Online Appendix for

"Fintech Lending and Credit Market Competition"

Internet Appendix A. Proofs of Propositions and Lemmas

A. Proof of Lemma 1

Proof of Lemma 1. In the case that two lenders play pure strategies, let r and $\tilde{r}$ denote the interest rate offered by lenders with signal g and $\tilde{g}$, respectively. Notice that all borrowers with signals b and $\tilde{g}$ from lenders' screening borrow from the lender that offers rate $\tilde{r}$, but not all borrowers with signals g and $\tilde{g}$ borrow from the lender that offers rate $\tilde{r}$. Therefore, the rate $\tilde{r}$ must be at least $r^{\tilde{g}}$ so that the lender make no loss on average when offering credit to borrowers whose screening results are $\tilde{g}$. Then, it is impossible that $r < \tilde{r}$ in a Nash equilibrium. The rate $\tilde{r} \geq r^{\tilde{g}}$ and thus if $r < \tilde{r}$, the lender with signal g would like to deviate by raising r and making it lower than $\tilde{r}$. Similarly, it is impossible that $r^{\tilde{g}} \leq \tilde{r} < r$ in a Nash equilibrium based on a similar argument. Finally, suppose that $r = \tilde{r} \geq r^{\tilde{g}}$ for contradiction. If observing signal g, the more informed lender would like to deviate by undercutting its opponent, i.e., reducing r by a sufficiently small amount. $\square$

B. Proof of Proposition 1

To prove Proposition 1, we consider a generalized version of lending competition with asymmetrically informed lenders. In this version, we extend the version in the main text by allowing a more flexible description of the success probability of borrowers' projects. Consider a continuum of borrowers with index $j \in [0, 1]$. There are two types of borrowers with different success probabilities: high-type borrowers succeed with probability q_h and low-type borrowers succeed with probability q_l. The high-type borrowers have a higher success probability than the low-type, i.e., $0 \leq q_l < q_h \leq 1$, and their proportion is $\pi \in (0, 1)$ among all the borrowers. The success probabilities and the distribution of borrower types are common knowledge. Borrowers have no private resources and resort to lenders for a loan. Borrower type is unknown to the lenders. Following the notation in the main text, let $q = \pi q_h + (1 - \pi) q_l$ denote the average probability of success.

The setup for lenders and the lending competition is the same as described in Section III. We impose the following assumptions:

Assumption A.1. $qR \geq 1$.

Assumption A.2. $\frac{1}{2} < \tilde{\phi} \leq \phi < 1$.

Assumption A.3. $q^{\tilde{b}} R < 1$.

Assumption A.4. $\pi q_h \geq (1 - \pi) q_l$.

Note that Assumptions A.1–A.4 are parametric assumptions in the generalized version of the lending competition. Particularly, Assumption A.4 says that the number of successful high-type borrowers is more than that of the low-type borrowers. In other words, the majority of the successful projects result from the investment of the high-type borrowers. This generalizes the requirement that $q_h = 1$ and $q_l = 0$ in the main text. Then, we have the following theorem to characterize the equilibrium in the lending competition. Proposition 1 is obtained by substituting $q_h = 1$ and $q_l = 0$ in Theorem 1.

Theorem 1. *Under Assumptions A.1–A.4, a pure–strategy equilibrium does not exist. However, there is a unique mixed-strategy equilibrium* $\Big((z, G), (\tilde{z}, \tilde{G})\Big)$. *Given parameters* (R, q_h, q_l, π, ϕ), *there exists a cutoff* $\phi^{\star} \in [1/2, \phi)$ *of* $\tilde{\phi}$ *such that it satisfies the following:*

(i) Suppose $\tilde{\phi} \leq \phi^{\star}$. *Then, the more informed lender accepts all loan applications with a good signal, i.e.,* $z = 0$, *and the less informed lender rejects loan applications with probability*

$\tilde{z} = 1 - {}^{q^g(R - r^{\tilde{g}})}/_{P_g^{\tilde{g}}(q^{g\tilde{g}}R-1)}$ *conditional on a good signal. If a loan application is accepted, then the interest rates offered by the more and the less informed lender are drawn from the distribution G and $\tilde{G}$, respectively, where G and $\tilde{G}$ have a common support $[r^{\tilde{g}}, R]$, and, for any $r \in [r^{\tilde{g}}, R)$,*

$$G(r) = \frac{q^{\tilde{g}}r - 1}{P_{\tilde{g}}^{g}(q^{g\tilde{g}}r - 1)} \text{ and } \tilde{G}(r) = \frac{q^{g\tilde{g}}R - 1}{q^g(R - r^{\tilde{g}})}\frac{q^g(r - r^{\tilde{g}})}{q^{g\tilde{g}}r - 1}.$$

(ii) Suppose $\tilde{\phi} > \phi^{\star}$. Then, both lenders accept all loan applications with a good signal, i.e., $z = \tilde{z} = 0$, and the interest rates offered by the more and the less informed lender are drawn from the distribution G and $\tilde{G}$, respectively, where G and $\tilde{G}$ have a common support $[r', R]$ with $r' = R - P_g^{\tilde{g}}(q^{g\tilde{g}}R - 1)/q^g$, and, for any $r \in [r', R)$,

$$G(r) = \frac{q^{\tilde{g}}(r - r')}{P_{\tilde{g}}^{g}(q^{g\tilde{g}}r - 1)} \text{ and } \tilde{G}(r) = \frac{q^g(r - r')}{P_g^{\tilde{g}}(q^{g\tilde{g}}r - 1)}.$$

Proof of Theorem 1. The proof of the theorem is constituted by the following series of lemmas. Then, the mixed equilibrium is constructed through Lemmas A.1–A.7 in the following. First, we define the following

$$r' = \inf \text{supp} G, \qquad \tilde{r}' = \inf \text{supp} \tilde{G},$$

$$r'' = \sup \text{supp} G, \qquad \tilde{r}'' = \sup \text{supp} \tilde{G},$$

We will show later that G and $\tilde{G}$ are atomless and strictly increasing on their supports, except that there can be a jump at r'' for G.

Lemma A.1. *G and $\tilde{G}$ are continuous and strictly increasing on $[r', r'')$ and $[\tilde{r}', \tilde{r}'')$, respectively, and $r', \tilde{r}' > r^{g\tilde{g}}$.*

Proof of Lemma A.1. Suppose that $r' \leq r^{g\tilde{g}}$ for contradiction. Then $q^{g\tilde{g}} r' \leq q^{g\tilde{g}} r^{g\tilde{g}} = 1$ and $q^{g\tilde{b}} < q^{g\tilde{g}}$ implies that $q^{g\tilde{b}} r' < 1$. Therefore,

$$V(r) = P_g^{\tilde{b}}(q^{g\tilde{b}} r - 1) + P_g^{\tilde{g}} \left[1 - (1 - \tilde{z})\tilde{G}(r)\right] (q^{g\tilde{g}} r - 1) < 0,$$

so it violates optimality. Hence, it must be that $r' > r^{g\tilde{g}}$ and similarly, $\tilde{r}' > r^{g\tilde{g}}$.

Suppose that G is discontinuous at $\hat{r} \in [r', r'')$ for contradiction. By the properties of c.d.f., it must be that $G(\hat{r}^-) < G(\hat{r})$ and it implies that $\Pr(r = \hat{r}) = G(\hat{r}) - G(\hat{r}^-) > 0$. Consequently, $\tilde{V}(\hat{r}^-) > \tilde{V}(\hat{r})$ since $q^{g\tilde{g}} r - 1 > 0$ implied by $\hat{r} \geq r' > r^{g\tilde{g}}$. Then, there exists some $\epsilon > 0$ such that, for any $r \in [\hat{r}, \hat{r} + \epsilon]$, $\tilde{V}(r) < \tilde{V}(\hat{r}^-)$ so that $\tilde{G}(r)$ is constant on $[\hat{r}, \hat{r} + \epsilon]$. Then, $V(r)$ is strictly increasing on $[\hat{r}, \hat{r} + \epsilon]$ and, hence, $V(\hat{r}) < V(\hat{r} + \epsilon)$. This further implies that $\hat{r} \notin \text{supp}G$, a contradiction. Hence, G is continuous on $[r', r'')$ and a similar argument applies for $\tilde{G}$.

Finally, suppose that G is constant on a nondegenerate interval $[\alpha, \beta] \subset [r', r'')$ for contradiction. Let $[a, b] \supseteq [\alpha, \beta]$ be the maximal interval that G is constant and contains $[\alpha, \beta]$. Then, $\tilde{V}$ is strictly increasing on $[a, b]$ and, hence, $\tilde{G}$ is constant on $[a, b)$. Then, V is strictly increasing on $[a, b)$ and $V(a) < V(b^-) \leq V(b)$. By continuity of $\tilde{G}$, there exists some $\epsilon > 0$ such that $V(a) < V(b+\epsilon)$ so that G is constant on $[a, b+\epsilon]$, which is contradictory to the maximality of $[a, b]$. The fact that G and $\tilde{G}$ are strictly increasing also implies that their supports are connected. □

Lemma A.2. *$r' = \tilde{r}' \geq r^{\tilde{g}}$ and $r'' = \tilde{r}'' = R$.*

Proof of Lemma A.2. Suppose that $r' < \tilde{r}'$ for contradiction. Then, $V(r) = q^g r - 1$ and it is strictly increasing on $[r', \tilde{r}')$. But by the optimality of equilibrium strategies, $[r', \tilde{r}') \nsubseteq \text{supp}G$, a contradiction. A similar argument negates that $\tilde{r}' < r'$, and, hence, $r' = \tilde{r}'$ is established.

Suppose that $r'' < \tilde{r}''$ for contradiction. Then, $\tilde{V}(r) = P_{\tilde{g}}^{b}(q^{b\tilde{g}}r - 1) + P_{\tilde{g}}^{g} z(q^{g\tilde{g}}r - 1)$ and it is strictly increasing on $(r'', \tilde{r}'')$. Consequently, $\tilde{G}$ is constant on $(r'', \tilde{r}'')$ and then, by Lemma A.1, $(r'', \tilde{r}'') \nsubseteq \text{supp}\tilde{G}$, a contradiction. Similarly, $\tilde{r}'' < r''$ is impossible.

Suppose that $r'' = \tilde{r}'' < R$. Then, the more informed lender finds it better to deviate by setting the interest rate to R with probability 1.

As $\tilde{V}(\tilde{r}') = q^{\tilde{g}}\tilde{r}' - 1 \geq 0$, we have $r' = \tilde{r}' \geq 1/q^{\tilde{g}} = r^{\tilde{g}}$. □

Lemma A.3. *In an equilibrium, $r' = r^{\tilde{g}}$ if and only if $R \leq r^{\star}$, where $r^{\star} := r^{g\tilde{b}} \left[1 + \left(q^{g} r^{\tilde{g}} - 1\right) / P_{g}^{\tilde{b}}\right]$ is a function of model parameters $(\pi, q_l, q_h, \phi, \tilde{\phi})$.*

Proof of Lemma A.3. Suppose $r' = r^{\tilde{g}}$. Note that $V(r') = V(r^{\tilde{g}}) = q^{g} r^{\tilde{g}} - 1$ and, in equilibrium, $V(r)$ is constant on $[r', R)$. So we have

$$
\begin{aligned}
V(R^{-}) &= P_{g}^{\tilde{b}}(q^{g\tilde{b}}R - 1) + P_{g}^{\tilde{g}} \left[1 - (1 - \tilde{z})\tilde{G}(R^{-})\right] (q^{g\tilde{g}}R - 1) \\
&= q^{g} r^{\tilde{g}} - 1.
\end{aligned}
$$

It implies that

$$
1 - (1 - \tilde{z})\tilde{G}(R^{-}) = \frac{\left(q^{g} r^{\tilde{g}} - 1\right) - P_{g}^{\tilde{b}}(q^{g\tilde{b}}R - 1)}{P_{g}^{\tilde{g}}(q^{g\tilde{g}}R - 1)},
$$

which has to be positive since it is a probability. Hence, it further requires that

$$
\left(q^{g} r^{\tilde{g}} - 1\right) \geq P_{g}^{\tilde{b}}(q^{g\tilde{b}}R - 1) \iff R \leq r^{g\tilde{b}} \left[1 + \left(q^{g} r^{\tilde{g}} - 1\right) / P_{g}^{\tilde{b}}\right] = r^{\star}.
$$

Conversely, suppose $r' > r^{\tilde{g}}$. We show that in this case $\tilde{G}(R^-) = 1$ and $\tilde{z} = 0$ later in Lemma A.6. It follows that

$$V(R) = P_g^{\tilde{b}}(q^{g\tilde{b}}R - 1) = q^g r' - 1 > q^g r^{\tilde{g}} - 1$$
$$\implies R > r^{g\tilde{b}}\left[1 + \left(q^g r^{\tilde{g}} - 1\right)/P_g^{\tilde{b}}\right] = r^\star.$$

□

Lemma A.4. *Suppose that $R \le r^\star$. In an equilibrium, $z = 0$, $\tilde{z} = 1 - \frac{q^g(R - r^{\tilde{g}})}{P_g^{\tilde{g}}(q^{g\tilde{g}}R - 1)}$, and G and $\tilde{G}$ have a common support $[r^{\tilde{g}}, R]$ with*

$$G(r) = \frac{q^{\tilde{g}}r - 1}{P_{\tilde{g}}^g(q^{g\tilde{g}}r - 1)} \text{ and}$$
$$\tilde{G}(r) = \frac{q^{g\tilde{g}}R - 1}{q^g(R - r^{\tilde{g}})}\frac{q^g(r - r^{\hat{g}})}{q^{g\tilde{g}}r - 1}, \tag{A.1}$$

for any $r \in [r^{\tilde{g}}, R)$. In this case, $V(r) = q^g r^{\tilde{g}} - 1$ and $\tilde{V}(r) = 0$ on $[r^{\tilde{g}}, R]$.

Proof of Lemma A.4. By Lemma A.2 and A.3, $R < r^\star$ implies that $r' = \tilde{r}' = r^{\tilde{g}}$.

Suppose $\phi = \tilde{\phi}$ for contradiction. Then, $r^\star = r^{g\tilde{b}} = 1/q \le R$ where the inequality follows from Assumption A.1. Thus, it must be that $\phi > \tilde{\phi}$ and, hence, $V(r^{\tilde{g}}) = q^g r^{\tilde{g}} - 1 > 0$, implying that $z = 0$. Also note that $\tilde{V}(r^{\tilde{g}}) = q^{\tilde{g}} r^{\tilde{g}} - 1 = 0$. Therefore, it is necessary in an equilibrium that, for any $r \in [r^{\tilde{g}}, R)$

$$\tilde{V}(r) = (q^{\tilde{g}}r - 1) - P_{\tilde{g}}^g G(r)(q^{g\tilde{g}}r - 1) = 0$$
$$\implies G(r) = \frac{q^{\tilde{g}}r - 1}{P_{\tilde{g}}^g(q^{g\tilde{g}}r - 1)}.$$

From the fact that $q^{\tilde{g}}r - 1 = P^g_{\tilde{g}}(q^{g\tilde{g}}r - 1) + P^b_{\tilde{g}}(q^{b\tilde{g}}r - 1)$, $G(R^-) = 1 + \frac{P^b_{\tilde{g}}(q^{b\tilde{g}}R-1)}{P^g_{\tilde{g}}(q^{g\tilde{g}}R-1)} < 1$ because $R < r^\star \le r^{b\tilde{g}}$ under Assumption A.4. In fact, we can show that $r^\star \le r^{b\tilde{g}}$ if and only if Assumption A.4 holds and the proof is available upon request.

Consequently, we must have that $\tilde{G}(R^-) = 1$. Suppose not, i.e., $\tilde{G}(R^-) < 1$, for contradiction. Then, $G(R^-) < 1$ indicates that there is a positive mass at R for G as well. However, at this time,

$$
\begin{aligned}
V(R) &= (q^g R - 1) - P^{\tilde{g}}_g(1-\tilde{z})\left[\tilde{G}(R^-) + \frac{1-\tilde{G}(R^-)}{2}\right](q^{g\tilde{g}}R - 1) \\
&< (q^g R - 1) - P^{\tilde{g}}_g(1-\tilde{z})\left[\tilde{G}(R^-)\right](q^{g\tilde{g}}R - 1) = V(R^-),
\end{aligned}
$$

which implies that there cannot be a positive mass at R for G, a contradiction.

Then, we solve the necessary conditions for $\tilde{z}$ and $\tilde{G}$ in an equilibrium. Note that

$$
\begin{aligned}
V(R) &= (q^g R - 1) - (1-\tilde{z})P^{\tilde{g}}_g(q^{g\tilde{g}}R - 1) \\
&= V(r^{\tilde{g}}) = q^{\tilde{g}}r^{\tilde{g}} - 1 \\
\implies \tilde{z} &= \frac{(q^g r^{\tilde{g}} - 1) - P^{\tilde{b}}_g(q^{g\tilde{b}}R - 1)}{P^{\tilde{g}}_g(q^{g\tilde{g}}R - 1)}.
\end{aligned}
$$

It can be shown that $\tilde{z} > 0 \iff R < r^\star$ after some algebra. In addition, by the fact that $(q^g R - 1) = P^{\tilde{b}}_g(q^{g\tilde{b}}R - 1) + P^{\tilde{g}}_g(q^{g\tilde{g}}R - 1)$,

$$
\tilde{z} = 1 - \frac{q^g(R - r^{\tilde{g}})}{P^{\tilde{g}}_g(q^{g\tilde{g}}R - 1)} < 1. \tag{A.2}
$$

Finally,

$$
\begin{aligned}
V(r) &= P_g^{\tilde{b}}(q^{g\tilde{b}}r - 1) + P_g^{\tilde{g}}\left[1 - (1-\tilde{z})\tilde{G}(r)\right](q^{g\tilde{g}}r - 1) \\
&= q^g r^{\tilde{g}} - 1 \\
\implies \tilde{G}(r) &= \frac{1}{1-\tilde{z}} \frac{q^g(r - r^{\tilde{g}})}{P_g^{\tilde{g}}(q^{g\tilde{g}}r - 1)},
\end{aligned}
$$

which yields equation (A.1) by substituting the expression of $\tilde{z}$ in equation (A.2). □

Lemma A.5. *Suppose that $R = r^{\star}$. Then $z = \tilde{z} = 0$, and G and $\tilde{G}$ have a common support $[r^{\tilde{g}}, R]$ with*

$$
\begin{aligned}
G(r) &= \frac{q^{\tilde{g}}(r - r')}{P_{\tilde{g}}^{g}(q^{g\tilde{g}}r - 1)} \text{ and} \\
\tilde{G}(r) &= \frac{q^{g}(r - r')}{P_{g}^{\tilde{g}}(q^{g\tilde{g}}r - 1)},
\end{aligned}
$$

for any $r \in [r^{\tilde{g}}, R)$.

Proof of Lemma A.5. By Lemma A.3, $r' = r^{\tilde{g}}$ in this case. Consider two cases: 1) $\phi > \tilde{\phi}$ and 2) $\phi = \tilde{\phi}$.

If $\phi > \tilde{\phi}$, then $V(r^{\tilde{g}}) = q^g r^{\tilde{g}} - 1 > 0$. Then, following the proof in Lemma A.4, we obtain that $z = 0$ and $G(r) = \frac{q^{\tilde{g}}r - 1}{P_{\tilde{g}}^{g}(q^{g\tilde{g}}r - 1)}$. Note that $G(R^{-}) = 1$ and $R \in \text{supp}G$ because $G'(R) > 0$. In this case, $\tilde{z} = 0$. Suppose not, i.e., $\tilde{z} > 0$, for contradiction. Then,

$$
\begin{aligned}
V(R) = V(r^{\star}) &= (q^g r^{\star} - 1) - P_g^{\tilde{g}} z(q^{g\tilde{g}}r^{\star} - 1) \\
&< P_g^{\tilde{b}}(q^{g\tilde{b}}r^{g\tilde{b}}\left[1 + \left(q^g r^{\tilde{g}} - 1\right)/P_g^{\tilde{b}}\right] - 1) = q^g r^{\tilde{g}} - 1,
\end{aligned}
$$

which, by continuity, implies that there exists an $\epsilon > 0$ such that G is constant on $[R-\epsilon, R]$. This results in a contradiction to Lemma A.1. Therefore, $\tilde{G}(r) = \frac{q^g(r-r^{\tilde{g}})}{P_g^{\tilde{g}}(q^{g\tilde{g}}r-1)}$.

If $\phi = \tilde{\phi}$, then $V(r^{\tilde{g}}) = \tilde{V}(r^{\tilde{g}}) = 0$ and $R = r^\star = \bar{r}$. Suppose $1-(1-\tilde{z})\tilde{G}(R^-) > 0$ for contradiction. Then

$$
\begin{aligned}
V(R) &= P_g^{\tilde{b}}(q^{g\tilde{b}}R-1) + P_g^{\tilde{g}}\left[1-(1-\tilde{z})\tilde{G}(R^-)\right](q^{g\tilde{g}}r-1) \\
&> P_g^{\tilde{b}}(q^{g\tilde{b}}R-1) = 0.
\end{aligned}
$$

That is, both lenders have incentives to deviate, a contradiction to the definition of an equilibrium. Hence, $(1-\tilde{z})\tilde{G}(R^-) = 1$ if and only if $\tilde{z} = 0$ and $\tilde{G}(R^-) = 1$. Similarly, $z = 0$ and $G(R^-) = 1$. In this case, both $G(r)$ and $\tilde{G}(r)$ solve the following function of $G(r)$ for all $r \in [r^{\tilde{g}}, 1/q]$,

$$
(q^g r - 1) - P_{\tilde{g}}^g G(r)(q^{g\tilde{g}}r-1) = 0 \implies G(r) = \tilde{G}(r) = \frac{q^g r - 1}{P_{\tilde{g}}^g(q^{g\tilde{g}}r-1)}.
$$

Note that $\phi = \tilde{\phi}$ implies that $P_g^{\tilde{g}} = P_{\tilde{g}}^g$ and $q^g = q^{\tilde{g}}$. Hence, in fact, the two cases coincide. □

Lemma A.6. *Suppose that $R > r^\star$. In an equilibrium, $z = \tilde{z} = 0$, and G and $\tilde{G}$ have a common support $[r', R]$ with*

$$
\begin{aligned}
G(r) &= \frac{q^{\tilde{g}}(r-r')}{P_{\tilde{g}}^g(q^{g\tilde{g}}r-1)} \text{ and} \\
\tilde{G}(r) &= \frac{q^g(r-r')}{P_g^{\tilde{g}}(q^{g\tilde{g}}r-1)},
\end{aligned}
$$

for any $r \in [r', R)$, where $r' = R - P_g^{\tilde{g}}(q^{g\tilde{g}}R-1)/q^g$.

Proof of Lemma A.6. By Lemma A.2 and A.3, $r' > r^{\tilde{g}}$. Hence,

$$V(r') = q^g r' - 1 > q^g r^{\tilde{g}} - 1 > 0 \text{ and}$$
$$\tilde{V}(r') = q^{\tilde{g}} r' - 1 > q^{\tilde{g}} r^{\tilde{g}} - 1 = 0$$

imply that $z = \tilde{z} = 0$. Then, for any $r \in [r', R)$, $G(r)$ and $\tilde{G}(r)$ solve equations $V(r) = V(r')$ and $\tilde{V}(r) = \tilde{V}(r')$, i.e.,

$$(q^g r - 1) - P_g^{\tilde{g}} \tilde{G}(r)(q^{g\tilde{g}} r - 1) = q^g r' - 1 \text{ and}$$
$$(q^{\tilde{g}} r - 1) - P_{\tilde{g}}^g G(r)(q^{g\tilde{g}} r - 1) = q^{\tilde{g}} r' - 1,$$

and we obtain that

$$G(r) = \frac{q^{\tilde{g}}(r - r')}{P_{\tilde{g}}^g (q^{g\tilde{g}} r - 1)},$$
$$\tilde{G}(r) = \frac{q^g (r - r')}{P_g^{\tilde{g}} (q^{g\tilde{g}} r - 1)}.$$

Note that it cannot be the case that both $G(R^-) < 1$ and $\tilde{G}(R^-) < 1$. Suppose that this is so for contradiction. Note that,

$$\tilde{V}(R) = (q^{\tilde{g}} R - 1) - P_{\tilde{g}}^g \left[G(R^-) + \frac{1 - G(R^-)}{2} \right] (q^{g\tilde{g}} R - 1)$$
$$< \left[q^{\tilde{g}} (R - \epsilon) - 1 \right] - P_{\tilde{g}}^g G(R - \epsilon) \left[q^{g\tilde{g}} (R - \epsilon) - 1 \right] = \tilde{V}(R - \epsilon)$$

for some $\epsilon > 0$ small enough, which contradicts the definition of an equilibrium.

Suppose that $\tilde{G}(R) < 1$ for contradiction. Then $G(R^-) = 1$. This yields $\tilde{G}(R) = \frac{P^g_{\tilde{g}} q^g}{P^{\tilde{g}}_g q^{\tilde{g}}}$ and we can show that

$$\frac{P^g_{\tilde{g}} q^g}{P^{\tilde{g}}_g q^{\tilde{g}}} < 1 \iff \pi q_h - (1-\pi) q_l < 0,$$

which contradicts with Assumption A.4. Therefore, it must be that $\tilde{G}(R^-) = 1$. Thus, we solve equations $V(R) = V(r')$, i.e.,

$$(q^g R - 1) - P^{\tilde{g}}_g (q^{g\tilde{g}} R - 1) = q^g r' - 1,$$

and we obtain that

$$r' = R - P^{\tilde{g}}_g (q^{g\tilde{g}} R - 1)/q^g.$$

In this case, $G(R^-) = {p^{\tilde{g}} q^{\tilde{g}}}/{p^g q^g}$ and $G(R^-) \leq 1$ under Assumption A.4. □

Lemma A.7. *Given model parameters $(R, \pi, q_l, q_h, \phi, \tilde{\phi})$, there exists a $\phi^\star \in (1/2, \phi)$ as a function of (R, π, q_l, q_h, ϕ) such that $\tilde{\phi} > \phi^\star$ if and only if $R > r^\star$.*

Proof of Lemma A.7. First, $r^\star = r^{g\tilde{b}} \left[1 + \left(q^g r^{\tilde{g}} - 1\right) / P^{\tilde{b}}_g\right]$ as a function of $(\pi, q_l, q_h, \phi, \tilde{\phi})$ is strictly decreasing in $\tilde{\phi}$. We apply cylindrical algebraic decomposition to obtain that $\partial r^\star / \partial \tilde{\phi} < 0$ under Assumptions A.1, A.3, and A.4. Obviously, $r^\star$ as a function of $\tilde{\phi}$ is also continuous on $[1/2, \phi]$. If $\tilde{\phi} = \phi$, $r^\star = \bar{r} < R$. Moreover, when $\tilde{\phi} = 1/2$, $r^\star$ can be either greater than or equal to R, or otherwise: If it is the case that $r^\star$ is greater than or equal to R, there must exist a unique $\phi^\star \in (1/2, \phi)$ such that it makes $r^\star = R$ hold. If otherwise, set $\phi^\star = 1/2$. Then, we obtain the desired $\phi^\star$.

Note that in the case $q_h = 1$ and $q_l = 0$, we can obtain an explicit expression of $\phi^\star = [(qR-1)/(1-q) + 1/\phi]^{-1}$. □

Lemmas A.1–A.6 describe the only set of necessary conditions of an equilibrium. Hence, it identifies a unique mixed strategy equilibrium of this lending competition game. Lemma A.7 states the equivalence between condition $R \leq r^\star$ (or $R > r^\star$) and $\tilde{\phi} \leq \phi^\star$ (or $\phi > \phi^\star$), where $r^\star$ and $\phi^\star$ are as defined in Lemma A.3 and A.7, respectively. □

C. Proof of Corollary 1

We show that the statement of Corollary 1 is true in the generalized version of the lending competition and, hence, it is also true in the lending competition in the main text.

Proof. Let $\gamma = \frac{q^{\tilde{g}}}{q^g} \frac{P_g^{\tilde{g}}}{P_{\tilde{g}}^g}$. Note that $\gamma \leq 1$ under Assumptions A.1–A.4. Moreover, inspecting the expression of $\tilde{G}$ and G and using the fact that $\frac{q^g}{P_g^{\tilde{g}}} = \frac{1}{\gamma} \frac{q^{\tilde{g}}}{P_{\tilde{g}}^g}$,

$$\tilde{G}(r) = \frac{1}{(1-\tilde{z})\gamma} G(r) \geq G(r).$$

□

D. Proof of Proposition 3

Proof. We first make two claims.

Claim A.1: $z_u < 1$ if and only if $R > r^{\star\star} := r^{b\tilde{g}} \left[1 + (q^{\tilde{g}}\bar{r} - 1)/P_{\tilde{g}}^b\right]$.

First, we show that $r^{\star\star} > r^\star$. Note that $\phi > \tilde{\phi} \implies q^{g\tilde{b}} \geq q \geq q^{b\tilde{g}} \implies r^{b\tilde{g}} \geq r^{g\tilde{b}}$ and

$\tilde{\phi} > 1/2 \implies \bar{r} > r^{\tilde{g}}$. Therefore,

$$r^{\star\star} = r^{b\tilde{g}}\left[1 + (q^{\tilde{g}}\bar{r} - 1)/P^{b}_{\tilde{g}}\right]$$
$$> r^{g\tilde{b}}\left[1 + \left(q^{g}r^{\tilde{g}} - 1\right)/P^{\tilde{b}}_{g}\right] = r^{\star}.$$

Let $R > r^{\star\star}$ and suppose, for contradiction, that $z_u = 1$. In this case, the uninformed lender withdraws from the competition and rejects all loan applications, and only the two informed lenders compete with each other. Moreover, as $R > r^{\star\star} > r^{\star}$, the lower bond of the common support of their bidding strategies G and $\tilde{G}$ is such that $r' = R - P^{\tilde{g}}_{g}(q^{g\tilde{g}}R - 1)/q^{g}$. $z_u = 1$ implies that $r' \leq \bar{r}$, otherwise the uninformed lender would have incentive to deviate by, for example, offering loans with interest rate $\frac{\bar{r}+r'}{2}$ for all borrowers. However,

$$r' = R - P^{\tilde{g}}_{g}(q^{g\tilde{g}}R - 1)/q^{g} \leq \bar{r}$$
$$\iff (q^{g}R - 1) - P^{\tilde{g}}_{g}(q^{g\tilde{g}}R - 1) \leq q^{g}\bar{r} - 1$$
$$\iff R \leq r^{g\tilde{b}}\left[1 + (q^{g}\bar{r} - 1)/P^{\tilde{b}}_{g}\right] = r^{\star\star},$$

which contradicts $R > r^{\star\star}$.

Suppose that $z_u < 1$. Let $r'_u = \inf \text{supp} G_u$. It must be that $r'_u = r' = \tilde{r}'$ following a similar argument as in Lemma A.2. Then, $r' \geq \bar{r}$, otherwise

$$r' < \bar{r} \implies \tilde{V}_u(r') = qr' - 1 < 0 \implies z_u = 1,$$

a contradiction. $r' \geq \bar{r} > r^{\tilde{g}} \implies z = \tilde{z} = 0$. Then, $V(r') = q^g r' - 1 > q^{\tilde{g}}\bar{r} - 1$ so that

$$V(R) = \left[1 - (1 - z_u)G_u(R^-)\right] \left\{P_g^{\tilde{b}}(q^{g\tilde{b}}R - 1) + \left[1 - \tilde{G}(R^-)\right] P_g^{\tilde{g}}(q^{g\tilde{g}}R - 1)\right\} > q^{\tilde{g}}\bar{r} - 1.$$

Therefore, $[1 - (1 - z_u)G_u(R^-)] \in (0, 1]$ and $\tilde{G}(R^-) \in (0, 1]$ implies that

$$P_g^{\tilde{b}}(q^{g\tilde{b}}R - 1) > q^{\tilde{g}}\bar{r} - 1$$
$$\iff R > r^{g\tilde{b}}\left[1 + (q^g\bar{r} - 1)/P_g^{\tilde{b}}\right] = r^{\star\star}.$$

Claim A.2: Assumption A.2 guarantees that $r^{\tilde{b}} < r^{\star\star}$. This is proved by applying cylindrical algebraic decomposition to see that Assumption A.2 is inconsistent with $r^{\tilde{b}} \geq r^{\star\star}$.

To conclude the proof of the proposition, as Assumption A.3 states that $q^{\tilde{b}}R < 1 \iff R < r^{\tilde{b}}$, by Claim A.1, $R < r^{\tilde{b}} < r^{\star\star}$. Consequently, by Claim A.2 and the fact that $z \in [0, 1]$, it must be that $z_u = 1$, i.e., the uninformed lender quits the market. Then, the characterization of the equilibrium must be equivalent to that in Proposition 1. □

E. Proof of Proposition 4

Proof. Fix a borrower at a distance x from its nearest bank. First, we consider the case that $\phi_F \leq \phi(x)$. In this case, the Fintech lender and the borrower's inside bank play the role of the less and more informed lender, respectively. Hence, let $\tilde{\phi} = \phi_F$ and $\phi = \phi(x)$. Moreover, we follow the notation in the analysis of the lending competition of Section III.

Before the Fintech lender's entry, note that the minimum interest rate offered by the banks is $\bar{r} = 1/q$. After the Fintech lender's entry, the lower bound r' of the inside bank's interest strategy is as follows:

$$r' = \begin{cases} r^{g_F} & \phi_F \leq \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1} \\ R - P_g^{g_F}(q^{gg_F}R-1)/q^g & \text{otherwise} \end{cases}.$$

It is apparent that $r^{g_F} < 1/q$. Moreover, our assumption $R < r^{b_F}$, along with the fact that

$$r^{b_F} - r^{gb_F}\left[1 + (q^g\bar{r} - 1)/P_g^{b_F}\right] = \frac{(1-q)\left[1 - 2\phi(x)\right]}{q\phi(x)} < 0,$$

implies that

$$\begin{aligned} & R < r^{gb_F}\left[1 + (q^g\bar{r} - 1)/P_g^{b_F}\right] \\ \Longleftrightarrow\ & P_g^{b_F}(q^{gb_F}R - 1) < q^g\bar{r} - 1 \\ \Longleftrightarrow\ & q^gR - 1 - P_g^{g_F}(q^{gg_F}R - 1) < q^g\bar{r} - 1 \\ \Longleftrightarrow\ & R - P_g^{g_F}(q^{gg_F}R - 1)/q^g < \bar{r}. \end{aligned}$$

Before the Fintech lender's entry, the inside bank's expected profit is $p^g(q^g\bar{r} - 1)$, which becomes $p^g(q^gr' - 1)$ after Fintech entry. As we have shown that $\bar{r} > r'$, it must be the case that $p^g(q^gr' - 1) < p^g(q^g\bar{r} - 1)$. That is, the inside bank's expected profit decreases after the Fintech lender's entry. The proof of the case $\phi_F > \phi(x)$ is similar, so we omit it. □

F. Proof of Proposition 5

Proof. Fix a borrower x who applies for loans from the two banks, the inside bank being informed and the outside bank being uninformed. Let $\hat{\rho}_h(x)$ and $\hat{\rho}_l(x)$, respectively, denote the high-type and low-type borrowers' credit availability before the Fintech lender enters the market. Explicitly,

$$\hat{\rho}_h(x) = \phi(x) + [1 - \phi(x)] [1 - z_u(x)],$$

$$\hat{\rho}_l(x) = 1 - \phi(x) + \phi(x) [1 - z_u(x)],$$

where $z_u(x) = \frac{q^g(x)\bar{r}-1}{q^g(x)R-1}$ is the outside bank's rejection probability (the expression of which can be found in Proposition 2) and $q^g(x) = \frac{q\phi(x)}{q\phi(x)+(1-q)[1-\phi(x)]}$ is the success probability conditional on a good signal of the inside bank. Similarly, let $\rho_h(x)$ and $\rho_l(x)$ be credit availability of the high-type and low-type borrowers, respectively, after the Fintech lender's entry. Consider two cases: (1) $\phi_F \leq \phi(x)$ and (2) $\phi_F > \phi(x)$.

Case (1). The inside bank and the Fintech lender play the roles of the more and the less informed lender, respectively, and the credit availability of a borrower x is as follows:

$$\rho_h(x) = \begin{cases} \phi(x) + [1 - \phi(x)] \phi_F [1 - z_F(x)] & \phi_F \leq \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1} \\ \phi(x) + \phi_F - \phi(x)\phi_F & \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1} < \phi_F \leq \phi(x) \end{cases},$$

and

$$\rho_l(x) = \begin{cases} 1 - \phi(x) + \phi(x)(1 - \phi_F) [1 - z_F(x)] & \phi_F \leq \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1} \\ 1 - \phi(x)\phi_F & \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1} < \phi_F \leq \phi(x) \end{cases},$$

where $z_F(x)$ is the Fintech lender's rejection probability for a borrower x, which is obtained by substituting ϕ and $\tilde{\phi}$ in $\tilde{z}$ in (A.2) by $\phi(x)$ and ϕ_F, respectively.

Case (2). The roles of the inside bank and the Fintech lender switch as in case (1), and, similarly,

$$\rho_h(x) = \begin{cases} \phi(x) + \phi_F - \phi(x)\phi_F & \phi(x) < \phi_F \leq \left[\frac{1}{\phi(x)} - \frac{qR-1}{1-q}\right]^{-1} \\ \phi_F + (1-\phi_F)\phi(x)\left[1 - z(x)\right] & \left[\frac{1}{\phi(x)} - \frac{qR-1}{1-q}\right]^{-1} < \phi_F \end{cases},$$

and

$$\rho_l(x) = \begin{cases} 1 - \phi(x)\phi_F & \phi(x) < \phi_F \leq \left[\frac{1}{\phi(x)} - \frac{qR-1}{1-q}\right]^{-1} \\ 1 - \phi_F + \phi_F\left[1 - \phi(x)\right]\left[1 - z(x)\right] & \left[\frac{1}{\phi(x)} - \frac{qR-1}{1-q}\right]^{-1} < \phi_F \end{cases},$$

where $z(x)$ is the inside bank's rejection probability for a borrower at a distance x from it and is obtained by substituting ϕ and $\tilde{\phi}$ in $\tilde{z}$ in (A.2) by ϕ_F and $\phi(x)$, respectively.

First, consider the case (1). If $\phi_F \leq \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1}$, the Fintech entrant may reject some good applicants with probability $z_F(x)$, and the changes in credit availability,

$$\begin{aligned} \Delta\rho_h(x) &= \rho_h(x) - \hat{\rho}_h(x) \\ &= \left[1 - \phi(x)\right]\left\{\phi_F\left[1 - z_F(x)\right] - \left[1 - z_u(x)\right]\right\}, \\ \Delta\rho_l(x) &= \rho_l(x) - \hat{\rho}_l(x) \\ &= \phi(x)\left\{(1 - \phi_F)\left[1 - z_F(x)\right] - \left[1 - z_u(x)\right]\right\}, \end{aligned}$$

depend on the relative magnitude between $\left[1 - z_u(x)\right] / \left[1 - z_F(x)\right]$ and ϕ_F. In fact, we can show that

$$\left[1 - z_u(x)\right] / \left[1 - z_F(x)\right] < 1 - \phi_F < 1/2 < \phi_F$$

under our parametric assumptions. Therefore, $\Delta\rho_h(x) > 0$ and $\Delta\rho_l(x) > 0$, i.e., both high-type and low-type borrowers' credit availability increase after the Fintech lender's entry.

If $\phi_F > \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1}$, the Fintech entrant accepts loan applications with good signals, and the changes in credit availability is then

$$\Delta\rho_h(x) = [1-\phi(x)]\{\phi_F - [1-z_u(x)]\},$$

$$\Delta\rho_l(x) = \phi(x)\{(1-\phi_F) - [1-z_u(x)]\}.$$

Our parametric assumptions imply that $\phi_F > 1 - z_u(x)$, and hence $\Delta\rho_h(x) > 0$. Moreover, $\Delta\rho_l(x)$ can be negative or positive, which depends on the parameters.

Second, consider the case (2). If $\phi_F \leq \left[\frac{1}{\phi(x)} - \frac{qR-1}{1-q}\right]^{-1}$, which is equivalent to $\phi(x) \geq \left(\frac{qR-1}{1-q} + \frac{1}{\phi_F}\right)^{-1}$, then

$$\Delta\rho_h(x) = [1-\phi(x)]\{\phi_F - [1-z_u(x)]\}.$$

Again, our parametric assumptions restrict that $\phi_F > 1 - z_u(x)$, and, therefore, $\Delta\rho_h(x) > 0$ in this case. For other cases, the signs of $\Delta\rho_h(x)$ and $\Delta\rho_l(x)$ are ambiguous and depend on the parameters. Particularly, applying cylindrical algebraic decomposition algorithm, we can find a region in the parameter space that the high-type's credit availability decreases after the Fintech lender's entry under this condition. □

G. Proof of Proposition 6

Proof. We first consider an asymmetrically informed lending competition game as described in Section III of the main text and follow the same notations in that section. By applying calculus, we can obtain the following facts that $\partial G(r)/\partial\tilde{\phi} > 0$ and $\partial\tilde{G}(r)/\partial\tilde{\phi} > 0$. Moreover, as $\tilde{\phi}$ converges to $1/2$, G and $\tilde{G}$, respectively, converge to the interest rate strategies of the informed and uninformed lenders as described by equations (3) and (4) in the main text.

Consider a borrower in the region where the Fintech lender is less informed than her inside bank, i.e., $\phi(x) \geq \phi_F$. For this borrower, the entry of the Fintech lender is equivalent to a change of the less informed lender's signal accuracy from $1/2$ to some $\phi_F > 1/2$. Such a change makes the interest rate strategies of both the more and less informed lenders decrease in the sense of first-order stochastic dominance after the Fintech lender's entry. Hence, the expected interest rates decrease with Fintech lending.

□

H. Proof of Lemma 2

Proof. Consider a borrower x, and let $\hat{w}(x)$ be the expected *net social surplus* resulting from the lending competition between the two incumbent banks without Fintech lending, that is,

(A.3) $$\hat{w}(x) = q\hat{\rho}_h(x)(R-1) - (1-q)\hat{\rho}_l(x).$$

Then social welfare $\hat{W}$ without Fintech lending is measured by the aggregation, i.e., $\hat{W} = 4\int_0^{1/4} \hat{w}(x)dx$. Let $w(x)$ be the expected net social surplus with Fintech lending, that is,

(A.4) $$w(x) = q\rho_h(x)(R-1) - (1-q)\rho_l(x),$$

and let $W = 4\int_0^{1/4} w(x)dx$ measure social welfare.

First, suppose that $\phi_F \leq \phi(x)$. Furthermore, consider the case $\phi_F \leq \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1}$, which is equivalent to $R \leq r^\star(x)$, and it is the case that the Fintech lender may reject some application from borrowers with good signals. We can show that $\Delta w(x) < 0$ if $R = 1/q (= \bar{r})$ and that $\Delta w(x) > 0$ if $R = r^\star(x)$. Note that $\Delta w(x)$, as a function of R, is continuous and strictly increasing on $(1/q, r^\star(x))$ given other parameters fixed, and thus there exists an $\hat{R}(x) \in (1/q, r^\star(x))$ such that $\Delta w(x) = 0$. As $\hat{R}(x)$ is unique for each x, $\hat{R}$ is a function of x. Hence, $\Delta w(x) > 0$ if and only if $R > \hat{R}(x)$ when $\phi_F \leq \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1}$.

For other cases, including $\left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)}\right]^{-1} < \phi_F \leq \phi(x)$ and $\phi_F > \phi(x)$, we verify that $\Delta w(x) > 0$ always hold under our parametric assumptions by cylindrical algebraic decomposition algorithm. □

I. Proof of Proposition 7

Proof. To prove (i) in the proposition, we remark that $\hat{R}(x)$ is a decreasing function of x. This is proved by obtaining its derivative from the equation $\Delta w(x) = 0$ by implicit function and by applying cylindrical algebraic decomposition algorithm along with our parametric assumptions. Let

$$\hat{R} = \hat{R}(0) \in \left(1/q, \frac{1}{q} + \frac{1-q}{q}\left(\frac{1}{\phi_F} - \frac{1}{\phi(0)}\right)\right).$$

Then, for any borrower x,

$$R > \hat{R} = \hat{R}(0) \geq \hat{R}(x) \implies \Delta w(x) > 0$$

by Lemma 2. Therefore, $\Delta W := W - \hat{W} = 4\int_0^{1/4} \Delta w(x) dx > 0$.

To prove (ii), let $R = 1/q + \epsilon$ and $\phi_F = \phi_F^* + \delta$ for some $\epsilon, \delta > 0$. Consider that the limiting case:

$$\lim_{\delta \to 0} \lim_{\epsilon \to 0} \int_0^{1/4} \Delta w(x) dx < 0$$

because, for all $x < 1/4$, $\Delta w(x) < 0$ implied by the fact that $1/q < \hat{R}(x)$ and $\phi_F < \left[\frac{qR-1}{1-q} + \frac{1}{\phi(x)} \right]^{-1}$ by Lemma 2. It justifies (ii). □

Internet Appendix B. Additional Numerical Results

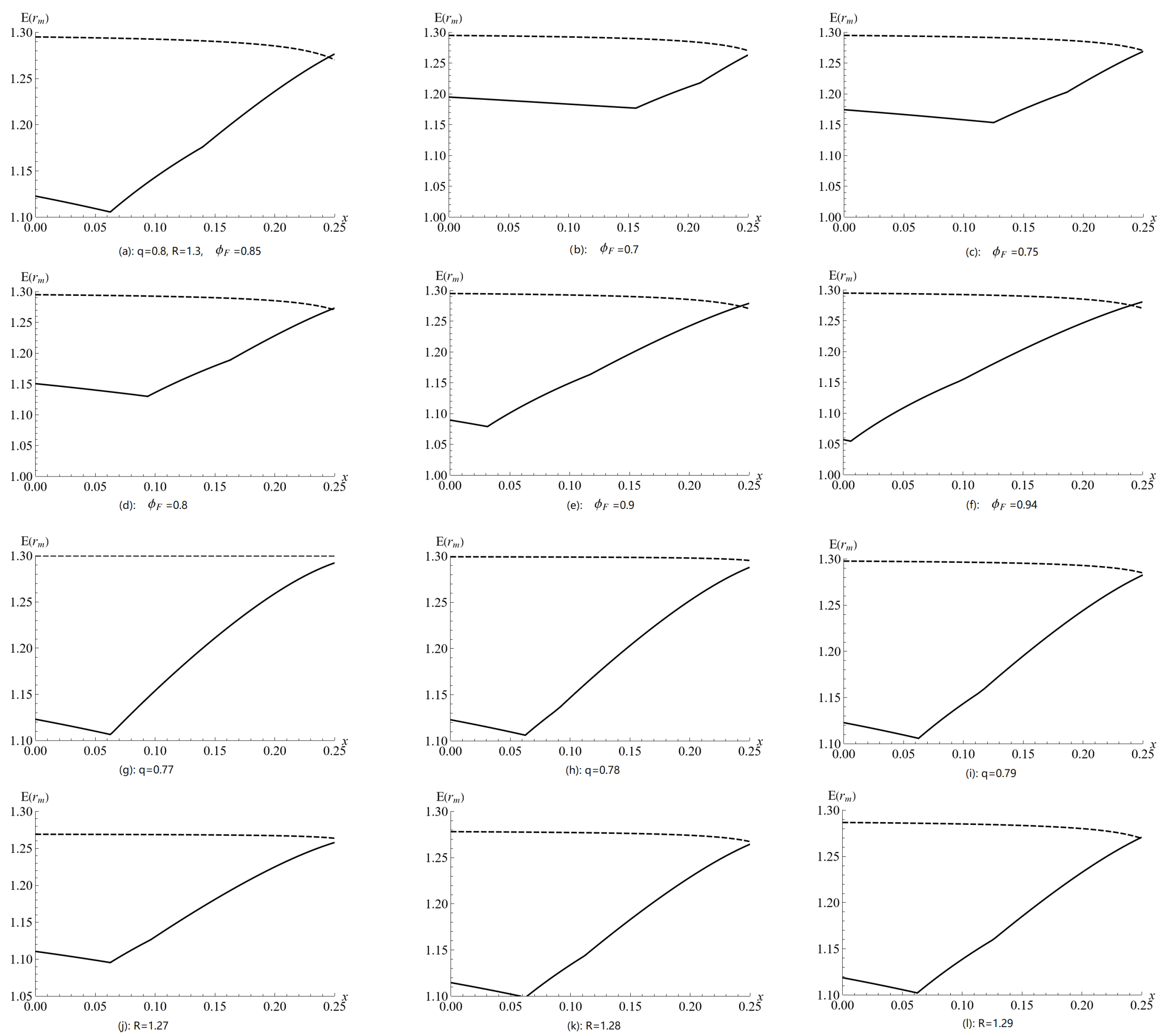
In this appendix, we provide more numerical examples to illustrate the effect of Fintech lending on the expected interest rates. We are particularly interested in the cases where the expected interest rates can possibly increase after the Fintech lender's entry. For the wide range of parameters that are tried, we did not find cases where the expected interest rates $E(r_L)$, $E(r_B)$, and $E(r_l)$ get higher after the Fintech lender's entry: the results are very similar to those in Figure 2 of the main text. For this reason, we only present the results of $E(r_M)$ and $E(r_h)$ here.

Figure B.1 plots the expected interest rate $E(r_M)$ as a function of a borrower's distance to its inside bank. The dotted and solid curves are the expected interest rates before and after the Fintech lender's entry, respectively. Panel (a) replicates the expected interest rates $E(r_M)$ under the same set of parameters as Figure 2. Panels (b)–(f) plot the expected interest rates $E(r_M)$ by setting a different ϕ_F (without changing other parameters) from panel (a). Panels (g)–(i) plot the expected interest rates $E(r_M)$ by setting a different q, and panels (j)–(l) only change parameter R from panel (a). From these illustrations, it seems that, for borrowers far away from their inside bank, $E(r_M)$ can increase after the Fintech lender's entry only if q, R, and/or ϕ_F is relatively large.

Figure B.2 plots the expected interest rate $E(r_h)$ as a function of a borrower's distance to

FIGURE B.1

Conditional expected interest rate $E(r_M)$ with and without the Fintech lender



the inside bank. The dotted and solid curves are the expected interest rates before and after the Fintech lender's entry, respectively. Panel (a) replicates the expected interest rates $E(r_h)$ under the same set of parameters as Figure 2. Panels (b)–(f) plot the expected interest rates $E(r_h)$ by setting a different ϕ_F (without changing other parameters) from panel (a). Panels (g)–(i) plot the expected interest rates $E(r_h)$ by setting a different q, and panels (j)–(l) only change parameter R from panel (a). In most cases, we cannot have the expected interest rates $E(r_h)$ surpass its pre-Fintech entry level. It is only possible for some extreme parameter values, for example, $q = 0.94$, and for those borrowers located at roughly 1/4 to their inside banks.

FIGURE B.2

Conditional expected interest rate $E(r_h)$ with and without the Fintech lender