Fintech Entry, Lending Market Competition and Welfare*

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Abstract

In a model of spatial competition, we study what drives fintech entry and how it affects competition, investment, and welfare. Fintechs with inferior monitoring efficiency can successfully enter because of their superior flexibility in pricing. Hence, 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. The entry of fintechs with high monitoring efficiency will increase social welfare if the intensity of inter-fintech competition is moderate.

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 one important development in the lending market is that FinTech and BigTech companies are playing an increasingly significant role. 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 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 of fintech entry? 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 fintech market share and quality of their borrowers (Avramidis et al., 2021; Gisbert, 2021).

- 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). Superior information technology by itself cannot explain the rise of fintech lending (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) 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. Martinez-Miera and Repullo, 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 on 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. In contrast, technology adoption and transformation to a customer-centric model are far from successful for banks because of

[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.

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.[3] 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 hence in good compliance with the law. However, non-bank lenders can bypass such regulations with the help of new technology and non-traditional data.[4] 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 analyze also what would happen if banks could also discriminate in Section 7.

In our baseline model depositors in banks are protected by (fairly priced) deposit insurance. This assumption can be relaxed as in Vives and Ye (2022). Investors in fintechs are not protected by insurance, but they can assess the risk position the fintechs take.

Under the set-up just described, we study how the emergence of fintech lenders affects the competition in the lending market and obtain results consistent with available empirical evidence.[5] 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

[3] "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).

[4] 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.

[5] Our model is best attuned to the SMEs lending market.

do not serve any entrepreneur. Finally, if fintech monitoring efficiency is good enough, banks cannot fully protect their market areas, so fintechs can lend to a positive mass of entrepreneurs, giving rise to the equilibrium with actual fintech entry.

In the equilibrium with potential entry, fintechs serve no entrepreneurs because of banks' actions. Protecting market areas from fintech penetration will be harder for banks if their competitive advantage over fintechs decreases. Hence banks must offer a lower loan rate if fintech monitoring efficiency improves relative to that of banks, or if the banking system has a higher concentration.

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 spurs more entrepreneurs to incur opportunity costs and 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 a large market power, thereby hurting entrepreneurs and reducing their investment. Therefore, the net effect of actual fintech entry on investment is ambiguous. However, if the competition among fintechs is sufficiently intense, then actual fintech entry will increase entrepreneurs' investment for sure because in this case fintechs will always provide quite 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 affect lenders' monitoring incentive, 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, then 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 whatever location if banks can break the uniform-pricing constraint; hence fintech entry must increase 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 enlarges a fintech's market power by a lot, then entrepreneurs' utility and investment will decrease. However, if the competition among fintechs is sufficiently intense, then 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 of all, our work belongs to the theoretical research that studies 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 and it is by fintechs, entities with distinct characteristics compared with banks. He et al. (2022) 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.

Our work builds on Vives and Ye (2022), where we analyze the impact of information technology on bank competition and show that the effects of an information technology improvement on competition, stability and welfare depend on whether or not it weakens the influence of bank-borrower distance on monitoring efficiency. The modeling of the return and monitoring technology are taken from that paper.

Our paper is also 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.[6] Some papers try to explain the rise of fintech lending: Philippon (2016) claims that the existing financial system's inefficiency can explain the emergence of new entrants that bring novel 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.

Some empirical studies look at the relation 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. 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 of 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

[6] 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 and cashless payment information (Ghosh et al., 2021; Ouyang, 2021) – to assess the quality of borrowers.

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 the equilibrium that obtains 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 analyzes how the properties of equilibria change when 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.[7]

2 The model

The economy and players. The economy is represented by a circular "city", of circumference 1, that 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 7 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 circle and thus equidistant from all entrepreneurs.[8] This assumption captures the idea that a fintech lender 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,

[7]Proofs are available upon request.

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

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, AI and machine learning techniques). Figure 1 gives a graphic illustration of the economy.

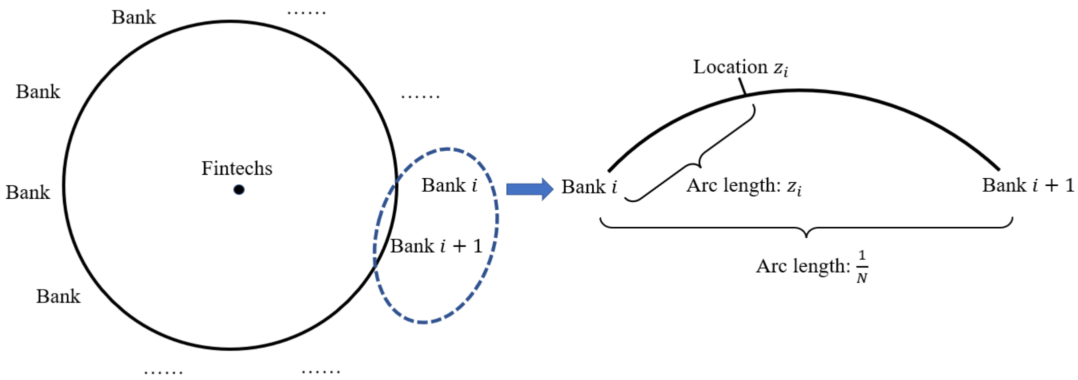

Figure 1: The Economy

A second difference is that fintech lenders, 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 rates can be contingent on entrepreneurs' locations. Specifically, we denote fintech j's ($j = \{1, 2\}$) loan rate by $r_{Fj}(z_i)$, which is a function of z_i. In Section 7 we allow banks to price discriminate to see how results will change.

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 investment projects, entrepreneurs require funding from lenders, which can be a bank or a fintech. The investment 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 call $m(z_i)$ the "monitoring intensity" of the lender.

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 $m(z_i)$, then 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 investment 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 can be written as

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

The funding costs of lenders. For simplicity, we assume that lenders have no initial capital and therefore must raise funds to finance their loans. Banks raise funds from risk-neutral depositors who are protected by a deposit insurance scheme; whenever bank i cannot fully repay depositors, a deposit insurance fund (DIF) would intervene and ensure a full repayment to depositors. The funding supply of depositors is perfectly elastic when the insured deposit rate is no less than ι_B. In exchange for the DIF's service, bank i must pay a fraction τ_i of its monetary profit to the DIF as a premium if the bank is still solvent after paying depositors.[9] We assume that τ_i is fairly determined and so based on bank i's risk (i.e., on bank i's monitoring intensity); this means bank i's expected payment to the DIF always equals the DIF's expected payment to depositors no matter how the bank chooses its monitoring intensity for entrepreneurs.

Fintechs do not have access to depositors' funding for regulatory reasons; instead, their funding is from sophisticated investors who require an expected (per-unit) return ι_F and can observe fintechs' monitoring intensities. Hence fintechs' expected return to investors is no less than ι_F regardless of how intensely fintechs monitor their entrepreneurs.

Monitoring cost. Non-pecuniary costs will be incurred when lenders monitor en-

[9] If the loan repayment a bank receives from entrepreneurs can cover its promised payment to depositors, then the bank's monetary profit is the loan repayment minus the promised deposit payment; otherwise, the bank's monetary profit is zero.

trepreneurs. Specifically, if a bank monitors an entrepreneur at z_i on the arc between banks i and $i+1$ with intensity $m(z_i)$, then the (non-pecuniary) 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 $d \geq 0$.[10] 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. 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. 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 $m(z_i)$, then the non-pecuniary monitoring cost it incurs 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.

Interpretation of monitoring. Lenders typically monitor their borrowers through information collection and covenant restrictions (Wang and Xia, 2014; Minnis and Suther-

[10] 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 $1/2$.

land, 2017; Gustafson et al., 2021). Specifically, lenders can collect entrepreneurs' data (e.g., by onsite visit or frequently requesting information) and assess whether borrowers are acting appropriately to return their loans; if not, then lenders can give warnings and suggestions, which disciplines borrowers and potentially improves their behavior. For bigtech lenders, this kind of monitoring can be conducted almost in real time due to their access to a large stock of comprehensive real-time transactional and locational data on borrowers' online activities (Chen et al., 2022). If the collected information shows the breach of covenants, then lenders can obtain control rights and directly intervene to fix borrowers' behavior.

Monitoring benefits not only lenders but also entrepreneurs; hence 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. Duquerroy et al. (2022) document that an SME borrows less if its account is reallocated from a branch with expertise in the SME's industry to one without such expertise.

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. Table 1 provides a summary of technology improvements and the corresponding effects on monitoring efficiency in banks and fintechs. Banks traditionally have dealt with soft information, which is at the basis of relationship banking. Physical bank-borrower distance impairs relationship banking, but communication technology (like videoconferencing) can reduce such impairment (i.e., decreasing q in the model). Improvements in AI, machine learning (ML), big data and credit scoring 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); AI and ML 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).[11]

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

[11]In Vives and Ye (2022) we provide a more comprehensive discussion of information technology improvements.

Table 1: Technology Improvements and Monitoring Efficiency.

Improvement of efficiency	Related technology
Decreasing c_B and c_{Fj} (improvement in processing information)	AI, ML with big/unconventional data advances in cloud storage and computing, information management software
Decreasing q (physical distance friction) (improvement in communication)	Diffusion of internet, video conferencing, smart phone, mobile apps, social media
Decreasing q (expertise friction) (extending competence of human capital/ hardening soft information)	AI, ML with big/unconventional data, credit scoring, remote learning and code sharing

after observing banks' loan rates.[12] Second, after lenders' loan rates are chosen and hence observable, each entrepreneur decides (a) whether or not to implement her project (which will incur opportunity cost $\underline{u}$) and (b) which lender to approach for funding if implementation is chosen. Given entrepreneurs' decisions and lenders' loan rates, each lender chooses its optimal monitoring intensity as a function of entrepreneurs' locations.[13] After observing the banks' monitoring intensities, the DIF determines τ_i for bank i, ensuring that the deposit insurance is fairly priced. Finally, depositors (resp. investors) put their money into banks (resp. fintechs) and ask for an expected (per-unit) return ι_B (resp. ι_F); investors can observe fintechs' monitoring intensities.

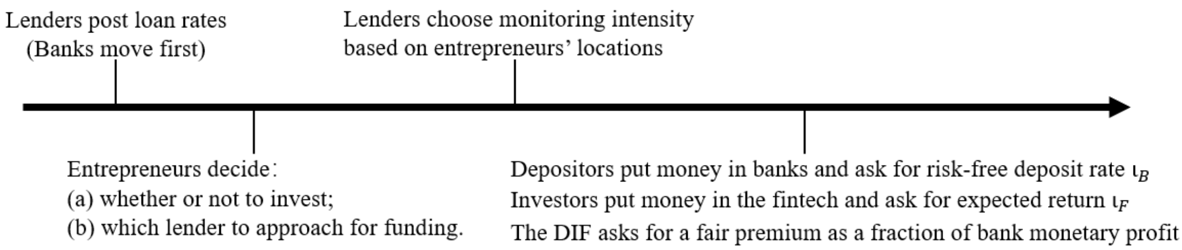

Figure 2: Timeline.

[12]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.

[13]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.

3 Equilibrium regimes

In this section we seek to establish how the fintech technology 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) whose loan rate is r_B, then 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 expected marginal cost of raising funding. Because deposits are riskless under the deposit insurance scheme, the bank need only promise a nominal return of ι_B to depositors when raising funds from them. However, the bank can fully repay depositors (and hence stay solvent) only if the total loan repayment it receives from all locations can cover the promised amount to all its depositors. The DIF assumes full repayment to depositors when the bank is insolvent. In exchange for the deposit insurance, the bank must pay the DIF a premium, which is a fraction τ_j of the bank's monetary profit if the bank is still solvent after paying depositors. The DIF fairly determines τ_j such that the bank's expected premium to the DIF exactly equals the DIF's expected payment to the banks' depositors. Therefore, bank's expected cost of raising a unit of funding is ι_B considering its direct payment to depositors and the premium to the DIF.

The third term of $\pi_B(z_i)$ represents the non-pecuniary monitoring costs of the bank that monitors 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) whose loan rate is $r_{Fj}(z_i)$ for this location, then 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 expected marginal cost of raising funds from investors. The expected funding cost equals investors' required expected return ι_F because investors can observe the fintech's risk, which means they can react according to the fintech's risk to ensure themselves an expected return ι_F. Finally, the third term represents the fintech's non-pecuniary monitoring costs.

Taking as given lenders' loan rates and entrepreneurs' decisions, a lender (a bank or a fintech) chooses its monitoring intensity at a location (e.g., location z_i) to maximize its expected profit at this location, which leads to Lemma 1.

Lemma 1. *If a bank's loan rate is r_B, then the bank's optimal monitoring intensity for entrepreneurs at z_i (on the arc between banks i and $i+1$) 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.

If fintech j offers loan rate $r_{Fj}(z_i)$ to entrepreneurs at location z_i, then its optimal monitoring intensity at this location 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 marginal benefit of increasing an entrepreneur's success probability.

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.

Entrepreneurs' decisions. According to Lemma 1, the monitoring intensities of lenders can be correctly anticipated once their loan rates are posted. An entrepreneur will approach the lender that can provide the highest expected utility. For example, 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:

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

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 care also 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 is 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 also 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 types

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.

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

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

(iii) If $c_{F1} < \underline{c}_F$, then 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 graphically illustrates how the equilibrium type and its basic properties are determined by fintech 1's monitoring efficiency.

Figure 3: Fintech Entry and the Type of Equilibrium.

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' efficiency of monitoring entrepreneurs and/or raising funds will increase. Such an efficiency improvement increases banks' competitive 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 the symmetric equilibria with a focus on the case with potential or actual entry.

4.1 Potential fintech entry

The competitiveness of fintech 1 is reflected by the entrepreneurial utility it can provide, which is characterized in the following lemma.

Lemma 3. *At any location, 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:

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

*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

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

if she approaches fintech j whose loan rate (resp. monitoring intensity) is $r_{Fj}(z_i)$ (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}; Proposition 1).

The following proposition provides the basic properties of the equilibrium with potential fintech entry.

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:*

$$\frac{r_B^{ep}(1 - \frac{q}{2N})(R - r_B^{ep})}{c_B} = \overline{U}_{F1}, \tag{3}$$

where r_B^{ep} is banks' equilibrium loan rate in the equilibrium with potential entry.

With potential fintech entry, the lending market is served only by banks. Since a bank's monitoring efficiency is decreasing in the lending distance, in equilibrium 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 entrepreneurs at $z_i \in [0, 1/(2N)]$).

Although fintechs do not serve any entrepreneur in such an equilibrium, they do affect banks' behavior. For a 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 sufficiently low such that the entrepreneurial utility provided by banks is at least $\overline{U}_{F1}$ even if the bank-borrower distance is at the maximal level $1/(2N)$, which implies Equation (3).

The following proposition provides the comparative statics of banks' loan rate r_B^{ep} in the case with potential entry.

Proposition 3. *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} makes monitoring less costly for fintech 1, which 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 (3) holding.

4.2 Actual fintech entry

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

$$\overline{U}_{F1} < \frac{\overline{r}_B(0)(R - \overline{r}_B(0))}{c_B}, \tag{4}$$

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).

Condition (4) 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 (4) 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 4 characterizes the equilibrium with actual fintech entry.

Proposition 4. *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 $c_{F1} < c_{F2}$, then 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 finance 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 $i+1$.

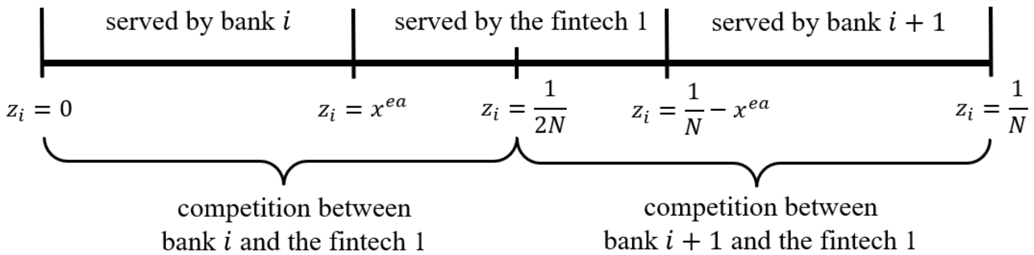

Figure 4: Competition on the Arc between Banks i and $i+1$ (Actual Entry).

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 $z_i \in [0, 1/(2N)]$ in the case with actual entry.

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*

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

where r^m_{F1} is fintech 1's monopolistic loan rate. r^*_{F1} is independent of z_i.

Lemma 4 means that the upper bound of fintech 1's loan rate (at any location) is r^*_{F1}, which 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 a location (e.g., location z_i), it will offer its monopolistic loan rate r_{F1}^m to maximize its lending profit at z_i.[14] r_{F1}^m is the highest possible loan rate fintech 1 would offer because further increasing the loan rate above r_{F1}^m reduces fintech 1's profit without making the fintech more attractive to entrepreneurs.

If c_{F2} is sufficiently low such that the expected utility provided by fintech 1's monopolistic loan rate r_{F1}^m is lower than $\overline{U}_{F2}$, then the upper bound of fintech 1's loan rate cannot be as high as r_{F1}^m. 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 5. *In the case with actual fintech entry, fintech 1's loan rate at* $z_i \in [x^{ea}, 1/N - x^{ea}]$ *is given by*

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

with

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

The pricing strategy of fintech 1 at $z_i \in [x^{ea}, 1/N - x^{ea}]$ is simple: maximizing its lending profit at this location while ensuring that entrepreneurs there do not approach any 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_B^{ea} because it is too low to ensure a non-negative lending profit for any bank. In this (Non 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. The **NBT** case will arise if and only if $(r_B^{ea})^2(1 - qd^{ea})/(2c_B) < 0$ holds, which means that at location z_i even the nearest bank (with the lending distance d^{ea}) cannot make a non-negative profit

[14]The monopolistic loan rate r_{F1}^m balances between entrepreneurs' funding demand and fintech 1's lending profit from each individual borrower at z_i, and hence is lower than R.

by financing an entrepreneur with the uniform loan rate r_B^{ea}.

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

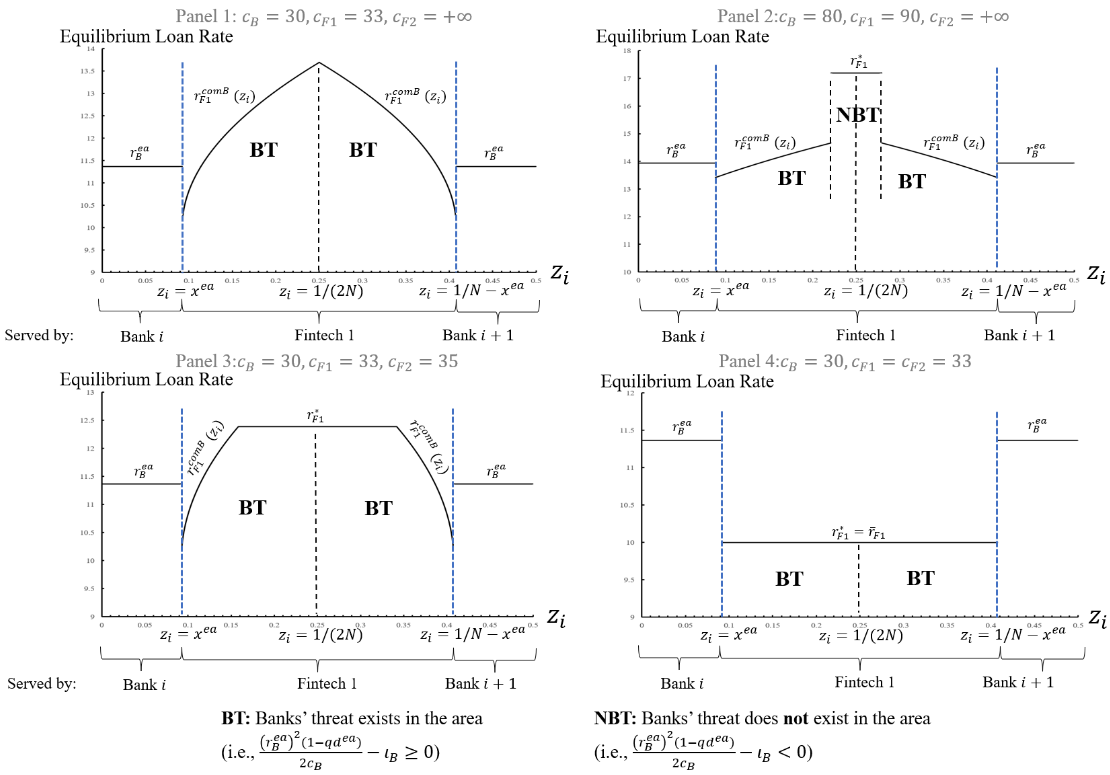

Figure 5: Equilibrium Loan Rates on the Arc between Banks i and $i+1$ (Actual Entry). This figure plots the equilibrium loan rate against the entrepreneurial location on the arc between banks i and $i+1$ when there is actual fintech entry. Fintechs can price discriminate but banks cannot. The parameter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

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_B^{ea}; fintech 1 offers $r_{F1}^{comB}(z_i)$ 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 become not willing to serve distant locations with the loan rate r_B^{ea}. 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 entrepreneurial utility than banks' loan rate r_B^{ea} at locations near $z_i = 1/(2N)$. For such locations, fintech 1 offers the upper bound loan rate 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. 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 exists but is not effective in fintechs' market area.

The following corollary shows how fintech 1's loan rate $r_{F1}(z_i)$ varies with z_i.

Corollary 2. *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 $z_i = 1/N - x^{ea}$), $r_{F1}(z_i) = \overline{r}_{F1}$.*[15]

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.[16] 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.

[15] 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.

[16] 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 6 sheds lights on the question.

Proposition 6. *With actual fintech entry, if no lender has an advantage in funding cost $\iota_B = \iota_F$, at the indifference location $z_i = x^{ea}$ fintech 1 has a higher cost of monitoring and a lower loan rate:*

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

Under $\iota_B = \iota_F$, the inequality $c_B/(1 - qx^{ea}) < c_{F1}$ in Proposition 6 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 6 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, because 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 $r_B^{ea} > r_{F1}(x^{ea})$. 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. Proposition 6 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:

$$m_B(x^{ea}) = \frac{r_B^{ea}(1 - qx^{ea})}{c_B} > m_{F1}(x^{ea}) = \frac{r_{F1}(x^{ea})}{c_{F1}}, \tag{5}$$

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 (5) 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.[17]

Proposition 6 directly leads to the following corollary.

Corollary 3. *Actual fintech entry can occur even if fintech 1 has no advantage in either monitoring efficiency or funding cost (i.e., even if both $\frac{c_B}{1-\frac{1}{2N}q} < c_{F1}$ 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 $\frac{c_B}{1-\frac{1}{2N}q}$ 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.[18] Therefore, Corollary 3 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 6. 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 cost.

Comparative statics with actual entry. First, we look at how x^{ea}, which measures the market area served by an individual bank, varies with different parameters.

Proposition 7. *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}.

[17] Chava et al. (2021) provide a 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.

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

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

Corollary 4. *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 7.[19] A decrease in N has no effect on x^{ea} but increases the arc-distance between two adjacent banks, which widens the region where fintech 1 has a competitive advantage over banks. Consequently, less (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) who find that FinTech/BigTech platforms lend more in economies with a less competitive banking system.[20]

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

Proposition 8. *With actual fintech entry, banks' equilibrium loan rate r_B^{ea} is increasing in c_{F1} and independent of N.*

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 7).

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. Note that 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 improves (by decreasing c_{F1}); this is in line with Blickle et al. (2021) who document that bank specialization is associated with more favorable

[19]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.

[20]Similarly, Hau et al. (2021) document that Ant Financial extends more credit lines in China's rural areas with less 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.

loan rates, especially when the threat of non-banks or other sources of credit is high. The effects of other parameters on r_B^{ea} are displayed in Table 2.

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:

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

where $D\left(z_i\right)$, defined in Equation (1), is fintech 1's lending volume (i.e., the mass of the entrepreneurs undertaking projects) at z_i. The following corollary provides a property of fintech 1's average loan quality.

Corollary 5. *In the case with actual fintech entry, fintech 1's average loan quality is weakly decreasing in N.*

A smaller N implies that the arc-distance between adjacent banks becomes larger, so there are more locations that are 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 closings, which can be viewed as a decrease in N.

Table 2 summarizes the comparative statics results in the case with actual entry.

Table 2: 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.

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).[21]

5 Fintech entry and entrepreneurs' investment

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

$$I \equiv N \int_{0}^{1/N} D(z_i) dz_i, \tag{6}$$

where $D(z_i)$, defined in Equation (1), is the funding demand (which equals the mass of the entrepreneurs undertaking projects) 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; this spurs more entrepreneurs to undertake investment projects. We summarize the result as follows.

Proposition 9. *Potential fintech entry increases total investment I, in which case it is decreasing in c_{F1}.*

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 10. *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.*

[21] 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.

To better explain the result, we consider first a more general case with no restriction on c_{F2}. 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 5); 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 fintech 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}.

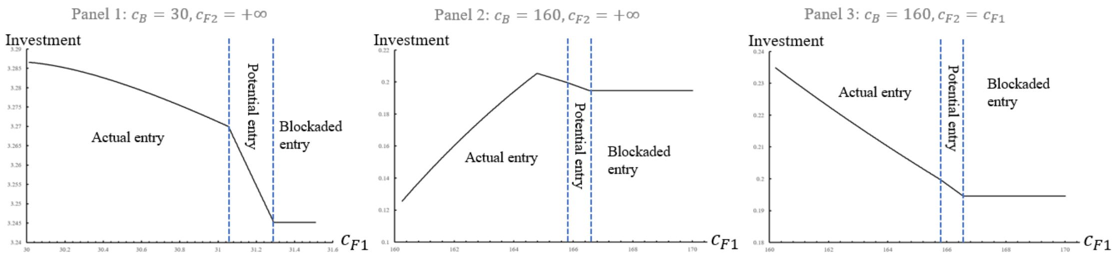

Figure 6: Entrepreneurs' Total Investment. This figure plots entrepreneurs' total investment I (i.e., the mass of entrepreneurs undertaking investment projects) against c_{F1}. The parameter values are: $R = 20$, $q = 1.8$ $\iota_B = \iota_F = 1$, $N = 30$.

Figure 6 illustrates the effect of fintech entry on total investment I. Consistent with Proposition 9, in all three panels potential fintech entry increases total investment. 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 that banks are not willing to serve. 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, in Panel 1 total investment becomes higher after actual fintech entry even if $c_{F2} = +\infty$. 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 (4) - which ensures that fintech entry cannot drive out banks - is reduced to $c_{F1} > c_B$. Social welfare can be written as follows:

$$W = U_E + N\Pi_B + \Pi_F. \tag{7}$$

The first term U_E of Equation (7) 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, then obviously $\Pi_F = 0$.

On the arc between banks i and $i+1$, denote the loan rate and monitoring intensity at location z_i by $r(z_i)$ and $m(z_i)$ respectively; denote the marginal funding cost of the lender serving location z_i by $\iota(z_i)$ (which is either ι_B or ι_F depending on the type of the lender); 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 (7) can be reorganized as follows:

$$W = N\int_0^{1/N} \left(\underbrace{D(z_i)}_{\text{investment at } z_i} \left(\overbrace{m(z_i)R}^{\text{expected project value}} - \overbrace{\iota(z_i)}^{\text{funding cost}} - \overbrace{C(z_i)}^{\text{monitoring cost}} \right) - \underbrace{\int_0^{D(z_i)} \underline{u}\, d\underline{u}}_{\text{opportunity cost at } z_i} \right) dz_i. \tag{8}$$

Equation (8) 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 $\underline{c}_F \leq c_{F1} < \overline{c}_F$. 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. In the case with potential fintech 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, thereby decreasing the success probabilities of implemented projects. In the case with potential entry the presence of fintechs decreases banks' loan rate, hence generating a welfare-reducing monitoring effect.

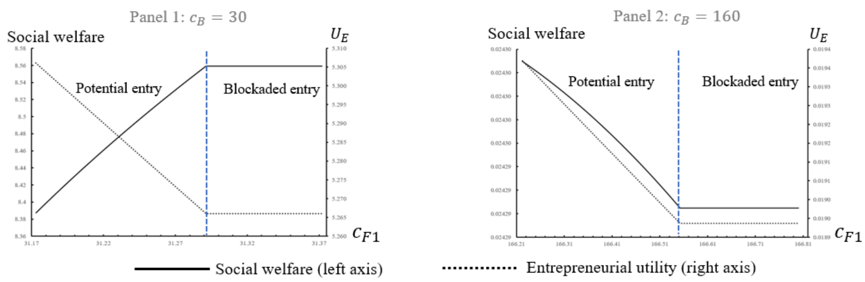

Figure 7: Welfare Effect of c_{F1} (from Blockaded Entry to Potential Entry). This figure plots social welfare (solid curve) and entrepreneurial utility (dotted curve) against c_{F1} when there is blockaded or potential fintech entry. The parameter values are: $R = 20$, $q = 1.8$ $\iota_B = \iota_F =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

The net effect of potential fintech entry depends on which effect dominates. The following numerical result characterizes the net effect.

Numerical Result 1. [22] *Potential fintech entry increases social welfare (i.e., it is decreasing in c_{F1}) 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. The intensity of bank competition and entrepreneurs' investment thus 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, thereby increasing social welfare (Panel 2 of Figure 7). In contrast, if c_B and q are not sufficiently large (Panel 1 of Figure 7), then there is sufficient bank 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.

The direction of the investment effect is ambiguous when there is actual entry. At a location served by banks, investment will be spurred because actual fintech entry forces banks to provide higher utility to entrepreneurs. However, at a location 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 high market power and generating a welfare-reducing investment effect. If fintech 1 serves only quite a small market area, then the investment-spurring effect in banks' market areas will dominate.

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.[23] If fintech 1 serves

[22] 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.

[23] Decreasing c_{F1} has an ambiguous effect on fintech 1's loan rate (see Table 2). 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

only a small market area, then the monitoring-reducing effect in banks' market areas will dominate.

In addition to the two aforementioned effects, actual fintech entry brings *cost-saving* and *business stealing* effects.

Cost-saving effect: a smaller c_{F1} renders monitoring cheaper for fintech 1, so it can monitor entrepreneurs more efficiently, which improves 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. 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 near indifference locations banks make higher profits and have better monitoring efficiency than fintech 1 does (see Proposition 6).

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. [24] *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.*[25]

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 efficiency improvement generates a strong cost-saving effect. Because of the cost-saving

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reduce their loan rate r_B^{ea}, which implies higher banks' threat to fintech 1 in **BT** areas.

[24] 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.

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

$$\left.\frac{R+\sqrt{R^2-4c_{F1}\overline{U}_{F2}}}{2}\right|_{c_{F2}=c_{F2}^*}=\frac{2R^2+4c_{F1}\iota_F+\sqrt{\left(2R^2+4c_{F1}\iota_F\right)^2-24c_{F1}\iota_F R^2}}{6R}. \tag{9}$$

Equation (9) 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. See Vives and Ye (2022) for more details about socially optimal loan rates of price-discriminatory lenders.

effect, social welfare will increase unless the entry reduces entrepreneurs' investment or lenders' monitoring incentive by too much. 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.

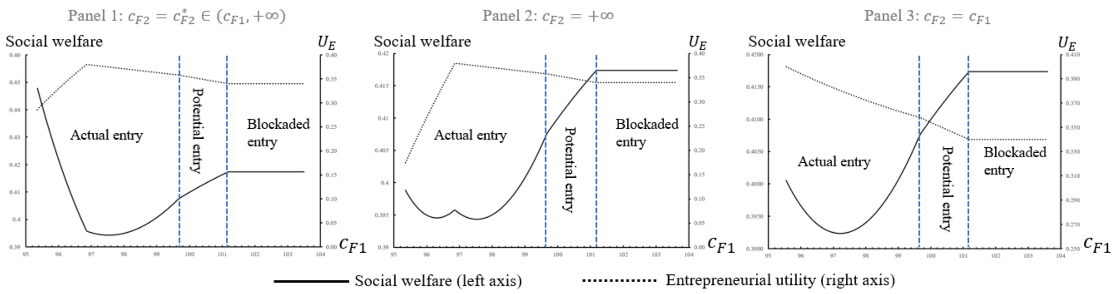

Figure 8: Welfare Effect of c_{F1}. This figure plots social welfare (solid curve) and entrepreneurial utility (dotted curve) against c_{F1} (from blockaded entry to actual entry). The parameter values are: $R = 20$, $q = 1.8$, $c_B = 95$, $N = 30$ and $\iota_B = \iota_F = 1$.

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 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, and actual fintech entry balances 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 actual fintech entry (with c_{F1} sufficiently close to c_B) generates a strong welfare-reducing investment effect, which weakens the cost-saving effect.[26] As a result, social welfare (with c_{F1} close to c_B)

[26]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 will arise and become wider as c_{F1} further decreases. Since $c_{F2} = +\infty$ in this panel, entrepreneurial utility will decrease very rapidly as **NBT** areas become wider, which causes the kink and weakens the cost-saving effect.

is lower than that with blockaded entry. A similar result arises in Panel 3 where c_{F2} is low, because the cost-saving effect is weakened by a strong negative monitoring effect.

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 3 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 3: 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".

7 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. Only in this section we assume that bank i's loan rate is also a function of location z_i.[27]

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

Lemma 5. *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.

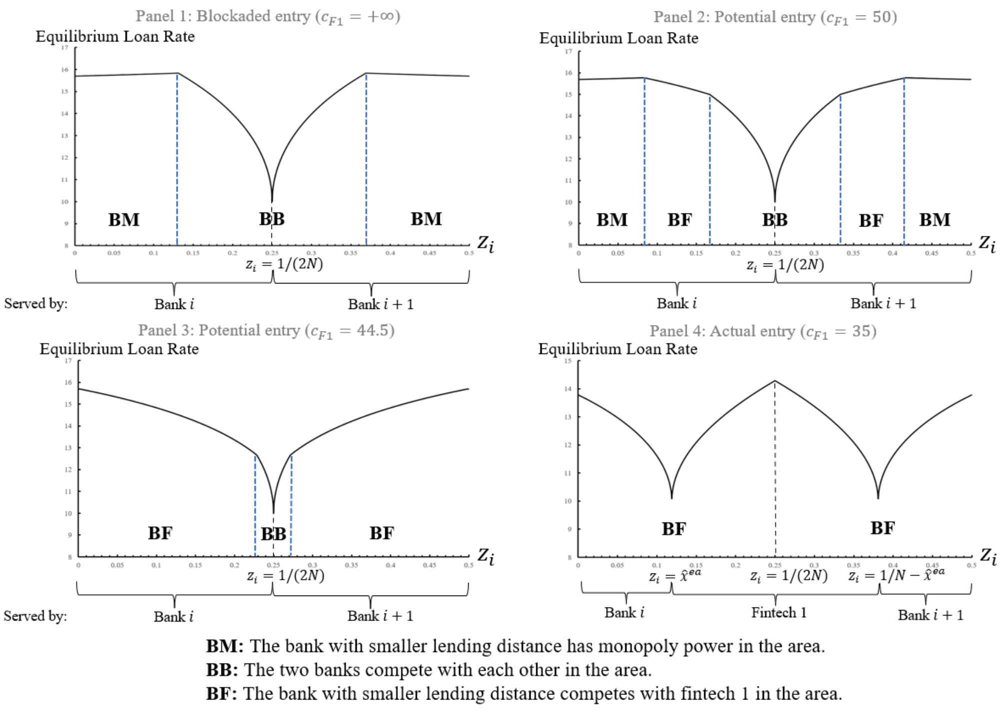

Figure 9: Equilibrium Loan Rates on the Arc between Banks i and $i+1$. This figure plots the equilibrium loan rate against the entrepreneurial location on the arc between banks i and $i+1$. All lenders (banks and fintechs) can price discriminate. The parameter values are $R = 20$, $\iota_B = \iota_F = 1$, $c_B = 30$, $q = 1.2$, $N = 2$, $c_{F2} = +\infty$.

[27] 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.

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 9 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 obtains entrepreneurs. As a result, in a **BM** area there does not exist effective lending competition.[28] 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 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 9 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.[29] 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 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.[30] As c_{F1} decreases further, the **BF**

[28]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.

[29]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 $\overline{U}_{F1}$.

[30]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.

areas will gradually erode the **BM** and **BB** areas (Panel 3 of Figure 9).

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 9 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.

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

$$\frac{c_B}{1 - q\hat{x}^{ea}} = c_{F1} \text{ and } \hat{r}_B^{ea}(\hat{x}^{ea}) = \hat{r}_{F1}(\hat{x}^{ea}) = \overline{r}_{F1}, \tag{10}$$

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 11 and 6 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 (10). Panel 4 of Figure 9 illustrates the result.

If we do not restrict $\iota_B = \iota_F$, then Proposition 11 leads to the following corollary.

Corollary 6. *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 3 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 11 and 6 can yield following corollary.

Corollary 7. *With actual fintech entry, $x^{ea} < \hat{x}^{ea}$ holds.*

Corollary 7 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 12. *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 12 does not require a sufficiently low c_{F2}, which is different from Proposition 10. 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 10). Moreover, Proposition 12 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.[31]

[31] 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 improves social welfare more than under the latter weaker condition.

Summary: When banks can also price discriminate, 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 11 and Corollary 6), which flips Proposition 6 and Corollary 3. The ability to discriminate increases banks' competitive advantage (relative to fintech 1), and hence enables banks to serve larger market areas (Corollary 7). Finally, potential or actual fintech entry will always increase total investment when banks can price discriminate, because then **NBT** areas will not arise (Proposition 12).

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 10). At $t = 0$, there are $N^0 \geq 3$ banks (incumbents) in the lending market.[32] 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, which means that different banks have different 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 technology 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).

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 11 illustrates how banks' equilibrium loan rate and the number of remaining

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

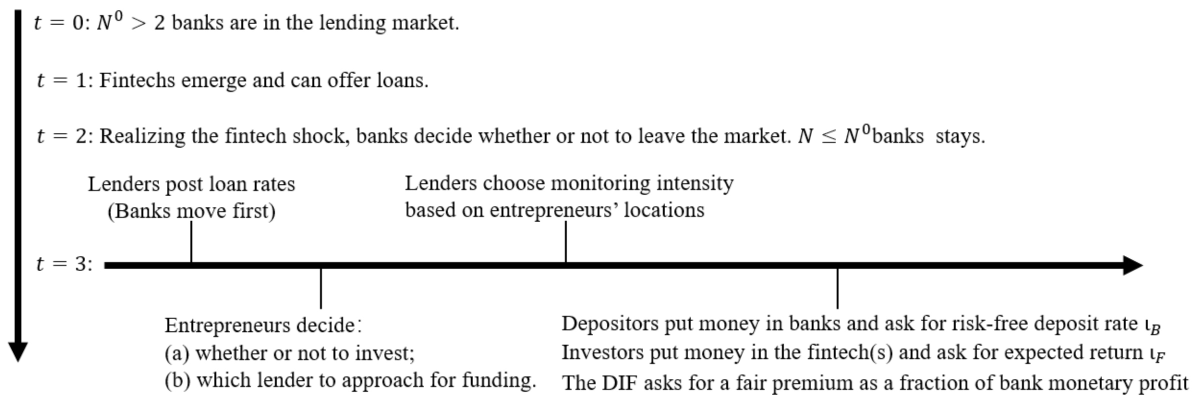

Figure 10: Timeline in the Long Run.

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 in this case with blockaded entry. 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 11), inducing a decrease in N. Since N is an integer, its variation must be discontinuous. The discontinuous decrease in N (caused by a decrease in c_{F1}) will induce banks' loan rate to discontinuously jump down in the case with potential fintech entry for the reason explained after Proposition 3. 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 (Proposition 8).

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.

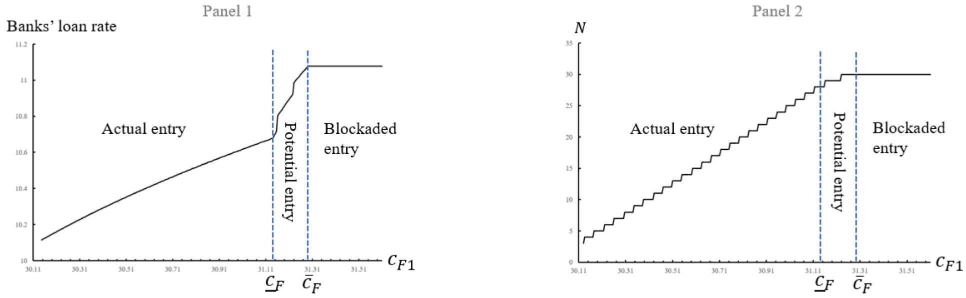

Figure 11: **Fintech Entry and Banks' Behavior.** This figure plots how the type of the equilibrium, banks' equilibrium loan rate and the number of bank N vary with c_F. The parameter values are $R = 20$, $\iota_B = \iota_F = 1$, $c_B = 30$, $q = 1.8$, $N^0 = 30$, $L = 0.1098$ and $\lambda(i) = (i-1)/N^0$.

Figure 12 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 12 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.

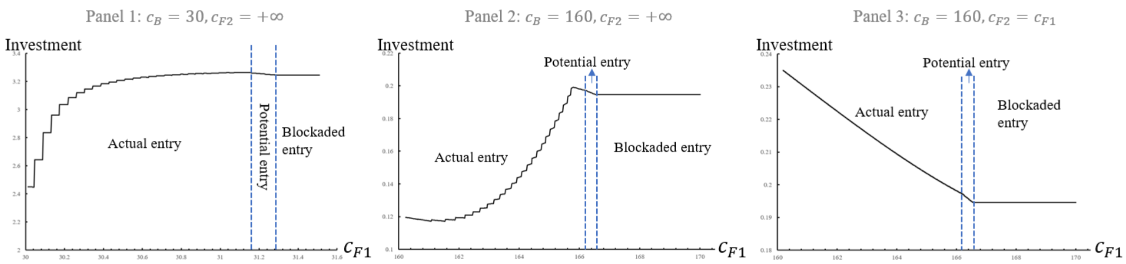

Figure 12: **Entrepreneurs' Total Investment When Banks Can Exit.** This figure plots entrepreneurs' total investment I (i.e., the mass of entrepreneurs undertaking investment projects) against c_{F1}. The parameter values are: $R = 20$, $q = 1.8$ $\iota_B = \iota_F = 1$, $N^0 = 30$ and $\lambda(i) = (i-1)/N^0$ 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. In this section social welfare should be written as follows:

$$W = U_E + N\Pi_B + \Pi_F + 1_{\{N<N^0\}} \cdot \sum_{i=N+1}^{N^0} \lambda(i)\, L. \tag{11}$$

The first three terms of Equation (11) have been explained after Equation (7). What is special in this section is the fourth term of Equation (11), $1_{\{N<N^0\}} \cdot \sum_{i=N+1}^{N^0} \lambda(i) L$, 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 (11), 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 13 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 13 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 13 - where banks can exit and recover salvage values - than in Figure 8 where banks cannot. Comparing Panels 2 and 3 of Figure 13 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}.

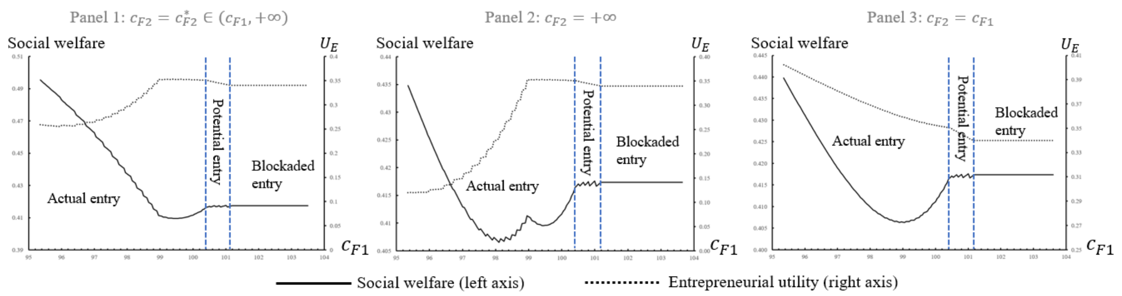

Figure 13: Welfare Effect of c_{F1} When Banks Can Exit. This figure plots social welfare (solid curve) and entrepreneurial utility (dotted curve) against c_{F1} (from blockaded entry to actual entry). The parameter values are: $R = 20$, $q = 1.8$, $c_B = 95$, $\iota_B = \iota_F = 1$, $N^0 = 30$, $\lambda(i) = (i-1)/N^0$ 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 13).

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 lights on the debate about whether or not fintech entry is driven by superior information technology. If banks can also price discriminate, then 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. This result does not hold if banks can also price discriminate.

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 in general 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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