniform expertise/ability in dealing with different types of entrepreneurs: In a physical interpretation, a fintech connects digitally with entrepreneurs of different geographic locations; in a characteristics interpretation, a fintech has a uniform ability to collect and process information of entrepreneurs with different characteristics (e.g., those in different industries) due to its highly digitized information infrastructure (based on big data and machine learning techniques). Figure 1 gives a graphic illustration of the economy.

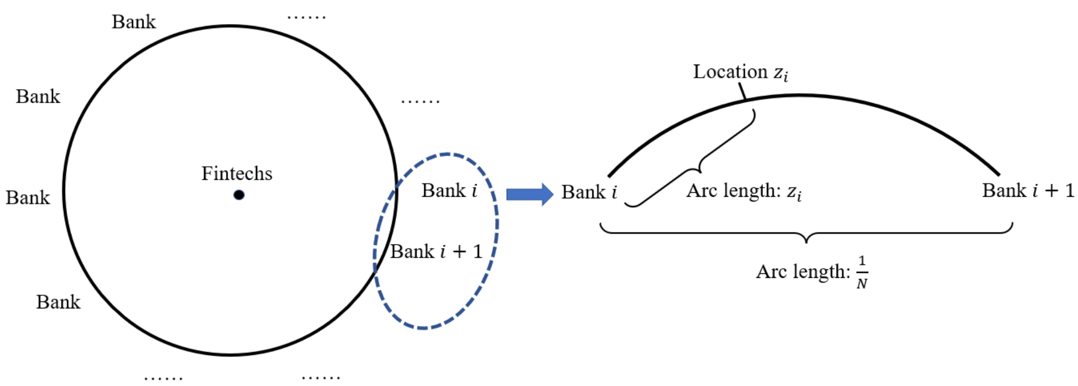

Figure 1: The Economy

A second difference is that fintechs, by adopting information technology more rapidly, can price more flexibly than banks. To capture this difference starkly, we assume that a bank must offer a uniform loan rate to all locations it serves, while a fintech's loan

[9] We will see that even if more than two fintechs exist, only two of them matter to the credit market.

rates can be contingent on entrepreneurs' locations. Specifically, we denote fintech j's ($j \in \{1,2\}$) loan rate by $r_{Fj}(z_i)$, which is a function of z_i.

Entrepreneurs and monitoring intensity. At each location (e.g., location z_i), there is a potential mass M of entrepreneurs. Each entrepreneur has no initial capital but is endowed with a risky investment project that requires a unit of funding. To undertake a project, an entrepreneur requires funding from a lender, which can be a bank or a fintech. The project of an entrepreneur at z_i yields the following risky return:

$$\tilde{R}(z_i) = \begin{cases} R & \text{with probability } m(z_i), \\ 0 & \text{with probability } 1 - m(z_i). \end{cases}$$

In the event of success (resp. failure), the entrepreneur's investment yields R (resp. 0). The probability of success is $m(z_i) \in [0,1]$, which represents how intensely the entrepreneur is monitored by the lender that provides the loan. We refer to $m(z_i)$ as the lender's "monitoring intensity".

Entrepreneurs' investment decisions and funding demand. An entrepreneur at location z_i can borrow and invest at most 1 unit of funding. If an entrepreneur at z_i borrows at loan rate $r(z_i)$ and is monitored with intensity $m(z_i)$, her expected utility on the investment is

$$\pi^e(z_i) \equiv (R - r(z_i))m(z_i).$$

We assume that the entrepreneur derives net utility $\pi^e(z_i) - \underline{u}$ by implementing the risky project, so she seeks funding if and only if $\pi^e(z_i) > \underline{u}$. Here $\underline{u}$ is the reservation utility (i.e., opportunity cost) of the entrepreneur's alternative activities. For each entrepreneur at z_i, $\underline{u}$ is independently and uniformly distributed on $[0, M]$. The total funding demand (which is also the mass of entrepreneurs who undertake projects) at location z_i is therefore

$$D(z_i) \equiv M \int_0^M \frac{1}{M} 1_{\{\pi^e(z_i) \geq \underline{u}\}} \, d\underline{u} = \pi^e(z_i), \tag{1}$$

and total entrepreneurial utility (net of opportunity costs) at location z is

$$M \int_0^M \frac{1}{M} (\pi^e(z_i) - \underline{u}) 1_{\{\pi^e(z_i) \geq \underline{u}\}} \, d\underline{u} = \frac{(\pi^e(z_i))^2}{2}.$$

The funding costs of lenders. For simplicity, we abstract from the capital structure of lenders and assume that they can provide loans at given marginal funding costs.[10] Specifically, banks' marginal funding cost is ι_B, while fintechs' is ι_F.

Monitoring cost. Monitoring is costly for lenders. Specifically, if a bank monitors an entrepreneur at z_i on the arc between banks i and $i+1$ with intensity $m(z_i)$, the monitoring cost the bank needs to incur is:

$$C_B\left(m(z_i), d\right) = \frac{c_B}{2\left(1 - qd\right)}(m(z_i))^2,$$

with $c_B > R$, $R > \sqrt{2c_B\iota_B}$, $q \in (0,2)$ and $d \geq 0$.[11] Variable d is the arc-distance between the bank and the monitored entrepreneur (for bank i /resp. bank $i+1$, $d = z_i$ /resp. $d = 1/N - z_i$). Parameters c_B and q are inverse measures of the efficiency of banks' monitoring technology. Parameter c_B is the slope of marginal monitoring costs when the bank-borrower distance d is zero. Parameter q measures the negative effect of the bank-borrower distance on banks' monitoring efficiency. The cost function $C_B\left(m(z_i), d\right)$ captures the idea that a bank has lower efficiency in monitoring entrepreneurs who are more distant from the bank's expertise or geographic location.[12] The constraint $R > \sqrt{2c_B\iota_B}$ must hold to guarantee that banks are willing to provide loans to a positive mass of entrepreneurs in the market. The constraint $c_B > R$ ensures that a bank's monitoring intensity - which is equal to the success probability of monitored entrepreneurs - is always smaller than 1.

If fintech j monitors an entrepreneur at z_i with intensity $m(z_i)$, the monitoring cost is:

$$C_{Fj}\left(m(z_i)\right) = \frac{c_{Fj}}{2}(m(z_i))^2,$$

where $c_{Fj} > R$ is the slope of marginal monitoring costs, which inversely measures the monitoring efficiency of the fintech. Note that $C_{Fj}\left(m(z_i)\right)$ is not affected by the location of the monitored entrepreneur for a given $m(z_i)$, which corresponds to the fintech's location at the center of the circle as explained above. The constraint $c_{Fj} > R$ ensures that the fintech's monitoring intensity is always smaller than 1.

Without loss of generality, throughout the paper we let $c_{F1} \leq c_{F2}$ hold; that is, fintech 1 has a weakly better monitoring efficiency than the other fintech.

[10]Similar simplifications are adopted in Holmstrom and Tirole (1997), Hauswald and Marquez (2003, 2006), and He et al. (2023).

[11]The restriction $q < 2$ ensures that $1 - qd > 0$ always holds because the arc-distance between a bank and location z_i is at most 1/2.

[12]This is consistent with Giometti and Pietrosanti (2022) who document that banks specialize in lending to specific industries because of their information advantages in monitoring those industries.

Interpretation of monitoring. Lenders typically monitor their borrowers through information collection and covenant restrictions (Wang and Xia, 2014; Minnis and Sutherland, 2017; Gustafson et al., 2021; Branzoli and Fringuellotti, 2022). Specifically, lenders can collect entrepreneurs' data (e.g., by frequently requesting information) and assess how the business is doing. If borrowers are not acting appropriately, lenders can provide warnings and advice, which potentially improve their behavior. If the collected information shows a breach of covenants, lenders can obtain control rights and directly intervene to fix borrowers' behavior. Such intervention is easier for BigTech lenders since they have advantages in information collection and contract enforcement in their ecosystems (Liu et al., 2022 and Boualam and Yoo, 2022).[13]

Monitoring relies on lenders' ability to collect and process information about borrowers and it is facilitated by advancements in lenders' information technology, which is represented by c_B and q for banks and c_{Fj} for fintech j. Banks traditionally have dealt with soft information, which is the basis of relationship banking. Physical bank-borrower distance impairs relationship banking, but communication technology (like videoconferencing) can reduce such impairment (i.e., decrease q in the model). Improvements in Big Data and machine learning (ML) techniques help codify soft information into hard information and reduce the reliance on human-based decisions, which decreases the expertise friction for banks (i.e., decreases q in the model); ML and Big Data also improve the basic efficiency in information processing (at zero lending distance) for both banks and fintechs (i.e., decrease c_B and c_{Fj} in the model).[14]

Timeline. In the lending game, the following events take place in sequence. First, lenders (i.e., banks and fintechs) post their loan rates. The incumbent banks post their uniform loan rates first and fintechs move second posting their discriminatory loan rates after observing banks' loan rates.[15] Second, after lenders' loan rates are chosen and hence observable, each entrepreneur (i.e., borrower) decides (a) whether or not to implement her project (which will incur the opportunity cost $\underline{u}$) and (b) which lender to

[13]Monitoring creates value for both lenders and entrepreneurs; we can view it as lenders' expertise-based advising, mentoring or/and information production that is helpful for entrepreneurs. There is evidence that borrowers do value the expertise of lenders. Paravisini et al. (2021) find that an exporter prefers borrowing from a bank with better expertise in the target market. Lee and Sharpe (2009) find that more intense lender monitoring leads to higher stock returns of borrowers; similarly, Dass and Massa (2011) show that lender monitoring can improve corporate governance of borrowers, thereby increasing their firm values.

[14]Vives and Ye (2023) provide a more comprehensive discussion of the effects of information technology improvements.

[15]As in Thisse and Vives (1988) a pure-strategy equilibrium may not exist if a uniform-pricing firm and a price-discriminating one simultaneously post prices.

approach for funding if she decided to undertake her project. Given lenders' loan rates and entrepreneurs' decisions, each lender decides whether to provide funding to its loan applicants. Banks' marginal funding cost of providing loans is ι_B, while fintechs' is ι_F. After providing loans, each lender chooses its optimal monitoring intensity as a function of borrowers' locations.[16]

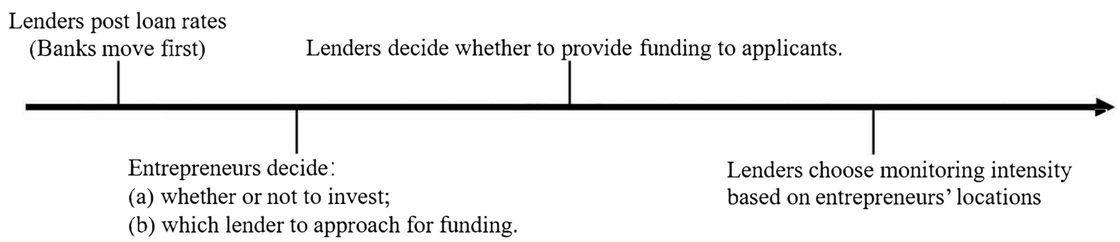

Figure 2: Timeline.

3 Equilibrium regimes

In this section, we seek to establish how the fintech shock affects the lending market equilibrium. We deal with the monitoring choices of the lenders and the decisions of entrepreneurs first, and then the different possible equilibrium regimes. Throughout the paper, we concentrate our analyses on symmetric equilibria that may arise.

A standard feature of this class of spatial competition models is that symmetric equilibria can be fully characterized by studying the competition among neighbors. Hence, it suffices to concentrate our analyses on the arc between banks i and $i+1$.

3.1 Monitoring intensity and entrepreneurs' decisions

We analyze the equilibrium by backward induction and hence look at lenders' optimal monitoring intensity first.

According to the timeline, an entrepreneur has decided which lender to approach for funding *before* lenders choose their monitoring intensities. If an entrepreneur at z_i (on the arc between banks i and $i+1$) approaches a bank (say, bank j) and gets a loan at

[16]A bank can determine its monitoring intensity based on entrepreneurs' locations, but cannot discriminate when pricing. We want to highlight here that banks are less flexible in pricing than fintechs, be it because of technological or infrastructure constraints (e.g., use of mainframe instead of the cloud), regulatory and compliance constraints, or both.

rate r_B, the bank's expected profit from financing the entrepreneur can be written as:

$$\pi_B(z_i) \equiv r_B m_B(z_i) - \iota_B - \frac{c_B}{2(1-qd)}(m_B(z_i))^2, \tag{2}$$

where $m_B(z_i)$ is the bank's monitoring intensity at z_i and d is the arc-distance between bank j and location z_i. The first term of $\pi_B(z_i)$ is the expected loan repayment the bank receives from an entrepreneur at z_i, because the entrepreneur repays r_B with probability $m_B(z_i)$. The second term of $\pi_B(z_i)$ is the bank's marginal funding cost. The third term represents the bank's costs of monitoring the entrepreneur with intensity $m_B(z_i)$.

Reasoning in a similar way, if an entrepreneur at z_i approaches a fintech (say, fintech j) and gets a loan at rate $r_{Fj}(z_i)$, the fintech's expected profit from financing the entrepreneur is:

$$\pi_{Fj}(z_i) \equiv r_{Fj}(z_i)\, m_{Fj}(z_i) - \iota_F - \frac{c_{Fj}}{2}(m_{Fj}(z_i))^2,$$

where $m_{Fj}(z_i)$ is the fintech's monitoring intensity for entrepreneurs at location z_i. The first term of $\pi_{Fj}(z_i)$ is the expected loan repayment the fintech receives from the entrepreneur who repays $r_{Fj}(z_i)$ with probability $m_{Fj}(z_i)$. The second term of $\pi_{Fj}(z_i)$ is the fintech's marginal funding cost. The third term represents the fintech's monitoring costs.

After providing loans to entrepreneurs at some location (e.g., location z_i), a lender (a bank or a fintech) chooses its monitoring intensity to maximize its expected profit at this location, taking as given the loan rate, entrepreneurs' choices, and the marginal funding cost. Lemma 1 presents the result.

Lemma 1. *At location z_i, if a bank provides loans at the loan rate r_B, its optimal monitoring intensity is given by*

$$m_B(z_i) \equiv \frac{r_B}{c_B/(1-qd)},$$

where d is the arc-distance between the bank and location z_i.

At location z_i, if fintech j provides loans at the loan rate $r_{Fj}(z_i)$, its optimal monitoring intensity is given by

$$m_{Fj}(z_i) \equiv \frac{r_{Fj}(z_i)}{c_{Fj}}.$$

According to Lemma 1, a bank's monitoring intensity $m_B(z_i)$ will decrease as c_B or/and q increase (except if $d = 0$) because in both cases monitoring becomes more costly. Furthermore, $m_B(z_i)$ is decreasing in d because it is more costly for a bank to monitor entrepreneurs that are located farther away from its expertise or geographic location. The slope of the marginal monitoring cost $c_B/(1-qd)$ is an inverse measure of the bank's monitoring efficiency when the lending distance is d. Finally, $m_B(z_i)$ is increasing in the bank's loan rate r_B because a higher r_B implies a larger skin in the game and, hence, a higher monitoring incentive for the bank.

A fintech's monitoring intensity $m_{Fj}(z_i)$ is increasing in $r_{Fj}(z_i)$ and decreasing in c_{Fj} because of similar considerations. The only difference is that for a given loan rate $r_{Fj}(z_i)$, the fintech's monitoring intensity $m_{Fj}(z_i)$ does not rely on entrepreneurs' locations.

When do lenders provide loans to their applicants? If an entrepreneur at z_i applies for a loan from a bank (with lending distance d and loan rate r_B), the bank will provide the loan if and only if $\pi_B(z_i) \geq 0$ (see Equation 2). According to Lemma 1, $m_B(z_i)$ can be anticipated, so the bank will provide the loan if and only if:

$$\frac{(1-qd)r_B^2}{2c_B} - \iota_B \geq 0 \tag{3}$$

Note that whether Condition (3) holds can be anticipated by all market participants after lenders post their loan rates. Reasoning in the same way, fintech j will provide a loan to an applicant at z_i if and if $\pi_{Fj}(z_i) \geq 0$, with $m_{Fj}(z_i)$ given in Lemma 1.

Entrepreneurs' decisions. An entrepreneur will approach the lender that can provide the highest expected utility. Consider the case that all lenders are willing to provide loans to entrepreneurs at z_i. Then, entrepreneurs at z_i will approach bank k - whose loan rate and (anticipated) monitoring intensity are r_k and $m_k(z_i)$ respectively - for loans if and only if they get the highest expected utility by approaching the bank instead of other lenders:

$$(R-r_k)m_k(z_i) = \max_{h\in\{1,2,\ldots,N\},j\in\{1,2\}} \left\{(R-r_{Fj}(z_i))m_{Fj}(z_i), (R-r_h)m_h(z_i)\right\},$$

where r_h (resp. $m_h(z_i)$) is the loan rate (resp. monitoring intensity) of bank h; $r_{Fj}(z_i)$ (resp. $m_{Fj}(z_i)$) is the loan rate (resp. monitoring intensity) of fintech j. Both $m_h(z_i)$ and $m_{Fj}(z_i)$ follow the rules given in Lemma 1.

Entrepreneurs do not simply choose the lender with the lowest loan rate because they also care about monitoring intensities. Since a bank's (resp. a fintech's) monitoring intensity is affected by q and c_B (resp. c_{Fj}), the monitoring efficiency of lenders is important in determining the expected entrepreneurial utility they can provide.

Decreasing a lender's loan rate will increase the payoff to entrepreneurs upon success, but decrease the lender's monitoring intensity according to Lemma 1, which leads to the following lemma.

Lemma 2. *For any location, the expected entrepreneurial utility provided by a lender is decreasing in the lender's loan rate if and only if the loan rate is no less than $R/2$. Hence, a lender's loan rate will be no less than $R/2$.*

Lemma 2 states that when a lender's loan rate is as low as $R/2$, further decreasing the loan rate cannot provide higher utility to entrepreneurs because the negative effect on monitoring becomes dominant. Since a lower loan rate implies a smaller lending profit from financing an individual entrepreneur, decreasing a lender's loan rate below $R/2$ hurts both the lender and the entrepreneurs it serves. As a result, at any location, $R/2$ is the lower bound of a lender's loan rate. Given that all lenders price above $R/2$, decreasing a lender's loan rate at z_i must imply higher entrepreneurial utility at this location, despite a lower monitoring intensity.

3.2 Equilibrium regimes and fintech entry

The following definition presents different types of equilibria depending on the status of fintech entry.

Definition 1. *There is* blockaded *fintech entry if entrepreneurs and incumbent banks behave as if there were no fintechs. There is* potential *fintech entry if fintechs do not lend to any entrepreneur because of banks' behavior. There is* actual *fintech entry if fintechs lend to a positive mass of entrepreneurs.*

In the case with *blockaded* fintech entry, fintechs cannot make any difference to the lending market, so banks and entrepreneurs behave as if fintechs do not exist; banks' pricing strategies are independent of c_{Fj}. In the case with *potential* fintech entry, banks modify their pricing (depending on c_{Fj}) to protect their market areas from fintechs' penetration. Although in this case fintechs do not serve any entrepreneur, they are effective potential competitors that banks cannot ignore in the lending market. In the case with *actual* fintech entry, banks give up fully protecting their market areas, so fintechs can lend to a positive mass of entrepreneurs.

When there is blockaded fintech entry (or there are no fintechs), two cases may arise: (a) there is effective competition between adjacent banks, or (b) there does not exist such competition (which is called the *pre-entry local monopoly* case hereafter). In order to concentrate our analysis on effective competition, throughout the paper we focus on the former case, which is equivalent to assuming Condition (11) in Lemma A.2 of Appendix A. The pre-entry local monopoly case is relegated to Appendix B.

The following proposition provides the conditions for the three types of symmetric equilibria to arise.

Proposition 1. *A unique symmetric equilibrium exists. There exist $\overline{c}_F$ and $\underline{c}_F$ ($< \overline{c}_F$) such that:*

(i) If $c_{F1} \geq \overline{c}_F$, there is blockaded fintech entry; banks' loan rate is denoted by r_B^{eb}.

(ii) If $\underline{c}_F \leq c_{F1} < \overline{c}_F$, there is potential fintech entry; banks' loan rate is $r_B^{ep} < r_B^{eb}$.

(iii) If $c_{F1} < \underline{c}_F$, there is actual fintech entry; banks' loan rate is $r_B^{ea} < r_B^{eb}$.

From the perspective of banks, the competitiveness of fintechs is equivalent to that of fintech 1 since it has a (weakly) better monitoring efficiency and hence can provide (weakly) higher entrepreneurial utility than fintech 2. Therefore, the type of the equilibrium depends on the value of c_{F1}. If the monitoring efficiency of fintech 1 is low (i.e., if $c_{F1} \geq \overline{c}_F$), borrowing from fintechs implies too low monitoring intensities (i.e., too low success probabilities) for entrepreneurs; hence banks and entrepreneurs need not consider the presence of fintech lenders when making decisions. If the monitoring efficiency of fintech 1 is at an intermediate level (i.e., if $\underline{c}_F \leq c_{F1} < \overline{c}_F$), then fintech 1 will bring effective competitive pressure to banks; the fintech could attract entrepreneurs at some locations if banks did nothing to respond to fintech 1's competitive threat. In this case, banks have to decrease their loan rate (from r_B^{eb} to r_B^{ep}) to protect their market areas from fintech penetration. However, doing so is costly for banks because they must decrease their loan rate to the extent that fintech 1 cannot attract entrepreneurs at *any* location of the city. Therefore, if the monitoring efficiency of fintech 1 is sufficiently good (i.e., if $c_{F1} < \underline{c}_F$), banks will let actual fintech entry occur, instead of posting quite low a loan rate to fully protect their market areas. In this case banks' loan rate r_B^{ea} is lower than r_B^{eb} because actual fintech entry increases the competitive pressure faced by banks.

Figure 3 illustrates how the equilibrium type and its basic properties are determined by fintech 1's monitoring efficiency.

The following corollary provides comparative statics for $\overline{c}_F$ and $\underline{c}_F$.

Corollary 1. *Monitoring efficiency thresholds $\overline{c}_F$ and $\underline{c}_F$ are increasing in c_B, q and ι_B.*

As c_B, q and/or ι_B decrease, banks' monitoring efficiency will increase and marginal funding cost will decrease. Such an efficiency improvement increases banks' competitive

Figure 3: Fintech Entry and the Type of Equilibrium.

advantage over fintechs, thereby making it easier for banks to maintain the blockaded or potential fintech entry regime (i.e., making $\overline{c}_F$ and $\underline{c}_F$ lower).

4 Characterizing equilibria

In this section, we characterize symmetric equilibrium focusing on the case with potential or actual entry. The case with blockaded entry is relegated to Internet Appendix C.

Measuring the competitiveness of a fintech. The following lemma characterizes the maximum utility a fintech can provide, which can represent the fintech's competitiveness.

Lemma 3. *At any location, the fintech j's loan rate that maximizes entrepreneurs' expected utility is given by*

$$\overline{r}_{Fj} \equiv \max\left\{\frac{R}{2}, \sqrt{2c_{Fj}\iota_F}\right\},$$

which implies the following entrepreneurial utility from investment:

$$\overline{U}_{Fj} \equiv \underbrace{\frac{\overline{r}_{Fj}}{c_{Fj}}}_{monitoring\ intensity} \times \underbrace{(R-\overline{r}_{Fj})}_{return\ from\ success},$$

*with $\overline{U}_{F1} \geq \overline{U}_{F2}$ holding. We call $\overline{r}_{Fj}$ the "**best loan rate**" of fintech j.*

We can best explain Lemma 3 by proving it here. For an entrepreneur at z_i, the expected utility from investment equals

$$U_{Fj}(z_i) \equiv m_{Fj}(z_i)\left(R - r_{Fj}(z_i)\right)$$

if she secures a loan from fintech j with the loan rate (resp. monitoring intensity) $r_{Fj}(z_i)$ (resp. $m_{Fj}(z_i)$). By Lemma 1, we know $m_{Fj}(z_i) = r_{Fj}(z_i)/c_{Fj}$. Hence, if the fintech maximizes $U_{Fj}(z_i)$ by choosing $r_{Fj}(z_i)$, the resulting loan rate is exactly $R/2$. However,

$R/2$ may not be feasible for the fintech because its expected profit from serving location z_i must be non-negative. The non-negative profit requirement implies the following condition:

$$\pi_{Fj}(z_i) = r_{Fj}(z_i)\, m_{Fj}(z_i) - \iota_F - \frac{c_{Fj}}{2}(m_{Fj}(z_i))^2 \geq 0,$$

which is equivalent to $r_{Fj}(z_i) \geq \sqrt{2c_{Fj}\iota_F}$. Hence, the feasible fintech loan rate that maximizes entrepreneurs' utility is $\overline{r}_{Fj}$; the corresponding maximum entrepreneurial utility from investment is $\overline{U}_{Fj}$.

Note that $\overline{U}_{Fj}$ is not a function of z_i because a fintech is equidistant from all locations. Since fintech 1 has a weakly better monitoring efficiency than fintech 2, $\overline{U}_{F1} \geq \overline{U}_{F2}$ must hold, which confirms the result that the competitiveness of fintechs is equivalent to that of fintech 1 (i.e., the type of fintech entry depends on the value of c_{F1}).

Fintech monitoring efficiency and banks' pricing.

Corollary 2. *If $c_{F1} < \overline{c}_F$ (i.e., with potential or actual fintech entry), banks' equilibrium loan rate is increasing in c_{F1}.*

A decrease in c_{F1} makes monitoring less costly for fintech 1, which increases its competitiveness and hence forces banks to decrease their loan rates to prevent (resp. mitigate) the fintech's penetration when there is potential (resp. actual) entry.

4.1 Potential fintech entry

The following proposition characterizes the symmetric equilibrium.

Proposition 2. *With potential fintech entry, bank i (resp. bank $i+1$) serves locations $z_i \in [0, 1/2N]$ (resp. $z_i \in (1/2N, 1/N]$) on the arc between banks i and $i+1$. In this equilibrium, the expected entrepreneurial utility from investment equals $\overline{U}_{F1}$ at location $z_i = 1/(2N)$, that is:*

$$\frac{r_B^{ep}(1-\frac{q}{2N})(R-r_B^{ep})}{c_B} = \overline{U}_{F1}, \tag{4}$$

where r_B^{ep} is banks' equilibrium loan rate.

With potential fintech entry, the lending market is served only by banks. Since a bank's monitoring efficiency is decreasing in its lending distance, each bank will serve the market area in which it has a smaller lending distance (and hence higher monitoring efficiency) than rival banks (e.g., bank i will specialize in the area $z_i \in [0, 1/(2N)]$).

Although fintechs do not serve any entrepreneur in such an equilibrium, they do affect banks' behavior. Given banks' loan rate r_B^{ep}, entrepreneurial utility is lowest when the bank-borrower distance reaches the maximum value $1/(2N)$ (e.g., at location $z_i = 1/(2N)$ on the arc between banks i and $i+1$). To protect banks' market areas (i.e., to ensure that fintech 1 does not serve any location), r_B^{ep} must be so low that the entrepreneurial utility provided by banks is at least $\overline{U}_{F1}$ even if the bank-borrower distance is at the maximal level $1/(2N)$, implying Equation (4).

Internet Appendix C provides the comparative statics of banks' loan rate r_B^{ep} in the case with potential entry.

4.2 Actual fintech entry

Before proceeding, we assume that the following inequality holds for the rest of the paper:

$$\overline{U}_{F1} < \frac{\overline{r}_B(0)(R - \overline{r}_B(0))}{c_B}, \tag{5}$$

where $\overline{r}_B(0) \equiv max\{R/2, \sqrt{2c_B\iota_B}\}$ is a bank's "*best loan rate*" at zero lending distance; that is, the bank's loan rate that maximizes entrepreneurial utility when the lending distance is zero (a similar concept is a fintech's best loan rate; see Lemma 3). A bank's best loan rate at a general lending distance d is given in Lemma A.1 of Appendix A.

Condition (5) implies that at $z_i = 0$ bank i can provide entrepreneurs with higher expected utility than fintech 1, which thereby ensures that banks still maintain positive market shares after actual fintech entry. If Condition (5) does not hold, then fintech 1 will completely drive banks out of the market. In reality, the banking sector still plays an important role in the lending market, so we focus on the more interesting and realistic case that fintech entry does not drive out banks.

Proposition 3. *With actual fintech entry, there exists an* $x^{ea} \in (0, 1/(2N))$ *such that fintechs serve entrepreneurs at* $z_i \in [x^{ea}, 1/N - x^{ea}]$ *on the arc between banks* i *and* $i+1$*, while bank* i *(resp. bank* $i+1$*) serves entrepreneurs at* $z_i \in [0, x^{ea})$ *(resp.* $z_i \in (1/N - x^{ea}, 1/N]$*). If* $c_{F1} < c_{F2}$*, fintech 2 does not serve any entrepreneur.*

A bank's monitoring efficiency is decreasing in its lending distance, while a fintech's monitoring efficiency is the same for all locations. Hence, fintechs – if they actually enter the market – have a competitive advantage over banks at locations that are far away from all banks. Specifically, on the arc between banks i and $i+1$, fintechs serve entrepreneurs in the middle area (i.e., at $z_i \in [x^{ea}, 1/N - x^{ea}]$) that is far from both banks i and $i+1$, while bank i (resp. bank $i+1$) attracts its nearby entrepreneurs at $z_i \in [0, x^{ea})$ (resp. $z_i \in (1/N - x^{ea}, 1/N]$). The point $z_i = x^{ea}$ (resp. $z_i = 1/N - x^{ea}$) is the "*indifference location*" where bank i (resp. bank $i+1$) provides the same entrepreneurial utility as fintech 1 does.

If $c_{F1} < c_{F2}$ holds, fintech 1 can always provide strictly higher entrepreneurial utility than fintech 2, so the latter cannot serve any entrepreneur. In the boundary case $c_{F1} = c_{F2}$, the two fintechs are identical, so entrepreneurs at $z_i \in [x^{ea}, 1/N - x^{ea}]$ are indifferent between the two fintechs; in this case, we also let fintech 1 serve all borrowers in the region $[x^{ea}, 1/N - x^{ea}]$. Therefore, for the rest of the paper we need only focus on fintech 1 when studying fintechs' behavior. Figure 4 graphically illustrates the three regions served respectively by fintech 1 and banks i and $i+1$.

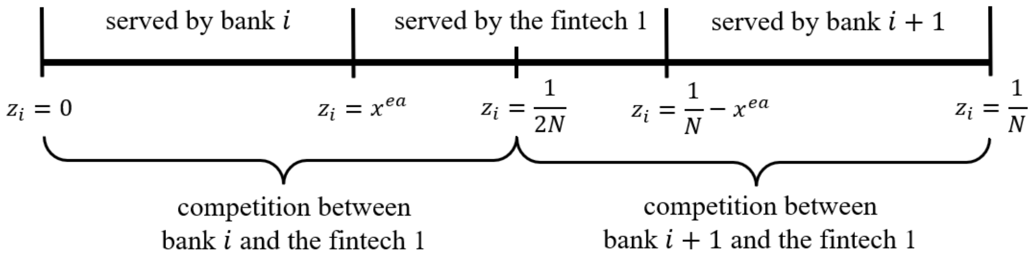

Figure 4: Competition on the Arc between Banks i and $i+1$ (Actual Entry).

Note that the interaction between adjacent banks is cut off by actual fintech entry. Specifically, bank i (resp. bank $i+1$) competes with fintech 1 at $z_i \in [0, 1/(2N)]$ (resp. $z_i \in (1/(2N), 1/N]$). In contrast, bank i no longer faces effective competitive threat from bank $i+1$ because the entrepreneurial utility provided by the latter bank must be lower than $\overline{U}_{F1}$ at $z_i \in [0, 1/(2N)]$.

Fintech loan rates. The following lemma characterizes the *upper bound* of fintech 1's loan rate.

Lemma 4. *If fintech 1 faces no competition from banks at z_i, then its optimal loan rate at this location equals*

$$r_{F1}^* \equiv \min\left\{ r_{F1}^m, \frac{R + \sqrt{R^2 - 4c_{F1}\overline{U}_{F2}}}{2} \right\},$$

where r_{F1}^m is fintech 1's monopolistic loan rate, which is characterized in Lemma A.3 of Appendix A. r_{F1}^* is independent of z_i.

The upper bound r^*_{F1} of fintech 1's loan rate (at any location) is determined by: (a) fintech 1's monopolistic loan rate r^m_{F1} and (b) the competitiveness of fintech 2. If fintech 1 faces no competitive pressure from any other lenders at location z_i, it will offer its monopolistic loan rate r^m_{F1} to maximize its lending profit at z_i.[17] r^m_{F1} is the highest possible loan rate fintech 1 would offer because further increasing the loan rate above r^m_{F1} reduces fintech 1's profit without making the fintech more attractive to entrepreneurs.

Fintech 1 must also consider the threat of fintech 2, which can provide utility $\overline{U}_{F2}$. If fintech 1's monopolistic loan rate r^m_{F1} provides utility lower than $\overline{U}_{F2}$ – which happens when c_{F2} is sufficiently low – the upper bound of fintech 1's loan rate cannot be as high as r^m_{F1}. Instead, now the upper bound is $(R + \sqrt{R^2 - 4c_{F1}\overline{U}_{F2}})/2$, which provides entrepreneurs with exactly utility $\overline{U}_{F2}$ and hence ensures that entrepreneurs do not approach fintech 2.

In sum, when fintech 1 does not face competitive pressure from banks at z_i, it will offer the upper bound loan rate r^*_{F1} - which considers both its monopolistic loan rate and fintech 2's competitiveness - at this location. Since fintechs' monitoring efficiency does not vary with locations, r^*_{F1} is independent of z_i. With Lemma 4, we can characterize fintech 1's equilibrium loan rate $r_{F1}(z_i)$ in the following proposition.

Proposition 4. *With actual fintech entry, fintech 1's loan rate at* $z_i \in [x^{ea}, 1/N - x^{ea}]$ *is given by*

$$r_{F1}(z_i) = \begin{cases} r^*_{F1} & \text{if } \frac{(r^{ea}_B)^2(1-qd^{ea})}{2c_B} - \iota_B < 0 \quad [\textbf{NBT } \textit{case}] \\ \min\left\{r^{comB}_{F1}(z_i), r^*_{F1}\right\} & \text{if } \frac{(r^{ea}_B)^2(1-qd^{ea})}{2c_B} - \iota_B \geq 0 \quad [\textbf{BT } \textit{case}] \end{cases}$$

with

$$r^{comB}_{F1}(z_i) \equiv \frac{R}{2} + \sqrt{\frac{R^2}{4} - \frac{c_{F1} r^{ea}_B (R - r^{ea}_B)}{c_B/(1-qd^{ea})}} \text{ and } d^{ea} \equiv \min\{z_i, 1/N - z_i\}.$$

The pricing strategy of fintech 1 at $z_i \in [x^{ea}, 1/N - x^{ea}]$ is simple: maximizing its lending profit while ensuring that entrepreneurs at this location do not approach rival lenders (i.e., banks or fintech 2). Two cases may arise when fintech 1 implements this strategy. In the first case, no bank is willing to serve location z_i with the uniform loan rate r^{ea}_B because it is too low to ensure a non-negative lending profit for a bank. In

[17] The monopolistic loan rate r^m_{F1} balances between entrepreneurs' funding demand and fintech 1's lending profit from each individual borrower at z_i, and hence is lower than R. See Lemma A.3 of Appendix A for details.

this (No Bank Threat **NBT**) case, banks' competitive threat does not exist at z_i, so fintech 1 will choose the upper bound loan rate r^*_{F1} as described in Lemma 4. According to Condition (3), the **NBT** case will arise if and only if $(r^{ea}_B)^2(1 - qd^{ea})/(2c_B) < 0$ holds, which means that at location z_i even the nearest bank (with the lending distance d^{ea}) cannot make a non-negative profit by financing an entrepreneur with the loan rate r^{ea}_B.

If $(r^{ea}_B)^2(1 - qd^{ea})/(2c_B) \geq 0$ holds, the bank nearest to location z_i is willing to serve the location with the uniform loan rate r^{ea}_B, so banks' competitive threat (to fintech 1) exists. In this (Bank Threat **BT**) case, fintech 1 must gauge whether banks' threat is effective. If, by offering the upper bound loan rate r^*_{F1}, fintech 1 can provide higher utility than the bank nearest to z_i, then banks' threat is not effective for the fintech; in this case, fintech 1 will post r^*_{F1} at z_i as in the **NBT** case. However, if fintech 1's upper bound loan rate r^*_{F1} provides lower utility than the loan rate r^{ea}_B of the bank nearest to z_i, banks' threat will be effective at this location; in this case, fintech 1's loan rate is $r^{comB}_{F1}(z_i)$ $(< r^*_{F1})$, which provides the same utility at z_i as the nearest bank's loan rate r^{ea}_B. The superscript "*comB*" of $r^{comB}_{F1}(z_i)$ means "competition with banks".

Figure 5 provides a graphic illustration of equilibrium loan rates on the arc between banks i and $i+1$. In Panel 1, monitoring is not very costly for banks, so at every location there exists a bank (e.g., the nearest bank) willing to serve entrepreneurs with the loan rate r^{ea}_B; fintech 1 offers $r^{comB}_{F1}(z_i)$ at $z_i \in [x^{ea}, 1/N - x^{ea}]$ because of banks' effective competitive threat. In Panel 2, however, monitoring is very costly, so banks are unwilling to serve distant locations with the loan rate r^{ea}_B. As a result, the **NBT** case arises at locations near $z_i = 1/(2N)$, which is far from all banks. In the **NBT** area, banks' threat suddenly disappears, so fintech 1's loan rates discontinuously jump up to the upper bound r^*_{F1}. In Panel 3, c_{F2} is low, so fintech 1's upper bound loan rate r^*_{F1} is also low such that it provides higher utility than banks' loan rate r^{ea}_B at locations near $z_i = 1/(2N)$. For such locations, fintech 1 offers r^*_{F1} because banks' competitive threat – although it exists – is not effective. Panel 4 illustrates the boundary case $c_{F1} = c_{F2}$, in which the two fintechs are identical.[18]

Corollary 3. *Fintech 1's equilibrium loan rate $r_{F1}(z_i)$ is weakly increasing (resp. decreasing) in z_i if $z_i \in [x^{ea}, 1/(2N)]$ (resp. $z_i \in (1/(2N), 1/N - x^{ea}]$). At the indifference location $z_i = x^{ea}$ (or $z_i = 1/N - x^{ea}$), $r_{F1}(z_i) = \overline{r}_{F1}$.*[19]

[18]Bertrand competition between identical fintechs forces both of them to offer their best loan rates, implying $r_{F1}(z_i) = r_{F2}(z_i) = \overline{r}_{F1}$ for all locations served by fintechs. In this case, banks' threat is not effective in fintechs' market area.

[19]Fintech 2 always offers its best loan rate $\overline{r}_{F2}$ since it has weakly lower monitoring efficiency in the Bertrand competition with fintech 1.

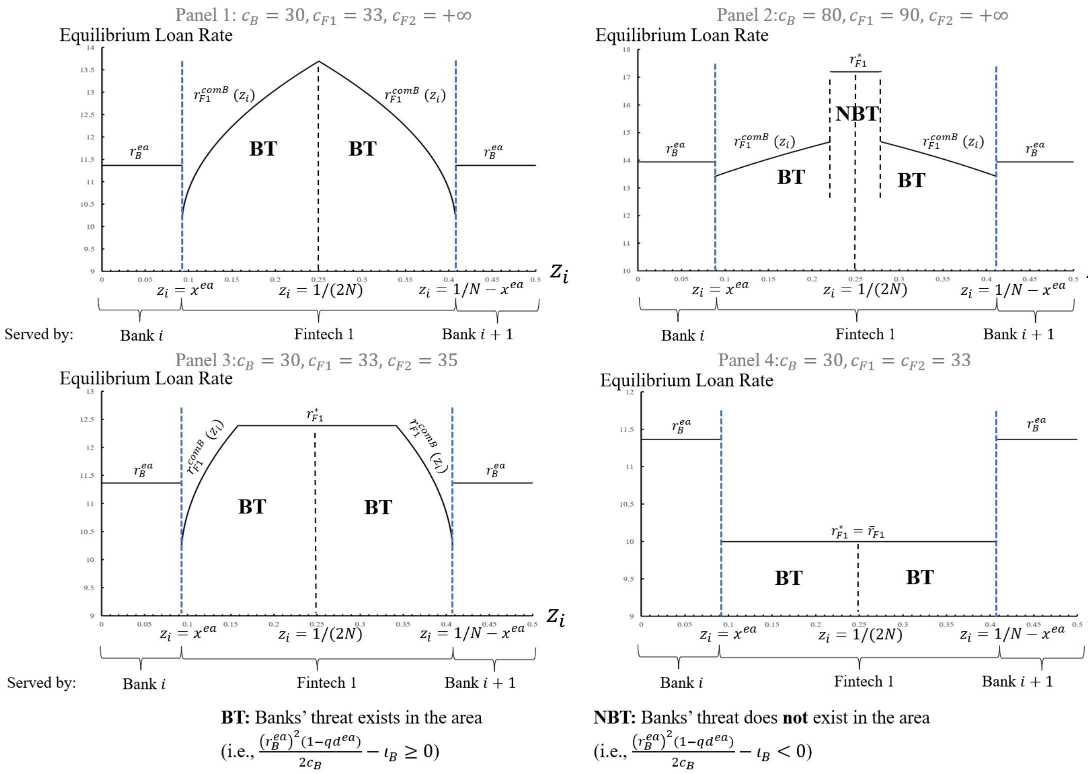

Figure 5: Equilibrium Loan Rates on the Arc between Banks i and $i+1$ (Actual Entry). This figure plots the equilibrium loan rate against the entrepreneurial location on the arc between banks i and $i+1$ when there is actual fintech entry. Fintechs can price discriminate but banks cannot. The parameter values are $R = 20$, $\iota_B = \iota_F = 1$, $c_B = 30$, $q = 0.8$, $N = 2$.

As z_i increases in $[x^{ea}, 1/(2N)]$, the utility an entrepreneur can derive by approaching bank i (which is the bank nearest to this location) will decrease because the bank's monitoring efficiency becomes lower. Hence fintech 1's competitive advantage over bank i increases, which allows the fintech to choose a higher $r_{F1}^{comB}(z_i)$ when banks' threat is effective. If banks' threat is not effective (or if banks' threat does not exist), fintech 1's loan rate is r_{F1}^*, which is independent of z_i. Overall, fintech 1's equilibrium loan rate $r_{F1}(z_i)$ is weakly increasing in z_i in the area $[x^{ea}, 1/(2N)]$. At the indifference location $z_i = x^{ea}$, bank i's equilibrium loan rate r_B^{ea} can provide utility $\overline{U}_{F1}$, so fintech 1 must offer its best loan rate $\overline{r}_{F1}$ at this location to compete with the bank.[20] Note that $r_{F1}(z_i)$ reaches its maximum at (or around) the mid location $z_i = 1/(2N)$ where banks' threat to fintech 1 is at the lowest level (see Figure 5); the result is consistent with Butler et al.

[20]Reasoning symmetrically, as z_i increases in the region $(1/(2N), 1/N - x^{ea}]$, fintech 1's competitive advantage (over bank $i+1$) will decrease, which forces the fintech to reduce $r_{F1}(z_i)$ if banks' threat is effective. At the indifference location $z_i = 1/N - x^{ea}$, fintech 1 must offer its best loan rate $\overline{r}_{F1}$ to compete with bank $i+1$.

(2017) who find that borrowers with better access to bank financing can request loans at lower interest rates on a fintech platform.

What drives actual fintech entry? Proposition 5 sheds light on the question.

Proposition 5. *Let $c_{F1} < \underline{c}_F$ and $\iota_B = \iota_F$ hold (i.e., actual fintech entry occurs and all lenders have the same marginal funding cost). At the indifference location $z_i = x^{ea}$, fintech 1 has lower monitoring efficiency and loan rate than bank i:*

$$\frac{c_B}{1 - qx^{ea}} < c_{F1} \text{ and } r_B^{ea} > r_{F1}(x^{ea}) = \overline{r}_{F1}.$$

Under $\iota_B = \iota_F$, the inequality $c_B/(1 - qx^{ea}) < c_{F1}$ in Proposition 5 is equivalent to $C_B(m, x^{ea}) < C_{F1}(m)$ for a given m. This implies that the market area gained by fintech 1 cannot be explained by its superior monitoring technology, because at the indifference location $z_i = x^{ea}$ it is bank i that has better monitoring efficiency.

Proposition 5 follows because fintechs can price discriminate, while banks cannot. When fintech 1 competes with bank i for entrepreneurs at a location (e.g., z_i), the fintech's loan rate $r_{F1}(z_i)$ can range from $\overline{r}_{F1}$ (the lower bound) to r_{F1}^* (the upper bound) depending on the bank's competitiveness. In particular, the fintech need not worry that lowering $r_{F1}(z_i)$ at location z_i would reduce its profits from other locations. As a consequence, the fintech offers its best loan rate (i.e., $\overline{r}_{F1}$) at the indifference location $z_i = x^{ea}$. In contrast, bank i has the concern that decreasing r_B^{ea} will reduce its profits from all locations it serves. Therefore, at the indifference location bank i still maintains a relatively high loan rate compared with the best loan rate of fintech 1, giving rise to the inequality $r_B^{ea} > r_{F1}(x^{ea})$.[21] Proposition 5 is graphically illustrated by Figure 5: In the region served by banks, the equilibrium loan rate is flat because banks cannot discriminate; in all the four panels, banks' loan rate is higher than fintech 1's at indifference locations for the aforementioned reason.

Since bank i has both a higher loan rate and better monitoring efficiency than fintech 1 at the indifference location $z_i = x^{ea}$, the monitoring intensity of bank i must be higher than that of the fintech at this location; that is:

$$m_B(x^{ea}) = \frac{r_B^{ea}}{c_B/(1 - qx^{ea})} > m_{F1}(x^{ea}) = \frac{r_{F1}(x^{ea})}{c_{F1}}, \tag{6}$$

[21] Entrepreneurs at $z_i = x^{ea}$ are indifferent between bank i and fintech 1 because the bank has superior monitoring efficiency, which implies higher monitoring intensity (i.e., success probability), while the fintech offers a lower loan rate, which implies a higher entrepreneurial return in the event of success.

where $m_B(x^{ea})$ (resp. $m_{F1}(x^{ea})$) is bank i's (resp. fintech 1's) monitoring intensity at $z_i = x^{ea}$ according to Lemma 1. Around location $z_i = x^{ea}$, bank borrowers and fintech borrowers have similar characteristics because their locations are almost the same. Hence, Inequality (6) implies that bank borrowers have higher success probabilities than fintech borrowers with similar characteristics. This result is consistent with Di Maggio and Yao (2021) who find that fintech borrowers are more likely to default than bank borrowers after controlling for observable characteristics.[22]

Proposition 5 directly leads to the following corollary.

Corollary 4. *Actual fintech entry can occur even if fintech 1 has no advantage in either monitoring efficiency or funding cost (i.e., even if both* $\frac{c_B}{1-q/(2N)} < c_{F1}$ *and* $\iota_B < \iota_F$ *hold).*

For convenience, we focus on the arc between banks i and $i+1$ when explaining the result. Note that $\frac{c_B}{1-q/(2N)}$ inversely measures bank i's (or bank $i+1$'s) monitoring efficiency at the mid location $z_i = 1/(2N)$, where fintech 1 will penetrate first when actual fintech entry occurs.[23] Therefore, Corollary 4 states that fintech 1 can attract entrepreneurs at $z_i = 1/(2N)$ even if its monitoring efficiency (resp. funding cost) is lower (resp. higher) than that of banks i and $i+1$ at this location.

The intuition underlying the result directly follows that of Proposition 5. The discrimination ability of fintech 1 enables it to offer the best loan rate $\overline{r}_{F1}$ to penetrate the lending market, but banks cannot offer too low a loan rate to prevent actual fintech entry. Therefore, fintechs' exclusive discrimination ability is a competitive advantage that can compensate for their potential disadvantage in monitoring efficiency or funding costs.

Comparative statics with actual entry. Table 1 summarizes the results. We explain some results here and relegate other explanations to Internet Appendix C.

Increasing c_{F1} will decrease fintech 1's market area and increase banks'. The reason is that increasing c_{F1} will reduce the maximum utility fintech 1 can provide (i.e., reduce $\overline{U}_{F1}$), thereby decreasing the fintech's competitive advantage over banks.[24]

According to Table 1 and Corollary 2, a bank will specialize in a smaller market area (i.e., x^{ea} will decrease) and charge a lower loan rate if fintech 1's monitoring efficiency

[22] Chava et al. (2021) provide similar evidence that consumers who borrow from marketplace lending platforms have higher default rates than those borrowing from traditional banks. Beaumont et al. (2021) also document that fintech borrowers are more likely than bank borrowers to enter a bankruptcy procedure.

[23] Note that in the limiting case $x^{ea} \to 1/(2N)$, fintech 1 serves only location $z_i = 1/(2N)$.

[24] Open banking policy can be viewed as a decrease in c_{F1} because it improves customer data availability for fintechs. Therefore, our result is consistent with Babina et al. (2022) who document that open banking policy significantly enlarges venture capital investment in fintechs, which can be viewed as a proxy for fintechs' expansion.

improves (by decreasing c_{F1}); this is in line with Blickle et al. (2021) who document that bank specialization is associated with more favorable loan rates, especially when the threat of non-banks or other sources of credit is high.

Reducing N increases the arc-distance between two adjacent banks, widening the region where fintech 1 has a competitive advantage over banks. Consequently, fewer (resp. more) locations and entrepreneurs are served by banks (resp. fintech 1). This result is consistent with Claessens et al. (2018) and Frost et al. (2019): FinTech/BigTech platforms lend more in economies with a less competitive banking system.[25]

Table 1: Summary of Comparative Statics (Actual Entry)

	q	c_B	c_{F1}	ι_B	N
An individual bank's market area (x^{ea})	$\downarrow$	$\downarrow$	$\uparrow$	$\downarrow$	- -
Fintech market area ($1-2Nx^{ea}$)	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$
Banks' loan rate (r_B^{ea})	- -	ambiguous	$\uparrow$	$\uparrow$	- -
Fintech 1's loan rate at z_i ($r_{F1}^{comB}(z_i)$) under effective banks' threat	$\uparrow$	$\uparrow$	ambiguous	$\uparrow$	$\downarrow$
Fintech 1's average loan quality	$\uparrow^{num}$	$\uparrow^{num}$	$\downarrow^{num}$	$\uparrow^{num}$	$\downarrow$

This table summarizes how endogenous variables (in the first column) is affected by parameters (in the first row) in the case with actual fintech entry. "$\uparrow$" (resp. "$\downarrow$") means that an endogenous variable is increasing or weakly increasing (resp. decreasing or weakly decreasing) in the corresponding parameter. "- -" means that an endogenous variable is independent of the corresponding parameter. "$\uparrow^{num}$" (resp. "$\downarrow^{num}$") means that an endogenous variable is increasing or weakly increasing (resp. decreasing or weakly decreasing) in the corresponding parameter based on numerical studies. "Ambiguous" means that the effect of a parameter can be positive or negative based on numerical studies.

According to Lemma 1, borrowers at $z_i \in [x^{ea}, 1/N - x^{ea}]$ (which is served by fintech 1) succeeds with probability $r_{F1}(z_i)/c_{F1}$, so we can define fintech 1's (lending volume weighted) average *loan quality* as follows:

$$\frac{\int_{x^{ea}}^{1/N-x^{ea}} D(z_i)\, r_{F1}(z_i)/c_{F1} dz_i}{\int_{x^{ea}}^{1/N-x^{ea}} D(z_i)\, dz_i},$$

where $D(z_i)$, defined in Equation (1), is fintech 1's lending volume (i.e., the mass of the entrepreneurs undertaking projects) at z_i.

According to Table 1 (see also Corollary C.2 in Internet Appendix C), fintech 1's average loan quality is weakly decreasing in N. A smaller N implies that the arc-distance

[25] Similarly, Hau et al. (2021) document that Ant Financial extends more credit lines in China's rural areas with fewer banks. Avramidis et al. (2021) and Gisbert (2021) find that merger-induced bank closings, which can be viewed as a decrease in N, lead to an increase in fintech lending volume.

between adjacent banks becomes larger, so there are more locations far from all banks. Fintech 1 thus can offer high loan rates for a larger market area, which improves its average monitoring intensity and loan quality. This result is consistent with Avramidis et al. (2021) who document that the overall quality of fintech borrowers increased after an exogenous merger-induced bank closing, which can be viewed as a decrease in N.

Remark: pre-entry local monopoly. In this case, there exist locations that are too distant from all banks and hence have no access to bank finance. Banks do not compete with each other and will set quite high monopolistic loan rates if there exist no fintechs (or if there is blockaded fintech entry). Actual fintech entry will occur if and only if the maximum utility fintech 1 can provide is positive (i.e., $\overline{U}_{F1} > 0$), which means the fintech can spur a positive mass of entrepreneurs to undertake their projects at locations with no access to bank finance. Therefore, actual fintech entry on the one hand substitutes bank lending by eroding banks' market areas, but on the other hand complements it by extending the market to locations with no access to banks (i.e., improving financial inclusion).[26] See Appendix B for more details about the pre-entry local monopoly case.

5 Fintech entry and entrepreneurs' investment

Entrepreneurs' investment, denoted by I, is measured by the aggregate mass of entrepreneurs undertaking investment projects:

$$I \equiv N \int_0^{1/N} D(z_i) dz_i, \tag{7}$$

where $D(z_i)$, defined in Equation (1), is the funding demand at z_i.

Potential fintech entry. In this case, fintech 1 brings additional competitive pressure to banks, forcing them to provide higher utility to entrepreneurs and hence spur entrepreneurial investment. We summarize the result as follows.

Proposition 6. *With respect to blockaded entry, potential fintech entry increases total investment I, in which case it is decreasing in c_{F1}.*

[26] Tang (2019) finds that fintech lending is a substitute for bank lending in terms of serving inframarginal bank borrowers, yet complements bank lending with respect to small loans. Jiang et al. (2022) find that digital disruption induces fintech entry and hence improves financial inclusion by reducing the unbanked rate of young customers. Huang et al. (2020) document that BigTech lending improves financial inclusion for SMEs that are smaller and in smaller cities.

A lower c_{F1} implies higher fintech 1's competitiveness and a lower banks' loan rate, which leads to higher entrepreneurial utility and total investment I.

Actual fintech entry. The following proposition shows that actual fintech entry increases total investment under certain conditions.

Proposition 7. *If c_{F2} ($\geq c_{F1}$) is sufficiently close to c_{F1}, total investment I with actual fintech entry is higher than that with blockaded entry.*

To better explain the result, we consider first the case that c_{F2} ($\geq c_{F1}$) is not close to c_{F1}. Actual fintech entry increases the competitive pressure faced by banks, thereby forcing them to provide higher entrepreneurial utility. As a result, the investment (i.e., funding demand) at a location served by a bank will increase after actual fintech entry. However, entrepreneurs may become worse off and hence demand less funding at locations served by fintech 1. The reason is that actual fintech entry may generate **NBT** areas that banks are not willing to serve (Proposition 4); in such areas, fintech 1 faces no threat from banks and hence offers the upper bound loan rate r^*_{F1}, which can hurt entrepreneurs if c_{F2} is high. Therefore, actual fintech entry does not necessarily spur entrepreneurs' investment if there is no restriction on c_{F2}.

If c_{F2} ($\geq c_{F1}$) is sufficiently close to c_{F1}, the competition among the two fintechs will make fintech 1's upper bound loan rate r^*_{F1} quite low. In this case, even if actual fintech entry generates **NBT** areas, the competitiveness of fintech 2 will ensure that entrepreneurs in those areas can derive sufficiently high utility from fintech 1's upper bound loan rate r^*_{F1}. Therefore, actual fintech entry will increase entrepreneurs' investment if c_{F2} ($\geq c_{F1}$) is sufficiently close to c_{F1}.

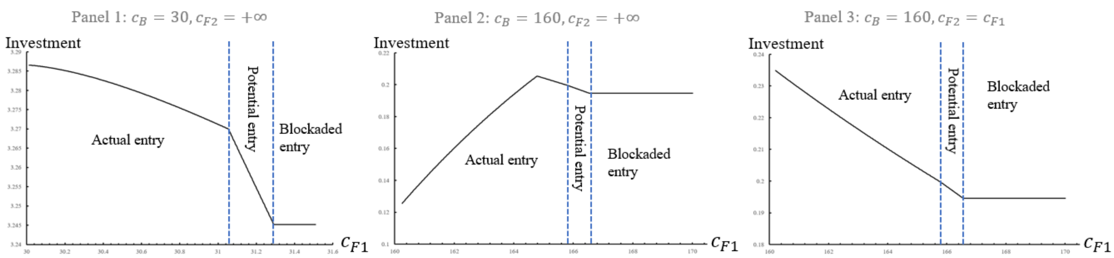

Figure 6: Entrepreneurs' Total Investment. This figure plots entrepreneurs' total investment I (i.e., the mass of entrepreneurs undertaking investment projects) against c_{F1}. The parameter values are: $R = 20$, $q = 1.8$ $\iota_B = \iota_F = 1$, $N = 30$.

Figure 6 illustrates the effect of fintech entry on total investment I. Consistent with Proposition 6, potential fintech entry increases total investment in all three panels. With actual fintech entry, different results may arise. In Panel 1, monitoring is not very costly for banks, so actual fintech entry does not generate **NBT** areas. In this case, actual fintech entry forces banks to provide higher entrepreneurial utility; banks' competitive threat in turn forces fintech 1 to provide higher entrepreneurial utility. Therefore, total investment becomes higher after actual fintech entry even if $c_{F2} = +\infty$ in Panel 1. In Panel 2, monitoring is very costly for banks, so actual fintech entry can generate **NBT** areas where entrepreneurs become worse-off and hence invest less when c_{F2} is too high. As c_{F1} (as well as r_B^{ea}) decreases, such **NBT** areas will be widened, thereby decreasing the total investment. In Panel 3, fintech 2's monitoring efficiency is sufficiently good (i.e., c_{F2} is sufficiently close to c_{F1}), so the competition among fintechs ensures that fintech 1 must provide high utility to entrepreneurs even in **NBT** areas. As a result, actual fintech entry increases total investment in this panel.

6 Welfare analysis

In this section, we analyze how fintech entry affects social welfare, focusing on the benchmark case $\iota_B = \iota_F$. With $\iota_B = \iota_F$, Condition (5) – which ensures that fintech entry cannot drive out banks – is reduced to $c_{F1} > c_B$. The inequality $c_{F1} > c_B$ means that banks have higher basic monitoring efficiency than fintechs when the lending distance is zero. This makes sense because the banks have an advantage in accumulating data about customers.[27]

Social welfare can be written as follows:

$$W = U_E + N\Pi_B + \Pi_F. \tag{8}$$

The first term U_E of Equation (8) represents the aggregate utility (net of opportunity costs) of all entrepreneurs who undertake their investment projects. The second term $N\Pi_B$ is the total lending profits of the N incumbent banks with Π_B representing the lending profit of an individual bank. The third term Π_F represents fintech 1's expected profit; if actual fintech entry does not occur, obviously $\Pi_F = 0$.

On the arc between banks i and $i+1$, we denote the loan rate and monitoring intensity at z_i by $r(z_i)$ and $m(z_i)$, denote the marginal funding cost of the lender serving location

[27]Banks' advantage in the access to customer data is the rationale of the Open Banking initiative launched by several governments, including the European Union and the United Kingdom. See Babina et al. (2022) and He et al. (2023).

z_i by $\iota(z_i)$ (which is ι_B or ι_F depending on the type of the lender), and finally denote the lender's costs of monitoring an entrepreneur at z_i by $C(z_i)$. Then, in a symmetric equilibrium the welfare function (8) can be reorganized as follows:

$$W = N \int_0^{1/N} \left(\underbrace{D(z_i)}_{\text{investment at } z_i} \left(\overbrace{m(z_i)R}^{\text{expected project value}} - \overbrace{\iota(z_i)}^{\text{funding cost}} - \overbrace{C(z_i)}^{\text{monitoring cost}} \right) - \underbrace{\int_0^{D(z_i)} \underline{u}\, d\underline{u}}_{\text{opportunity cost at } z_i} \right) dz_i. \quad (9)$$

Equation (9) means that social welfare equals the expected value of all undertaken projects (net of all social costs), which is determined by (a) the mass of projects implemented by entrepreneurs (i.e., total investment), (b) the success probabilities of implemented projects (i.e., monitoring intensities) and (c) the incurred social costs, including funding, monitoring and opportunity costs.

6.1 Potential fintech entry

First we consider the case with $\underline{c}_F \leq c_{F1} < \bar{c}_F$. Potential fintech entry brings two competing effects: an *investment effect* and a *monitoring effect*.

Investment effect: By changing entrepreneurs' utility from investment, fintech entry affects the mass of projects implemented, thereby affecting welfare. The investment effect is welfare-improving if fintech entry increases the mass of undertaken projects. With potential entry, fintech 1 – which does not serve any location – forces banks to provide higher utility to entrepreneurs, thereby generating a welfare-improving investment effect.

Monitoring effect: By changing lenders' loan rates, fintech entry affects lenders' monitoring incentive, thereby affecting the success probabilities of undertaken projects. From the social point of view, lenders' monitoring intensities are always excessively low, because each lender cares only about its own lending profit when choosing monitoring intensities, which underestimates the marginal benefit of monitoring to the expected value (net of social costs) of implemented projects. Therefore, the monitoring effect is welfare-reducing if fintech entry induces lenders to post lower loan rates, decreasing the success probabilities of implemented projects. Potential fintech entry decreases banks' loan rate, hence generating a welfare-reducing monitoring effect.

The net effect of potential fintech entry depends on which effect dominates.

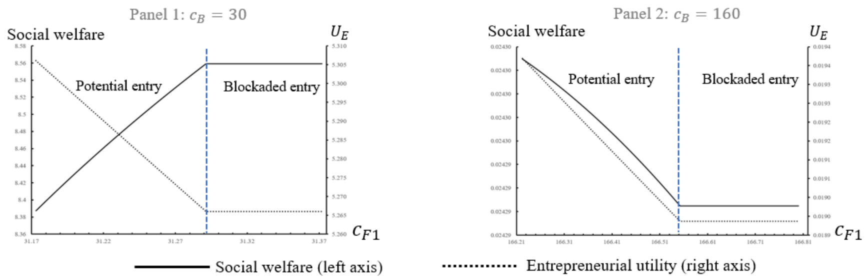

Figure 7: Welfare Effect of c_{F1} (from Blockaded Entry to Potential Entry). This figure plots social welfare (solid curve) and entrepreneurial utility (dotted curve) against c_{F1} when there is blockaded or potential fintech entry. The parameter values are: $R = 20$, $q = 1.8$ $\iota_B = \iota_F = 1$, $N = 30$.

Numerical Result 1. [28] *With respect to blockaded entry, potential fintech entry increases social welfare if c_B and q are sufficiently large; otherwise, potential fintech entry decreases social welfare.*

If c_B and q are sufficiently large, serving distant locations brings banks very low profits, so banks have low incentive to extend their market area. As a result, the intensity of bank competition and entrepreneurs' investment would be excessively low if there is no fintech entry threat (or if there is blockaded fintech entry). In this case, the investment-spurring effect of potential fintech entry dominates the welfare-reducing monitoring effect, increasing social welfare (Panel 2 of Figure 7). In contrast, if c_B and q are not sufficiently large (Panel 1 of Figure 7), there is already sufficient lending competition when there is no fintech threat (or when there is blockaded fintech entry); in this case, the monitoring-reducing effect of potential fintech entry dominates the investment-spurring effect and hence reduces social welfare.

6.2 Actual fintech entry

Now we look at the case with actual entry ($c_{F1} < \underline{c}_F$). The two aforementioned effects (i.e., investment and monitoring effects) still exist.

With actual entry, the direction of the investment effect is ambiguous. At locations served by banks, investment will be spurred because actual fintech entry forces banks to provide higher utility. However, at locations served by fintech 1, entrepreneurs' utility and investment may be lower because actual entry can generate **NBT** areas that banks are not willing to serve, potentially giving fintech 1 too high market power. If fintech

[28] The grid of parameters is as follows: R ranges from 10 to 50; c_B ranges from $(3/2)R$ to $8R$; q ranges from 0.1 to 2; ι_B and ι_F range from 0.9 to 1.1. N ranges from 2 to 50.

1 serves a small market area, the investment-spurring effect in banks' market areas will dominate the investment-reducing effect in fintech 1's market area.

The monitoring effect also has an ambiguous direction in the case with actual entry. As c_{F1} decreases, banks' loan rate r_B^{ea} will decrease, which reduces banks' monitoring intensities and hence generates a welfare-reducing monitoring effect at locations served by banks. However, in fintech 1' market area, decreasing c_{F1} may increase fintech 1's loan rates, thereby generating a welfare-improving monitoring effect.[29] If fintech 1 serves only a small market area, the monitoring-reducing effect in banks' market areas will dominate the potential monitoring-improving effect in fintech 1's market area.

Furthermore, actual fintech entry brings *cost-saving* and *business stealing* effects.
Cost-saving effect: a smaller c_{F1} renders monitoring cheaper for fintech 1, improving the lending efficiency of the credit market and hence benefits social welfare. Note that the cost-saving effect works only for locations served by fintech 1, so it does not arise in the case with potential entry. As fintech 1's market area increases (i.e., as c_{F1} decreases), the cost-saving effect will be stronger.
Business stealing effect: a decrease in c_{F1} marginally displaces banks' higher lending profits and better monitoring efficiency (at indifference locations) with fintech 1's lower lending profits and worse monitoring efficiency, which should decrease social welfare.[30]

The net welfare effect of actual fintech entry depends on which effect(s) dominate. The following numerical result characterizes the net effect.

Numerical Result 2. [31] *Actual entry (with c_{F1} sufficiently close to c_B) will increase social welfare compared to blockaded entry if the intensity of competition among fintechs is at an intermediate level.*[32]

[29]Decreasing c_{F1} has an ambiguous effect on fintech 1's loan rate (see Table 1). It may increase fintech 1's loan rate because (a) fintech 1's competitive advantage increases and (b) **NBT** areas can potentially arise. However, a lower c_{F1} also gives fintech 1 the incentive to decrease its loan rate because banks reduce their loan rate r_B^{ea}, which implies higher banks' threat to fintech 1 in **BT** areas.

[30]Because of fintechs' exclusive ability to discriminate, fintech 1 can extend its market area by posting the best loan rate at indifference locations. Such a pricing strategy of fintech 1 implies that, around indifference locations, banks make higher profits and have better monitoring efficiency than fintech 1. See Proposition 5.

[31]The grid of parameters is as follows: R ranges from 10 to 50; c_B ranges from $(3/2)R$ to $8R$; q ranges from 0.1 to 2; ι_B and ι_F range from 0.9 to 1.1. N ranges from 2 to 50.

[32]That is, if c_{F2} is sufficiently close to $c_{F2}^* \in (c_{F1}, +\infty)$, which is the unique solution of the following equation:

$$\left.\frac{R+\sqrt{R^2-4c_{F1}\overline{U}_{F2}}}{2}\right|_{c_{F2}=c_{F2}^*} = \frac{2R^2+4c_{F1}\iota_F+\sqrt{\left(2R^2+4c_{F1}\iota_F\right)^2-24c_{F1}\iota_F R^2}}{6R}. \tag{10}$$

When c_{F1} is sufficiently close to c_B, actual fintech entry will significantly improve the monitoring efficiency of the credit market because fintechs face no distance friction. Such an efficiency improvement generates a strong cost-saving effect, so social welfare will increase unless the entry substantially reduces entrepreneurs' investment or lenders' monitoring incentive. To avoid a strong welfare-reducing investment or monitoring effect, c_{F2} should be neither too high nor too low. If c_{F2} is too high (i.e., fintech 1's upper bound loan rate r^*_{F1} is too high), in **NBT** areas fintech 1 will charge quite high loan rates, thereby largely reducing entrepreneurs' investment. If c_{F2} is too low (i.e., r^*_{F1} is too low), fintech 1 must always charge quite low loan rates because of fintech 2's competitiveness, which implies a strong welfare-reducing monitoring effect. If c_{F2} takes an intermediate value such that the intensity of competition among the two fintechs is also at an intermediate level, fintech 1's upper bound loan rate r^*_{F1} will balance the investment and monitoring effects; in this case actual fintech entry (with c_{F1} sufficiently close to c_B) will increase social welfare because of the strong cost-saving effect.

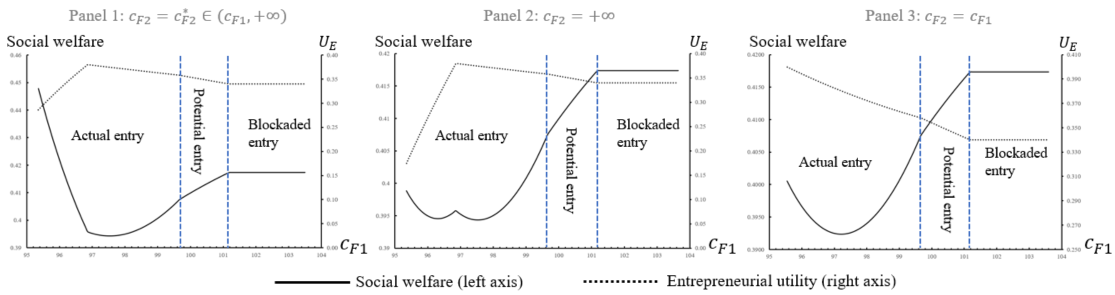

Figure 8: Welfare Effect of c_{F1}. This figure plots social welfare (solid curve) and entrepreneurial utility (dotted curve) against c_{F1} (from blockaded entry to actual entry). The parameter values are: $R = 20$, $q = 1.8$, $c_B = 95$, $N = 30$ and $\iota_B = \iota_F = 1$.

Figure 8 illustrates the welfare effect of fintech entry. When fintech 1 actually enters but serves only a small market area (i.e., c_{F1} is much higher than c_B), social welfare decreases as c_{F1} decreases because the welfare-reducing business stealing effect dominates. As c_{F1} further decreases, the cost-saving effect will gradually become strong, and then different results may arise depending on the value of c_{F2}. In Panel 1, c_{F2} and the intensity of competition among fintechs are at an intermediate level, meaning that actual fintech entry balances its investment and monitoring effects. In this case, the cost-saving effect will rapidly raise social welfare when c_{F1} is sufficiently small. In Panel 2, c_{F2} is high, so

Equation (10) means that when $c_{F2} = c^*_{F2}$, fintech 1's upper bound loan rate r^*_{F1} equals the socially optimal loan rate that perfectly balances entrepreneurs' investment and lenders' monitoring incentive.

actual fintech entry (with c_{F1} sufficiently close to c_B) generates a strong welfare-reducing investment effect, which counteracts the cost-saving effect.[33] As a result, social welfare (with c_{F1} close to c_B) is lower than that with blockaded entry. A similar result arises in Panel 3, where the cost-saving effect is counteracted by a strong negative monitoring effect because c_{F2} is low.

Remark: pre-entry local monopoly. In this case, actual fintech entry will increase social welfare for any c_{F2} ($\geq c_{F1}$) based on numerical studies. Three reasons contribute to the result. First, there is no bank competition when there is no fintech threat, so actual fintech entry will not decrease the intensity of lending competition (i.e., will not generate a negative investment effect) even if $c_{F2} \to +\infty$. Second, the intensity of lending competition must be quite low in the pre-entry local monopoly case, implying excessively low investment. In this case, the welfare-improving investment effect will dominate the welfare-reducing monitoring effect if actual fintech entry decreases lenders' loan rates. As a result, there is no need to worry that a strong negative monitoring effect may arise and dominate other welfare-improving effects, even if r^*_{F1} is quite low because of a low c_{F2}. Finally, there is a cost-saving effect that improves the monitoring efficiency of the credit market. The three reasons together ensure that the positive effects of actual fintech entry always dominate and thereby raise social welfare.

Table 2 summarizes the effects of fintech entry on social welfare respectively for the case with potential entry, the case with actual entry and the case with pre-entry local monopoly (LM).

Table 2: The Effects of Fintech Entry on Social Welfare

	potential entry	actual entry	pre-entry LM
Investment	+	+ if x^{ea} large	+
Monitoring	−	− if x^{ea} large	− if x^{ea} large
Cost-saving	null	+	+
Business-stealing	null	−	−
Net effect	+ if q and c_B large	+ if c_{F1} close to c_B and c_{F2} at an intermediate level	+

In the table, +/−/null means "welfare-improving"/"welfare-reducing"/"no effect".

[33] In Panel 2, the curve of social welfare has a (non-monotonic) kink in the region with actual entry. This kink means that **NBT** areas arise and become wider as c_{F1} further decreases. Since $c_{F2} = +\infty$ in this panel, entrepreneurs' utility will decrease very rapidly as **NBT** areas become wider, which causes the kink and counteracts the cost-saving effect.

7 Price-discriminating banks

If banks can also price discriminate (analyzed in detail in Internet Appendix D), again we can show that three possible equilibria may arise: blockaded entry, potential entry, and actual entry (Lemma D.1). The fundamental change is that the ability to price discriminate is no longer fintech 1's competitive advantage over banks. As a result, actual fintech entry occurs *if and only if* fintech 1 has advantage in funding cost or/and in monitoring efficiency at some locations (Proposition D.1 and Corollary D.1), which flips Proposition 5 and Corollary 4. The ability to discriminate increases banks' competitive advantage (relative to fintech 1), so banks serve larger market areas compared with the case where they cannot discriminate (Corollary D.2). Potential or actual fintech entry will always increase total investment when banks can price discriminate because then **NBT** areas will not arise (Proposition D.2). As for the welfare effect, Proposition D.2 implies that potential or actual fintech entry always brings a positive investment effect when banks can price discriminate. Therefore, our numerical study finds that actual fintech entry (with c_{F1} sufficiently close to c_B) will increase social welfare if c_{F2} is sufficiently large, which avoids a strong negative monitoring effect.[34]

8 Long-run effect of fintech entry: banks' exit

In the long run, some banks may exit from the credit market if fintech entry decreases their profitability by too much. In this section, we consider this possibility and check how the results in previous sections may change.

We consider the following timeline for this section (see Figure 9). At $t = 0$, there are $N^0 \geq 3$ banks (incumbents) in the lending market.[35] At $t = 1$, there is an unanticipated event that two fintechs emerge and can offer loans. At $t = 2$, realizing the presence of fintechs, the incumbent N^0 banks decide whether or not to stay in the market. If bank i chooses to leave the market, it can recover a salvage (liquidation) value of $\lambda(i)L$ ($i = 1, 2, ..., N^0$). Parameter $L \geq 0$ measures the general magnitude of salvage values for banks while $\lambda(i)$ varies across different i's, meaning that different banks have different

[34] This result does not contradict Numerical result 2. Requiring an intermediate level of inter-fintech competition (in Numerical result 2) is a stronger condition than requiring a sufficiently large c_{F2}. Under the former stronger condition actual fintech entry (with sufficiently small c_{F1}) can more efficiently balance investment and monitoring effects and hence improve social welfare more than under the latter weaker condition.

[35] $N^0 \geq 3$ ensures that there exist at least two banks (and the arc between them) even if a bank exits.

salvage values. For convenience, we assume that $\lambda(i)$ is weakly increasing in i; $\lambda(2)L$ is sufficiently small such that at least two banks will stay in the market after the fintech emergence shock. The number of banks adjusts from N^0 to N after banks make their "leave-or-stay" decisions at $t = 2$; banks that stay in the market adjust to symmetric locations. Note that previous sections can be viewed as the case with $L = 0$. At $t = 3$, lending competition occurs following the timeline given in Figure 2 (in Section 2).

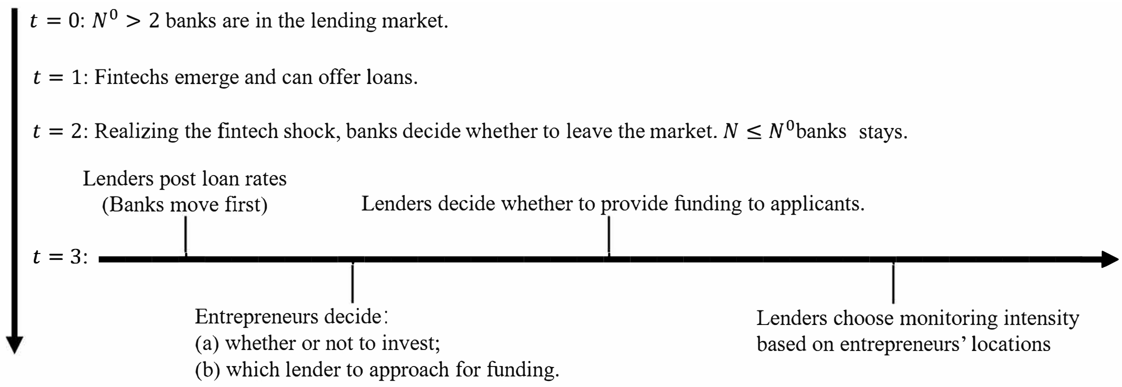

Figure 9: Timeline in the Long Run.

Fintech entry and banks' exit. As in previous sections, there still exist thresholds $\overline{c}_F$ and $\underline{c}_F$ for fintech 1's monitoring efficiency c_{F1}, which can induce three types of equilibria: blockaded, potential or actual entry.

Figure 10 illustrates how banks' equilibrium loan rate and the number of remaining banks N simultaneously change as c_{F1} decreases. When fintech 1's monitoring efficiency is low, banks will ignore the presence of fintech lenders, so decreasing c_{F1} has no effect on banks' behavior (i.e., entry is blockaded). If fintech 1's monitoring efficiency is at an intermediate level ($\underline{c}_F \leq c_{F1} < \overline{c}_F$), then banks have to reduce their loan rate to protect their market areas from fintech penetration. In this case, the profitability of each bank will be decreased by potential fintech entry, so some banks may leave the market to recover their salvage values (Panel 2 of Figure 10), inducing a decrease in N. Since N is an integer, its variation must be discontinuous. The discontinuous decrease in N will induce banks' loan rate to discontinuously jump down in the case with potential fintech entry (For the effect of N on r_B^{ep}, see Proposition C.2 in Internet Appendix C). As c_{F1} further decreases below $\underline{c}_F$, fully protecting market areas will be too expensive for banks, so they have to allow actual fintech entry. In this case, banks' loan rate decreases smoothly as c_{F1} becomes lower, even if N decreases discontinuously. The reason is that the number of remaining banks N does not affect the competitive pressure fintech 1 brings to each individual bank in the case with actual entry (See Table 1 and Proposition C.4).

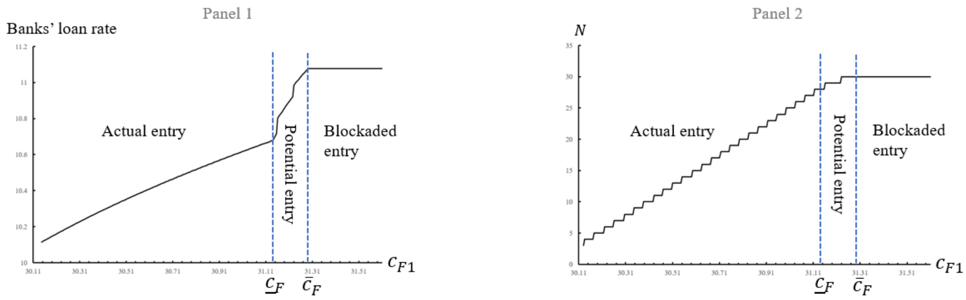

Figure 10: Fintech Entry and Banks' Behavior. This figure plots how the type of the equilibrium, banks' equilibrium loan rate and the number of bank N vary with c_F. The parameter values are $R = 20$, $\iota_B = \iota_F = 1$, $c_B = 30$, $q = 1.8$, $N^0 = 30$, $L = 0.1098$ and $\lambda(i) = (i-1)/N^0$.

The properties of banks' and fintech 1's pricing strategies and market areas discussed in Section 4 still hold when banks can exit. However, the effects of fintech entry on investment and social welfare significantly change.

Banks' exit and total investment. Allowing banks to exit enlarges the potential negative effect of fintech entry on entrepreneurs' investment. As potential or actual fintech entry reduces N, the arc-distance between adjacent banks will increase, which decreases banks' threat to fintech 1. Such a decrease in banks' threat will translate into lower entrepreneurial utility and investment unless fintech 2 can put sufficient competitive pressure on fintech 1. See Figure E.1 of Internet Appendix E for a graphic illustration.

Banks' exit and social welfare. When banks have the option to exit, potential or actual fintech entry will generate an *option value effect*, in addition to those effects discussed in Section 6 (Internet Appendix E provides a detailed analysis of this case). The option value effect means that banks can protect themselves by executing the option to exit and recover salvage values as fintech entry decreases their profitability. Hence the negative effect of decreasing an individual bank's lending profit Π_B on social welfare will be mitigated. The option value effect is welfare-improving because potential or actual fintech entry transfers bank profit to other parties (entrepreneurs or/and fintech 1) and lets banks exit, which fulfills their option values. Due to the option value effect, actual fintech entry (with c_{F1} sufficiently close to c_B) is more likely to improve social welfare compared to the case with blockaded entry. See Figure E.2 for an illustration.

9 Conclusion

Three types of equilibria may arise depending on the monitoring efficiency of fintechs: blockaded entry, potential entry, and actual entry. A fintech with no advantage in monitoring efficiency or funding cost can actually enter the credit market if it can price more flexibly than banks. This prediction sheds light on the debate about whether or not fintech entry is driven by superior information technology. If banks can also price discriminate, a fintech's advantage in monitoring efficiency or funding cost is a necessary condition for its successful (actual) entry.

Another consequence of fintechs' superior flexibility in pricing is that fintechs have lower monitoring efficiency and charge lower loan rates than banks when serving entrepreneurs of similar locations. Based on this result, a testable prediction is that fintech borrowers are more likely to default than bank borrowers with similar characteristics.

Our model predicts that higher bank concentration (e.g., exogenous bank closures) will lead to higher fintech lending volume and loan quality, which can be proxied by the ratio of non-performing loans. Fintechs will have a higher competitive advantage and hence serve a larger market area if their monitoring efficiency improves. The implication is that fintechs' IT investment or policies that increase fintechs' information advantage over banks (e.g., open banking) will induce fintech lenders to penetrate more industries. Allowing banks to price more flexibly (e.g., easing regulatory restrictions on banks' pricing) will increase their competitive advantage over fintechs, thereby enlarging the market area served by banks.

If there is sufficiently intense competition among fintechs, our model predicts that fintech entry will make entrepreneurs better off and hence increase total investment. The welfare effect of fintech entry is ambiguous and depends on the interaction of four effects: investment, monitoring, cost-saving, and business stealing. Actual fintech entry (with a large fintech market share) will increase social welfare when the intensity of competition among fintechs is at an intermediate level.

Since potential or actual fintech entry decreases banks' profitability, in the long run, banks can exit and recover salvage values, which may hurt entrepreneurs (and reduce investment) but will generate a welfare-improving option value effect.

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Appendix A: Proofs

Proof of Lemma 1. A bank chooses $m_B(z_i)$ to maximize $\pi_B(z_i)$, yielding the first order condition (FOC): $r_B - c_B m_B(z_i)/(1-qd) = 0 \Rightarrow m_B(z_i) = r_B\,(1-qd)/c_B$. In the same way, we can show that $m_{Fj}(z_i) = r_{Fj}(z_i)/c_{Fj}$.

Proof of Lemma 2. If bank j serves location z_i with loan rate r_B (and the lending distance d), then the expected utility the bank provides to an entrepreneur at this location is $r_B\,(R - r_B)\,(1-qd)\,/c_B$, which is decreasing in r_B if and only if $r_B \geq R/2$. The bank will not offer a loan rate below $R/2$ because both $\pi_B(z_i)$ (with $m_B(z_i) = r_B\,(1-qd)\,/c_B$) and $r_B\,(R - r_B)\,(1-qd)\,/c_B$ (entrepreneurial utility, which is also funding demand at z_i) are increasing in r_B when r_B is below $R/2$. In the same way, we can show that the result applies also to fintechs.

Proof of Lemma 3. The proof is given in the main text.

Lemma A.1. *At location z_i, a bank's loan rate that maximizes an entrepreneur's utility from investment is given by $\overline{r}_B(d) \equiv \max\left\{R/2, \sqrt{2c_B\iota_B/(1-qd)}\right\}$, where d is the arc-distance between the bank and location z_i. If the bank serves location z_i with loan rate $\overline{r}_B(d)$, then an entrepreneur at this location will derive the expected utility $\overline{U}_B(d)$ from investment, where $\overline{U}_B(d) \equiv (1-qd)\,\overline{r}_B(d)(R - \overline{r}_B(d))/c_B$. We call $\overline{r}_B(d)$ the "**best loan rate**" of the bank at location z_i.*

Proof of Lemma A.1. The proof of this Lemma A.1 directly follows that of Lemma 3.

Lemma A.2. *Let r_B^m denote the (monopolistic) loan rate a bank will offer when it faces no competition from any other lender. In the case with blockaded fintech entry there is effective competition between banks i and $i+1$ if and only if*

$$\frac{(r_B^m)^2(1-\frac{q}{2N})}{2c_B} - \iota_B > 0. \tag{11}$$

Proof of Lemma A.2. Denote bank i's loan rate by r_i. Based on Lemma 1 and Equation (2), the bank's expected profit from serving an entrepreneur at z_i equals $(r_i)^2\,(1-qz_i)\,/\,(2c_B) - \iota_B$. If bank i faces no competition from any other lenders, then the farthest location (denoted by $x^{\uparrow}$) the bank is willing to serve on the arc between banks i and $i+1$ is determined by the equation $(r_i)^2\left(1-qx^{\uparrow}\right)/(2c_B) - \iota_B = 0$.

We need only consider the case that r_i is sufficiently high such that $x^{\uparrow} > 0$; otherwise bank i serves no entrepreneurs and makes zero profits, which is never optimal. $x^{\uparrow} > 0$ implies that $r_i > \sqrt{2c_B\iota_B}$. According to Lemma 2, $r_i \geq R/2$ should also hold. Therefore, the lower bound for r_i is $\overline{r}_B(0) \equiv \max\left\{\sqrt{2c_B\iota_B}, R/2\right\} < R$ (see Lemma A.1 for a detailed definition of function $\overline{r}_B(\cdot)$).

The bank's profit from all locations is $2\int_0^{x^\uparrow} D(z_i)\left((r_i)^2(1-qz_i)/(2c_B)-\iota_B\right)dz_i$ when there is no competition. $D(z_i) = (1-qz_i)\,r_i\,(R-r_i)/c_B$ is the funding demand at z_i. Maximizing the bank's profit implies the following (simplified) FOC with respect to r_i:

$$f^m(r_i) \equiv \underbrace{\frac{2r_i(R-r_i)}{3}}_{\text{positive}} + \underbrace{(R-2r_i)\,r_i}_{\text{negative}} \underbrace{\left(\frac{1}{3} - \frac{c_B\iota_B}{(r_i)^2}\frac{1-\left(\frac{2c_B\iota_B}{(r_i)^2}\right)^2}{1-\left(\frac{2c_B\iota_B}{(r_i)^2}\right)^3}\right)}_{\text{denoted by } y\text{; positive}} = 0. \qquad (12)$$

Here y equals $\int_0^{x^\uparrow}\left((r_i)^2(1-qz_i)/(2c_B)-\iota_B\right)(1-qz_i)\,dz_i$ multiplied by a positive value, and hence must be positive. Note that $f^m(\overline{r}_B(0)) > 0$ and $f^m(R) \leq 0$ hold. Meanwhile, it is easy to show that y is increasing in r_i, so $f^m(r_i)$ is decreasing in r_i when $r_i \in [\overline{r}_B(0), R]$. This means the FOC $f^m(r_i) = 0$ has a unique solution, denoted by r_B^m, in the interval $[\overline{r}_B(0), R]$; such a solution r_B^m is the optimal loan rate of the bank when it faces no competition from any other lenders. If $r_i = r_B^m$ and Condition (11) hold, then $x^\uparrow$ must be larger than $1/(2N)$. Hence, there exist locations that both banks i and $i+1$ are willing to serve, implying that effective competition between the two banks exists.

Proof of Proposition 1. First we need to derive the first order condition for the equilibrium with blockaded fintech entry. Since we look only at symmetric equilibria, we can focus the analysis on the arc between banks i and $i+1$. Assume that bank i offers the loan rate r_i while the other banks offer r_{i+1}. The indifference location x^{eb}, where entrepreneurs are indifferent between banks i and $i+1$, is determined by

$$\frac{r_i\left(1-qx^{eb}\right)}{c_B}(R-r_i) = \frac{r_{i+1}\left(1-q(\frac{1}{N}-x^{eb})\right)}{c_B}(R-r_{i+1}).$$

Then bank i's total profit is equal to $2\int_0^{x^{eb}} D(z_i)\left((r_i)^2(1-qz_i)/(2c_B)-\iota_B\right)dz_i$, where $D(z_i) = (1-qz)\,r_i\,(R-r_i)/c_B$. For a given $r_{i+1} \in [R/2, R]$, we can show that bank i's marginal benefit of increasing r_i is decreasing in r_i in the interval $[R/2, R]$. Denoting the symmetric equilibrium loan rate by $r_B^{eb} \in [R/2, R]$, the following FOC must hold for r_B^{eb}:

$$g^{eb}\left(r_B^{eb}\right) \equiv \left.\left(\begin{array}{c} \int_0^{x^{eb}} \frac{\partial D(z_i)\left(\frac{(r_i)^2(1-qz_i)}{2c_B}-\iota_B\right)}{\partial r_i}dz_i \\ +D\left(x^{eb}\right)\left(\frac{(r_i)^2\left(1-qx^{eb}\right)}{2c_B}-\iota_B\right)\frac{\partial x^{eb}}{\partial r_i}\end{array}\right)\right|_{r_i=r_{i+1}=r_B^{eb},\,x^{eb}=\frac{1}{2N}} = 0. \qquad (13)$$

In the symmetric equilibrium, we have $r_i = r_{i+1} = r_B^{eb}$, which means $x^{eb} = 1/(2N)$ and

$$\left.\frac{\partial x^{eb}}{\partial r_i}\right|_{r_i=r_{i+1}=r_B^{eb}} = \frac{(2N-q)\left(R-2r_B^{eb}\right)}{4Nq\left(R-r_B^{eb}\right)r_B^{eb}}. \tag{14}$$

Then the FOC (13) can be reduced to

$$f^{eb}\left(r_B^{eb}\right) \equiv \left(\begin{array}{c} \frac{2r_B^{eb}\left(R-r_B^{eb}\right)}{3} + r_B^{eb}\left(R-2r_B^{eb}\right)\overbrace{\left(\frac{1}{3} - \frac{c_B\iota_B}{\left(r_B^{eb}\right)^2}\frac{1-\left(1-\frac{q}{2N}\right)^2}{1-\left(1-\frac{q}{2N}\right)^3}\right)}^{\text{denoted by } y_1\text{; positive}} \\ +\frac{\left(1-\frac{q}{2N}\right)}{\left(1-\left(1-\frac{q}{2N}\right)^3\right)}\underbrace{\left(\frac{r_B^{eb}\left(1-\frac{q}{2N}\right)}{2} - \frac{c_B\iota_B}{r_B^{eb}}\right)}_{\text{denoted by } y_2\text{; positive}}\frac{\left(2-\frac{q}{N}\right)\left(R-2r_B^{eb}\right)}{2} \end{array}\right) = 0. \tag{15}$$

Here y_1 equals $\int_0^{1/(2N)}\left(\left(r_B^{eb}\right)^2(1-qz_i)/(2c_B)-\iota_B\right)(1-qz_i)\,dz_i$ multiplied by a positive value and hence is positive. y_2 equals a positive value times $\left(r_B^{eb}\right)^2(1-q/(2N))/(2c_B)$ $-\iota_B$, which is bank i's profit from serving an entrepreneur at $z_i = 1/(2N)$. Therefore $y_2 \geq 0$ holds, implying $r_B^{eb} \geq \underline{r}_B^{eb} \equiv \max\left\{\sqrt{2c_B\iota_B/(1-q/(2N))}, R/2\right\}$. Furthermore, we can show $y_2 \neq 0$; otherwise $f^{eb}\left(r_B^{eb}\right) = 0$ is equivalent to $f^m\left(r_B^{eb}\right) = 0$ (see Equation 12), which means: (a) r_B^{eb} is bank i's monopolistic loan rate (i.e., $r_B^{eb} = r_B^m$) and (b) $\left(r_B^m\right)^2(1-q/(2N))/(2c_B)-\iota_B = 0$ holds. However, this contradicts Condition (11) that we assume to hold. Therefore, $y_2 > 0$ must hold.

Condition (11) also ensures $r_B^m > \sqrt{2c_B\iota_B/(1-q/(2N))}$, so $f^{eb}\left(\underline{r}_B^{eb}\right) > 0$ must hold. Meanwhile, $f^{eb}(R) < 0$ holds, and $f^{eb}(\cdot)$ is a decreasing function in the interval $\left[\underline{r}_B^{eb}, R\right]$. Therefore, there exists a unique $r_B^{eb} \in \left(\underline{r}_B^{eb}, R\right)$ that solves $f^{eb}\left(r_B^{eb}\right) = 0$; such a r_B^{eb} is the symmetric equilibrium loan rate in the case with blockaded entry.

Next we show that $r_B^{eb} < r_B^m$, which is useful for other proofs. Because of $y_2 > 0$, $1-q/(2N) > 2c_B\iota_B/(r_B^{eb})^2$ must hold, which means

$$f^m\left(r_B^{eb}\right) > \frac{2r_B^{eb}\left(R-r_B^{eb}\right)}{3} + r_B^{eb}\left(R-2r_B^{eb}\right)\left(\frac{1}{3} - \frac{c_B\iota_B}{\left(r_B^{eb}\right)^2}\frac{1-\left(1-\frac{q}{2N}\right)^2}{1-\left(1-\frac{q}{2N}\right)^3}\right) > f^{eb}\left(r_B^{eb}\right) = 0$$

Therefore, $r_B^{eb} < r_B^m$ must hold because $f^m(r_i) = 0$ has a unique solution $r_i = r_B^m$ in the interval $[\overline{r}_B(0), R]$.

The existence of $\bar{c}_F$. In the blockaded entry equilibrium, entrepreneurial utility is lowest at location $z_i = 1/(2N)$, so fintech is blockaded if $r_B^{eb}(1-q/(2N))\left(R-r_B^{eb}\right)/c_B \geq$

$\overline{U}_{F1} = \overline{r}_{F1}(R - \overline{r}_{F1})/c_{F1}$, where $\overline{U}_F$ and $\overline{r}_{F1}$ are defined in Lemma 3. Since $\overline{r}_{F1}$ is also a function of c_{F1}, in the proof we sometimes write $\overline{r}_{F1}$ as $\overline{r}_{F1}(c_{F1})$ to highlight that $\overline{r}_{F1}$ is not independent of c_{F1}. Obviously, $\overline{r}_{F1}(c_{F1})$ is weakly increasing in c_{F1} according to Lemma 3, so $\overline{c}_F$ is determined by the following equation:

$$\frac{r_B^{eb}\left(1 - \frac{q}{2N}\right)\left(R - r_B^{eb}\right)}{c_B} = \frac{\overline{r}_{F1}(\overline{c}_F)\left(R - \overline{r}_{F1}(\overline{c}_F)\right)}{\overline{c}_F}. \tag{16}$$

If $c_{F1} < \overline{c}_F$, the blockaded entry equilibrium cannot be sustained.

Lending competition with actual fintech entry. Consider the case $c_{F1} < \overline{c}_F$. If actual fintech entry occurs, bank i no longer competes with bank $i+1$. To see this, we let $z_i = z_F \in [0, 1/N]$ be a location served by fintech 1. This means, at $z_i = z_F$ fintech 1 can provide the highest utility among all lenders. Since a bank's monitoring efficiency is decreasing in the lending distance, at $z_i \in [0, z_F]$ fintech 1 can still provide higher utility than bank $i+1$, so bank i need only compete with fintech 1 at $z_i \in [0, z_F]$. Reasoning symmetrically, bank $i+1$ competes with the fintech at $z_i \in [z_F, 1/N]$.

We look at the competition between bank i and fintech 1 when there is actual fintech entry. Let x^{ea} denote the indifference location where an entrepreneur is indifferent between bank i and the fintech. Then x^{ea} is determined by

$$\frac{r_i^{ea}(1 - qx^{ea})(R - r_i^{ea})}{c_B} = \overline{U}_{F1} \Leftrightarrow x^{ea} = \frac{\left(1 - \frac{c_B \overline{U}_{F1}}{r_i^{ea}\left(R - r_i^{ea}\right)}\right)}{q}, \tag{17}$$

where r_i^{ea} is bank i's loan rate in the case with actual fintech entry. Bank i serves locations $z_i \in [0, x^{ea}]$ when competing with fintech 1. Since banks i and $i+1$ are symmetric, the actual entry case can arise only if $x^{ea} < 1/(2N)$ holds in equilibrium; otherwise, bank i will touch and compete directly with bank $i+1$.

We need only consider the case $x^{ea} > 0$; otherwise, $x^{ea} = 0$ holds and bank i serves no entrepreneurs, which is not optimal for the bank. According to Condition (5), if bank i offers a loan rate that is higher than but sufficiently close to $\overline{r}_B(0)$, then it can serve a positive mass of locations and make positive lending profits. Hence, in the equilibrium with actual entry, $x^{ea} > 0$ indeed must hold.

With actual fintech entry and $x^{ea} > 0$, bank i's expected lending profit is equal to

$2\int_0^{x^{ea}} D(z_i) \left((r_i^{ea})^2 (1-qz_i)/(2c_B) - \iota_B \right) dz_i$, which implies the following FOC:

$$g^{ea}(r_i^{ea}) \equiv \int_0^{x^{ea}} \frac{\partial D(z_i) \left(\frac{(r_i^{ea})^2 (1-qz_i)}{2c_B} - \iota_B \right)}{\partial r_i^{ea}} dz_i + D(x^{ea}) \left(\frac{(r_i^{ea})^2 (1-qx^{ea})}{2c_B} - \iota_B \right) \frac{\partial x^{ea}}{\partial r_i^{ea}} = 0. \tag{18}$$

Simplifying Equation (18) using Equation (17) yields:

$$f^{ea}(r_i^{ea}) \equiv \left(\begin{array}{c} \frac{2r_i^{ea}(R-r_i^{ea})}{3} + r_i^{ea}(R-2r_i^{ea}) \underbrace{\left(\frac{1}{3} - \frac{c_B \iota_B}{(r_i^{ea})^2} \frac{1-y_{ea}^2}{1-y_{ea}^3} \right)}_{\text{positive; increasing in } r_i^{ea}} \\ +2 \underbrace{\left(\frac{\overline{U}_{F1}}{2(R-r_i^{ea})} - \frac{\iota_B}{r_i^{ea}} \right)}_{\text{non-negative}} \frac{(R-2r_i^{ea}) c_B y_{ea}^2}{1-y_{ea}^3} \end{array} \right) = 0, \tag{19}$$

where $y_{ea} \equiv c_B \overline{U}_{F1}/(r_i^{ea}(R-r_i^{ea}))$; $y_{ea} < 1$ must hold because of $x^{ea} > 0$ (note that $x^{ea} = (1-y_{ea})/q$). According to Condition (5) and $\lim_{r_i^{ea} \to R} y_{ea} = +\infty$, there must exist a $\overline{r}_B^{ea} \in (\overline{r}_B(0), R)$ such that $\lim_{r_i^{ea} \to \overline{r}_B^{ea}} x^{ea} = 0$. This $\overline{r}_B^{ea}$ is the upper bound of bank i's loan rate, because the bank cannot serve any entrepreneur if its loan rate is above $\overline{r}_B^{ea}$. In Equation (19), $1/3 - c_B \iota_B (1-y_{ea}^2)/((r_i^{ea})^2 (1-y_{ea}^3))$ is equal to a positive value times $\int_0^{x^{ea}} \left((r_i^{ea})^2 (1-qz_i)/(2c_B) - \iota_B \right) (1-qz_i)\, dz_i$, which is positive. For the same reason, $\overline{U}_{F1}/(2(R-r_i^{ea})) - \iota_B/r_i^{ea}$ has the same sign as $(r_i^{ea})^2 (1-qx^{ea})/(2c_B) - \iota_B$, which is non-negative because bank i must ensure itself a non-negative profit at $z_i = x^{ea}$.

To ensure bank i a non-negative profit at $z_i = x^{ea}$, r_i^{ea} must have the following restriction:

$$\frac{(r_i^{ea})^2 (1-qx^{ea})}{2c_B} - \iota_B \geq 0 \Leftrightarrow \frac{\overline{U}_{F1}}{2(R-r_i^{ea})} - \frac{\iota_B}{r_i^{ea}} \geq 0 \Leftrightarrow r_i^{ea} \geq \frac{2\iota_B R}{\overline{U}_{F1} + 2\iota_B}.$$

This means the lower bound of bank i's loan rate is $\underline{r}_B^{ea} \equiv \max\left\{ R/2, 2\iota_B R/(\overline{U}_{F1} + 2\iota_B) \right\}$.

Next we show that $f^{ea}(\underline{r}_B^{ea}) > 0$ holds. If $\underline{r}_B^{ea} = R/2$, then $f^{ea}(\underline{r}_B^{ea}) = R^2/6 > 0$. If $\underline{r}_B^{ea} = 2\iota_B R / \left(\overline{U}_{F1} + 2\iota_B \right) \geq R/2$, then $f^{ea}(\underline{r}_B^{ea}) = f^m(\underline{r}_B^{ea})$ holds (see Equation 12). Note that if $r_i^{ea} = \underline{r}_B^{ea}$, then at location $z_i = x^{\uparrow}$ (the farthest location bank i is willing to serve) bank i provides utility $\overline{U}_{F1}$; in contrast, if $r_i^{ea} = r_B^m$, then at location $z_i = x^{\uparrow}$ the utility provided by bank i is smaller than $\overline{U}_{F1}$ because

$$\underbrace{\frac{r_B^m\left(R-r_B^m\right)\left(1-qx^{\uparrow}\right)}{c_B}<\frac{r_B^m\left(R-r_B^m\right)\left(1-\frac{q}{2N}\right)}{c_B}}_{\text{because } x^{\uparrow}>1/(2N) \text{ when } r_i^{ea}=r_B^m\text{; see Condition (11)}}\overbrace{<\frac{r_B^{eb}\left(R-r_B^{eb}\right)\left(1-\frac{q}{2N}\right)}{c_B}}^{\text{because } r_B^{eb}<r_B^m}<\overline{U}_{F1},$$

where the last inequality holds because $c_{F1}<\bar{c}_F$ (i.e., fintech entry is not blockaded). Since the utility provided by bank i at location $z_i=x^{\uparrow}$ is equal to $2c_B\iota_B\left(R-r_i^{ea}\right)/\left(r_i^{ea}c_B\right)$, which is decreasing in r_i^{ea}, $r_B^m>\underline{r}_B^{ea}$ must hold. As a result $f^{ea}\left(\underline{r}_B^{ea}\right)=f^m\left(\underline{r}_B^{ea}\right)>f^m\left(r_B^m\right)=0$. Meanwhile, it is easy to find that $\lim_{r_i^{ea}\to\overline{r}_B^{ea}}f^{ea}\left(r_i^{ea}\right)<0$, and that $f^{ea}\left(r_i^{ea}\right)$ is decreasing in r_i^{ea} (because $\left(1-y_{ea}^2\right)/\left(1-y_{ea}^3\right)$ is decreasing in y_{ea}) in the interval $\left(\underline{r}_B^{ea},\overline{r}_B^{ea}\right)$. Therefore, in this interval $\left(\underline{r}_B^{ea},\overline{r}_B^{ea}\right)$ there exists a unique r_B^{ea} that solves $f^{ea}\left(r_B^{ea}\right)=0$. Such a loan rate is the equilibrium bank loan rate when actual fintech entry occurs.

In the case with actual entry fintech 1 must serve positive mass of locations, which means $x^{ea}|_{r_i^{ea}=r_B^{ea}}<1/(2N)$ is a necessary condition for actual entry to occur.
The existence of the potential entry case. Next we show that actual fintech entry cannot occur if c_{F1} is smaller than but sufficiently close to $\bar{c}_F$. According to the formulae of $\bar{c}_F$ and x^{ea} (see Equations 16 and 17), if $c_{F1}=\bar{c}_F$ holds and if actual fintech entry occurs (which means bank i competes only with fintech 1), the indifference location x^{ea} is equal to $1/(2N)$ when bank i chooses $r_i^{ea}=r_B^{eb}$. Then according to FOC Equations (13) and (18), $g^{ea}\left(r_B^{eb}\right)\big|_{c_{F1}=\bar{c}_F}<g^{eb}\left(r_B^{eb}\right)\big|_{c_{F1}=\bar{c}_F}=0$ holds because (a) $x^{ea}|_{r_i^{ea}=r_B^{eb}}=1/(2N)$ holds when $c_{F1}=\bar{c}_F$, and (b) according to Equation (14), we have:

$$\left.\frac{\partial x^{ea}}{\partial r_i^{ea}}\right|_{r_i^{ea}=r_B^{eb},x^{ea}=1/(2N)}=\frac{(2N-q)\left(R-2r_B^{eb}\right)}{2Nq\left(R-r_B^{eb}\right)r_B^{eb}}<\left.\frac{\partial x^{eb}}{\partial r_i}\right|_{r_i=r_{i+1}=r_B^{eb}}<0.$$

The inequality $g^{ea}\left(r_B^{eb}\right)\big|_{c_{F1}=\bar{c}_F}<0$ implies $f^{ea}\left(r_B^{eb}\right)\big|_{c_{F1}=\bar{c}_F}<0$, which means that in the case with actual entry $r_B^{ea}<r_B^{eb}$ must hold if $c_{F1}=\bar{c}_F$. Since $x^{ea}|_{r_i^{ea}=r_B^{eb}}=1/(2N)$, the relation $r_B^{ea}<r_B^{eb}$ will lead to $x^{ea}|_{r_i^{ea}=r_B^{ea}}>1/(2N)$, which contradicts the fact that $x^{ea}|_{r_i^{ea}=r_B^{ea}}<1/(2N)$ is a necessary condition for actual entry to occur. If c_{F1} is smaller than but sufficiently close to $\bar{c}_F$, $x^{ea}|_{r_i^{ea}=r_B^{ea}}>1/(2N)$ must still hold because $g^{ea}(\cdot)$ and $g^{eb}(\cdot)$ are continuous functions. As a result, actual fintech entry cannot occur if c_{F1} is smaller than but sufficiently close to $\bar{c}_F$.

Meanwhile, fintech entry cannot be blockaded when $c_{F1}<\bar{c}_F$, so there must be potential fintech entry if c_{F1} is smaller than but sufficiently close to $\bar{c}_F$. In the symmetric potential entry equilibrium, bank i's loan rate (denoted by $r_B^{ep} \in [R/2, R]$) that exactly prevents fintech penetration at $z_i = 1/(2N)$ is determined by $r_B^{ep}(1 - q/(2N))(R - r_B^{ep})/c_B = \overline{U}_{F1}$ (i.e., Equation 4). Obviously $r_B^{ep} < r_B^{eb}$ holds because $c_{F1} < \bar{c}_F$. Note that $\lim_{c_{F1} \to \bar{c}_F} r_B^{ep} = r_B^{eb}$. Therefore, $g^{ea}(r_B^{ep}) \leq 0$ must hold when c_{F1} is smaller than but sufficiently close to $\bar{c}_F$, because $g^{ea}\left(r_B^{eb}\right)\big|_{c_{F1}=\bar{c}_F} < 0$. When $g^{ea}(r_B^{ep}) \leq 0$ holds (which is equivalent to $f^{ea}(r_B^{ep}) \leq 0$), bank i has no incentive to increase its loan rate above r_B^{ep} to compete directly with fintech 1. Meanwhile, the relation $r_B^{ep} < r_B^{eb}$ implies that bank i has no incentive to decrease its loan rate below r_B^{ep}, because $f^{eb}(r_B^{ep}) > 0$ must hold (which means, if fintech entry is blockaded and banks compete with each other, then both banks i and $i+1$ have incentive to increase their loan rates). In sum, if c_{F1} is smaller than but sufficiently close to $\bar{c}_F$ (such that $g^{ea}(r_B^{ep}) \leq 0$ holds), banks have no incentive to deviate from offering r_B^{ep}.

The existence of $\underline{c}_F$. Now we show the existence of $\underline{c}_F$. When $c_{F1} < \bar{c}_F$, actual fintech entry will occur if and only if $g^{ea}(r_B^{ep}) > 0$, which means bank i has an incentive to increase its loan rate above r_B^{ep} to compete directly with fintech 1. Note that $g^{ea}(r_B^{ep}) > 0$ is equivalent to $x^{ea}|_{r_i^{ea}=r_B^{ea}} < 1/(2N)$. Therefore, if both $x^{ea}|_{r_i^{ea}=r_B^{ea}} \geq 1/(2N)$ and $c_{F1} < \bar{c}_F$ hold (i.e., when c_{F1} is smaller than but sufficiently close to $\bar{c}_F$), there is potential entry; if $x^{ea}|_{r_i^{ea}=r_B^{ea}} < 1/(2N)$, actual fintech entry occurs. If c_{F1} is sufficiently low such that $\overline{U}_{F1} > R^2(1 - q/(2N))/(4c_B)$ holds, fintech 1 can provide higher utility at location $z_i = 1/(2N)$ than any bank, so $x^{ea}|_{r_i^{ea}=r_B^{ea}} < 1/(2N)$ indeed holds in this case; this means the threshold $\underline{c}_F$ exists. The fact that $x^{ea}|_{r_i^{ea}=r_B^{ea}}$ is increasing in c_{F1} in the actual entry case is shown in the proof of Corollary 2. Therefore, such a threshold $\underline{c}_F$ is unique. When $c_{F1} = \underline{c}_F$, $x^{ea}|_{r_i^{ea}=r_B^{ea}} = 1/(2N)$ (i.e., $g^{ea}(r_B^{ep}) = 0$) holds, in which case $r_B^{ea} = r_B^{ep} < r_B^{eb}$. In the proof of Corollary 2 we will show that r_B^{ea} is increasing in c_{F1} when there is actual fintech entry, so $r_B^{ea} < r_B^{eb}$ always holds when $c_{F1} < \underline{c}_F$.

Proof of Corollary 1. $\bar{c}_F$ is determined by the Equation (16). According to FOC (15), r_B^{eb} (which is higher than $\underline{r}_B^{eb}$) is increasing in q, c_B and ι_B, which means the left hand side (LHS) of Equation (16) is decreasing in q, c_B and ι_B. To ensure that Equation (16) holds, $\bar{c}_F$ must be increasing in q, c_B and ι_B.

Next we look at $\underline{c}_F$. Actual fintech entry occurs if and only if $x^{ea}|_{r_i^{ea}=r_B^{ea}} < 1/(2N)$ holds according to the proof of Proposition 1. In the proof of Corollary 2, we will show that $x^{ea}|_{r_i^{ea}=r_B^{ea}} < 1/(2N)$ (hereafter, written as x^{ea} for simplicity) is increasing in c_{F1}. Therefore, $\underline{c}_F$ is the highest value of the c_{F1} that ensures $x^{ea} < 1/(2N)$. If q, c_B or ι_B increases, then x^{ea} will decrease (see the proof of Corollary 2), which makes $x^{ea} < 1/(2N)$ easier to hold. Therefore, $\underline{c}_F$ will increase as q, c_B or ι_B increases.

Proof of Proposition 2. The result has been proven in the proof of Proposition 1.

Proof of Corollary 2. In the potential entry case, r_B^{ep} is determined by Equation (4). As c_B or q increases, the left hand side (LHS) of Equation (4) will decrease for a given r_B^{ep}. As a result, r_B^{ep} must decrease to ensure Equation (4) holds. If c_{F1} increases, the right-hand side (RHS) of (4) will decrease. As a result, r_B^{ep} must increase to ensure Equation (4) holds. If N decreases, the LHS of Equation (4) will decrease. As a result, r_B^{ep} must decrease to ensure Equation (4) holds.

Next, we look at the case with actual entry. According to Equation (19), a bank's loan rate r_B^{ea} in the actual entry case satisfies:

$$f^{ea}\left(r_B^{ea}\right) = \left(\begin{array}{c} \frac{2r_B^{ea}\left(R-r_B^{ea}\right)}{3} + \overbrace{r_B^{ea}\left(R-2r_B^{ea}\right)\left(\frac{1}{3} - \frac{c_B \iota_B}{\left(r_B^{ea}\right)^2}\frac{1-y_{ea}^2}{1-y_{ea}^3}\right)}^{\text{term A; negative}} \\ \underbrace{+2\left(\frac{r_B^{ea}}{2}y_{ea} - \frac{c_B \iota_B}{r_B^{ea}}\right)\frac{\left(R-2r_B^{ea}\right)y_{ea}^2}{1-y_{ea}^3}}_{\text{term B; negative}} \end{array} \right) = 0 \tag{20}$$

with $y_{ea} \equiv c_B \overline{U}_{F1} / \left(r_B^{ea}\left(R - r_B^{ea}\right)\right)$. Since Equation (20) is independent of q and N, r_B^{ea} must also be independent of q and N. Then x^{ea} is decreasing in q and independent of N according to Equation (17).

If c_{F1} increases, then y_{ea} will decrease for a given r_B^{ea}; terms A and B will increase (i.e., become less negative) for a given r_B^{ea}. As a result, r_B^{ea} must increase to keep Equation (20) holding (recall that $f^{ea}\left(r_B^{ea}\right)$ is decreasing in r_B^{ea} in the interval $\left(\underline{r}_B^{ea}, \overline{r}_B^{ea}\right)$).

Next we look at how c_{F1} affects x^{ea}. According to Equation (17), $x^{ea} = \left(1 - y_{ea}\right)/q$, which is decreasing in y_{ea}. If c_{F1} increases but y_{ea} does not adjust, terms A and B in Equation (20) will decrease (i.e., become more negative) because r_B^{ea} is increasing in c_{F1}. Meanwhile, $2r_B^{ea}\left(R - r_B^{ea}\right)/3$ will also decrease (i.e., become less positive) because $r_B^{ea} > R/2$. Hence, y_{ea} must decrease (i.e., x^{ea} increases) to keep Equation (20) holding.

Proof of Proposition 3. In the proof of Proposition 1, we have shown that actual fintech entry occurs if and only if $x^{ea} < 1/(2N)$, in which case bank i serves entrepreneurs at $z_i \in [0, x^{ea})$. Symmetrically, bank $i+1$ serves entrepreneurs at $z_i \in (1/N - x^{ea}, 1/N]$. Therefore, fintechs serve entrepreneurs at $z_i \in [x^{ea}, 1/N - x^{ea}]$.

If $c_{F1} < c_{F2}$, then $\overline{U}_{F1} > \overline{U}_{F2}$. As a result, fintech 2 cannot serve any entrepreneur in a Bertrand competition with fintech 1.

Lemma A.3. *In the case with actual fintech entry, if fintech 1 faces no competition from any other lender at z_i, then the fintech will provide entrepreneurs at this location with the* *monopolistic loan rate r_{F1}^m, which is the largest solution of the following equation:*

$$g_{F1}^m\left(r_{F1}^m\right) \equiv \frac{(r_{F1}^m)^2(3R - 4r_{F1}^m)}{2c_{F1}} + (2r_{F1}^m - R)\iota_F = 0. \tag{21}$$

The monopolistic loan rate r_{F1}^m is smaller than R.

Proof of Lemma A.3. If fintech 1 faces no competition from any other lender at z_i, it will choose a loan rate $r_{F1}(z_i)$ to maximize its lending profit at this location. The lending profit at z_i is $D(z_i)\big((r_{F1}(z_i))^2(1-qz_i)/(2c_{F1}) - \iota_F\big)$. Maximizing this profit yields $r_{F1}(z_i) = r_{F1}^m$, which is determined by Equation (21). Note that $g_{F1}^m(-\infty) > 0$, $g_{F1}^m(0) < 0$, $g_{F1}^m(R/2) > 0$ and $g_{F1}^m(R) = -R\left(R^2/(2c_{F1}) - \iota_F\right) < 0$ hold. $g_{F1}^m(R) < 0$ holds because $\overline{U}_{F1} > 0$ when there is actual fintech entry, which means $R^2/(2c_{F1}) - \iota_F > (\overline{r}_{F1})^2/(2c_{F1}) - \iota_F > 0$. Therefore, $g_{F1}^m(r_{F1}^m) = 0$ has a unique solution in $(R/2, R)$. Such a solution is the fintech's monopolistic loan rate. Equation (21) is independent of z_i, so is r_{F1}^m.

Proof of Lemma 4. If fintech 1 need only consider the threat of fintech 2, then two cases may arise. First, if $r_{F1}^m(R - r_{F1}^m)/c_{F1} \geq \overline{U}_{F2}$, then fintech 1 can still offer r_{F1}^m. If not, then fintech 1's loan rate must provide utility $\overline{U}_{F2}$ to ensure that entrepreneurs will not approach fintech 2. This leads to the following loan rate

$$\frac{r_{F1}(z_i)(R - r_{F1}(z_i))}{c_{F1}} = \overline{U}_{F2} \Rightarrow r_{F1}(z_i) = \frac{R + \sqrt{R^2 - 4c_{F1}\overline{U}_{F2}}}{2},$$

which is independent of z_i. Therefore, the upper bound loan rate of fintech 1 is r_{F1}^*.

Proof of Proposition 4. At location $z_i \in [x^{ea}, 1/(2N)]$, the nearest bank is bank i, whose lending distance is z_i. Symmetrically, at $z_i \in (1/(2N), 1/N - x^{ea}]$, the nearest bank is bank $i+1$, whose lending distance is $1/N - z_i$. Overall, $d^{ea} \equiv \min\{z_i, 1/N - z_i\}$ can represent the lending distance of the nearest bank at $z_i \in [x^{ea}, 1/N - x^{ea}]$.

The lending profit of the nearest bank by serving an entrepreneur at $z_i \in [x^{ea}, 1/N - x^{ea}]$ equals $(r_B^{ea})^2(1 - qd^{ea})/(2c_B) - \iota_B$. If this profit is negative, then no bank is willing to serve location z_i. In such a location fintech 1 will offer r_{F1}^* according to Lemma 4.

If $(r_B^{ea})^2(1 - qd^{ea})/(2c_B) - \iota_B \geq 0$ holds at z_i, the nearest bank is willing to serve location z_i, so fintech 1 must ensure that entrepreneurs at this location will not approach the nearest bank. The loan rate that exactly ensures this is determined by the equation $r_B^{ea}(1 - qd^{ea})\left(R - r_B^{ea}\right)/c_B = r_{F1}(z_i)(R - r_{F1}(z_i))/c_{F1}$. The solution (in the interval $[R/2, R]$) is $r_{F1}(z_i) = r_{F1}^{comB}(z_i)$.

However, $r_{F1}^{comB}(z_i)$ may be higher than r_{F1}^*; if so, then fintech 1 still offers r_{F1}^*, which can also ensure that entrepreneurs will not approach any bank. In sum, fintech 1's loan rate is $\min\left\{r_{F1}^{comB}(z_i), r_{F1}^*\right\}$ in the case $(r_B^{ea})^2(1-qd^{ea})/(2c_B) - \iota_B \geq 0$.

Proof of Corollary 3. We focus on the region $[x^{ea}, 1/(2N)]$ on the arc between banks i and $i+1$. In this region the nearest bank is bank i, so $d^{ea} = z_i$. Obviously, $r_{F1}^{comB}(z_i)$ is increasing in z_i when $d^{ea} = z_i$. Fintech 1's loan rate $r_{F1}(z_i)$ is weakly increasing in z_i in this region because (a) r_{F1}^* is independent of z_i and (b) $(r_B^{ea})^2(1-qd^{ea})/(2c_B) - \iota_B$ is decreasing in z_i. At the indifference location $z_i = x^{ea}$, $r_F(z_i) = \overline{r}_{F1}$ holds because by definition fintech 1 offers utility $\overline{U}_{F1}$ there (see Equation 17).

Proof of Proposition 5 and Corollary 4. First we consider the case $\iota_B = \iota_F$. In the proof of Proposition 1 we have shown $f^{ea}(\underline{r}_B^{ea}) > 0$, which means $r_B^{ea} > R/2$ and bank i's profit at $z_i = x^{ea}$ is positive. Therefore, r_B^{ea} is higher than $\max\left\{R/2, \sqrt{2c_B\iota_B/(1-qx^{ea})}\right\}$. Defining $c_{Bx} \equiv c_B/(1-qx^{ea})$, we have that $r_B^{ea} > \max\left\{R/2, \sqrt{2c_{Bx}\iota_B}\right\}$. At $z_i = x^{ea}$, we have $r_{F1}(x^{ea}) = \overline{r}_{F1}$. Equation (17) can be written as $r_B^{ea}(R - r_B^{ea})/c_{Bx} = \overline{r}_{F1}(R - \overline{r}_{F1})/c_{F1}$, which means $c_{Bx} < c_{F1}$ and $r_B^{ea} > \overline{r}_{F1}$ must hold because $r_B^{ea} > \max\left\{R/2, \sqrt{2c_{Bx}\iota_B}\right\}$, $\overline{r}_F = \max\left\{R/2, \sqrt{2c_{F1}\iota_F}\right\}$ and $\iota_B = \iota_F$ hold.

Next we prove Corollary 4. Proposition 5 implies that $c_B/(1-q/(2N)) < c_{F1}$ must hold in the actual entry case if $c_{F1} \to \underline{c}_F$ and if $\iota_B = \iota_F$. By letting ι_F marginally increase from being equal to ι_B, and c_{F1} marginally decrease from being equal to $\underline{c}_F$, actual fintech entry can still occur without changing the relation $c_B/(1-q/(2N)) < c_{F1}$, because $f^{ea}(r_B^{ea})$ and x^{ea} vary continuously with c_{F1} and ι_B.

Proof of Proposition 6. When there is potential fintech entry, $R/2 \leq r_B^{ep} < r_B^{eb}$ hold. Then at each location entrepreneurs will derive higher expected utility, which implies a larger mass of entrepreneurs implementing their projects.

Proof of Proposition 7. We consider the case that $c_{F1} = c_{F2}$. Before fintech entry (or when fintech entry is blockaded), total investment (denoted by I^{eb}) equals $2N\int_0^{1/(2N)} r_B^{eb}\left(R - r_B^{eb}\right)(1-qz_i)/c_B dz_i$. With actual fintech entry and $c_{F1} = c_{F2}$, total investment (denoted by I^{ea}) is $2N\left(\int_0^{x^{ea}} r_B^{ea}(R - r_B^{ea})(1-qz_i)/c_B dz_i + \int_{x^{ea}}^{1/(2N)} \overline{U}_{F1} dz_i\right)$.

In the proof of Proposition 1 we have shown that $r_B^{ea} < r_B^{eb}$ in the case with actual entry, so $I^{ea} > I^{eb}$ holds when $c_{F1} = c_{F2}$. Since r_{F1}^* changes continuously with c_{F2}, $I^{ea} > I^{eb}$ must also hold when c_{F2} is sufficiently close to c_{F1}.

Appendix B: Pre-entry local monopoly

In this appendix, we consider the pre-entry local monopoly case; that is, there is no effective competition between adjacent banks when there is no fintech threat (or when fintech entry is blockaded). For convenience, we concentrate our analysis on the arc between banks i and $i+1$.

In the pre-entry local monopoly case, each bank (e.g., bank i) faces no competition from any other lender. Therefore, the bank will offer its monopolist loan rate r_B^m according to Lemma A.2. With the monopolistic loan rate r_B^m, the farthest location bank i can reach on arc between banks i and $i+1$ is $z_i = x_m^{\uparrow}$, which is determined by

$$\frac{(r_B^m)^2\left(1-qx_m^{\uparrow}\right)}{2c_B} - \iota_B = 0. \tag{22}$$

Equation (22) means that bank i makes zero profit at $z_i = x_m^{\uparrow}$.

Bank i can indeed enjoy pre-entry local monopoly if and only if $x_m^{\uparrow} \leq 1/(2N)$, which is equivalent to

$$\frac{(r_B^m)^2(1-\frac{q}{2N})}{2c_B} - \iota_B \leq 0. \tag{23}$$

Note that Condition (23) is exactly the opposite of Condition (11). According to Equation (12) that determines r_B^m, $(r_B^m)^2/(c_B\iota_B)$ is decreasing in c_B and ι_B and independent of q. Hence Inequality (23) holds when N is sufficiently small and/or c_B, q and ι_B are sufficiently large.

In this pre-entry local monopoly case, bank i does not care about whether or not to serve location $z_i = x_m^{\uparrow}$ because the bank makes only zero profit there. For convenience, we assume that bank i does not serve that boundary location.[36] Then bank i serves the region $\left[0, x_m^{\uparrow}\right)$. Reasoning symmetrically, bank $i+1$ serves the region $\left(1/N - x_m^{\uparrow}, 1/N\right]$. As a result, entrepreneurs in the region $\left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ have no access to bank finance.

Hence fintech 1 can affect the equilibrium if it can provide loans to entrepreneurs at $z_i \in \left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$, which implies the following proposition.

Proposition B.1. *Let Inequality (23) hold. Actual (resp. blockaded) fintech entry occurs if and only if*

$$\overline{U}_{F1} > 0 \text{ (resp. } \overline{U}_{F1} \leq 0\text{)}.$$

If actual fintech entry occurs, there exists an $x^{ea} \in (0, 1/(2N)]$ such that fintech 1 serves

[36] We can imagine that serving a location will incur an infinitesimal fixed cost for bank i, so the bank does not serve the boundary location $z_i = x_m^{\uparrow}$.

entrepreneurs at $z_i \in [x^{ea}, 1/N - x^{ea}]$ on the arc between banks i and i_{+1}, while bank i (resp. bank i_{+1}) serves entrepreneurs at $z_i \in [0, x^{ea})$ (resp. $z_i \in (1/N - x^{ea}, 1/N]$).

Since entrepreneurs at $z_i \in \left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ have no access to bank finance, their utility from investment is zero when there is no fintech threat. As a result, fintech 1 can enter the market and serve locations $z_i \in \left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ if $\overline{U}_{F1} > 0$, which means the fintech can provide positive entrepreneurial utility to those locations and thereby spur some entrepreneurs there to implement their investment projects. Note that $\overline{U}_{F1} > 0$ is equivalent to

$$\overline{r}_{F1} = \max\left\{\frac{R}{2}, \sqrt{2c_{F1}\iota_F}\right\} < R \Leftrightarrow \frac{R^2}{2c_{F1}} - \iota_F > 0,$$

which means fintech 1 can make a positive lending profit by serving an entrepreneur with the loan rate R. Recall that $\overline{U}_{F1}$ is determined by only c_{F1} and ι_F; hence whether or not actual fintech entry occurs depends only on fintech 1's own monitoring technology (i.e., c_{F1}) and funding cost (i.e., ι_{F1}). If c_{F1} or/and ι_{F1} is/are sufficiently small such that fintech 1 can provide entrepreneurs at $z_i \in \left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ with positive expected utility from investment, actual fintech entry occurs. In the actual entry case, fintech 1 serves entrepreneurs that are distant from both banks i and $i+1$ as in Proposition 3.

Note that there does not exist a potential entry equilibrium if banks enjoy pre-entry local monopolies. The reason is that entrepreneurs at $z_i \in \left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ have no access to bank finance. If $\overline{U}_{F1} > 0$ holds, banks cannot prevent fintech 1 from obtaining entrepreneurs at those locations. If $\overline{U}_{F1} > 0$ does not hold, then fintech 1 will not serve any entrepreneur because doing so cannot bring positive lending profits; as a result, fintech entry is blockaded.

Entrepreneurs at $z_i \in \left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ will not be served by any bank in the blockaded entry case. However, if actual fintech entry occurs (i.e., if $\overline{U}_{F1} > 0$), then entrepreneurs at $z_i \in \left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ will be served by fintech 1. Therefore, fintech lending can complement bank lending by meeting the funding demand of locations with no access to banks.

The next corollary characterizes x^{ea} when banks enjoy pre-entry local monopolies.

Corollary B.1. *Let Inequality (23) and $\overline{U}_{F1} > 0$ hold. If*

$$\overline{U}_{F1} \leq \frac{r_B^m(1 - qx_m^{\uparrow})\,(R - r_B^m)}{c_B}, \tag{24}$$

then $x^{ea} = x_m^{\uparrow}$; in this case, there is no competition between fintech 1 and banks. If

Condition (24) does not hold, then $x^{ea} < x_m^{\uparrow}$; in this case, there is competition between fintech 1 and banks.

This corollary means that when banks enjoy pre-entry local monopoly, competition between fintech 1 and banks may not arise even after actual fintech entry. The reason is that at location $z_i = x_m^{\uparrow}$ banks can still provide positive entrepreneurial utility (i.e., $r_B^m < R$). When determining r_B^m, banks will consider not only the lending profit from each individual entrepreneur but also the entrepreneurs' funding demand. Therefore, offering a loan rate of R is not optimal for a bank because such a high loan rate implies zero funding demand of entrepreneurs, which also implies zero lending profit. Since $r_B^m < R$ holds, $r_B^m(1 - qx_m^{\uparrow})\left(R - r_B^m\right)/c_B$, which is the utility an entrepreneur (served by bank i) can derive when $z_i \to x_m^{\uparrow}$, must be positive. When Condition (24) holds, fintech 1 cannot provide utility higher than $r_B^m(1 - qx_m^{\uparrow})\left(R - r_B^m\right)/c_B$, so banks' behavior will not be affected by fintech 1 even if actual entry occurs. In this case, fintech 1's loan rate is the upper bound loan rate r_{F1}^* for locations $z_i \in \left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ because the fintech does not face banks' competitive threat in this region (i.e., $\left[x_m^{\uparrow}, 1/N - x_m^{\uparrow}\right]$ is an **NBT** region).

When Condition (24) does not hold, fintech 1 can extend its market area into $\left[0, x_m^{\uparrow}\right)$ and $(1/N - x_m^{\uparrow}, 1/N]$, giving rise to the competition between banks and fintech 1. In this case, the properties of the equilibrium are the same as those displayed in Section 4 (the actual entry case). No matter how banks compete with fintech 1, there always exists an **NBT** region on the arc between banks i and $i + 1$, so the curve of the equilibrium loan rates will take the same pattern as Panel 2 of Figure 5.

Internet Appendices

Internet Appendix C: Supplementary analyses

In this appendix, we provide some supplementary analyses that can facilitate understanding the model. First, we characterize the case with the blockaded entry, which is not analyzed in the main text. Second, we provide a more detailed comparative-statics analysis for both the potential and the actual entry cases.

Blockaded fintech entry

The following proposition provides the basic properties of the equilibrium with blockaded entry (i.e., when $c_{F1} \geq \overline{c}_F$).

Proposition C.1. *In the blockaded entry equilibrium, banks' loan rate r_B^{eb} is smaller than the monopolistic loan rate r_B^m (characterized in Lemma A.2 of Appendix A). On the arc between banks i and $i+1$, bank i (resp. bank $i+1$) serves locations $z_i \in [0, 1/(2N)]$ (resp. $z_i \in (1/(2N), 1/N]$).*

Since the monitoring efficiency of a bank is decreasing in its lending distance, in equilibrium each bank will serve the market area in which it has better monitoring efficiency than rival banks (e.g., bank i will specialize in entrepreneurs at $z_i \in [0, 1/(2N)]$).

Banks' loan rate r_B^{eb} is smaller than r_B^m because there is effective bank competition – which is ensured by Condition (11) – that prevents banks from offering monopolistic loan rates.

Comparative statics with potential fintech entry

Proposition C.2. *With potential fintech entry, banks' loan rate r_B^{ep} is increasing in c_{F1} and N, while decreasing in c_B and q.*

A decrease in c_{F1} increases the fintech's competitiveness (i.e., increases $\overline{U}_{F1}$) and hence forces banks to decrease r_B^{ep} to protect their market areas from potential fintech entry. Reasoning in a symmetric way, a lower c_B and/or q increase the competitive advantage of banks, thereby allowing them to post a higher loan rate.

As N decreases, the arc-distance between two adjacent banks will be larger, which increases the maximal bank-borrower distance (i.e., the distance from bank i or $i+1$ to the mid location $z_i = 1/(2N)$). As a result, fully protecting banks' market areas from fintech penetration - which requires bank i to provide utility $\overline{U}_{F1}$ at the mid location $z_i = 1/(2N)$ - becomes harder and forces banks to decrease their loan rate r_B^{ep} to keep Equation (4) holding.

Comparative statics with actual fintech entry

Section 4 does not explain all the results presented in Table 1. Here we provide some supplementary explanations for this table.

Proposition C.3. *With actual fintech entry, bank i's market area (measured by x^{ea}) is decreasing in c_B, q and ι_B, increasing in c_{F1}, and independent of N.*

As c_{F1} increases, the maximum utility fintech 1 can provide will decrease (i.e., $\overline{U}_{F1}$ will decrease), thereby decreasing the fintech's competitive advantage over banks. Consequently, bank i can maintain a larger market area. Reasoning symmetrically, as c_B, q and/or ι_B increase, monitoring and/or funding will become more costly for banks, which decreases their competitive advantage over fintech 1 and thereby leads to a smaller x^{ea}.

If N decreases, the arc-distance between two adjacent banks will increase. However, the competitiveness of fintech 1 is determined by $\overline{U}_{F1}$, which does not vary with locations, so fintech 1's competitive pressure on each bank is not affected by the distance between adjacent banks in the bank-fintech competition. As a result, x^{ea} is independent of N in the case with actual fintech entry.

Proposition C.3 directly leads to the following corollary about fintech 1's market area, which is measured by $1 - 2Nx^{ea}$.

Corollary C.1. *With actual fintech entry, fintech 1's market area (measured by $1 - 2Nx^{ea}$) is increasing in c_B, q and ι_B, decreasing in c_{F1} and N.*

Parameters c_{F1}, c_B, q and ι_B affects fintech 1's market area by changing each individual bank's market area x^{ea}, which has been explained after Proposition C.3. The effect of N has been explained in Section 4 of the main text.

The following proposition characterizes banks' equilibrium loan rate r_B^{ea}.

Proposition C.4. *With actual fintech entry, banks' equilibrium loan rate r_B^{ea} is increasing in c_{F1} and ι_B, and independent of N and q. The effect of c_B on r_B^{ea} is ambiguous.*

Changing N has no effect on a bank's loan rate r_B^{ea} in the case with actual entry because fintech 1's competitive pressure (represented by $\overline{U}_{F1}$) on a bank is not affected by the distance between two adjacent banks (see the explanation of Proposition C.3).

A lower c_{F1} will increase the competitive advantage of fintech 1, which forces banks to reduce their loan rate r_B^{ea} to mitigate the fintech's expansion.

Increasing q has two competing effects on banks' pricing. First, a higher q means that banks' monitoring efficiency becomes lower, which decreases banks' competitive advantage over fintech 1. Therefore, banks should have an incentive to decrease their loan rate r_B^{ea} to protect their market areas. However, a higher q also means that extending (or maintaining) the market areas becomes harder for banks because the distance friction becomes larger. Therefore, banks have a lower incentive to extend (or maintain) their market areas, which implies a higher r_B^{ea}. The two competing effects offset each other, so r_B^{ea} is independent of q.

As banks' marginal funding cost ι_B increases, a bank's expected profit from serving an individual entrepreneur will decrease for a given loan rate. This outcome reduces a bank's marginal benefit of enlarging lending volume, which thereby induces the bank to raise its loan rate.

Increasing c_B also has two competing effects on banks' pricing strategy. First, a higher c_B decreases banks' competitive advantage over fintech 1, which should decrease banks' loan rate r_B^{ea} because banks have an incentive to protect their market area. Second, for a given r_B^{ea}, a higher c_B decreases a bank's lending profit from financing an individual entrepreneur, which reduces the marginal benefit of enlarging the bank's lending volume. As a result, a bank has the incentive to increase its loan rate (and thereby decrease its lending volume). Either effect may dominate based on our numerical study, so the net effect of c_B on r_B^{ea} is ambiguous.

Corollary C.2. *With actual fintech entry, fintech 1's average loan quality is weakly decreasing in N.*

This result has been explained in Section 4 of the main text.

Numerical result: The effects of q, c_B, c_{F1} and ι_B on fintech 1's loan quality. As q, c_B or ι_B increases, banks' competitive advantage will decrease, which enables fintech 1 to charge weakly higher loan rates, and thereby increases the fintech's monitoring incentive and loan quality. In the special case $c_{F1} = c_{F2}$, fintech 1 always offers the best loan rate $\overline{r}_{F1}$, so its loan quality is independent of q, c_B and ι_B.

As c_{F1} increases, fintech 1's loan rates may either decrease or increase. However, the fintech's overall monitoring intensity (i.e., loan quality) is determined not only by its loan rates but also by c_{F1}. Our numerical study finds that fintech 1's monitoring intensity will decrease as c_{F1} increases, even if the fintech's loan rates are increasing in c_{F1}. This means the direct cost effect of increasing c_{F1} dominates.

Corollary C.3. *With actual fintech entry and effective bank threat, fintech 1's loan rate at z_i (i.e., $r_{F1}^{comB}(z_i)$) is increasing in q, c_B, and ι_B, while it is decreasing in N. The effect of c_{F1} on $r_{F1}^{comB}(z_i)$ is ambiguous.*

When banks' threat to fintech 1 is effective at z_i (i.e., when $r_{F1}(z_i) < r_{F1}^*$ holds), a higher c_B, q or ι_B will decrease banks' competitive advantage and thereby enable fintech 1 to offer a higher loan rate $r_{F1}^{comB}(z_i)$.

Decreasing c_{F1} has an ambiguous effect on fintech 1's loan rate $r_{F1}^{comB}(z_i)$ (under effective banks' threat) because of two competing effects. First, a lower c_{F1} increases fintech 1's competitive advantage, which tends to increase $r_{F1}^{comB}(z_i)$. However, a lower c_{F1} also gives fintech 1 the incentive to decrease $r_{F1}^{comB}(z_i)$ because banks will reduce their loan rate r_B^{ea}, which implies higher banks' threat to fintech 1 in **BT** areas.

As N decreases, the arc-distance between two adjacent banks will increase, so the mid location $z_i = 1/(2N)$ becomes farther away from both banks i and $i+1$. Therefore, fintech 1's competitive advantage over banks will increase, which weakly increases $r_{F1}^{comB}(z_i)$. More specifically, $r_{F1}^{comB}(z_i)$ is not affected by a decrease in N if $z_i \in [x^{ea}, 1/(2N)]$ holds before N decreases; the reason is that r_B^{ea} is independent of N, so the competition between bank i and fintech 1 at z_i is not affected by N for a given z_i (i.e., for a given lending distance of bank i). However, if $z_i \in (1/(2N), 1/N - x^{ea}]$ holds before N decreases (i.e., at location z_i fintech 1 competes with bank $i+1$ before N decreases), a decrease in N will increase the lending distance from location z_i to bank $i+1$, which increases $r_{F1}^{comB}(z_i)$.

Internet Appendix D: Price-discriminating banks

We consider the case that both fintechs and banks can price discriminate to analyze how the properties of equilibria depend on banks' inability to discriminate. In this appendix, we assume that bank i's loan rate is also a function of location z_i.[37]

Types of equilibria. The following lemma presents the types of equilibria that may arise when banks can also price discriminate.

Lemma D.1. *A unique equilibrium exists. There exist* $\widetilde{c}_F$ *and* $\underset{\sim}{c}_F$ $(< \widetilde{c}_F)$ *such that:*

(i) If $c_{F1} \geq \widetilde{c}_F$*, then there is blockaded fintech entry.*

(ii) If $\underset{\sim}{c}_F \leq c_{F1} < \widetilde{c}_F$*, then there is potential fintech entry.*

(iii) If $c_{F1} < \underset{\sim}{c}_F$*, then there is actual fintech entry. In this case, there exists an* $\hat{x}^{ea} \in (0, 1/(2N))$ *such that fintech 1 serves locations* $z_i \in [\hat{x}^{ea}, 1/N - \hat{x}^{ea}]$ *on the arc between banks* i *and* $i+1$*; banks* i *(resp. bank* $i+1$*) serves locations* $z_i \in [0, \hat{x}^{ea})$ *(resp.* $z_i \in (1/N - \hat{x}^{ea}, 1/N]$*).*

Consistent with Proposition 1, three types of equilibria may arise depending on fintech 1's monitoring efficiency: blockaded, potential or actual entry.

If the monitoring efficiency of fintech 1 is low (i.e., if $c_{F1} \geq \widetilde{c}_F$), borrowing from the fintech implies low success probabilities, so bank competition is not affected by the presence of fintech lenders (i.e., there is blockaded fintech entry). Panel 1 of Figure D.1 illustrates the lending competition between banks i and $i+1$ in the case with blockaded entry. At each location (e.g., location z_i) on the arc between banks i and $i+1$, there is localized Bertrand competition between the two banks. Locations in a **BM** area are sufficiently close to the bank with a smaller lending distance, so this bank has a large competitive advantage in monitoring efficiency over the other lenders. Because of this advantage, the bank offers its monopolistic loan rates in this area, while the other lenders cannot provide higher utility to obtain entrepreneurs. As a result, in a **BM** area, there is no effective lending competition.[38] In a **BB** area, there is effective competition between banks i and $i+1$ because the competitive advantage of the bank with a smaller lending distance is not sufficiently large. Bank competition is most intense when the two banks

[37] When all lenders can price discriminate, there is a localized Bertrand competition at each location. In this case, assuming that banks move first will yield the same equilibrium outcomes as assuming that all lenders post loan rates simultaneously.

[38] The **BM** areas do not necessarily exist. For example, if the distance friction for banks is weak (i.e., if q is small), then bank $i+1$ can bring effective competitive pressure to bank i even at $z_i = 0$, so there are no **BM** areas.

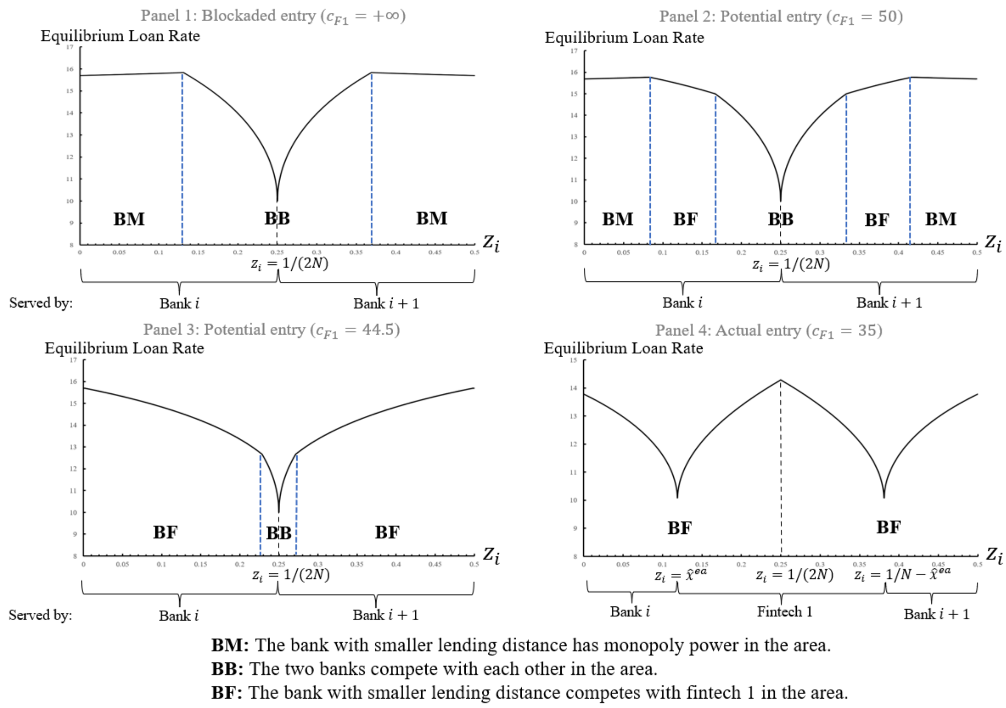

Figure D.1: Equilibrium Loan Rates on the Arc between Banks i and $i + 1$. This figure plots the equilibrium loan rate against the entrepreneurial location on the arc between banks i and $i+1$. All lenders (banks and fintechs) can price discriminate. The parameter values are $R = 20$, $\iota_B = \iota_F = 1$, $c_B = 30$, $q = 1.2$, $N = 2$, $c_{F2} = +\infty$.

have the same monitoring efficiency, so the equilibrium loan rate is lowest at the mid location $z_i = 1/(2N)$ where banks i and $i + 1$ have the same lending distance.

If the monitoring efficiency of fintech 1 is at an intermediate level (i.e., if $\underset{\sim}{c}_F \leq c_{F1} < \widetilde{c}_F$), banks can no longer behave as if the fintechs did not exist. Panel 2 of Figure D.1 illustrates this case. Compared with Panel 1, **BF** areas will arise when c_{F1} is at an intermediate level. In such an area, the bank with a smaller lending distance competes with fintech 1, rather than with the other bank, because the latter has lower monitoring efficiency than fintech 1 in this region. The bank with a smaller lending distance has higher monitoring efficiency than fintech 1 in each **BF** region, so the fintech cannot serve any entrepreneur there (i.e., there is potential entry); the equilibrium loan rates (offered by the bank with a smaller lending distance) in such an area are decreased by the presence of fintechs.[39] Note that **BM** areas may still exist in the case with potential entry, because $\overline{U}_{F1}$ may be lower than the utility provided by a bank's monopolistic loan

[39]In the case with potential entry, the bank with a smaller lending distance will provide utility $\overline{U}_{F1}$ in a **BF** area. Entrepreneurs in such an area will not approach fintech 1 because the bank has higher monitoring efficiency and can provide utility slightly higher than $\overline{U}_{F1}$.

rate if the bank's lending distance is small enough. In the **BB** area fintech 1's monitoring efficiency is lower than that of both bank i and $i+1$, so the two banks compete with each other, ignoring the presence of fintechs in this region.[40] As c_{F1} decreases further, the **BF** areas will gradually erode the **BM** and **BB** areas (Panel 3 of Figure D.1).

If fintech 1's monitoring efficiency is sufficiently good (i.e., if $c_F < \underaccent{\tilde}{c}_F$), then near the mid location $z_i = 1/(2N)$ – which is far away from both banks i and $i+1$ – the fintech's monitoring efficiency is better than that of both banks. As a result, actual fintech entry occurs with the middle region $[\hat{x}^{ea}, 1/N - \hat{x}^{ea}]$ served by fintech 1. Panel 4 of Figure D.1 provides a graphic illustration. In this case fintech 1 cuts off bank competition (i.e., each bank competes only with fintech 1), so in Panel 4, the **BB** area no longer exists.

What changes when banks can discriminate? The essential difference is that now a bank can change the loan rate for one location (e.g, z_i) without affecting its lending profits from other locations. Hence at each location, a bank can offer its "best loan rate" – which maximizes entrepreneurial utility there (a similar concept is a fintech's best loan rate; see Lemma 3) – to compete with other lenders. Lemma A.1 in Appendix A characterizes a bank's best loan rate in detail.

The following proposition compares the monitoring efficiency and loan rate of bank i with those of fintech 1 in the case with actual entry.

Proposition D.1. *With actual fintech entry, if $\iota_B = \iota_F$, then the following equations hold:*

$$\frac{c_B}{1 - q\hat{x}^{ea}} = c_{F1} \text{ and } \hat{r}_B^{ea}(\hat{x}^{ea}) = \hat{r}_{F1}(\hat{x}^{ea}) = \overline{r}_{F1}, \tag{D.1}$$

where $\hat{r}_B^{ea}(\hat{x}^{ea})$ (resp. $\hat{r}_{F1}(\hat{x}^{ea})$) is bank i's (resp. fintech 1's) loan rate at location $z_i = \hat{x}^{ea}$.

The difference between Propositions D.1 and 5 results from banks' ability to price discriminate. When bank i can discriminate, its loan rate at one location will not affect its lending profits from other locations, so both bank i and fintech 1 will offer their best loan rates at the indifference location $z_i = \hat{x}^{ea}$; meanwhile, entrepreneurs at $z_i = \hat{x}^{ea}$ are indifferent between bank i and fintech 1. Under the condition $\iota_B = \iota_F$, this can happen only if bank i and fintech 1 have the same monitoring efficiency and loan rate at $z_i = \hat{x}^{ea}$, implying Equation (D.1). Panel 4 of Figure D.1 illustrates the result.

If we do not restrict $\iota_B = \iota_F$, then Proposition D.1 leads to the following corollary.

[40]At an intersection location of **BF** and **BB** areas, fintech 1's monitoring efficiency is the same as that of the bank with a larger lending distance.

Corollary D.1. *If* $\frac{c_B}{1-\frac{1}{2N}q} < c_{F1}$ *and* $\iota_B < \iota_F$ *both hold, then actual fintech entry does not occur.*

This result means that Corollary 4 will be completely flipped if banks can price discriminate because then fintech 1's ability to discriminate no longer contributes to the fintech's competitive advantage over banks. Now actual fintech entry occurs if and only if fintech 1 has an advantage over banks in monitoring efficiency at some locations or/and in funding cost.

Comparing Propositions D.1 and 5 can yield the following corollary.

Corollary D.2. *With actual fintech entry,* $x^{ea} < \hat{x}^{ea}$ *holds.*

Corollary D.2 states that in the equilibrium with actual entry, banks will serve larger market areas when they can price discriminate than when they cannot. The intuition is straightforward: The ability to price discriminate enables banks to offer their best loan rates to compete with fintech 1, which increases the banks' competitive advantage hence enlarges their market areas.

Finally, allowing banks to price discriminate also changes the effect of fintech entry on investment, which is reflected in the following proposition.

Proposition D.2. *Total investment* I *with potential or actual fintech entry is higher than that with blockaded fintech entry.*

This proposition holds because potential or actual fintech entry will always make entrepreneurs better off if banks can price discriminate. When all lenders can price discriminate, at each location (e.g. location z_i) a localized Bertrand competition will arise. In this case, potential or actual fintech entry introduces new lenders (i.e., fintechs) to each location, which increases the intensity of lending competition and hence benefits entrepreneurs.

Note that Proposition D.2 does not require a sufficiently low c_{F2}, which is different from Proposition 7. The reason is that now banks are no longer constrained by a uniform-pricing policy, so at each location fintech 1 must face the threat of banks that are willing to offer their best loan rates. In other words, actual fintech entry cannot generate **NBT** areas that banks are not willing to serve if banks can also price discriminate.

As for the welfare effect of fintech entry in the benchmark case $\iota_B = \iota_F$, allowing banks to discriminate eliminates the welfare-reducing business stealing effect, because banks and fintech 1 have the same loan rate and monitoring efficiency at indifferent locations (Proposition D.1). Moreover, Proposition D.2 implies that potential or actual fintech entry always brings a positive investment effect when banks can price discriminate. Therefore, our numerical study finds that actual fintech entry (with c_{F1} sufficiently close to c_B) will increase social welfare if c_{F2} is sufficiently large, which avoids a strong negative monitoring effect.

Internet Appendix E: Investment and welfare when banks can exit

Banks' exit and total investment. Figure E.1 illustrates the effect of fintech entry on investment when banks can exit. In Panels 1 and 2, fintech 2 brings no competitive pressure to fintech 1, so entrepreneurs' investment will jump down whenever a bank leaves the market. Comparing Panel 1 of Figure E.1 with that of Figure 6, we can find that banks' exit completely flips the effect of actual fintech entry on total investment. In Panel 3, fintech 2 puts sufficient competitive pressure on fintech 1, so the decrease in c_{F1} increases total investment, even if the exit of banks reduces their threat to fintech 1. This means Proposition 7 is robust.

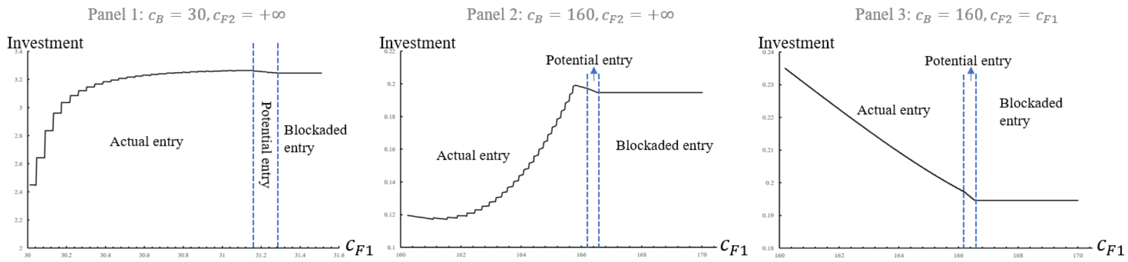

Figure E.1: Entrepreneurs' Total Investment When Banks Can Exit. This figure plots entrepreneurs' total investment I (i.e., the mass of entrepreneurs undertaking investment projects) against c_{F1}. The parameter values are: $R = 20$, $q = 1.8$ $\iota_B = \iota_F = 1$, $N^0 = 30$ and $\lambda(i) = (i-1)/N^0$ in all panels; $L = 0.1098$ in Panel 1 and $L = 1.7845 \times 10^{-4}$ in Panels 2 and 3.

Banks' exit and social welfare. When banks can exit, social welfare should be written as follows:

$$W = U_E + N\Pi_B + \Pi_F + 1_{\{N<N^0\}} \cdot \sum_{i=N+1}^{N^0} \lambda(i) L. \tag{E.1}$$

The first three terms of Equation (E.1) have been explained after Equation (8). What is special in this section is the fourth term of Equation (E.1), $1_{\{N<N^0\}} \cdot \sum_{i=N+1}^{N^0} \lambda(i) L$, which measures the total salvage value recovered by banks that leave the market at $t = 2$. $1_{\{N<N^0\}}$ is an indicator function that equals 1 (resp. 0) if $N < N^0$ (resp. $N = N^0$) holds (which means no salvage value is recovered if no bank leaves the market). If $N < N^0$, then it means banks $N+1$, $N+2$... N^0 leave the market because they have the highest salvage values; in this case the total recovered value is $\sum_{i=N+1}^{N^0} \lambda(i) L$.

Because of the fourth term of Equation (E.1), potential or actual fintech entry will generate an *option value effect*, in addition to those effects discussed in Section 6. The option value effect means that banks can protect themselves by executing the option to exit and recover salvage values as fintech entry decreases their profitability. Hence the negative effect of decreasing an individual bank's lending profit Π_B on social welfare will be mitigated. The option value effect is welfare-improving because potential or actual fintech entry transfers bank profit to other parties (entrepreneurs or/and fintech 1) and lets banks exit, which fulfills their option values.

Comparing Figures 8 and E.2 can illustrate how the option value effect makes a difference to the welfare effect of fintech entry. The only difference between the two figures is that in Figure E.2 there is a positive L, which can cause banks to exit. Because of the option value effect, social welfare (with c_{F1} sufficiently close to c_B) is significantly higher in Figure E.2 - where banks can exit and recover salvage values - than in Figure 8 where banks cannot. Comparing Panels 2 and 3 of Figure E.2 with those (counterparts) of Figure 8, we can see that a strong enough option value effect (i.e., a larger enough L) can flip the welfare effect of actual fintech entry with a sufficiently low c_{F1}.

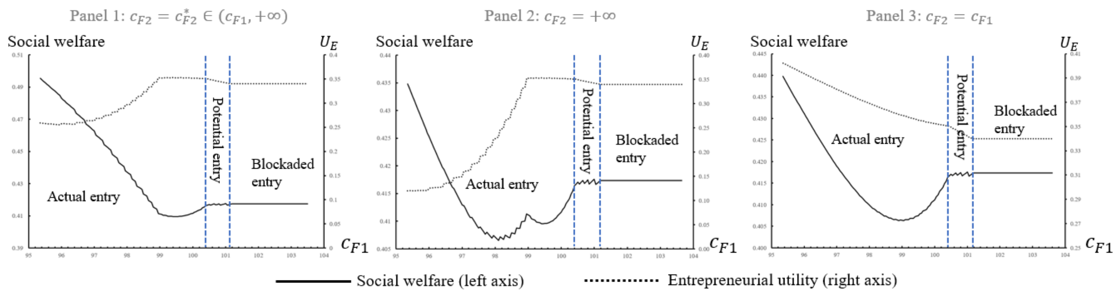

Figure E.2: Welfare Effect of c_{F1} When Banks Can Exit. This figure plots social welfare (solid curve) and entrepreneurial utility (dotted curve) against c_{F1} (from blockaded entry to actual entry). The parameter values are: $R = 20$, $q = 1.8$, $c_B = 95$, $\iota_B = \iota_F = 1$, $N^0 = 30$, $\lambda(i) = (i-1)/N^0$ and $L = 0.0026$.

Numerical Result 2 still holds when banks can exit. As fintech entry reduces the number of remaining banks N, banks' threat to fintech 1 will decrease. However, if c_{F2} is at an intermediate level, the competitiveness of fintech 2 will ensure that fintech 1's upper bound loan rate r^*_{F1} balances the investment and monitoring effects, so the decrease in banks' threat will not induce fintech 1 to charge excessively high loan rates. As a result, the cost-saving effect (together with the option value effect in this section) will increase social welfare rapidly (Panel 1 of Figure E.2).