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Fintech entry, lending market competition, and welfare☆

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A B S T R A C T

We provide a spatial framework to study competition between banks and fintechs in the lending market and examine the impact on investment and welfare. Based on the key differences between banks and fintechs, we derive results consistent with the empirical evidence available. We find that fintechs with inferior monitoring efficiency can successfully enter because of their superior flexibility in pricing and that higher bank concentration leads to higher fintech loan volume. If fintechs and banks have similar funding costs, fintech borrowers pay lower loan rates and have higher default rates than bank borrowers with similar characteristics; however, the result will flip if fintechs have much higher funding costs than banks. The advantage of fintechs in offering convenience can also induce them to charge higher loan rates than banks. Fintech entry will improve welfare if fintechs have high monitoring efficiency and inter-fintech competition intensity is intermediate. Fintech entry may induce banks' exit and reduce investment; however, it will increase investment if inter-fintech competition is intense enough.

1. Introduction

In recent years, FinTech and BigTech companies have played an increasingly significant role in the lending market. FinTech lenders have made inroads in lending to small and medium enterprises (SMEs) in developed economies. In emerging and developing markets, BigTech companies have a relevant penetration.[1]

What are the determinants of the entry of Fin/BigTech lenders ("fintechs" hereafter)? How does fintech entry affect lending competition, the behavior of traditional banks, and entrepreneurs' investment? What are the welfare implications? To answer those questions and to help explain some facts about fintech lending, we build a model of spatial competition in which incumbent banks and entering fintechs compete to provide loans to entrepreneurs. We highlight three potential key differences between incumbent banks and fintechs, concerning pricing flexibility, monitoring efficiency depending on specialization, and cost of funding. We also look at the effect of convenience for fintech customers.

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 distributed along the city. By incurring opportunity costs, entrepreneurs can undertake risky investment projects, which may either succeed or

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[1] In the US, the Federal Reserve's Small Business Credit Survey (2019) reports that almost one-third of SMEs that sought financing applied with a FinTech firm or online lender, up from 19% in 2016. The annual growth rate of FinTech business lending volume in the US was over 40% from 2016 to 2020 (Berg et al., 2022). In China, Ant Financial and WeBank provide lending to millions of SMEs (Frost et al., 2019). The COVID-19 pandemic likely accelerated the penetration of FinTech/BigTech firms because of government support (e.g., cooperation with SBA to distribute PPP loans) and the increasing demand for digital services (Demirgüç-Kunt et al., 2021).

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fail. Entrepreneurs do not have 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, lenders monitor entrepreneurs to increase the success probabilities of their projects. Monitoring is more costly for a bank if there is more “distance” between the bank and the monitored entrepreneur. This distance can be physical[2] or in a characteristics space from the expertise of the bank in certain sectors or industries.[3] Fintechs, however, are equidistant from all entrepreneurs, which captures the idea that the use of digital technology by a fintech lender makes its monitoring efficiency independent of the physical lender–borrower distance or its expertise in certain sectors or industries. Banks are incumbents and post uniform loan rates first in the lending competition, while fintechs are entrants, moving second and posting discriminatory loan rate schedules based on entrepreneurs’ locations.

Fintechs can price more flexibly for two reasons. First, fintechs are better able to fine-tune pricing to borrowers’ characteristics due to their higher capacity to process data and less rigid internal procedures. For example, Buchak et al. (2018) find that standard variables for predicting interest rates explain less variation in mortgage interest rates of fintech lenders relative to non-fintech lenders, indicating that technology-based pricing uses non-standard methods and is more dispersed. Jagtiani and Lemieux (2019) show that fintechs adopt alternative data to price credit and that fintech pricing (for borrowers with different FICO scores) is more dispersed than bank pricing. Fuster et al. (2022), in a hypothetical exercise, show that using machine learning increases the loan rate disparity among borrowers.[4] Johnson et al. (2023) find that in the US personal loan market, fintechs charge much higher interest rates for nonprime borrowers than for prime borrowers with similar default risk, indicating significant discrimination that is unrelated to credit risk.[5]

Second, lenders face regulations about discrimination, and different types of lenders may vary in their risk aversion with respect to these regulations.[6] In particular, banks may be more cautious about price discrimination than fintechs because the former are more scrutinized and have more to lose (e.g., deposit franchise) after customer or regulatory complaints. In addition, banks must curb the flexibility of local branches’ (or officers’) behavior to avoid operational and legal risks.[7] However, fintechs typically do not have physical branches and use more opaque technologies, making enforcing compliance with regulations more difficult.[8] 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. However, in Section 7, we also analyze what would happen if banks could discriminate as fintechs.

With the setup just described, we study how the emergence of fintech lenders affects competition in the lending market and obtain results consistent with available empirical evidence. Our model is best attuned to the SME lending market. We find that three types of equilibria may arise depending on the monitoring efficiency of fintechs: blockaded entry (BE), potential entry (PE), and actual entry (AE). In the BE regime, which occurs when fintech monitoring efficiency is very low, fintechs cannot make any difference to the lending market. If fintech monitoring efficiency is at an intermediate level, the PE regime will be obtained, where banks decrease their loan rates to protect their market areas from fintech penetration. As a result, fintechs 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 AE regime.

When actual entry occurs, fintechs lend to entrepreneurs sufficiently far from all banks. Fintechs will serve larger market areas and have higher lending volumes when the bank concentration is higher because there are more locations distant from all banks. A borrower will receive a (weakly) lower fintech loan rate if she is closer to banks.

The competitive advantage of fintechs will increase if their monitoring efficiency improves relative to that of banks. Then, fintechs will serve larger market areas and force banks to lower loan rates. When fintech monitoring efficiency is sufficiently high, a bank’s uniform loan rate will be so low that serving distant locations is unprofitable. In this case, banks are unwilling to serve locations far from them, so fintechs can potentially gain augmented market power and charge very high loan rates at those locations.

Fintechs’ ability to price discriminate contributes to their competitive advantage. In bank-fintech competition, a bank worries that lowering its loan rate at one location will decrease its profits from all other locations. In contrast, the fintech does not have such concerns since it can offer discriminatory loan rates based on location. Therefore, fintechs can penetrate the credit market by offering very low loan rates at specific locations, implying that actual fintech entry can occur even if fintechs have no advantage over banks in monitoring efficiency or funding costs.

When a bank and a fintech have the same funding cost and serve borrowers at close locations, the fintech’s advantage in discrimination allows it to offer lower loan rates and exert less monitoring effort than the bank. Therefore, fintech borrowers have lower success probabilities (i.e., higher default rates) than bank borrowers with similar characteristics. However, if the fintech has much higher funding costs than the bank, the result will flip: The fintech will increase its loan rate above the bank rate, concentrate on smaller market areas, and do more monitoring than the bank.

If fintech lending can provide borrowers with significant convenience benefits, banks will face higher competitive pressure and concentrate on serving nearby market areas where they have high monitoring efficiency. As a result, banks will charge lower loan rates and do more monitoring than fintechs when serving entrepreneurs of similar characteristics.

Potential fintech entry forces banks to protect their market areas with a lower loan rate, which benefits all entrepreneurs and thereby increases their 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 tends to spur investment. On the other hand, actual entry decreases

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

[3] Blickle et al. (2025) find that a bank “specializes” by concentrating its lending into one industry about which the bank has better knowledge. Paravisini et al. (2023) document that exporters to a given country are more likely to be financed by a bank that has better expertise in the country.

[4] De Roure et al. (2022) shows that Auxmoney – the largest P2P lender in Germany – has a higher standard deviation of risk-adjusted interest rates than banks. Ueda et al. (2023) find that fintechs charge higher (resp. lower) loan rates than banks for subprime (resp. prime) borrowers, indicating that fintech pricing is more dispersed.

[5] Note, however, that Johnson et al. (2023) consider fintech pricing to be “LowTech” as it remains heavily based on FICO scores. Di Maggio and Yao (2021) also find that in the US personal loan market, fintech pricing heavily relies on traditional hard information, rather than alternative data.

[6] US Courts have established that practices aimed at statistical discrimination that go beyond credit risk assessment are not legal (Morse and Pence, 2021). In our model, lenders have a profit motive but not a credit assessment motive to price discriminate. Discrimination is based on firm characteristics that are not directly related to credit risk.

[7] In a related vein, Begenau and Stafford (2023) show that US banks – in particular large ones – adopt uniform deposit rate setting policy across different branches.

[8] 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.

banks' uniform loan rate, potentially making it unprofitable for banks to serve distant locations. At such locations, banks' competitive threat disappears, so fintechs may gain elevated market power, hurting entrepreneurs and reducing their investment. Therefore, the net effect of actual entry on investment is ambiguous. However, if competition among fintechs is sufficiently intense, actual entry will increase entrepreneurs' investment.

Social welfare equals the net expected value of implemented projects, which is determined by (a) the mass of projects implemented by entrepreneurs (i.e., total investment), (b) their success probabilities (determined by lender monitoring), and (c) the social costs (monitoring, funding, and opportunity costs). If a fintech has high monitoring efficiency (compared to banks), its actual entry will improve the monitoring efficiency of the market, generating a cost-saving effect. Social welfare may either increase because of the cost-saving effect or decrease if entry substantially reduces entrepreneurs' investment or lenders' monitoring. If the inter-fintech competition intensity is at an intermediate level, the entry of fintechs with high monitoring efficiency will increase social welfare because it generates a significant cost-saving effect while balancing 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 areas served by fintechs will be smaller because allowing banks to price discriminate increases their competitive advantage over fintechs. Third, potential or actual fintech entry always makes entrepreneurs better off and increases their investment. The reason is that banks' competitive threat will not disappear at any location if they can break the uniform-pricing constraint; hence, fintech entry always increases the competition intensity among lenders. Finally, we find that allowing banks to price discriminate has ambiguous welfare consequences. In any case, lenders' equilibrium discriminatory pricing cannot achieve optimal welfare. Rates by banks or fintechs will be too high from the social point of view when either of them wields a high degree of market power and may be too low otherwise.

In the long run, fintech entry can induce banks to leave the market and recover their salvage values, which reduces banks' competitive threat and makes actual fintech entry easier to occur. If such a reduction in banks' threat substantially raises fintechs' market power, entrepreneurs' utility and investment will decrease. However, if competition among fintechs is sufficiently intense, fintech entry will increase investment.

Related literature. Our work belongs to the theoretical research on lending competition (see, e.g., Hauswald and Marquez, 2003, 2006) but has a focus on monitoring and how a new entrant affects competition.

He et al. (2023) and Goldstein et al. (2023) study 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 intensity of lending competition and social welfare. Unlike those two papers, we focus on what drives fintech entry and its equilibrium consequences.

Several papers study competition between lenders with different characteristics (e.g., Dell'Ariccia and Marquez, 2004; Bouvard et al., 2022; Blickle et al., 2024).[9] Unlike those papers, our model considers bank-fintech differences in the flexibility of pricing, funding costs, monitoring technology, and the ability to provide convenience.

Vives and Ye (2025) analyze the impact of information technology on lender competition, investment, and welfare, and show that the effects depend on whether it weakens the influence of lender–borrower distance on monitoring efficiency. That paper follows Holmstrom and Tirole (1997) with monitoring reducing borrowers' private benefits from shirking. The present paper – building on Allen et al. (2011) and Martinez-Miera and Repullo (2017), assumes that lender monitoring can increase the success probability of entrepreneurs' projects.

Our paper is related to the thriving empirical literature on the rise of fintech in lending (see Vives, 2019 and Thakor, 2020 for surveys). There is considerable evidence showing that fintech lenders can use digital technology and non-traditional data to enter the lending market.[10] Our model captures this by assuming that fintechs' monitoring efficiency is not affected by lending distance or lender expertise in a certain industry. Another stylized fact is that 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), which is consistent with our model prediction.

Buchak et al. (2018), Fuster et al. (2019), and Liu et al. (2024) find that fin/big tech lenders' advantage in offering convenience is a key reason for their popularity. We find that a large advantage in offering convenience induces fintechs to charge higher loan rates than banks (controlling for borrowers' characteristics), which is consistent with the empirical evidence.[11]

Some empirical studies look at the relationship between bank lending and fintech credit. Gopal and Schnabl (2022) and Eça et al. (2022) find a substitute relationship between bank and fintech credit. In contrast, Hau et al. (2024) and Cornelli et al. (2024) document that fintech lending complements traditional lending by extending credit to SMEs that were less likely to receive credit from banks. Our model shows that actual fintech entry will erode the market area served by banks, indicating a substitution relation; however, if banks have local monopolies, fintechs will complement banks by lending to those previously underserved borrowers.

Whether or not fintech loans are riskier is an important question in the literature. Di Maggio and Yao (2021) find that fintech borrowers are more likely to default than bank borrowers after controlling for observable characteristics.[12] However, Buchak et al. (2018) document that fintech borrowers have very similar default rates as traditional bank borrowers. Fuster et al. (2019) find that fintech-originated loans have lower delinquency rates than bank loans in the US mortgage market. Liu et al. (2024) find that the overdue rate of bigtech loans is substantially lower than that of regular loans taken out by the same set of borrowers. Our model shows that the relationship between fintech loan risk and bank loan risk (controlling for borrower characteristics) is ambiguous and depends on the interplay of fintechs' advantage to discriminate and offer convenience and their disadvantage in funding costs, thus providing a way to reconcile mixed empirical findings.

The rest of our paper proceeds as follows: Section 2 presents the model set-up. In Section 3, we examine lenders' monitoring choices

[9] Dell'Ariccia and Marquez (2004) study the competition between an informed lender and an uninformed one with lower funding costs. Bouvard et al. (2022) study what drives the entry of a BigTech platform into a fully competitive lending market. Parlour et al. (2022) study how a bank competes with competitive fintechs for payment flows that contain borrowers' credit information. Huang (2023) studies credit market competition where banks and fintechs differ in their lending technologies: fintechs learn from data, while banks rely on physical collateral. Hu and Zryumov (2024) study bank-fintech competition and collaboration when banks can provide funding to fintechs. Blickle et al. (2024) analyze the competition between a general lender and a specialized one.

[10] Such as soft information (Iyer et al., 2016), contract terms (Kawai et al., 2022) digital footprints (Berg et al., 2020) and cashless payment information (Ghosh et al., 2022) – to assess the quality of borrowers.

[11] Fuster et al. (2019) find that fintechs charge lower interest rates than non-fintech lenders, but the difference is small in magnitude. This finding is also compatible with our model since we can show that fintechs, with their advantage in pricing flexibly, will charge lower loan rates than banks if the convenience benefits offered by fintechs are not large enough.

[12] Beaumont et al. (2024) document that in the French SME market, fintech borrowers are more likely than bank borrowers to enter a bankruptcy procedure. Therefore, they claim that superior information processing technology itself cannot explain the rise of fintech lending.

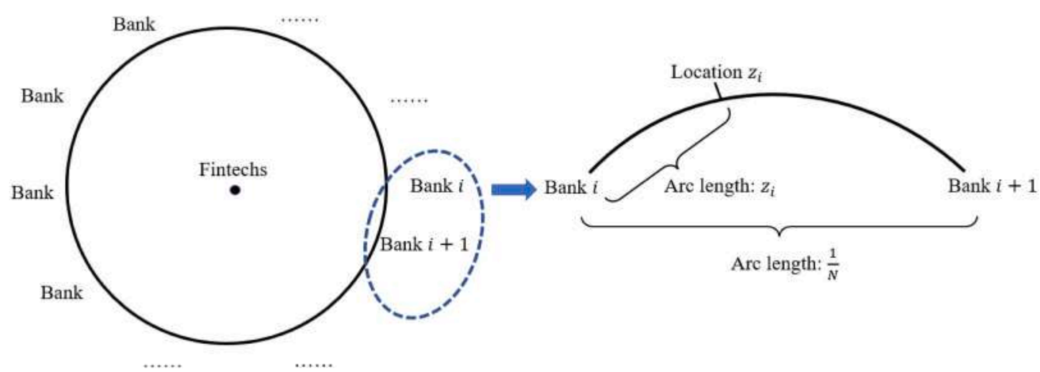

Fig. 1. The Economy.

and entrepreneurs' decisions. Section 4 characterizes the different equilibrium regimes. Section 5 compares banks and fintechs with respect to monitoring, funding costs, and convenience. Section 6 provides a welfare analysis. Section 7 considers the case where banks can also price discriminate. In Section 8, we check the long-run effect of fintech entry by allowing banks to exit. We conclude in Section 9 with a summary of our findings. Appendix A presents all the proofs. Online appendices provide supplementary analyses and extensions.

2. The model

The economy and players. The economy is represented by a circular "city"of circumference 1, inhabited by entrepreneurs and lenders. A point on the circumference represents the characteristics of an entrepreneur (type of project, technology, geographical position, or industry) at this location.

The economy has two types of lenders: $N \geq 2$ banks and two fintechs. The banks are located *equidistantly* around the city, so the arc-distance between two adjacent banks is $1/N$. A bank is closer to some entrepreneurs than to others. For example, banks are specialized in different sectors of the economy.[13] Throughout the paper, we use bank i to denote an arbitrary bank on the circle, and bank $i+1$ to represent the bank to the right and adjacent to bank i. On the arc between banks i and $i+1$, we say that an entrepreneur is at (location) z_i if the arc-distance between the entrepreneur and bank i is z_i. Hence, the arc-distance between location z_i and bank $i+1$ is $1/N - z_i$. From Section 2 to 7, we take N as given. In Section 8, banks may exit, so N is endogenous there.

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

A second difference is that fintechs – which adopt information technology more rapidly and have fewer concerns using price discrimination – 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 locations. Specifically, we denote fintech j's ($j \in \{1,2\}$) loan rate by $r_{Fj}(z_i)$, which is a function of z_i. 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 a project, an entrepreneur requires funding from a lender, which can be a bank or a fintech. The project of an entrepreneur at z_i yields the following risky return:

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

In the event of success (resp. failure), the entrepreneur's investment yields R (resp. 0). The probability of success is $m(z_i) \in [0,1]$, which represents how intensely the entrepreneur is monitored by the lender that provides the loan (i.e., monitoring intensity). Project returns of different entrepreneurs are independent.[14]

Entrepreneurs' investment decisions and funding demand. An entrepreneur at location z_i can borrow and invest at most 1 unit of funding. If an entrepreneur at z_i borrows at loan rate $r(z_i)$ and is monitored with intensity $m(z_i)$, her expected utility on the investment is $\pi^e(z_i) \equiv (R - r(z_i))m(z_i)$. We assume that the entrepreneur derives net utility $\pi^e(z_i) - u$ by implementing the risky project, so she seeks funding if and only if $\pi^e(z_i) > u$. Here u is the reservation utility (i.e., opportunity cost) of the entrepreneur's alternative activities. For each entrepreneur at z_i, u is independently and uniformly distributed on $[0, M]$. The total funding demand (which is also the mass of entrepreneurs who undertake projects) at location z_i is therefore

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

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

Monitoring cost. If a bank monitors an entrepreneur at z_i with intensity $m(z_i)$, the monitoring cost it needs to incur is:

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

with $c_B > R$, $R > \sqrt{2c_B\iota_B}$, $q \in (0,2)$ and $d \geq 0$.[15] Variable d is the arc-distance between the bank and the monitored entrepreneur (for

13 See Paravisini et al., 2023 for export-related lending, Duquerroy et al., 2022 for SME lending and Giometti and Pietrosanti, 2023 for syndicated corporate loans.

14 We can relax this assumption by letting project returns be correlated (i.e., affected by a common factor) at the same location, while independent across locations.

15 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 $1/2$. The constraint $R > \sqrt{2c_B\iota_B}$ must hold to guarantee that banks are willing to provide loans to

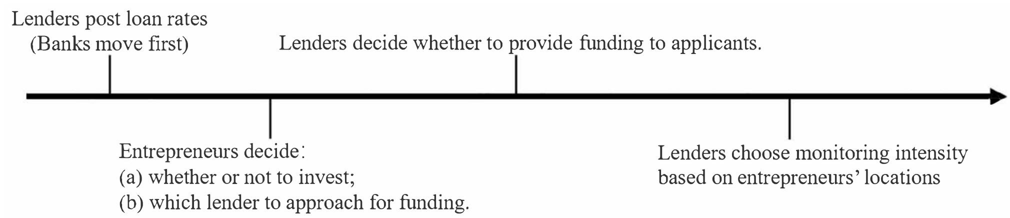

Fig. 2. Timeline.

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 distance on banks' monitoring efficiency. A bank has lower efficiency in monitoring entrepreneurs farther away from the bank's expertise or location (see Giometti and Pietrosanti, 2023).

If fintech j (with $j \in \{1,2\}$) monitors an entrepreneur at z_i with intensity $m(z_i)$, the monitoring cost is:

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

where c_{Fj} (with $c_{Fj} > R$) inversely measures the monitoring efficiency of the fintech.[16] Note that $C_{Fj}\left(m(z_i)\right)$ is not affected by the entrepreneur's location for a given $m(z_i)$, which corresponds to the fintech's location at the center of the circle as explained above.

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

Timeline. The following events take place in sequence. The incumbent banks post their uniform loan rates first, and fintechs move second posting their discriminatory loan rates after observing banks' loan rates.[17] After lenders' loan rates are chosen and hence observable, each entrepreneur decides (a) whether or not to implement her project and (b) which lender to approach for funding if she decides to undertake her project. Given lenders' loan rates and entrepreneurs' decisions, each lender decides whether to provide funding to its loan applicants. After providing loans, each lender chooses its optimal monitoring intensity as a function of borrowers' locations (see Fig. 2).

Parameter assumptions. To focus our analyses on interesting and realistic scenarios, we make some assumptions on parameters. First, we assume the following inequality, which ensures that there is effective competition between adjacent banks when there are no fintechs, holds:

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

where r_B^m is the (monopolistic) loan rate a bank will offer when it faces no competition from any other lender.[18] If Inequality (2) does not hold – a case analyzed in Online Appendix B – a bank does not compete with other lenders when there is no fintech entry.

Second, we assume:

$$R \le \min\{2\sqrt{2c_{F1}\iota_F}, 2\sqrt{2c_B\iota_B}\}, \tag{3}$$

which ensures that entrepreneurs always want lenders to decrease their loan rates. As a result, intensifying competition will gradually drive lenders' profits to zero.

Finally, we assume:

$$\frac{\sqrt{2c_{F1}\iota_F}(R-\sqrt{2c_{F1}\iota_F})}{c_{F1}} < \frac{\sqrt{2c_B\iota_B}(R-\sqrt{2c_B\iota_B})}{c_B}, \tag{4}$$

which implies that at $z_i = 0$, bank i can provide entrepreneurs with higher expected utility than fintechs. As a result, banks still maintain positive market shares after fintech entry. Condition (4) is reduced to $c_{F1} > c_B$ when $\iota_F = \iota_B$.[19] If Inequality (4) does not hold, then fintechs will completely drive banks out of the market. Actually, the banking sector plays an important role in the lending market, so we focus on the more interesting case that fintech entry does not drive out banks.

Interpretation of monitoring. Monitoring creates value for lenders and entrepreneurs through expertise-based advising, mentoring or/and information production helpful for entrepreneurs.[20] Lenders can collect entrepreneurs' data (e.g., by frequently requesting information) and assess how the business is doing (Minnis and Sutherland, 2017; Gustafson et al., 2021; Branzoli and Fringuellotti, 2022). If borrowers are not acting appropriately, lenders can provide warnings and advice, potentially improving their behavior. If the collected information shows a breach of covenants, lenders can obtain control rights and directly intervene to fix borrowers' behavior. Such intervention is easier for BigTech lenders since they have advantages in information collection and contract enforcement in their ecosystems (Liu et al., 2024).

Lenders' monitoring efficiency can be facilitated by advancements in technology. Improvements in artificial intelligence (AI) make it easier for bank officers to process the information of firms they do not specialize in, decreasing q. Developments of AI, machine learning (ML), and Big Data help codify soft information into hard information, allowing fintechs to get rid of human-based decisions and distance friction. Those technologies also improve the basic efficiency in information processing for banks and fintechs (i.e., decrease c_B and c_{Fj} in the model).[21]

3. Fintech threat and possible equilibrium regimes

In this section, we deal with lenders' monitoring choices and entrepreneurs' decisions first. Then, we define the different possible equilibrium regimes. Throughout the paper, we concentrate our analysis on symmetric equilibria.

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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.

[16] The constraint $c_{Fj} > R$ ensures that the fintech's monitoring intensity is always smaller than 1.

[17] 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.

[18] See the proof of Proposition 1 (in Appendix A) for the derivation of r_B^m, which is determined by Eq. (A.1).

[19] The inequality $c_{F1} > c_B$ means that banks have higher basic monitoring efficiency than fintechs when the distance is zero. This makes sense since banks have an advantage in accumulating data about customers, which is the rationale of the Open Banking initiative launched by several governments. See He et al. (2023) and Babina et al. (2024).

[20] There is evidence that borrowers value lenders' expertise. Paravisini et al. (2023) find that an exporter prefers borrowing from a bank with better expertise in the target market. Lee and Sharpe (2009) find that more intense lender monitoring leads to higher stock returns of borrowers; similarly, Dass and Massa (2011) shows that lender monitoring can improve the corporate governance of borrowers, increasing their firm values.

[21] Vives and Ye (2025) provide a more comprehensive discussion of the effects of information technology improvements.

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

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

$$\pi_B\left(z_i\right) \equiv r_B m_B\left(z_i\right) - \iota_B - \frac{c_B}{2(1-qd)}(m_B(z_i))^2, \tag{5}$$

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 $\pi_B\left(z_i\right)$ is the expected loan repayment the bank receives from an entrepreneur at z_i, the second is the bank's marginal funding cost, and the third is the cost of monitoring the entrepreneur.

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

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

where $m_{Fj}\left(z_i\right)$ is the fintech's monitoring intensity at z_i. The first term of $\pi_{Fj}\left(z_i\right)$ is the expected loan repayment the fintech receives from the entrepreneur, the second term is the fintech's marginal funding cost, and the third term is the monitoring cost.

After providing loans, a lender (a bank or a fintech) chooses monitoring intensities to maximize its expected profits, taking as given the loan rates, entrepreneurs' choices, and the marginal funding cost. Lemma 1 presents the result.

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

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

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

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

$$m_{Fj}(z_i) = \frac{r_{Fj}\left(z_i\right)}{c_{Fj}}.$$

As c_B or/and q increase, monitoring becomes more costly, reducing a bank's monitoring intensity $m_B(z_i)$ (except if $d=0$). Furthermore, $m_B(z_i)$ is decreasing in d since it is more costly for a bank to monitor entrepreneurs farther away. The slope of the marginal monitoring cost $c_B/(1-qd)$ is an inverse measure of the bank's monitoring efficiency with distance d. Finally, $m_B(z_i)$ is increasing in r_B since a higher r_B implies a larger skin in the game (i.e., higher monitoring incentive) for the bank.

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

When do lenders provide loans to their applicants? If an entrepreneur at z_i applies for a loan from a bank (with lending distance d and loan rate r_B), the bank will provide the loan if and only if $\pi_B\left(z_i\right) \geq 0$ (see Eq. (5)). According to Lemma 1, $m_B(z_i)$ is a function of r_B, so $\pi_B\left(z_i\right) \geq 0$ is equivalent to:

$$\frac{(1-qd)r_B^2}{2c_B} - \iota_B \geq 0 \tag{6}$$

Note that whether Condition (6) holds can be anticipated by all market participants once r_B is observable. Reasoning in the same way, fintech j will provide a loan to an applicant at z_i if and only if $\pi_{Fj}\left(z_i\right) \geq 0$, with $m_{Fj}(z_i)$ given in Lemma 1.

Entrepreneurs' decisions. An entrepreneur will approach the lender that can provide the highest expected utility. Suppose that in equilibrium, all lenders are willing to provide loans at z_i. Then, entrepreneurs at z_i will approach bank k – whose loan rate and (anticipated) monitoring intensity are r_k and $m_k(z_i)$ respectively – for loans only if:

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

where r_h (resp. $m_h(z_i)$) is the loan rate (resp. monitoring intensity) of bank h; $r_{Fj}(z_i)$ (resp. $m_{Fj}(z_i)$) is the loan rate (resp. monitoring intensity) of fintech j. If the highest utility is provided by more than one lender at z_i in equilibrium, we make the standard assumption that entrepreneurs at z_i will choose the lender that is willing to marginally cut price and provide higher utility. Note that entrepreneurs do not simply choose the lender with the lowest loan rate since they also care about monitoring intensities.

3.2. Equilibrium regimes

The following lemma characterizes the maximum utility a fintech can provide, which represents its competitiveness.

Lemma 2. *At any location, the fintech j's loan rate that maximizes entrepreneurs' expected utility is given by*

$$\bar{r}_{Fj} \equiv \sqrt{2c_{Fj}\iota_F},$$

which implies the following entrepreneurial utility from investment:

$$\overline{U}_{Fj} \equiv \underbrace{(\bar{r}_{Fj}/c_{Fj})}_{\text{monitoring intensity}} \times \underbrace{\left(R-\bar{r}_{Fj}\right)}_{\text{return from success}},$$

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

To provide higher utility to an entrepreneur, fintech j needs to decrease its loan rate. When the loan rate is as low as $\bar{r}_{Fj}$, fintech j will make zero profit and cannot decrease the rate anymore. Therefore, $\bar{r}_{Fj}$ is the best loan rate fintech j can offer entrepreneurs, which implies utility $\overline{U}_{Fj}$. As c_{Fj} or ι_F increases, monitoring or funding becomes more costly for fintech j, so it needs a higher $\bar{r}_{Fj}$ to break even, thus reducing $\overline{U}_{Fj}$.

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, meaning that the competitiveness of fintechs depends on that of fintech 1.

We define different types of equilibria based on the status of fintech entry.

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

In the BE regime, fintechs cannot make any difference to the lending market and banks' pricing strategies are independent of fintechs' characteristics. In the PE regime, banks modify their pricing to protect their market areas from fintechs' penetration; although fintechs do not serve any entrepreneur, they are effective potential competitors that banks cannot ignore. In the AE regime, banks give up fully protecting their market areas, and fintechs lend to a positive mass of entrepreneurs.

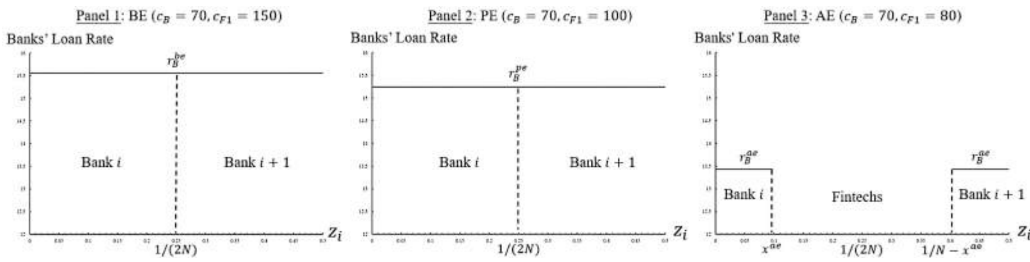

Fig. 3. Banks' Coverage and Pricing under Different Regimes of Fintech Entry. This figure plots banks' equilibrium loan rate against the entrepreneurial location on the arc between banks i and $i+1$. The parameter values are $R = 20$, $\iota_B = \iota_F = 1$, $c_B = 70$, $q = 0.8$, $N = 2$.

4. Characterizing equilibria

In this section, we first provide the conditions for the three types of equilibria (see Definition 1) to arise, and then characterize loan rates focusing on the PE and AE regimes. The BE regime is relegated to Online Appendix C. The section ends with the impact of fintech entry on total investment.

4.1. Fintech monitoring efficiency and equilibrium regimes

The following proposition shows how fintech 1's monitoring efficiency determines the equilibrium regime.

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

(i) If $c_{F1} \geq \bar{c}_F$, there is blockaded fintech entry (BE); banks' loan rate is r_B^{be}.

(ii) If $\underline{c}_F \leq c_{F1} < \bar{c}_F$, there is potential fintech entry (PE); banks' loan rate is r_B^{pe} ($< r_B^{be}$). At location $z_i = 1/(2N)$, banks' rate r_B^{pe} exactly provides utility $\overline{U}_{F1}$:

$$\frac{r_B^{pe}(1 - \frac{q}{2N})(R - r_B^{pe})}{c_B} = \overline{U}_{F1}. \tag{7}$$

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

In the BE or PE regime, 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 the AE regime, there exists an $x^{ae} \in (0, 1/(2N))$ such that fintechs serve entrepreneurs at $z_i \in [x^{ae}, 1/N - x^{ae}]$, while bank i (resp. bank $i+1$) serves entrepreneurs at $z_i \in [0, x^{ae})$(resp. $z_i \in (1/N - x^{ae}, 1/N]$).

From the perspective of banks, the competitiveness of fintechs is equivalent to that of fintech 1 since it has a (weakly) better monitoring efficiency 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., $c_{F1} \geq \bar{c}_F$), borrowing from fintechs implies very low monitoring intensities (i.e., success probabilities), so banks and entrepreneurs need not consider the presence of fintechs. In this BE regime, an entrepreneur will seek funding from the nearest bank since a bank's monitoring efficiency is decreasing in its lending distance. Panel 1 of Fig. 3 illustrates banks' coverage and loan rate in the BE regime.

If the monitoring efficiency of fintech 1 is at an intermediate level (i.e., $\underline{c}_F \leq c_{F1} < \bar{c}_F$), fintech 1 will bring effective competitive pressure to banks. Then, banks decrease their loan rate (from r_B^{be} to r_B^{pe}) to protect their market areas, giving rise to the PE regime. Fintechs cannot serve any entrepreneur due to banks' reaction to the fintech threat. Again, an entrepreneur seeks funding from the nearest bank. See Panel 2 of Fig. 3. The entrepreneurial utility provided by banks is lowest when the bank-borrower distance reaches the maximum value $1/(2N)$ (i.e., the distance between bank i and $z_i = 1/(2N)$). To fully protect banks' market areas, r_B^{pe} must be so low that the lowest utility provided by banks can match $\overline{U}_{F1}$.

If the monitoring efficiency of fintech 1 is sufficiently good (i.e., $c_{F1} < \underline{c}_F$), banks cannot prevent fintech penetration and the AE regime occurs. Fintechs' monitoring efficiency does not vary with locations, so they gain a competitive advantage and serve entrepreneurs in the middle area $z_i \in [x^{ae}, 1/N - x^{ae}]$, which is far from all banks. Bank i (resp. bank $i+1$) serves its nearby entrepreneurs at $z_i \in [0, x^{ae})$ (resp. $z_i \in (1/N - x^{ae}, 1/N]$). As a result, the interaction between adjacent banks is cut off in the AE regime. The point $z_i = x^{ae}$ (resp. $z_i = 1/N - x^{ae}$) is the *indifference location* where the utility provided by bank i (resp. bank $i+1$) exactly matches the maximum utility $\overline{U}_{F1}$ fintech 1 can provide. Panel 3 of Fig. 3 illustrates this regime.

Corollary 1. *Monitoring efficiency thresholds $\bar{c}_F$ and $\underline{c}_F$ are increasing in c_B, q and ι_B, and decreasing in ι_F. A numerical study finds that $\bar{c}_F$ and $\underline{c}_F$ are increasing in R.*

Decreasing c_B and/or q (i.e., higher bank monitoring efficiency) will increase the utility banks can provide, thereby making it harder for fintech 1 to change the equilibrium regime (i.e., $\bar{c}_F$ and $\underline{c}_F$ become lower). Similarly, decreasing ι_B reduces banks' funding costs, enabling them to use lower loan rates to protect market areas and thus reducing $\bar{c}_F$ and $\underline{c}_F$.

In contrast, as ι_F decreases, fintech 1 is able to offer a lower best loan rate (see Lemma 2), implying a higher $\overline{U}_{F1}$. As a result, fintech 1's competitiveness increases, making it harder for banks to maintain the BE or PE regime (i.e., $\bar{c}_F$ and $\underline{c}_F$ will increase).

Decreasing R lowers the profitability of entrepreneurs' projects, thus reducing the utility provided by banks and fintechs. We find numerically that decreasing R reduces $\bar{c}_F$ and $\underline{c}_F$. As R decreases, incumbent banks – which make positive profits before fintech entry – will offer lower loan rates. In contrast, fintech 1, as an entrant, uses its best loan rate $\bar{r}_{F1}$ to penetrate the market and cannot reduce it anymore following a lower R. As a result, the utility provided by the entering fintech decreases faster than that provided by incumbent banks, making it harder for fintech 1 to change the equilibrium regime.[22]

4.2. Equilibrium loan rates

In this section, we characterize lenders' loan pricing, focusing on the PE and the AE regimes (see Online Appendix C for the BE regime).

Proposition 2 (*Bank Pricing in the PE Regime*)**.** *In the PE regime, banks' loan rate r_B^{pe} is increasing in c_{F1}, ι_F and N, decreasing in c_B and q, and independent of ι_B.*

A decrease in c_{F1} or ι_F increases the fintech's competitiveness (i.e., increases $\overline{U}_{F1}$) and hence forces banks to decrease r_B^{pe} to protect

[22] To confirm that banks' loan rate reduction in response to a lower R drives the result, we did a counterfactual analysis by fixing banks' loan rate and decreasing R. In this case, a lower R increases $\bar{c}_F$ and $\underline{c}_F$ when $\iota_B = \iota_F$.

their market areas from potential fintech entry. Reasoning in a symmetric way, a lower c_B and/or q increase the competitiveness of banks, allowing them to post a higher loan rate.

As N decreases, the arc-distance between adjacent banks will be larger, increasing the maximal bank-borrower distance $1/(2N)$. Therefore, fully protecting banks' market areas from fintech penetration becomes harder, forcing banks to decrease r_B^{pe} to keep Eq. (7) holding.

Note that ι_B does not play a role in Eq. (7) since the utility provided by a bank does not directly depend on its marginal funding cost. As a result, r_B^{pe} is independent of ι_B. However, ι_B does affect banks' competitiveness since Corollary 1 shows that a higher ι_B makes it harder for banks to maintain the BE or PE regime.

Proposition 3 (*Bank Pricing in the AE Regime*). *In the AE regime, banks' equilibrium loan rate r_B^{ae} is increasing in c_{F1}, ι_B, and ι_F, and independent of N.*

In the AE regime, every bank competes with fintech 1. Changing N has no effect on a bank's loan rate r_B^{ae} because fintech 1's competitive pressure on a bank – represented by $\overline{U}_{F1}$ – is not affected by the number of banks. A lower c_{F1} or ι_F will increase fintech 1's competitiveness, forcing banks to reduce r_B^{ae} to mitigate fintech expansion.

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

Changing q does not affect r_B^{ae}, while the effect of c_B on r_B^{ae} is ambiguous (see Table 1). We explain the results in Online Appendix C.

Next, we analyze fintechs' pricing. 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. When $c_{F1} = c_{F2}$, the two fintechs are identical; in this case, we also let fintech 1 serve all borrowers in the region $\left[x^{ae}, 1/N - x^{ae}\right]$ for convenience. Then, for the rest of the paper, we need only focus on fintech 1 when studying fintechs' behavior. The following lemma characterizes the *upper bound* of fintech 1's loan rate.

Lemma 3. *If fintech 1 faces no competition from banks at z_i, its optimal loan rate at this location is independent of z_i and equals*

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

where $r_{F1}^m \in (\overline{r}_{F1}, R)$ is fintech 1's monopolistic loan rate (derived in Appendix A) and $(R + \sqrt{R^2 - 4c_{F1}\overline{U}_{F2}})/2$ is the loan rate of fintech 1 that provides the maximum utility $\overline{U}_{F2}$ fintech 2 can offer. If fintech 1 faces competition from banks at z_i, r_{F1}^* is the upper bound of its loan rate.

With no bank threat, fintech 1's optimal loan rate is determined by: (a) its monopolistic loan rate r_{F1}^m and (b) the competitiveness of fintech 2. Increasing the loan rate above r_{F1}^m will reduce fintech 1's profit at z_i since entrepreneurs' funding demand will decrease rapidly. Fintech 1 must also ensure that entrepreneurs will not choose fintech 2, which can provide utility $\overline{U}_{F2}$. To match the utility $\overline{U}_{F2}$, fintech 1's loan rate cannot exceed $(R + \sqrt{R^2 - 4c_{F1}\overline{U}_{F2}})/2$.

Therefore, when fintech 1 faces no competition from banks, its optimal loan rate r_{F1}^* is the minimum of r_{F1}^m and $(R + \sqrt{R^2 - 4c_{F1}\overline{U}_{F2}})/2$. Fintech 1's pricing will never exceed r_{F1}^*, so it is the upper bound when fintech 1 faces competition from banks. Since fintechs' monitoring efficiency does not vary with locations, r_{F1}^* is independent of z_i. With Lemma 3, we can characterize fintech 1's equilibrium loan rate $r_{F1}(z_i)$.

Proposition 4 (*Fintech Pricing in the AE Regime.*). *Fintech 1's loan rate at $z_i \in [x^{ae}, 1/N - x^{ae}]$ is given by*

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

with

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

*The No Bank Threat **NBT** case occurs for some locations if c_{F1} is sufficiently low.*

The pricing strategy of fintech 1 at $z_i \in [x^{ae}, 1/N - x^{ae}]$ maximizes its profit while ensuring that entrepreneurs at this location do not approach rival lenders (i.e., banks or fintech 2).

Two cases may arise when fintech 1 implements this strategy. In the first case (No Bank Threat **NBT**), no bank is willing to serve location z_i with the uniform rate r_B^{ae} because it is too low to ensure a non-negative profit. Thus, there is no bank competitive threat at z_i, allowing fintech 1 to choose the upper bound loan rate r_{F1}^* (Lemma 3). The **NBT** case will arise at z_i if and only if $(r_B^{ae})^2(1 - qd^{ae})/(2c_B) < \iota_B$ holds, meaning that at location z_i, even the nearest bank (with the distance d^{ae}) cannot make a non-negative profit with the loan rate r_B^{ae} (see Condition (6)). Otherwise, we are in the Bank Threat **BT** case.

In the **BT** case, if fintech 1's upper bound rate r_{F1}^* can provide higher utility at z_i than banks' rate r_B^{ae}, banks' threat will not be effective for the fintech; as a result, fintech 1 will post r_{F1}^* at z_i as in the **NBT** case. However, if r_{F1}^* provides lower utility than banks' rate r_B^{ae} at z_i, banks' threat will be effective; then, fintech 1 offers $r_{F1}^{comB}(z_i)$ $(< r_{F1}^*)$ at z_i to match the utility provided by banks' rate r_B^{ae}. The superscript "*comB*" of $r_{F1}^{comB}(z_i)$ means "competition with banks".

The **NBT** case will occur for some locations when c_{F1} is very low (i.e., fintech 1 is very competitive). This follows since a low c_{F1} will force bank i to price low (Proposition 3), making it unwilling to serve locations near $z_i = 1/(2N)$ with the rate r_B^{ae}.

Fig. 4 provides a graphic illustration of equilibrium loan rates on the arc between banks i and $i+1$. In Panels 1 to 3, c_{F1} is not very low, so banks i and $i+1$ are willing to serve location $z_i = 1/(2N)$ with the rate r_B^{ae}. Thus, fintech 1 faces banks' threat at all locations. In Panel 1, fintech 2 has no threat (since c_{F2} is high), so fintech 1 offers $r_{F1}^{comB}(z_i)$ at $z_i \in [x^{ae}, 1/N - x^{ae}]$ to compete with banks. In Panel 2, c_{F2} is at an intermediate level, so r_{F1}^* takes an intermediate value that provides higher utility than banks' rate r_B^{ae} at locations near $z_i = 1/(2N)$. For such locations, fintech 1 offers r_{F1}^* to compete with fintech 2 (banks' threat exists but is not effective). Panel 3 illustrates the boundary case $c_{F1} = c_{F2}$, in which fintech 1 always offers its best loan rate $\overline{r}_{F1}$ since the competition between the two identical fintechs is unbounded. In Panel 4, however, c_{F1} is very low – which drives down r_B^{ae} by a lot – so banks i and $i+1$ are unwilling to serve location $z_i = 1/(2N)$ with the rate r_B^{ae}. Therefore, 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}^*.

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

As z_i increases in $\left[x^{ae}, 1/(2N)\right]$, the utility an entrepreneur can derive by approaching bank i (the bank nearest to this location) will decrease. Hence, fintech 1's competitive advantage over bank i will increase, allowing the fintech to choose a higher $r_{F1}(z_i)$ $(= r_{F1}^{comB}(z_i))$ when banks' threat is effective. If banks' threat is not effective (or if it does not exist), fintech 1's loan rate is r_{F1}^*, which is independent of z_i.

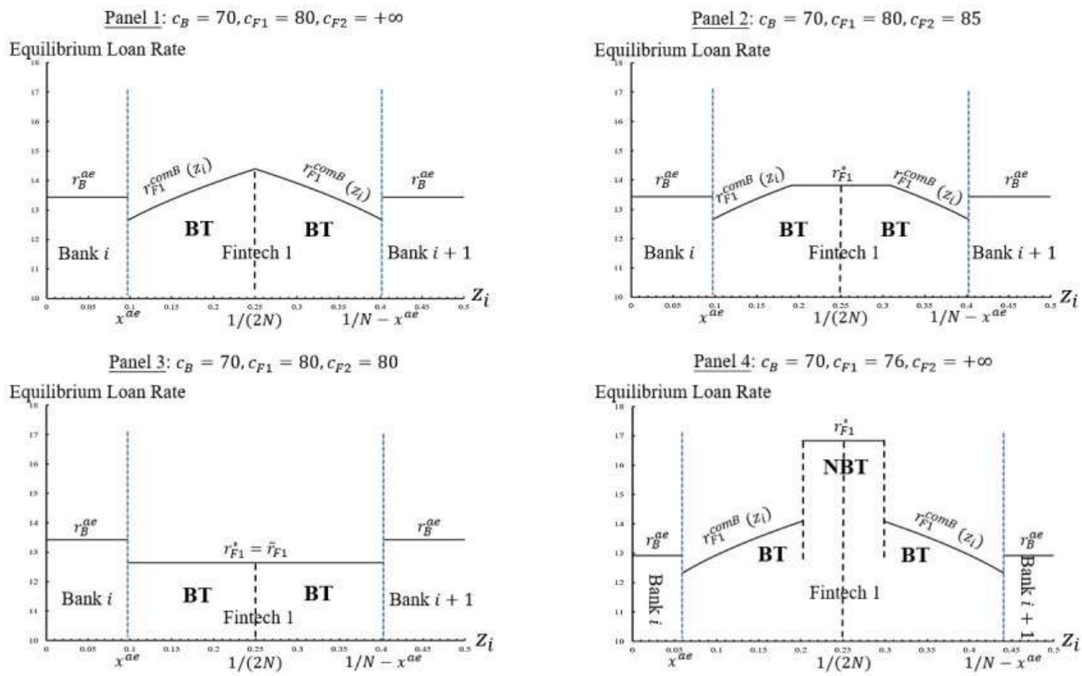

Fig. 4. Loan Rates on the Arc between Banks i and $i+1$ in AE with $\iota_B = \iota_F$. This figure plots the equilibrium loan rate against the entrepreneurial location on the arc between banks i and $i+1$ in the AE regime. Fintechs can price discriminate, while banks cannot. Location z_i belongs to the **NBT** area if $(r_B^{ae})^2(1 - qd^{ae})/(2c_B) < \iota_B$ holds at z_i, where $d^{ae} \equiv \min\{z_i, 1/N - z_i\}$; otherwise, location z_i belongs to the **BT** area. The parameter values are $R = 20$, $\iota_B = \iota_F = 1$, $q = 0.8$, $c_B = 70$, $N = 2$.

Overall, fintech 1's equilibrium loan rate $r_{F1}(z_i)$ is weakly increasing in z_i in the area $[x^{ae}, 1/(2N)]$. At the indifference location $z_i = x^{ae}$, bank i's equilibrium loan rate r_B^{ae} can provide utility $\overline{U}_{F1}$, so fintech 1 must offer its best loan rate $\bar{r}_{F1}$ at this location to compete with the bank.[23] 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 Fig. 4).

For a bank, an entrepreneur who is farther away is harder to monitor and has a lower success probability (i.e., lower credit quality. See Lemma 1). Therefore, Proposition 4 and Corollary 2 imply that fintechs often target riskier borrowers (from the point of view of banks) and adjust their loan rates based on borrowers' characteristics (see Di Maggio and Yao, 2021; Ueda et al., 2023; Johnson et al., 2023).

Comparative statics with actual entry. Table 1 summarizes the results and some explanations follow (and others are relegated to Online Appendix C).

Decreasing c_{F1} will enhance fintech 1's monitoring efficiency and competitiveness, thereby increasing its loan quality and market areas while reducing banks'.[24] As banks become more specialized with higher q, they serve a smaller area (i.e., x^{ae} decreases), and fintech 1 increases its loan rate (under bank threat). Reducing N widens the region served by fintech 1 and enhances its market power around the mid location $z_i = 1/(2N)$, hence increasing its loan volume and quality. This result predicts that 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). In contrast, reducing N does not change banks' loan rate and quality since fintech 1's threat to each bank – represented by $\overline{U}_{F1}$ – is not affected by N.

Table 1
Summary of comparative statics (Actual entry)

	q	c_B	c_{F1}	ι_B	ι_F	N
x^{ae}	↓	↓	↑	↓	↑	- -
Fintech market area (i.e., $1 - 2Nx^{ae}$)	↑	↑	↓	↑	↓	↓
Banks' loan rate (r_B^{ae})	- -	ambig.	↑	↑	↑	- -
$r_{F1}^{comB}(z_i)$	↑	↑	ambig.	↑	↑	↓
Fintech 1's average loan quality (i.e., average monitoring intensity)	$\uparrow^{num}$	$\uparrow^{num}$	$\downarrow^{num}$	$\uparrow^{num}$	ambig.	↓
Banks' average loan quality	$\downarrow^{num}$	$\downarrow^{num}$	$\uparrow^{num}$	$\uparrow^{num}$	$\uparrow^{num}$	- -

This table summarizes how endogenous variables (in the first column) is affected by parameters (in the first row) in the AE regime. "↑" (resp. "↓") 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. "Ambig." means that the effect of a parameter can be positive or negative based on numerical studies.

4.3. Fintech entry and entrepreneurs' investment

Entrepreneurs' investment, denoted by I, is measured by the aggregate mass of entrepreneurs undertaking investment projects: $I \equiv N\int_0^{1/N} D(z_i)dz_i$, where $D(z_i)$, defined in Eq. (1), is the funding demand at z_i.

Proposition 5. *With respect to the BE regime, PE increases total investment I, while AE does it also if c_{F2} ($\geq c_{F1}$) is sufficiently close to c_{F1}.*

[23] Reasoning symmetrically, as z_i increases in the region $(1/(2N), 1/N - x^{ae}]$, 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 $z_i = 1/N - x^{ae}$, fintech 1 must offer its best loan rate $\bar{r}_{F1}$ to compete with bank $i+1$.

[24] This is consistent with Babina et al. (2024) which documents that open banking – which improves fintechs' access to information and hence can be viewed as a decrease in c_{F1} – makes SMEs more likely to form new lending relationships with non-bank lenders.

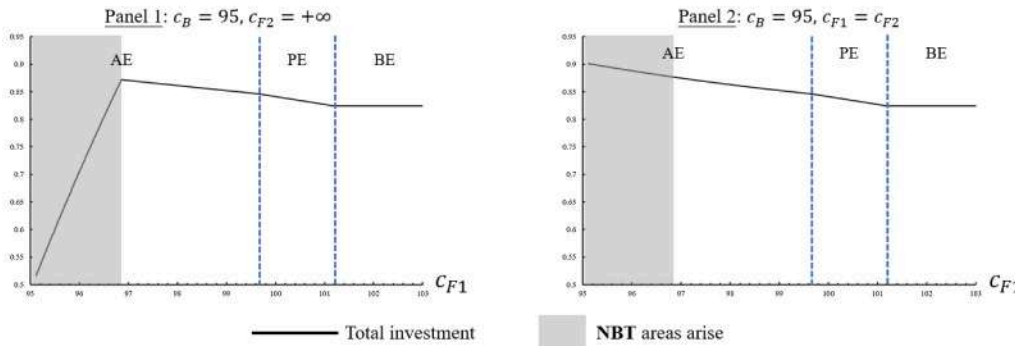

Fig. 5. Entrepreneurs' Total Investment. This figure plots entrepreneurs' total investment I (i.e., the mass of entrepreneurs undertaking investment projects) against c_{F1}. Panel 1 plots the case with $c_{F2} = +\infty$, while Panel 2 plots the case with $c_{F1} = c_{F2}$. The other parameter values are: $R = 20$, $q = 1.8$, $c_B = 95$, $\iota_B = \iota_F = 1$, $N = 30$. When c_{F1} is in the shaded region, **NBT** areas will arise (i.e., banks are not willing to serve sufficiently far-away locations). In the shaded region, **NBT** areas will grow larger as c_{F1} decreases.

In the PE regime, the fintech threat forces banks to provide higher utility to all entrepreneurs and hence spur their funding demand (i.e., investment).

In contrast, AE may not increase total investment because **NBT** areas may arise in such a regime (Proposition 4). We consider first the case that c_{F2} ($\geq c_{F1}$) is not close to c_{F1}. Then, for a location *outside* **NBT** areas, entrepreneurs' utility and investment in the AE regime must be higher than in BE because fintech entry intensifies competition and forces lenders to provide higher utility. However, at a location in **NBT** area, banks' threat disappears, so fintech 1 offers the upper bound loan rate r^*_{F1}, which can hurt entrepreneurs and reduce investment (with respect to BE) if c_{F2} is high. When such investment-reducing **NBT** areas are large enough, total investment in the AE regime will be lower than in BE. See Panel 1 (with $c_{F2} = +\infty$) of Fig. 5.

If c_{F2} ($\geq c_{F1}$) is sufficiently close to c_{F1}, the competition between the two fintechs will make fintech 1's upper bound loan rate r^*_{F1} quite low. In this case, even if AE generates **NBT** areas, the competitiveness of fintech 2 will ensure that entrepreneurs in those areas can derive sufficiently high utility. See Panel 2 (with $c_{F2} = c_{F1}$) of Fig. 5, where investment increases as c_{F1} decreases, despite the growth of **NBT** areas.

Note that Proposition 5 does not mean that marginally lowering c_{F1} may marginally reduce the investment of a **NBT** location when c_{F2} is high. In fact, for any location – be it in **BT** or **NBT** areas – lowering c_{F1} always marginally increases its investment unless the location switches from **BT** to **NBT** case. For a **BT** location, lowering c_{F1} intensifies competition and hence spurs investment; for a **NBT** location, lowering c_{F1} also increases investment since fintech 1's monitoring efficiency improves. Investment at a location may decrease only if it switches from **BT** to **NBT** case, discontinuously increasing fintech market power at the location. As lowering c_{F1} reduces banks' loan rate, more and more locations will switch from **BT** to **NBT** case, which may drive down total investment (see Panel 1 of Fig. 5).

5. Banks versus fintechs: monitoring, funding costs, and convenience

In this section, we analyze what drives actual fintech entry first, the effects of banks' funding cost advantage second, and the convenience advantage of fintechs third.

5.1. Determinants of actual fintech entry

Proposition 6. *Let $c_{F1} < \underline{c}_F$ and $\iota_B = \iota_F$ hold (the AE regime occurs and all lenders have the same marginal funding cost). At the indifference location $z_i = x^{ae}$, fintech 1 has lower monitoring efficiency and intensity, and loan rate than bank i:*

$$\frac{c_B}{1 - qx^{ae}} < c_{F1},\ m_B(x^{ae}) > m_{F1}(x^{ae}),\ \text{and}\ r^{ae}_B > r_{F1}(x^{ae}) = \overline{r}_{F1},$$

where $m_B(x^{ae})$ (resp. $m_{F1}(x^{ae})$) is bank i's (resp. fintech 1's) monitoring intensity at $z_i = x^{ae}$.

This result follows because fintechs can price discriminate, while banks cannot. When fintech 1 competes with bank i at location z_i, the fintech can choose $r_{F1}(z_i)$ from $\overline{r}_{F1}$ (the lower bound) to r^*_{F1} (the upper bound) without worrying that lowering $r_{F1}(z_i)$ would reduce its profits from other locations. As a consequence, the fintech offers its best loan rate $\overline{r}_{F1}$ at $z_i = x^{ae}$. In contrast, bank i has the concern that decreasing r^{ae}_B will reduce its profits from all locations it serves. Therefore, bank i's pricing at $z_i = x^{ae}$ will be higher (i.e., less aggressive) than fintech 1 if they have the same funding cost. The advantage of fintech 1's lower pricing allows it to reach locations where bank i has higher monitoring efficiency, implying $c_B/(1 - qx^{ae}) < c_{F1}$. Fig. 4 illustrates the result.

Bank i's higher loan rate and better monitoring efficiency at $z_i = x^{ae}$ lead to $m_B(x^{ae}) > m_{F1}(x^{ae})$ (Lemma 1). Note that around location $z_i = x^{ae}$, bank borrowers and fintech borrowers have similar characteristics since their locations are almost the same. Hence, this result predicts that when banks and fintechs have similar funding costs, bank borrowers have higher success probabilities than fintech borrowers with similar characteristics.

Corollary 3. *The AE regime can occur even if fintech 1 has no advantage in either monitoring efficiency or funding cost (i.e., even if both $c_B/(1 - q/(2N)) < c_{F1}$ and $\iota_B < \iota_F$ hold).*

Corollary 3 implies that fintech 1 can serve location $z_i = 1/(2N)$ even if its monitoring efficiency (resp. funding cost) is lower (resp. higher) than that of banks i and $i + 1$ at this location. The reason is that price discrimination is fintechs' competitive advantage, allowing them to penetrate the market with low pricing.

5.2. Banks' funding cost advantage

In practice, fintechs are likely to have higher marginal funding costs than banks (i.e., $\iota_F > \iota_B$ is likely to hold) because the latter can access cheap deposits (see Drechsler et al., 2021). Considering $\iota_F > \iota_B$ can flip the implication of Proposition 6.

Proposition 7. *Let $c_{F1} < \underline{c}_F$ hold (i.e., the AE regime occurs). If ι_F is sufficiently higher than ι_B, fintech 1 has higher monitoring efficiency and intensity, and loan rate than bank i at the indifference location $z_i = x^{ae}$:*

$$\frac{c_B}{1 - qx^{ae}} > c_{F1},\ m_B(x^{ae}) < m_{F1}(x^{ae}),\ \text{and}\ r^{ae}_B < r_{F1}(x^{ae}) = \overline{r}_{F1}. \tag{8}$$

According to Lemma 2, a higher ι_F will force fintech 1 to post a higher rate $\overline{r}_{F1}$ at $z_i = x^{ae}$ and serve smaller market areas (i.e., x^{ae} will increase). A higher x^{ae} implies that bank i's monitoring efficiency at $z_i = x^{ae}$ – which is measured by $(1 - qx^{ae})/c_B$ – will decrease. Therefore, when ι_F is high enough (i.e., sufficiently higher than ι_B), fintech 1 will have a higher loan rate and monitoring efficiency than bank i at $z_i = x^{ae}$, leading to $m_B(x^{ae}) < m_{F1}(x^{ae})$. That is, fintech borrowers

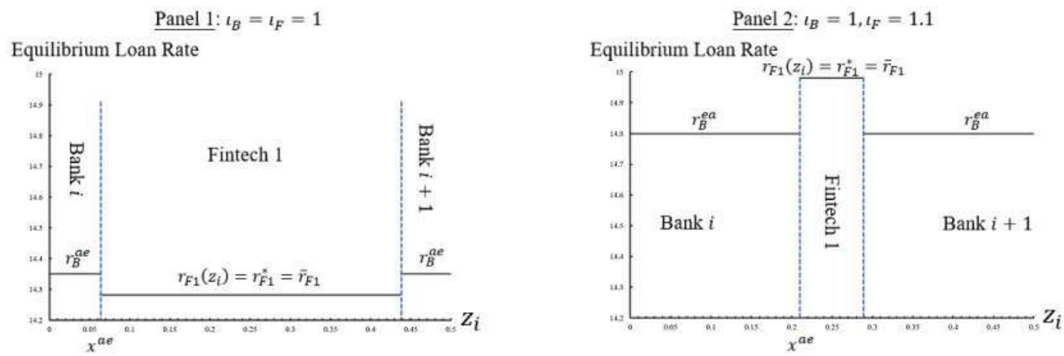

Fig. 6. The Effects of Funding Costs on Equilibrium Loan Rates in AE with $c_{F1} = c_{F2}$. This figure plots the equilibrium loan rate against the entrepreneurial location on the arc between banks i and $i+1$ when there is actual fintech entry and $c_{F1} = c_{F2}$ holds. Fintechs can price discriminate, while banks cannot. The parameter values are $R = 20$, $\iota_B = 1$, $c_B = 100$, $c_{F1} = c_{F2} = 102$, $q = 0.2$, and $N = 2$ for both panels. $\iota_F = 1$ in Panel 1, while $\iota_F = 1.1$ in Panel 2. .

have lower default risks than bank borrowers (controlling for borrower characteristics).

Fig. 6 illustrates how funding costs affect the relationship between banks' pricing and fintech 1's at the indifference location. To clearly show the difference, the figure adopts $c_{F1} = c_{F2}$, so fintech 1 always offers its best loan rate $\bar{r}_{F1}$. In Panel 1, $\iota_F = \iota_B$ holds, so banks' loan rate is higher than fintech 1's at $z_i = x^{ae}$ (see Proposition 6). In Panel 2, however, fintechs have much higher funding costs, forcing fintech 1 to price higher than bank i and serve smaller market areas.

Note that Propositions 6 and 7 provide opposite predictions, meaning that the relationship between fintech loan risk and bank loan risk (controlling for borrower characteristics) is ambiguous and depends on the extent of fintechs' funding cost disadvantage. The empirical evidence is indeed consistent with the mixed predictions (Buchak et al., 2018; Fuster et al., 2019; Di Maggio and Yao, 2021; Liu et al., 2024).

5.3. Convenience benefit of fintech loans

In practice, an important advantage of fin/big techs is that they can offer more convenience to borrowers (see Buchak et al., 2018, Fuster et al., 2019, and Liu et al., 2024). This subsection extends the model by assuming that an entrepreneur will derive a non-pecuniary convenience benefit θ when borrowing from a fintech. Then, in this subsection, the maximum entrepreneurial utility $\overline{U}_{Fj}$ provided by fintech j becomes:

$$\overline{U}_{Fj} = \underbrace{(\bar{r}_{Fj}/c_{Fj})}_{\text{monitoring intensity}} \times \underbrace{(R - \bar{r}_{Fj})}_{\text{return from success}} + \underbrace{\theta}_{\text{convenience benefit}},$$

with $\bar{r}_{Fj}$ defined in Lemma 2. We modify Condition (4) to the general version $\overline{U}_{F1} < \sqrt{2c_B\iota_B}(R - \sqrt{2c_B\iota_B})/c_B$, which again ensures that banks maintain positive market shares after fintech entry. All the other assumptions in Section 2 still apply here.

If AE occurs when $\theta = 0$, it must also occur when $\theta > 0$ since a higher θ increases fintechs' competitiveness. For the same reason, a higher θ will increase fintech 1's market areas (i.e., x^{ae} will decrease) and decrease banks' loan rate r_B^{ae} in the AE regime. The following proposition shows how convenience benefits affect the relationship between banks' pricing and fintech 1's.

Proposition 8. *In the AE regime with $\iota_B = \iota_F$, if θ is large enough, fintech 1 has lower monitoring efficiency and intensity, and a higher loan rate than bank i at the indifference location $z_i = x^{ae}$:*

$$\frac{c_B}{1 - qx^{ae}} < c_{F1},\ m_B(x^{ae}) > m_{F1}(x^{ae}) \text{ and } r_B^{ae} < r_{F1}(x^{ae}) = \bar{r}_{F1}.$$

This proposition implies that fintechs' advantage in providing convenience can induce them to price higher than banks (controlling for entrepreneurs' characteristics), which is consistent with the findings of Buchak et al. (2018) and Liu et al. (2024).

A higher θ will increase fintech 1's competitiveness and force banks to lower loan rates and serve smaller market areas (i.e., reduce x^{ae}), thus increasing bank i's monitoring efficiency at $z_i = x^{ae}$ (measured by $(1 - qx^{ae})/c_B$). Fintech 1's monitoring efficiency and best loan rate at $z_i = x^{ae}$ do not vary with θ. Therefore, a sufficiently high θ will induce bank i to price lower and have a higher monitoring efficiency than fintech 1 at $z_i = x^{ae}$ (controlling for lenders' funding costs). Bank i's higher monitoring efficiency at $z_i = x^{ae}$ will lead to $m_B(x^{ae}) > m_{F1}(x^{ae})$, implying that bank loans have lower default rates than fintech loans after controlling for entrepreneurs' characteristics.

We can put together Propositions 6, 7, 8 and make a summary. Fintechs' exclusive ability to discriminate tends to induce fintech 1 to price lower and have a higher loan default rate than bank i (controlling for entrepreneurs' characteristics). However, the higher funding costs of fintechs can overturn the result. Fintechs' advantage in offering convenience can also explain why fintech 1 may price higher bank i, but it cannot explain why fintech loans may have lower default rates than bank loans.

6. Welfare analysis

In this section, we analyze how the decrease in c_{F1} – which induces different regimes of fintech entry – affects social welfare, focusing on the benchmark case $\iota_B = \iota_F$. In this case, Condition (4) – which ensures that fintech entry cannot drive out banks – reduces to $c_{F1} > c_B$.

On the arc between banks i and $i+1$, we denote the loan rate and monitoring intensity at z_i by $r(z_i)$ and $m(z_i)$, denote the marginal funding cost of the lender serving location z_i by $\iota(z_i)$ $(= \iota_B = \iota_F)$, and finally denote the lender's costs of monitoring an entrepreneur at z_i by $C(z_i)$. In a symmetric equilibrium, social welfare is given by:

$$W = N \int_0^{1/N} \left(\begin{array}{c} \underbrace{D(z_i)}_{\text{investment at } z_i} \quad (m(z_i)R - \iota(z_i) - C(z_i)) \\ - \underbrace{\int_0^{D(z_i)} u\, du}_{\text{opportunity cost at } z_i} \end{array} \right) dz_i. \tag{9}$$

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 social costs, including funding, monitoring, and opportunity costs. Based on (9), we can decompose the welfare effects of fintech entry (driven by the decrease in c_{F1}) as follows:

- **Investment effect.** By changing entrepreneurs' utility from investment, fintech entry affects the mass of projects implemented. The effect is welfare-improving if fintech entry increases the mass of undertaken projects (i.e., investment).

The direction of the investment effect is ambiguous. On the one hand, the regimes PE or AE force banks to provide higher utility, tending to increase investment with respect to BE. On the other hand, **BT** areas may switch to **NBT** ones (as c_{F1} decreases) in the AE regime, which can reduce investment unless fintech 2's competitiveness is sufficiently high (see Proposition 5).

- **Monitoring effect.** By changing lenders' loan rates, fintech entry affects lenders' monitoring incentives and the success probabilities of projects. The monitoring effect is welfare-reducing if fintech entry induces lenders to post lower loan rates, decreasing the success probabilities of implemented projects.[25]

The monitoring effect also has an ambiguous direction. Lowering c_{F1} in the PE or AE regime will decrease banks' loan rates, reducing their monitoring intensities. However, after eroding banks' market areas, fintech 1 may gain market power and post high loan rates, potentially generating a welfare-improving monitoring effect.[26]

- **Cost-saving effect.** Decreasing c_{F1} renders monitoring cheaper for fintech 1, improving the lending efficiency of the credit market and social welfare.

The cost-saving effect works only for locations served by fintech 1, so it arises only in the AE regime. As fintech 1's market areas grow, the cost-saving effect of decreasing c_{F1} will be stronger since monitoring efficiency improves for larger areas. When c_{F1} is very close to c_B, fintech 1 will have higher monitoring efficiency than banks at most locations of the market since the fintech does not suffer from distance friction (i.e., $c_{F1} < c_B/(1 - qz_i)$ holds for a large range of z_i). In this case, fintech 1 will serve very large market areas and bring a significant cost-saving effect.

Generally speaking, the net welfare effect of fintech entry is ambiguous and depends on which effect(s) dominate. Figs. 7 and 8 illustrate the results.

Social welfare in the PE regime is higher than in the BE regime if c_B and q are sufficiently large. Potential fintech entry forces banks to reduce their loan rate, bringing a positive investment and a negative monitoring effect. When c_B and q are sufficiently large, serving distant locations brings banks very low profits, so banks have very low incentives to compete (by pricing aggressively) and extend their market areas. As a result, banks offer quite high loan rates in the BE regime, implying very low competition intensity and entrepreneurial investment. Then in the PE regime, as banks decrease rates, the positive investment effect will dominate the negative monitoring effect, increasing social welfare (Panel 1 of Fig. 7). In contrast, if c_B or q is not sufficiently large (Panels 2 and 3 of Fig. 7), there is already enough competition intensity in the BE regime, so social welfare is lower in the PE regime.

Social welfare in the AE regime is determined by the interplay of cost-saving, investment, and monitoring effects. When c_{F1} is close to c_B such that fintech 1 serves very large market areas, fintech entry will generate a significant cost-saving effect since fintechs do not face distance friction. However, social welfare in the AE regime (with c_{F1} close to c_B) may still be lower than that in the BE regime (see Panels 2 and 3 of Fig. 8). The reason is that, depending on the value of c_{F2}, AE can significantly reduce entrepreneurs' investment or lenders' monitoring incentives, potentially hurting welfare despite the cost-saving effect.

Recall that **NBT** areas will arise when c_{F1} is small enough (see Proposition 4 and the shaded regions in Fig. 8). If c_{F2} is very high, fintech 1 will charge quite high loan rates in **NBT** areas. In this case, decreasing c_{F1} will gradually turn **BT** areas into **NBT** ones, hence increasing lenders' (especially fintech 1's) profits while rapidly reducing the utility and investment of entrepreneurs. With such a strong investment-reducing effect, decreasing c_{F1} – despite a cost-saving effect and an increase in lender profit – may not be able to make the welfare in the AE regime higher than that in BE (see Panel 2 of Fig. 8).[27]

If c_{F2} is very low (i.e., r^*_{F1} is very low), fintech 1 must always charge quite low loan rates because of fintech 2's threat. Then, as fintech 1 erodes banks' market areas, banks' relatively high loan rates will be replaced by fintech 1's low rates. Meanwhile, banks will reduce their loan rates in response to fintech entry. As a result, fintech entry lowers lenders' pricing (and their skin in the game) in the credit market, decreasing their profits and monitoring incentives.[28] With such a negative monitoring effect, decreasing c_{F1} – despite a cost-saving effect and an increase in entrepreneurs' utility – may not be able to make the welfare in the AE regime higher than that in BE (see Panel 3 of Fig. 8).

An intermediate c_{F2} is needed to ensure a welfare-enhancing AE.

Proposition 9. ***Welfare in the AE regime.*** *Let $\iota_B = \iota_F$. Social welfare in the AE regime is higher than in BE if the following conditions hold:*

(i) c_{F1} is sufficiently close to c_B, and
(ii) c_{F2} is sufficiently close to $c^*_{F2} \in (c_{F1}, +\infty)$, the value of c_{F2} that induces an intermediate intensity of competition between fintechs, balancing the investment and the monitoring effects of entry.[29]

The first condition ensures that fintech entry generates a significant cost-saving effect since fintechs do not suffer from distance friction. The second condition means that c_{F2} should take an intermediate value, ensuring that the competition between fintechs 1 and 2 balances well entrepreneurs' investment and lenders' monitoring incentives. Specifically, if $c_{F2} = c^*_{F2}$, then fintech 1's upper bound loan rate r^*_{F1} – which is the fintech's pricing in **NBT** areas – exactly maximizes the sum of entrepreneurs' utility and fintech 1's lending profit. In this case, fintech 2's threat, on the one hand, ensures that fintech 1 cannot set very high loan rates (even in **NBT** areas), which avoids a strong investment-reducing effect.[30] On the other hand, it is not so competitive to force fintech 1 to always price very low, thus avoiding a large reduction in lenders' monitoring incentives.[31]

With both conditions, AE will generate a significant cost-saving effect while balancing the changes in entrepreneurs' investment and lenders' monitoring incentives well, thereby improving welfare with respect to the BE regime. See Panel 1 of Fig. 8 for an illustration.

Remark (*Pre-entry Local Monopoly*)**.** In this case, banks do not compete with each other and will set quite high monopolistic loan rates if there are no fintechs. Some locations are too far from all banks and hence have no access to bank finance. Fintech entry, on the one hand, substitutes bank lending by eroding banks' market areas and on the other hand, complements it by extending the market to locations with no

[25] From the social point of view, lenders' monitoring intensities are always insufficient since each lender cares only about its lending profit when choosing monitoring intensities, which underestimates the marginal benefit of monitoring to the total expected value of implemented projects.

[26] In the PE regime, fintech 1 serves no entrepreneur, so the monitoring effect of fintech entry is welfare-reducing since banks decrease their loan rate in response to PE.

[27] Before **NBT** areas begin to arise, decreasing c_{F1} in the AE regime increases competition intensity and entrepreneurs' utility since banks offer lower loan rates and are still willing to serve all locations.

[28] This case is illustrated by Panel 3 of Fig. 8 (with $c_{F2} = c_{F1}$), where decreasing c_{F1} always increases entrepreneurs' utility and decreases lenders' profit – even after **NBT** areas arise – because fintech 1 always posts its best loan rate $\bar{r}_{F1}$ due to fintech 2's threat.

[29] See the proof of *Proposition* 9 for the expression for c^*_{F2} and its derivation.

[30] This can be seen by comparing Panels 1 and 2 of Fig. 8. In Panel 1, decreasing c_{F1} in the shaded region reduces entrepreneurs' utility at a slower rate than in Panel 2.

[31] This can be seen by comparing Panels 1 and 3 of Fig. 8. When c_{F1} is very low, lenders' profits (and hence monitoring incentives) in Panel 1 are significantly higher than in Panel 3.

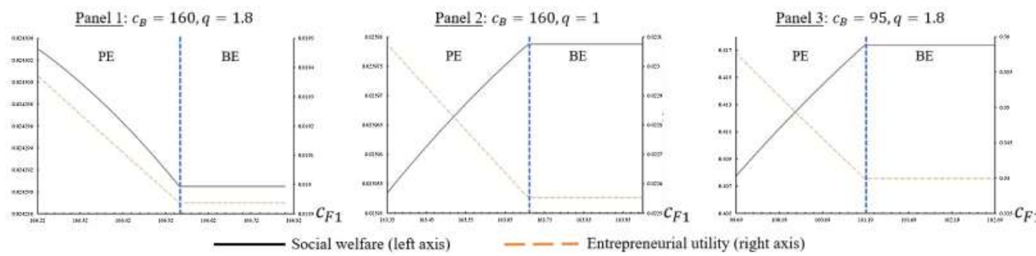

Fig. 7. Welfare Effect of c_{F1} (from BE to PE). This figure plots social welfare (solid curve) and entrepreneurial utility (dashed curve) against c_{F1}. The parameter values are: $R = 20$, $N = 30$, and $\iota_B = \iota_F = 1$. .

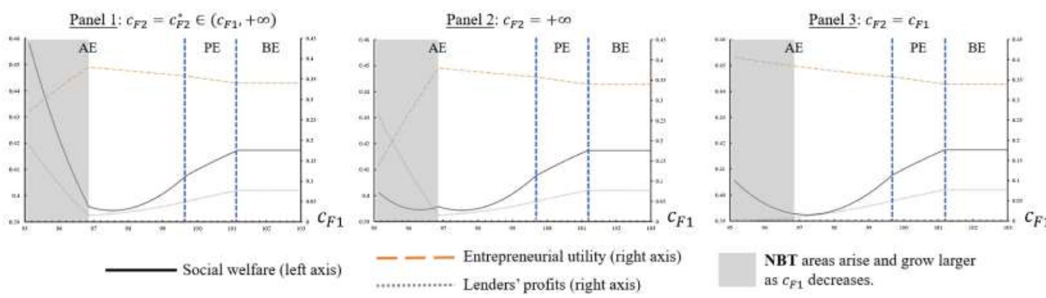

Fig. 8. Welfare Effect of c_{F1} (from BE to AE). This figure plots social welfare (solid curve), entrepreneurial utility (dashed curve), and lenders' profits (dotted curve) against c_{F1}. The parameter values are: $R = 20$, $q = 1.8$, $c_B = 95$, $N = 30$, and $\iota_B = \iota_F = 1$. When c_{F1} is in the shaded region, **NBT** areas will arise (i.e., banks are not willing to serve sufficiently distant locations). In the shaded region, **NBT** areas will grow larger as c_{F1} decreases. .

access to banks (Gopal and Schnabl, 2022; Eça et al., 2022; Hau et al., 2024; Cornelli et al., 2024; Alok et al., 2024). Based on a numerical study, fintech entry increases social welfare (with respect to the BE regime) for any c_{F2} ($\geq c_{F1}$) if banks have a pre-entry local monopoly. See Online Appendix B for detailed analysis and explanations.

7. Price-discriminating banks

By exploiting private soft information (see Liberti, 2018; Agarwal and Ben-David, 2018; He et al., 2024), banks may be able to discriminate against borrowers to some extent. If banks can also price discriminate (i.e., set loan rates based on entrepreneurs' locations) as fintechs, we can still show that three possible equilibria may arise: blockaded entry (BE), potential entry (PE), and actual entry (AE). See Online Appendix D for a detailed analysis. Here, we focus on the AE regime. Consistent with Proposition 1, actual entry also cuts off direct competition between banks: There exists an indifference location $\hat{x}^{ae} \in (0, 1/(2N))$ such that fintech 1 serves entrepreneurs at $z_i \in \left[\hat{x}^{ae}, 1/N - \hat{x}^{ae}\right]$ on the arc between banks i and $i+1$, while bank i (resp. bank $i+1$) serves entrepreneurs at $z_i \in [0, \hat{x}^{ae})$ (resp. $z_i \in (1/N - \hat{x}^{ae}, 1/N]$).

In this section, a variable with a "hat" is an equilibrium outcome when banks can price discriminate. For example, $z_i = \hat{x}^{ae}$ is the indifference location when banks can price discriminate, while $z_i = x^{ae}$ when banks cannot. When able to discriminate, a bank can change its loan rate for one location without affecting its lending profits from other locations. Hence the bank can offer its *best loan rate* to compete with other lenders at each location.

Lemma 4. *At location z_i, a bank's loan rate that maximizes an entrepreneur's utility is $\bar{r}_B(d) \equiv \sqrt{2c_B\iota_B/(1-qd)}$, where d is the arc-distance between the bank and location z_i. We call $\bar{r}_B(d)$ the "**best loan rate**" of the bank when its lending distance is d.*

Note that a bank's best loan rate $\bar{r}_B(d)$ has the same structure as a fintech's (see Lemma 2). A bank (with a distance d) makes zero profit at z_i by offering $\bar{r}_B(d)$ and cannot reduce the rate anymore. As $c_B/(1-qd)$ or ι_B increases, the bank needs a higher loan rate to beak even at z_i, hence increasing $\bar{r}_B(d)$.

Proposition 10. *Suppose that banks can price discriminate. In the AE regime with $\iota_B = \iota_F$, fintech 1 has the same monitoring efficiency and intensity, and loan rate as bank i at the indifference location $z_i = \hat{x}^{ae}$:*

$$\frac{c_B}{1-q\hat{x}^{ae}} = c_{F1},\ \hat{m}_B(\hat{x}^{ae}) = \hat{m}_{F1}(\hat{x}^{ae}),\ \text{and} \quad (10)$$
$$\hat{r}^{ae}_B(\hat{x}^{ae}) = \bar{r}_B(\hat{x}^{ae}) = \hat{r}_{F1}(\hat{x}^{ae}) = \bar{r}_{F1}.$$

In the AE regime with $\iota_B < \iota_F$, fintech 1 has higher monitoring efficiency and intensity, and loan rate than bank i at the indifference location $z_i = \hat{x}^{ae}$:

$$\frac{c_B}{1-q\hat{x}^{ae}} > c_{F1},\ \hat{m}_B(\hat{x}^{ae}) < \hat{m}_{F1}(\hat{x}^{ae}),\ \text{and} \quad (11)$$
$$\hat{r}^{ae}_B(\hat{x}^{ae}) = \bar{r}_B(\hat{x}^{ae}) < \hat{r}_{F1}(\hat{x}^{ae}) = \bar{r}_{F1}.$$

When banks can also discriminate, both bank i and fintech 1 will offer their best loan rates and provide the same utility at $z_i = \hat{x}^{ae}$, implying that they have the same monitoring efficiency and loan rate at $z_i = \hat{x}^{ae}$ if $\iota_B = \iota_F$. As a result, fintech 1 and bank i have the same monitoring intensity at $z_i = \hat{x}^{ae}$ according to Lemma 1.

The story differs when $\iota_F > \iota_B$. A higher ι_F increases fintech 1's best loan rate and reduces its market area (i.e., $\hat{x}^{ae}$ increases), so bank i's monitoring efficiency at $z_i = \hat{x}^{ae}$ will decrease and become lower than fintech 1's. Then, although fintech 1 and bank i still provide the same utility at $z_i = \hat{x}^{ae}$, their advantages are different: Fintech 1's higher monitoring efficiency at $z_i = \hat{x}^{ae}$ allows it to carry out more monitoring, while bank i offers a lower loan rate due to its funding cost advantage. The second part of Proposition 10 repeats the implication of Proposition 7: fintechs' funding cost disadvantage can explain why fintech loans can have higher interest rates and lower delinquency rates than bank loans. Several results follow.

Corollary 4. *Suppose $\iota_B \leq \iota_F$ and that banks can price discriminate. Then:*

(i) The AE regime will not occur if $c_B/(1-q/(2N)) < c_{F1}$ and $\iota_B < \iota_F$ both hold.

(ii) In the AE regime, $x^{ae} < \hat{x}^{ae}$ holds: allowing banks to discriminate reduces the market areas served by fintech 1.

(iii) With respect to the BE regime, PE and AE always increase total investment I.

Item (i) of Corollary 4 means that Corollary 3 will be overturned if banks can price discriminate. Now, banks are willing to use their best loan rates to protect market areas, so actual entry occurs if and only if fintech 1 has an advantage over banks in monitoring efficiency at some location(s) or/and in funding cost. Item (ii) follows since allowing banks to discriminate increases their competitiveness.

In contrast to Proposition 5, Item (iii) of Corollary 4 does not need a sufficiently low c_{F2} to ensure that the AE regime increases investment. The reason is that now banks are no longer constrained by a uniform pricing policy, so at each location, fintech 1 always faces the threat of banks willing to offer their best loan rates (i.e., **NBT** areas never arise).

As for the welfare effect of fintech entry with $\iota_B = \iota_F$, Item (iii) of Corollary 4 implies that the PE and AE regimes always bring a positive investment effect when banks can price discriminate. Therefore, even if c_{F2} is very high, actual entry will never generate **NBT** areas and reduce investment. As a result, our numerical study finds that AE (with c_{F1} sufficiently close to c_B) increases social welfare with respect to the BE regime if c_{F2} is not very low (i.e., is intermediate or high) because in this case, it generates a significant cost-saving effect while avoiding a strong negative monitoring effect.

Remark (*Price Discrimination and Social Welfare*)**.** For a given location (e.g., z_i), a lender's socially optimal loan rate should maximize the total surplus at this location (i.e., the sum of entrepreneurial utility and lender profit), balancing entrepreneurs' investment and lenders' monitoring incentives. We find that a lender's socially optimal loan rate is decreasing in its monitoring efficiency.[32] Therefore, a fintech's socially optimal rate is uniform for all locations (i.e., independent of z_i), indicating that fintechs' discriminatory pricing in general cannot achieve optimal welfare. A bank's socially optimal loan rate is increasing in its lending distance since a larger distance implies lower bank monitoring efficiency; in contrast, the bank's competitive discriminatory loan rate is decreasing in the distance since a larger distance implies lower competitiveness and market power in lending competition, indicating that banks' equilibrium discriminatory pricing cannot achieve optimal welfare either. Rates by banks or fintechs will be too high from the social point of view when either of them wields a high degree of market power.

Another question is whether allowing banks to discriminate improves welfare or not. The result is ambiguous. When banks can discriminate, fintech 1 will face more competitive pressure from banks, and **NBT** areas will disappear. This will improve (resp. hurt) welfare if fintech 1 serves large market areas and charges very high (resp. intermediate or very low) loan rates for its entrepreneurs, which tends to happen when c_{F2} is very high (resp. intermediate or very low).[33]

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

In the long run, some banks may exit the market and recover salvage (liquidation) values as fintech entry decreases their profitability. Online Appendix E presents the model setup with banks' exit and analyzes the equilibrium in detail. We provide the main results and their intuitions in this section.

There still exist thresholds $\bar{c}_F$ and $\underline{c}_F$ for c_{F1}, which can induce three types of equilibria: blockaded entry (BE), potential entry (PE), and actual entry (AE). PE and AE regimes reduce banks' profitability and can induce their exit (i.e., N gradually decreases as c_{F1} decreases in the PE or AE regime). The properties of banks' and fintech 1's pricing strategies, monitoring intensities, and market areas discussed in Sections 4 and 5 still hold when banks can exit. However, allowing banks to exit brings about some changes.

- Banks' exit makes the AE regime and **NBT** areas easier to arise.

As the fintech threat drives some banks to exit, the distance between banks will increase, so it is harder for banks to prevent fintech 1 from serving the mid location $z_i = 1/(2N)$. Therefore, it is easier for actual entry to occur. In addition, a longer distance between adjacent banks reduces bank i's profitability of serving the mid location $z_i = 1/(2N)$, so **NBT** areas become easier to arise (i.e., arise at a higher c_{F1}). Figure E.4 of Online Appendix E illustrates the results: Allowing banks to exit reduces PE regions (i.e., decreases $\bar{c}_F - \underline{c}_F$) and widens the regions where **NBT** areas exist.

- Allowing banks to exit enlarges the potential negative effect of fintech entry on entrepreneurs' investment.

As the potential or actual entry reduces N, the arc distance between adjacent banks will increase, reducing banks' threat to fintech 1. Such a decrease in banks' threat will translate into lower entrepreneurial utility and investment unless fintech 2 puts sufficient competitive pressure on fintech 1. See Figure E.3 of Online Appendix E.

- When banks have the option to exit, the PE and AE regimes will generate an *option value effect*, meaning 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 potential or actual entry transfers bank profit to other parties (entrepreneurs or/and fintech 1) and lets banks exit with their option values. Due to the option value effect, actual entry (with c_{F1} sufficiently close to c_B) is more likely to improve social welfare with respect to the BE regime. See Figure E.4 of Online Appendix E for an illustration.

9. Conclusion

Three types of equilibria may arise depending on the monitoring efficiency of fintechs: blockaded entry (BE), potential entry (PE), and actual entry (AE). A fintech with no advantage in monitoring efficiency or funding cost can actually enter the credit market if it can price more flexibly than banks. This prediction sheds light on the issue of whether fintech entry is driven by superior information technology. If banks can also price discriminate, a fintech's advantage in monitoring efficiency or funding cost is a necessary condition for its successful entry.

Another consequence of fintechs' superior flexibility in pricing is that if fintechs and banks have the same funding costs, fintechs perform less monitoring and charge lower loan rates than banks (for borrowers with similar characteristics). However, the result will flip if fintechs have significantly higher funding costs than banks. In addition, fintechs' advantage in offering convenience can induce them to charge higher loan rates than banks. Therefore, our model predicts an ambiguous relationship between the loan rates and risks of fintechs and those of banks, which is consistent with the empirical evidence received.

Our model predicts that higher bank concentration (e.g., exogenous bank closures) will lead to higher fintech lending volume. Fintechs will have a higher competitive advantage and hence serve larger market areas if their monitoring efficiency improves. The implication is that fintechs' information technology development or policies that increase fintechs' information advantage over banks (e.g., open banking)

[32] If the lender's monitoring efficiency at z_i improves, the surplus generated by one *individual* project – the entrepreneur's surplus plus the lender's profit from the project – will be higher at z_i. Then, the marginal social benefit of increasing the mass of implemented projects (i.e., investment) will be higher at z_i, hence lowering the socially optimal rate to spur investment. See Online Appendix D (Proposition D.1 and Figure D.2) comparing lenders' socially optimal loan rates with the equilibrium discriminatory rates.

[33] If banks have a pre-entry local monopoly, allowing discrimination will induce them to serve more distant locations and hence improve financial inclusion, thereby increasing welfare in the BE regime, according to a numerical study.

will induce fintech lenders to penetrate more industries and provide more credit. Allowing banks to price more flexibly (e.g., with pricing algorithms) will reduce the market areas served by fintechs.

If there is sufficiently intense competition among fintechs, our model predicts that fintech entry will make entrepreneurs better off and hence increase total investment. The welfare effect of fintech entry is ambiguous in general. Actual fintech entry (with a high fintech monitoring efficiency) 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, banks can exit and recover salvage values in the long run, which may hurt entrepreneurs (and reduce investment) but will generate a welfare-improving option value effect.

CRediT authorship contribution statement

Xavier Vives: Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization. **Zhiqiang Ye:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Proofs

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

Proof of Lemma 2. For an entrepreneur at z_i, the expected utility from investment equals $U_{Fj}(z_i) \equiv m_{Fj}(z_i)\left(R - r_{Fj}(z_i)\right)$ if she secures a loan from fintech j with the loan rate (resp. monitoring intensity) $r_{Fj}(z_i)$ (resp. $m_{Fj}(z_i)$). By Lemma 1, we know $m_{Fj}(z_i) = r_{Fj}(z_i)/c_{Fj}$. Hence, if the fintech maximizes $U_{Fj}(z_i)$ by choosing $r_{Fj}(z_i)$, the resulting loan rate is $R/2$. However, $R/2$ is not 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 $r_{Fj}(z_i) \geq \sqrt{2c_{Fj}\iota_F} > R/2$ (according to Inequality (3)). Hence, the feasible fintech loan rate that maximizes entrepreneurs' utility is $\bar{r}_{Fj} = \sqrt{2c_{Fj}\iota_F}$; the corresponding maximum entrepreneurial utility from investment is $\overline{U}_{Fj}$.

Proof of Proposition 1. First, we need to derive and characterize a bank's monopolistic loan rate (denoted by r_B^m) that the bank will offer when it faces no competition from any other lenders.

Deriving a bank's monopolistic loan rate r_B^m. Suppose that bank i offers the loan rate r_i. Based on Lemma 1 and Eq. (5), the bank's expected profit from serving an entrepreneur at z_i equals $(r_i)^2(1-qz_i)/(2c_B) - \iota_B$.

If bank i faces no competition from any other lenders, the farthest location (denoted by $x^\uparrow$) the bank is willing to serve on the arc between banks i and $i+1$ is determined by the equation $(r_i)^2(1-qx^\uparrow)/(2c_B) - \iota_B = 0$. We need only consider the case that r_i is so high that $x^\uparrow > 0$; otherwise bank i serves no entrepreneurs and makes zero profits, which is never optimal. $x^\uparrow > 0$ implies that $r_i > \sqrt{2c_B\iota_B}$. Therefore, the lower bound for r_i is $\sqrt{2c_B\iota_B}$, which is higher than $R/2$.

The bank's aggregate profit is $2\int_0^{x^\uparrow} D(z_i)\left((r_i)^2(1-qz_i)/(2c_B) - \iota_B\right) dz_i$ when there is no competition. Obviously, $(r_i)^2(1-qz_i)/(2c_B) - \iota_B > 0$ for $z_i \in [0, x^\uparrow)$. $D(z_i) = (1-qz_i)\, r_i (R-r_i)/c_B$ is the funding demand at z_i. Maximizing the bank's profit implies the following (simplified) FOC with respect to r_i:

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

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

Deriving a bank's equilibrium loan rate under competition. Next, we derive the first-order condition of a bank's pricing for the BE equilibrium. Since we look only at symmetric equilibria, we can focus on the arc between banks i and $i+1$. Assume that bank i offers the loan rate r_i while the other banks offer r_{i+1}. The indifference location x^{be}, where entrepreneurs are indifferent between banks i and $i+1$, is determined by

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

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

$$g^{be}(r_B^{be}) \equiv \underbrace{\left(\begin{array}{c} \int_0^{x^{be}} \frac{\partial D(z_i)\left(\frac{(r_i)^2(1-qz_i)}{2c_B} - \iota_B\right)}{\partial r_i} dz_i \\ + D(x^{be})\left(\frac{(r_i)^2(1-qx^{be})}{2c_B} - \iota_B\right)\frac{\partial x^{be}}{\partial r_i} \end{array} \right)}_{\text{Take derivative first, and then let } r_i = r_{i+1} = r_B^{be} \text{ and } x^{be} = \frac{1}{2N}.} = 0. \quad \text{(A.2)}$$

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

$$\left.\frac{\partial x^{be}}{\partial r_i}\right|_{r_i = r_{i+1} = r_B^{be}} = \frac{(2N-q)\left(R - 2r_B^{be}\right)}{4Nq\left(R - r_B^{be}\right) r_B^{be}}. \quad \text{(A.3)}$$

In equilibrium, r_B^{be} must be high enough to ensure that $\left(r_B^{be}\right)^2(1-q/(2N))/(2c_B) - \iota_B \geq 0$. If not, bank i will be unwilling to serve an entrepreneur at $z_i = 1/(2N)$. Therefore, the lower bound of r_B^{be} is $\underline{r}_B^{be} \equiv \sqrt{2c_B\iota_B/(1-q/(2N))} > R/2$ ($\underline{r}_B^{be}$ is the solution of $\left(\underline{r}_B^{be}\right)^2(1-q/(2N))/(2c_B) - \iota_B = 0$).

The FOC (A.2) can be reduced to

$$f^{be}\left(r_B^{be}\right) \equiv \left(\begin{array}{c} \dfrac{2r_B^{be}\left(R-r_B^{be}\right)}{3} + r_B^{be}\left(R-2r_B^{be}\right)y_1 \\ +y_2 \underbrace{\dfrac{\left(1-\frac{q}{2N}\right)\left(2-\frac{q}{N}\right)\left(R-2r_B^{be}\right)}{2\left(1-\left(1-\frac{q}{2N}\right)^3\right)}}_{\text{negative}} \end{array} \right) = 0. \tag{A.4}$$

with

$$\begin{cases} y_1 = \frac{1}{3} - \frac{c_B \iota_B}{\left(r_B^{be}\right)^2} \frac{1-\left(1-\frac{q}{2N}\right)^2}{1-\left(1-\frac{q}{2N}\right)^3} > 0 \\ y_2 = \frac{r_B^{be}\left(1-\frac{q}{2N}\right)}{2} - \frac{c_B \iota_B}{r_B^{be}} > 0 \end{cases}.$$

Here y_1 equals $\int_0^{1/(2N)} \left(\left(r_B^{be}\right)^2\left(1-qz_i\right)/(2c_B) - \iota_B\right)\left(1-qz_i\right)dz_i$ multiplied by a positive value and is thus positive (since $r_B^{be} \geq \underline{r}_B^{be}$). y_2 equals a positive value times $\left(r_B^{be}\right)^2\left(1-q/(2N)\right)/\left(2c_B\right) - \iota_B$, which is non-negative since $r_B^{be} \geq \underline{r}_B^{be}$.

It is easy to notice that $f^{be}\left(\underline{r}_B^{be}\right) = f^m\left(\underline{r}_B^{be}\right)$ (see Eq. (A.1)). Then, we can show $y_2 \neq 0$ (i.e., $r_B^{be} \neq \underline{r}_B^{be}$); otherwise $f^{be}\left(r_B^{be}\right) = f^m\left(r_B^{be}\right) = 0$ would hold, which means: (a) r_B^{be} is bank i 's monopolistic loan rate (i.e., $r_B^{be} = r_B^m$) and (b) $\left(r_B^m\right)^2\left(1-q/(2N)\right)/\left(2c_B\right) - \iota_B = 0$ holds. However, this contradicts Condition (2) which we assume to hold. Therefore, $y_2 > 0$ must hold (meaning that $r_B^{be} > \underline{r}_B^{be}$ must hold).

Condition (2) also ensures $r_B^m > \underline{r}_B^{be}$, so $f^{be}\left(\underline{r}_B^{be}\right) = f^m\left(\underline{r}_B^{be}\right) > 0 = f^m\left(r_B^m\right)$ must hold. Meanwhile, $f^{be}(R) < 0$ holds, and $f^{be}(\cdot)$ is a decreasing function in the interval $\left[\underline{r}_B^{be}, R\right]$. Therefore, there exists a unique $r_B^{be} \in \left(\underline{r}_B^{be}, R\right)$ that solves $f^{be}\left(r_B^{be}\right) = 0$; such a r_B^{be} is the unique symmetric equilibrium loan rate in the BE regime.

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

$$f^m\left(r_B^{be}\right) > \frac{2r_B^{be}\left(R-r_B^{be}\right)}{3} + r_B^{be}\left(R-2r_B^{be}\right)y_1 > f^{be}\left(r_B^{be}\right) = 0$$

Therefore, $r_B^{be} < r_B^m$ must hold since $f^m\left(r_i\right) = 0$ has a unique solution $r_i = r_B^m$ in the interval $\left[\sqrt{2c_B\iota_B}, R\right]$.

The existence of $\bar{c}_F$. In the BE equilibrium, entrepreneurial utility is lowest at location $z_i = 1/(2N)$, so fintech entry is blockaded if

$$\frac{r_B^{be}\left(1-q/(2N)\right)\left(R-r_B^{be}\right)}{c_B} \geq \overline{U}_{F1} = \frac{\bar{r}_{F1}\left(R-\bar{r}_{F1}\right)}{c_{F1}},$$

where $\overline{U}_{F1}$ and $\bar{r}_{F1}$ are defined in Lemma 2. Since $\bar{r}_{F1}$ is a function of c_{F1}, in the proof we sometimes write $\bar{r}_{F1}$ as $\bar{r}_{F1}\left(c_{F1}\right)$ to highlight that $\bar{r}_{F1}$ is not independent of c_{F1}. Therefore, $\bar{c}_F$ is determined by the following equation:

$$\frac{r_B^{be}\left(1-\frac{q}{2N}\right)\left(R-r_B^{be}\right)}{c_B} = \frac{\bar{r}_{F1}\left(\bar{c}_F\right)\left(R-\bar{r}_{F1}\left(\bar{c}_F\right)\right)}{\bar{c}_F}. \tag{A.5}$$

If $c_{F1} < \bar{c}_F$, the BE equilibrium cannot be sustained.

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

We examine the competition between bank i and fintech 1 in the AE regime. Let x^{ae} denote the indifference location where an entrepreneur is indifferent between bank i's loan rate, denoted by r_i^{ae}, and the fintech's best loan rate. Then, x^{ae} is determined by

$$\frac{r_i^{ae}\left(1-qx^{ae}\right)\left(R-r_i^{ae}\right)}{c_B} = \overline{U}_{F1} \Leftrightarrow x^{ae} = \frac{\left(1-\frac{c_B\overline{U}_{F1}}{r_i^{ae}\left(R-r_i^{ae}\right)}\right)}{q}. \tag{A.6}$$

Bank i serves locations $z_i \in [0, x^{ae}]$ when competing with fintech 1. Since banks i and $i+1$ are symmetric, the AE regime can arise only if $x^{ae} < 1/(2N)$ holds in equilibrium; otherwise, bank i will touch and compete directly with bank $i+1$.

Next, we derive the FOC of bank i in the AE regime. We need only consider $x^{ae} > 0$; otherwise, $x^{ae} = 0$ holds and bank i makes zero profit, which is not optimal for the bank. According to Condition (4), if bank i offers a loan rate slightly higher $\sqrt{2c_B\iota_B}$, then it can serve a positive mass of locations (close to $z_i = 0$) and make positive profits. Hence, in the AE regime, $x^{ae} > 0$ indeed must hold in equilibrium.

Bank i's total profit is $2\int_0^{x^{ae}} D(z_i)\left(\left(r_i^{ae}\right)^2\left(1-qz_i\right)/(2c_B) - \iota_B\right)dz_i$ in the AE regime. Note that in equilibrium, $\left(r_i^{ae}\right)^2\left(1-qz_i\right)/(2c_B) - \iota_B \geq 0$ must hold for $z_i \in [0, x^{ae}]$ to ensure that the bank is willing to serve the locations in $[0, x^{ae}]$. Maximizing the profit yields the following FOC:

$$g^{ae}\left(r_i^{ae}\right) \equiv \left(\begin{array}{c} \displaystyle\int_0^{x^{ae}} \frac{\partial D(z_i)\left(\frac{\left(r_i^{ae}\right)^2(1-qz_i)}{2c_B} - \iota_B\right)}{\partial r_i^{ae}} dz_i \\ +D\left(x^{ae}\right)\left(\frac{\left(r_i^{ae}\right)^2\left(1-qx^{ae}\right)}{2c_B} - \iota_B\right)\frac{\partial x^{ae}}{\partial r_i^{ae}} \end{array} \right) = 0. \tag{A.7}$$

Simplifying Eq. (A.7) using Eq. (A.6) yields:

$$f^{ae}\left(r_i^{ae}\right) \equiv \left(\begin{array}{c} \dfrac{2r_i^{ae}\left(R-r_i^{ae}\right)}{3} + \\ r_i^{ae}\left(R-2r_i^{ae}\right)\underbrace{\left(\dfrac{1}{3} - \dfrac{c_B\iota_B}{\left(r_i^{ae}\right)^2}\dfrac{1-y_{ae}^2}{1-y_{ae}^3}\right)}_{\text{positive; increasing in } r_i^{ae}} \\ +2\underbrace{\left(\dfrac{\overline{U}_{F1}}{2\left(R-r_i^{ae}\right)} - \dfrac{\iota_B}{r_i^{ae}}\right)}_{\text{non-negative}}\dfrac{\left(R-2r_i^{ae}\right)c_B y_{ae}^2}{1-y_{ae}^3} \end{array} \right) \tag{A.8}$$
$$= 0,$$

where $y_{ae} \equiv c_B\overline{U}_{F1}/(r_i^{ae}\left(R-r_i^{ae}\right))$; $y_{ae} < 1$ must hold because of $x^{ae} > 0$ (note that $x^{ae} = \left(1-y_{ae}\right)/q$). According to Condition (4) and $\lim_{r_i^{ae}\to R} y_{ae} = +\infty$, there must exist a $\bar{r}_B^{ae} \in \left(\sqrt{2c_B\iota_B}, R\right)$ such that $\lim_{r_i^{ae}\to\bar{r}_B^{ae}} x^{ae} = 0$. This $\bar{r}_B^{ae}$ is the upper bound of bank i's loan rate, because the bank will serve no location (and make zero profit) if its loan rate is above $\bar{r}_B^{ae}$. In Eq. (A.8), $1/3 - c_B\iota_B(1-y_{ae}^2)/(\left(r_i^{ae}\right)^2(1-y_{ae}^3))$ is equal to a positive value times $\int_0^{x^{ae}}\left(\left(r_i^{ae}\right)^2\left(1-qz_i\right)/(2c_B) - \iota_B\right)\left(1-qz_i\right)dz_i$, which is positive since $\left(r_i^{ae}\right)^2\left(1-qz_i\right)/(2c_B) - \iota_B \geq 0$ must hold for $z_i \in [0, x^{ae}]$. $\overline{U}_{F1}/(2\left(R-r_i^{ae}\right)) - \iota_B/r_i^{ae}$ has the same sign as $\left(r_i^{ae}\right)^2(1-qx^{ae})/(2c_B) - \iota_B$, which is non-negative.

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

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

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

Next we show that $f^{ae}\left(\underline{r}_B^{ae}\right) > 0$ holds. Note that $f^{ae}\left(\underline{r}_B^{ae}\right) = f^m\left(\underline{r}_B^{ae}\right)$ holds (see Eq. (A.1)). Suppose that location $z_i = x^{\dagger}$ is the location where bank i makes zero profit with the loan rate r_i^{ae} (i.e., $\left(r_i^{ae}\right)^2\left(1-qx^{\dagger}\right)/(2c_B) - \iota_B = 0$). If $r_i^{ae} = \underline{r}_B^{ae}$, then bank i provides the utility $\overline{U}_{F1}$ at location $z_i = x^{\dagger}$. In contrast, if $r_i^{ae} = r_B^m$, then at location $z_i = x^{\dagger}$, the utility provided by bank i is smaller than $\overline{U}_{F1}$

because

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

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

In the AE regime, fintech 1 must serve a positive mass of locations, which means $x^{ae}|_{r_i^{ae}=r_B^{ae}} < 1/(2N)$ is a necessary condition for AE to occur. Symmetrically, bank $i+1$ serves entrepreneurs at $z_i \in \left(1/N - x^{ae}, 1/N\right]$. Fintechs serve entrepreneurs at $z_i \in \left[x^{ae}, 1/N - x^{ae}\right]$.

The existence of the PE regime. Next we show that AE cannot occur if c_{F1} is smaller than but sufficiently close to $\overline{c}_F$. According to the formulae of $\overline{c}_F$ and x^{ae} (see Eqs. (A.5) and (A.6)), if $c_{F1} = \overline{c}_F$ holds and if AE occurs (which means bank i competes only with fintech 1), the indifference location x^{ae} is equal to $1/(2N)$ when bank i chooses $r_i^{ae} = r_B^{be}$. Then, according to FOC Eqs. (A.2) and (A.7), $g^{ae}\left(r_B^{be}\right)\Big|_{c_{F1}=\overline{c}_F} < g^{be}\left(r_B^{be}\right)\Big|_{c_{F1}=\overline{c}_F} = 0$ holds because (a) $x^{ae}|_{r_i^{ae}=r_B^{be}} = 1/(2N)$ holds when $c_{F1} = \overline{c}_F$, and (b) according to Eq. (A.3), we have:

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

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

Meanwhile, fintech entry cannot be blockaded when $c_{F1} < \overline{c}_F$, so there must be another type of entry (neither BE nor AE) if c_{F1} is smaller than but sufficiently close to $\overline{c}_F$. In this case (named as the PE regime), we will show that bank i's loan rate (denoted by $r_B^{pe} \in \left[\sqrt{2c_B\iota_B}, R\right]$) in the symmetric equilibrium exactly prevents fintech penetration at $z_i = 1/(2N)$, that is: $r_B^{pe}(1-q/(2N))\left(R-r_B^{pe}\right)/c_B = \overline{U}_{F1}$ (i.e., Eq. (7)). Obviously $r_B^{pe} < r_B^{be}$ holds because $c_{F1} < \overline{c}_F$. Note that $\lim_{c_{F1}\to\overline{c}_F} r_B^{pe} = r_B^{be}$. Therefore, $g^{ae}\left(r_B^{pe}\right) \le 0$ must hold when c_{F1} is smaller than but sufficiently close to $\overline{c}_F$, because $g^{ae}\left(r_B^{be}\right)\Big|_{c_{F1}=\overline{c}_F} < 0$. When $g^{ae}\left(r_B^{pe}\right) \le 0$ holds (which is equivalent to $f^{ae}\left(r_B^{pe}\right) \le 0$), bank i has no incentive to increase its loan rate above r_B^{pe} to compete directly with fintech 1. Meanwhile, the relation $r_B^{pe} < r_B^{be}$ implies that bank i has no incentive to decrease its loan rate below r_B^{pe}, because $f^{be}\left(r_B^{pe}\right) > 0$ must hold (which means, if fintech entry is blockaded and banks compete with each other, then both banks i and $i+1$ have incentives to increase their loan rates above r_B^{pe}). In sum, if c_{F1} is smaller than but sufficiently close to $\overline{c}_F$ (such that $g^{ae}\left(r_B^{pe}\right) \le 0$ holds), banks have no incentives to deviate from offering r_B^{pe}.

The existence of $\underline{c}_F$. Next, we show the existence of $\underline{c}_F$. When $c_{F1} < \overline{c}_F$, AE will occur if and only if $g^{ae}\left(r_B^{pe}\right) > 0$, which means bank i has an incentive to increase its loan rate above r_B^{pe} to compete directly with fintech 1. Note that $g^{ae}\left(r_B^{pe}\right) > 0$ is equivalent to $x^{ae}|_{r_i^{ae}=r_B^{ae}} < 1/(2N)$. Therefore, if both $x^{ae}|_{r_i^{ae}=r_B^{ae}} \ge 1/(2N)$ and $c_{F1} < \overline{c}_F$ hold (i.e., when c_{F1} is smaller than but sufficiently close to $\overline{c}_F$), there is potential entry; if $x^{ae}|_{r_i^{ae}=r_B^{ae}} < 1/(2N)$, actual fintech entry occurs. If c_{F1} is sufficiently low such that $\overline{U}_{F1} > R^2(1-q/(2N))/\left(4c_B\right)$ holds, the utility provided by bank i at $z_i = 1/(2N)$ must be lower than $\overline{U}_{F1}$ (no matter what loan rate the bank sets); therefore, fintech 1 will serve location $z_i = 1/(2N)$ (i.e., AE will occur), indicating $x^{ae}|_{r_i^{ae}=r_B^{ae}} < 1/(2N)$ and the existence of threshold $\underline{c}_F$. The fact that $x^{ae}|_{r_i^{ae}=r_B^{ae}}$ is increasing in c_{F1} in the AE regime is shown in the proof of Proposition 3. Therefore, such a threshold $\underline{c}_F$ is unique. When $c_{F1} = \underline{c}_F$, $x^{ae}|_{r_i^{ae}=r_B^{ae}} = 1/(2N)$ (i.e., $g^{ae}\left(r_B^{pe}\right) = 0$) holds, in which case $r_B^{ae} = r_B^{pe} < r_B^{be}$. In the proof of Proposition 3, we will show that r_B^{ae} is increasing in c_{F1} in the AE regime, so $r_B^{ae} < r_B^{be}$ always holds when $c_{F1} < \underline{c}_F$.

Proof of Corollary 1. $\overline{c}_F$ is determined by Eq. (A.5). According to FOC (A.4), r_B^{be} (which is higher than $\underline{r}_B^{be}$) must increase as q, c_B and ι_B increase. Then, the left hand side (LHS) of Eq. (A.5) will decrease. To keep Eq. (A.5) holding, $\overline{c}_F$ must increase. Increasing ι_F reduces the right hand side (RHS) of Eq. (A.5) without changing r_B^{be}, so $\overline{c}_F$ must decrease to keep Eq. (A.5) holding.

Next we look at $\underline{c}_F$. AE occurs if and only if $x^{ae}|_{r_i^{ae}=r_B^{ae}} < 1/(2N)$ holds. In the proof of Proposition 3, we will show that $x^{ae}|_{r_i^{ae}=r_B^{ae}}$ (hereafter, written as x^{ae} for simplicity) is increasing in c_{F1} in the AE regime. Therefore, $\underline{c}_F$ is the highest value of the c_{F1} ensuring $x^{ae} < 1/(2N)$. If q, c_B and/or ι_B increase, or if ι_F decreases, then x^{ae} will decrease (see the proof of Proposition 3), which makes $x^{ae} < 1/(2N)$ easier to hold. Therefore, $\underline{c}_F$ will increase as q, c_B or ι_B increases, or as ι_F decreases.

Proof of Proposition 2. In the PE regime, r_B^{pe} is determined by Eq. (7). If c_B or q increases, or if N decreases, the left hand side (LHS) of Eq. (7) will decrease for a given r_B^{pe}. As a result, r_B^{pe} must decrease to ensure that Eq. (7) holds. If c_{F1} or ι_F increases, the right-hand side (RHS) of (7) will decrease. As a result, r_B^{pe} must increase to ensure Eq. (7) holds. Obviously, ι_B does not play a role in Eq. (7).

Proof of Proposition 3. In this proof, we will show how r_B^{ae} and x^{ae} are affected by parameters in the AE regime (The effects of parameters on x^{ae} are useful for the proof of Corollary 1.). According to Eq. (A.8), a bank's loan rate r_B^{ae} in the AE regime satisfies:

$$f^{ae}\left(r_B^{ae}\right) = \left(\begin{array}{c} \dfrac{2r_B^{ae}\left(R-r_B^{ae}\right)}{3} + \\ \overbrace{r_B^{ae}\left(R-2r_B^{ae}\right)\left(\dfrac{1}{3} - \dfrac{c_B\iota_B}{\left(r_B^{ae}\right)^2}\dfrac{1-y_{ae}^2}{1-y_{ae}^3}\right)}^{\text{term A; negative}} \\ \underbrace{+2\left(\dfrac{r_B^{ae}}{2}y_{ae} - \dfrac{c_B\iota_B}{r_B^{ae}}\right)\dfrac{\left(R-2r_B^{ae}\right)y_{ae}^2}{1-y_{ae}^3}}_{\text{term B; negative}} \end{array}\right) = 0 \tag{A.9}$$

with $y_{ae} \equiv c_B\overline{U}_{F1}/\left(r_B^{ae}\left(R-r_B^{ae}\right)\right)$. Since Eq. (A.9) is independent of q and N, r_B^{ae} must also be independent of q and N. Then x^{ae} is decreasing in q and independent of N according to Eq. (A.6).

If c_{F1} or ι_F increases, then y_{ae} will decrease for a given r_B^{ae}; terms A and B will increase (i.e., become less negative) for a given r_B^{ae}. As a result, r_B^{ae} must increase to keep Eq. (A.9) holding (Note that increasing r_B^{ae} will increase y_{ae}).

If ι_B increases, terms A and B will increase (i.e., become less negative) for a given r_B^{ae}. Then, r_B^{ae} must increase to keep Eq. (A.9) holding. This implies that x^{ae} is decreasing in ι_B according to Eq. (A.6).

Next we look at how c_{F1} and ι_F affect x^{ae}. According to Eq. (A.6), $x^{ae} = \left(1-y_{ae}\right)/q$. If c_{F1} increases but y_{ae} does not adjust, terms A and B in Eq. (A.9) will decrease (i.e., become more negative) because r_B^{ae} is increasing in c_{F1}. Meanwhile, $2r_B^{ae}\left(R-r_B^{ae}\right)/3$ will also decrease (i.e., become less positive) because $r_B^{ae} > \underline{r}_B^{ae} > R/2$. Hence, y_{ae} must decrease (i.e., x^{ae} increases) to keep Eq. (A.9) holding. Reasoning in the same way, x^{ae} will increase if ι_F increases.

Finally, we look at how c_B affects x^{ae}. If c_B increases, two cases may arise. In the first case, r_B^{ae} increases or does not change; then x^{ae} decreases according to Eq. (A.6). In the second case, r_B^{ae} decreases; then terms A and B will increase (i.e., become less negative) for a given y_{ae}. Meanwhile, $2r_B^{ae}\left(R-r_B^{ae}\right)/3$ will increase (i.e., become more positive) because $r_B^{ae} > R/2$. As a result, y_{ae} must increase (i.e., x^{ae} must decrease) to keep Eq. (A.9) holding. Overall, no matter how r_B^{ae} changes with c_B, x^{ae} is decreasing in c_B.

Proof of Lemma 3. To prove this lemma, we need the following lemma first.

Lemma 5. *In the AE regime, if fintech 1 faces no competition from any other lender at z_i, the fintech will provide entrepreneurs at this location with the monopolistic loan rate r_{F1}^m, which is the largest solution of the following equation:*

$$g_{F1}^m\left(r_{F1}^m\right) \equiv \frac{(r_{F1}^m)^2(3R-4r_{F1}^m)}{2c_{F1}} + (2r_{F1}^m - R)\iota_F = 0. \tag{A.10}$$

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

First, we prove Lemma 5. If fintech 1 faces no competition from any other lender at z_i, it will choose a loan rate $r_{F1}\left(z_i\right)$ to maximize its lending profit at this location. The lending profit at z_i is $D(z_i)\Big(\left(r_{F1}\left(z_i\right)\right)^2\left(1-qz_i\right)/(2c_{F1}) - \iota_F\Big)$. Maximizing this profit yields $r_{F1}\left(z_i\right) = r_{F1}^m$, which is determined by Eq. (A.10). Note that $g_{F1}^m(-\infty) > 0$, $g_{F1}^m(0) < 0$, $g_{F1}^m\left(\sqrt{2c_{F1}\iota_F}\right) > 0$ and $g_{F1}^m(R) = -R\left(R^2/(2c_{F1}) - \iota_F\right) < 0$ hold. $g_{F1}^m\left(\sqrt{2c_{F1}\iota_F}\right) > 0$ and $g_{F1}^m(R) < 0$ holds because $\overline{U}_{F1} > 0$ in the AE regime, which means $R^2/(2c_{F1}) - \iota_F > \left(\overline{r}_{F1}\right)^2/(2c_{F1}) - \iota_F > 0$. Therefore, $g_{F1}^m\left(r_{F1}^m\right) = 0$ has a unique solution in $\left(\sqrt{2c_{F1}\iota_F}, R\right)$. Such a solution is the fintech's monopolistic loan rate. Eq. (A.10) is independent of z_i, so is r_{F1}^m.

Next, we prove Lemma 3. If fintech 1 need only consider the threat of fintech 2, then two cases may arise. First, if $r_{F1}^m\left(R - r_{F1}^m\right)/c_{F1} \geq \overline{U}_{F2}$, then fintech 1 can still offer r_{F1}^m. If not, fintech 1's loan rate must provide utility $\overline{U}_{F2}$ to ensure that entrepreneurs will not approach fintech 2. This leads to the following loan rate

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

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

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

The lending profit of the nearest bank by serving an entrepreneur at $z_i \in \left[x^{ae}, 1/N - x^{ae}\right]$ equals $(r_B^{ae})^2(1-qd^{ae})/(2c_B) - \iota_B$. If this profit is negative, then no bank is willing to serve location z_i. In such a location fintech 1 will offer r_{F1}^* according to Lemma 3.

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

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

When c_{F1} is so low that $\overline{U}_{F1}$ approaches $\sqrt{2c_B\iota_B}\left(R - \sqrt{2c_B\iota_B}\right)/c_B$, both $\underline{r}_B^{ae}$ – which equals $2\iota_B R/(\overline{U}_{F1} + 2\iota_B)$ – and $\overline{r}_B^{ae}$ will approach $\sqrt{2c_B\iota_B}$, implying that r_B^{ae} will also approach $\sqrt{2c_B\iota_B}$ (see the proof of Proposition 1). When $r_B^{ae} \to \sqrt{2c_B\iota_B}$, $(r_B^{ae})^2(1-qd^{ae})/(2c_B) \geq \iota_B$ holds only if d^{ae} is very close to 0, indicating that the **NBT** case will arise when d^{ae} is large enough.

Proof of Corollary 2. We focus on the region $\left[x^{ae}, 1/(2N)\right]$ on the arc between banks i and $i+1$. In this region, the nearest bank is bank i, so $d^{ae} = z_i$. Obviously, $r_{F1}^{comB}\left(z_i\right)$ is increasing in z_i when $d^{ae} = z_i$. Fintech 1's loan rate $r_{F1}\left(z_i\right)$ is weakly increasing in z_i in this region because (a) r_{F1}^* is independent of z_i and (b) $(r_B^{ae})^2(1-qd^{ae})/(2c_B) - \iota_B$ is decreasing in z_i. At the indifference location $z_i = x^{ae}$, $r_F\left(z_i\right) = \overline{r}_{F1}$ holds because fintech 1 offers utility $\overline{U}_{F1}$ there (see Eq. (A.6)).

Proof of Proposition 5. When PE occurs, $R/2 \leq r_B^{pe} < r_B^{be}$ hold. Then, at each location, entrepreneurs will derive higher expected utility, which implies a larger mass of entrepreneurs implementing their projects.

Next, we consider the effect of AE, assuming that $c_{F1} = c_{F2}$ holds. In the BE regime, total investment (denoted by I^{be}) is:

$$I^{be} = 2N\int_0^{1/(2N)} r_B^{be}\left(R - r_B^{be}\right)\left(1 - qz_i\right)/c_B dz_i.$$

In AE with $c_{F1} = c_{F2}$, total investment is

$$I^{ae} \equiv 2N\left(\int_0^{x^{ae}} r_B^{ae}\left(R - r_B^{ae}\right)\left(1 - qz_i\right)/c_B dz_i + \int_{x^{ae}}^{1/(2N)} \overline{U}_{F1} dz_i\right).$$

In the proof of Proposition 1 we have shown that $r_B^{ae} < r_B^{be}$ in AE, so $I^{ae} > I^{be}$ holds when $c_{F1} = c_{F2}$. Since r_{F1}^* changes continuously with c_{F2}, $I^{ae} > I^{be}$ must also hold when c_{F2} is sufficiently close to (and higher than) c_{F1}.

Proof of Proposition 6 and Corollary 3. First we consider the case $\iota_B = \iota_F$. In the proof of Proposition 1 we have shown $f^{ae}\left(\underline{r}_B^{ae}\right) > 0$, which means $r_B^{ae} > \underline{r}_B^{ae}$ holds and bank i's profit at $z_i = x^{ae}$ is positive in the AE equilibrium. Therefore, r_B^{ae} is higher than $\sqrt{2c_B\iota_B/(1-qx^{ae})}$. Defining $c_{Bx} \equiv c_B/(1-qx^{ae})$, we have that $r_B^{ae} > \sqrt{2c_{Bx}\iota_B}$. At $z_i = x^{ae}$, we have $r_{F1}(x^{ae}) = \overline{r}_{F1}$. Eq. (A.6) can be written as $r_B^{ae}\left(R - r_B^{ae}\right)/c_{Bx} = \overline{r}_{F1}\left(R - \overline{r}_{F1}\right)/c_{F1}$, which means $c_{Bx} < c_{F1}$ and $r_B^{ae} > \overline{r}_{F1}$ must hold because $r_B^{ae} > \sqrt{2c_{Bx}\iota_B}$, $\overline{r}_{F1} = \sqrt{2c_{F1}\iota_F}$, and $\iota_B = \iota_F$ hold.

Next, we prove Corollary 3. Proposition 6 implies that $c_B/(1-q/(2N)) < c_{F1}$ must hold in the AE regime if $c_{F1} \to \underline{c}_F$ and if $\iota_B = \iota_F$. By letting ι_F marginally increase from being equal to ι_B, and c_{F1} marginally decrease from being equal to $\underline{c}_F$, AE can still occur without changing the relation $c_B/(1-q/(2N)) < c_{F1}$, because $f^{ae}\left(r_B^{ae}\right)$ and x^{ae} vary continuously with c_{F1}, ι_B, and ι_F.

Proof of Proposition 7. Starting from the case $\iota_B = \iota_F$, we can increase ι_F to make $\sqrt{2c_{F1}\iota_F} \geq r_B^{be}$ hold (since r_B^{be} is not affected by ι_F). Then, in the AE regime – which can still occur if c_{F1} is small enough – it must hold that $\overline{r}_{F1} = \sqrt{2c_{F1}\iota_F} > r_B^{ae}$ since $r_B^{be} > r_B^{ae}$. Then, $r_B^{ae} < r_{F1}(x^{ae}) = \overline{r}_{F1}$ must hold since fintech 1 offers its best loan rate at $z_i = x^{ae}$. Since bank i exactly provides utility $\overline{U}_{F1}$ at location $z_i = x^{ae}$, $r_B^{ae} < r_{F1}(x^{ae})$ must implies $c_B/(1-qx^{ae}) > c_{F1}$. Therefore, $m_B(x^{ae}) < m_{F1}(x^{ae})$ holds according to Lemma 1.

Proof of Proposition 8. $\overline{U}_{F1} \leq \sqrt{2c_B\iota_B}\left(R - \sqrt{2c_B\iota_B}\right)/c_B$ must imply $c_B < c_{F1}$ when $\theta > 0$ and $\iota_B = \iota_F$ hold. In the AE regime, if θ is so high that $\overline{U}_{F1}$ is very close to $\sqrt{2c_B\iota_B}\left(R - \sqrt{2c_B\iota_B}\right)/c_B$, x^{ae} will be very close to 0 since $\sqrt{2c_B\iota_B}\left(R - \sqrt{2c_B\iota_B}\right)/c_B$ is the highest utility bank i can provide at location $z_i = 0$. When x^{ae} is very close to 0 (and θ is positive), $c_B/(1-qx^{ae}) < c_{F1}$ must hold since $c_B < c_{F1}$.

Meanwhile, according to the proof of Proposition 1, as $\overline{U}_{F1}$ approaches $\sqrt{2c_B\iota_B}\left(R-\sqrt{2c_B\iota_B}\right)/c_B$, both $\underline{r}_B^{ae}$ – which equals $2\iota_B R/(\overline{U}_{F1}+2\iota_B)$ – and $\overline{r}_B^{ae}$ will approach $\sqrt{2c_B\iota_B}$, implying that r_B^{ae} will also approach (but is higher than) $\sqrt{2c_B\iota_B}$. Then, $r_B^{ae} < \overline{r}_{F1} = \sqrt{2c_{F1}\iota_F}$ must hold since $c_B < c_{F1}$ and $\iota_B = \iota_F$ hold. When $c_B/(1-qx^{ae}) < c_{F1}$ holds, $m_B(x^{ae}) > m_{F1}(x^{ae})$ must hold since

$$\underbrace{\frac{r_B^{ae}}{c_B/(1-qx^{ae})}}_{=m_B(x^{ae})} \geq \frac{\sqrt{2c_B\iota_B/(1-qx^{ae})}}{c_B/(1-qx^{ae})} > \underbrace{\frac{\sqrt{2c_{F1}\iota_F}}{c_{F1}}}_{=m_{F1}(x^{ae})},$$

where the first inequality holds because $r_B^{ae} \geq \sqrt{2c_B\iota_B/(1-qx^{ae})}$ (i.e., bank i makes a non-negative profit at location $z_i = x^{ae}$).

Proof of Proposition 9. Consider the case $c_{F1} \to c_B$ and $\iota_B = \iota_F$. Then, $\overline{U}_{F1}$ approaches $\sqrt{2c_B\iota_B}\left(R-\sqrt{2c_B\iota_B}\right)/c_B$, so both $\underline{r}_B^{ae}$ – which equals $2\iota_B R/(\overline{U}_{F1}+2\iota_B)$ – and $\overline{r}_B^{ae}$ will approach $\sqrt{2c_B\iota_B}$, implying $r_B^{ae} \to \sqrt{2c_B\iota_B}$. In this case, bank i can match utility $\overline{U}_{F1}$ only at location $z_i = 0$; all locations in $(0, 1/N)$ (on the arc between banks i and i+1) will be served by fintech 1. In addition, $r_B^{ae} \to \sqrt{2c_B\iota_B}$ implies that bank i is willing to serve only location $z_i = 0$ since $(r_B^{ae})^2(1-qd^{ae})/(2c_B) < \iota_B$ holds for $d^{ae} > 0$ (with $d^{ae} \equiv \min\{z_i, 1/N - z_i\}$) if $r_B^{ae} \to \sqrt{2c_B\iota_B}$. Therefore, all locations in $(0, 1/N)$ belong to the **NBT** area, implying that fintech 1 posts r_{F1}^* at those locations. Note that $c_{F1} < c_B/(1-qd^{ae})$ holds for any $z_i \in (0, 1/N)$ if $c_{F1} \to c_B$. Therefore, if r_{F1}^* maximizes the welfare at locations served by fintech 1, social welfare of the entire market in the AE regime – where fintech 1 (with $c_{F1} < c_B/(1-qd^{ae})$ for any $z_i \in (0, 1/N)$) serves almost all locations – must be higher than in the BE regime, where banks serve all locations.

When fintech 1 serves $z_i \in (0, 1/N)$ with the rate r_{F1}^*, Eq. (9) reduces to

$$W = \frac{(R - r_{F1}^*)r_{F1}^*}{c_{F1}}\left(\frac{1}{2}\frac{r_{F1}^* R}{c_{F1}} - \iota_F\right).$$

Then, maximizing W by choosing r_{F1}^* (within the interval $\left[\sqrt{2c_{F1}\iota_F}, R\right]$) yields $r_{F1}^* = r_{F1}^o$, with

$$r_{F1}^o \equiv \frac{R^2 + 2c_{F1}\iota_F + \sqrt{R^4 - 2c_{F1}\iota_F R^2 + \left(2c_{F1}\iota_F\right)^2}}{3R}.$$

Therefore, if $r_{F1}^* = r_{F1}^o$ and $c_{F1} \to c_B$ hold, social welfare in the AE regime must be strictly higher than that in the BE regime. It is easy to check $r_{F1}^o \in \left(\sqrt{2c_{F1}\iota_F}, r_{F1}^m\right)$, so there exists a c_{F2} making $r_{F1}^* = r_{F1}^o$ hold. Specifically, such a c_{F2} should satisfy

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

which yields $c_{F2} = c_{F2}^*$, with

$$c_{F2}^* \equiv \left(\frac{36\sqrt{2\iota_F}R^3 c_{F1}}{(3R)^2\left(R^2 + 8\iota_F c_{F1}\right) - \left(\begin{array}{c} 2\sqrt{R^4 - 2c_{F1}\iota_F R^2 + \left(2c_{F1}\iota_F\right)^2} \\ +4c_{F1}\iota_F - R^2 \end{array}\right)^2}\right)^2.$$

Since social welfare is a continuous function of parameters, social welfare in the AE regime must be strictly higher than that in the BE regime if c_{F1} is sufficiently close to c_B and c_{F2} is sufficiently close to c_{F2}^*.

Proof of Lemma 4. The proof of this lemma directly follows that of Lemma 2.

Proof of Proposition 10. We look at the arc between banks i and $i+1$. At location $z_i = \hat{x}^{ae}$, bank i will offer its best loan rate $\sqrt{2c_B\iota_B/(1-q\hat{x}^{ae})}$, which exactly provides utility $\overline{U}_{F1}$. With $\iota_B = \iota_F$, this implies $c_B/(1-q\hat{x}^{ae}) = c_{F1}$, $\overline{r}_{F1} = \overline{r}_B(\hat{x}^{ae})$, and $\hat{m}_B(\hat{x}^{ae}) = \hat{m}_{F1}(\hat{x}^{ae})$.

If $\iota_B < \iota_F$, still, bank i and fintech 1 both offer their best loan rates and provide the same utility at $z_i = \hat{x}^{ae}$, implying

$$\frac{\sqrt{\frac{2c_B\iota_B}{1-q\hat{x}^{ae}}}\left(R - \sqrt{\frac{2c_B\iota_B}{1-q\hat{x}^{ae}}}\right)}{c_B/(1-q\hat{x}^{ae})} = \frac{\sqrt{2c_{F1}\iota_F}\left(R - \sqrt{2c_{F1}\iota_F}\right)}{c_{F1}}.$$

This equation holds (with $\iota_B < \iota_F$) if and only if $c_B/(1-q\hat{x}^{ae}) > c_{F1}$, so $\hat{m}_B(\hat{x}^{ae}) < \hat{m}_{F1}(\hat{x}^{ae})$ holds according to Lemma 1.

Proof of Corollary 4. Item (i): If $c_B/(1-q/(2N)) < c_{F1}$ and $\iota_B < \iota_F$ both hold, then $\overline{r}_B(1/(2N))$ is lower than $\overline{r}_{F1}$. Then, at location $z_i = 1/(2N)$, the highest utility bank i can provide is higher than $\overline{U}_{F1}$. Therefore, AE cannot occur at locations $z_i \in \left[0, 1/(2N)\right]$. Reasoning symmetrically, AE cannot occur at locations $z_i \in \left(1/(2N), 1/N\right]$ because of bank $i+1$'s competitiveness. Item (ii) holds because bank i offers its best loan rate at the indifference location $z_i = \hat{x}^{ae}$.

Item (iii): When all lenders can price discriminate, at each location, there is an independent localized Bertrand competition. On the arc between banks i and $i+1$, fintech entry implies that at each location (e.g., location z_i), the competitors of the Bertrand game change from banks (i and $i+1$) to banks and fintechs, which will unambiguously intensify lending competition and make entrepreneurs better off if fintech entry changes banks' behavior (i.e., PE or AE occurs).

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