

Internet Appendix for “Open Banking: Credit Market Competition When Borrowers Own the Data”

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A Proof of Lemma 2

In this proof, denote by p_{ij} the probability that the bank observes signal i and the fintech observes signal j , regardless of which lender has a better screening ability. This is slightly different from its definition in the baseline case in Section 4.2.1, but it is more convenient to use in this extension. To be consistent, let

$$\phi(r, x_f) \equiv \frac{p_{LH}}{p_{HH}[\mu_{HH}(1+r) - 1]} = \frac{x_b(1-x_f)}{\tau r - (1-x_b)(1-x_f)},$$

regardless of which lender has a better screening ability. Throughout this proof, we highlight the argument x_f in $\phi(r, x_f)$ since Lemma 2 is about the property of V_h as function of x_f ; and it is easy to see that $\phi(r, x_f)$ decreases in x_f .

Given $\xi \in (0, 1)$, recall that we implicitly define a threshold $\hat{x}_f(\xi)$ based on the equality in (16), i.e., $\hat{x}_f(\xi)$ is the unique solution to the following equation (with x_f being the argument; note that RHS decreases while LHS increases in x_f)

$$\frac{1 - \xi}{1 - \xi\phi(\bar{r}, x_f)} = \frac{x_f(1 - x_b)}{x_b(1 - x_f)}.$$

Such solution $\hat{x}_f(\xi) \in (0, 1)$ always exists for any $\xi \in (0, 1)$ as the RHS ranges from 0 to ∞ when x_f goes from 0 to 1, while the LHS takes a value between zero and one.

We also define $\tilde{x}_f(\xi)$ as the solution to the following equation

$$\xi = 1 - \frac{p_{HL}}{p_{LH}} \phi(\bar{r}, x_f) = 1 - \underbrace{\frac{x_f(1-x_b)}{\tau\bar{r} - (1-x_b)(1-x_f)}}_{\equiv \Phi(\bar{r}, x_f)}. \quad (\text{IA.1})$$

One can easily show that $\Phi(\bar{r}, x_f)$ is increasing in x_f given $\tau\bar{r} - 1 + x_b > 0$ which holds under condition (PC), so $\tilde{x}_f(\xi)$ is uniquely defined. And, $\Phi(\bar{r}, x_f = 0) = 0$ implies that $\tilde{x}_f(\xi) > 0$, but it is possible that $\tilde{x}_f(\xi) > 1$.

Scenario 1. Suppose that $\tilde{x}_f(\xi) \leq 1$. Since $\hat{x}_f(\xi) \in (0, 1)$, we can define

$$\hat{\hat{x}}_f(\xi) \equiv \max(\hat{x}_f(\xi), \tilde{x}_f(\xi)) \leq 1,$$

which implies the following result that will be useful in our later proof:

$$\xi > 1 - \frac{p_{HL}}{p_{LH}} \phi(\bar{r}, x_f) \text{ for } x_f > \hat{\hat{x}}_f(\xi). \quad (\text{IA.2})$$

We now prove our claim in Lemma 2. There are potentially three cases to consider, and from now on we denote $\hat{x}_f(\xi)$ and $\hat{\hat{x}}_f(\xi)$ by \hat{x}_f and $\hat{\hat{x}}_f$ for simplicity.

Case 1. $x_f \in [0, \hat{x}_f)$. From the indifference conditions (14) and (15), it is ready to derive

$$m_f = \frac{1 - \phi(\bar{r}, x_f)}{1 - \xi \phi(\bar{r}, x_f)},$$

which increases in ξ as claimed in the main text. We also have $\underline{r} = \frac{1-x_f}{\tau}$ and

$$\bar{F}_f(r) = \frac{\phi(r, x_f) - \phi(\bar{r}, x_f)}{1 - \phi(\bar{r}, x_f)}.$$

Both are the same as in the baseline model with $\xi = 0$. That is, the fintech affinity only affects the probability that the fintech will make an offer upon seeing a good signal, but does not affect its interest rate distribution. We also have

$$\bar{F}_b(r) = \frac{\phi(r, x_f) - \xi}{1 - \xi},$$

which has a mass point at the top with a size of $\lambda_b = \frac{\phi(\bar{r}, x_f) - \xi}{1 - \xi}$. It is clear that the bank sets a lower interest rate in the sense of FOSD when ξ is higher. This because when the fintech makes offer more frequently, the bank has to compete more fiercely.

The expected payment of a high-type borrower is

$$(1 - m_f)\mathbb{E}[r_b] + m_f[\xi\mathbb{E}[r_f] + (1 - \xi)\mathbb{E}[\min\{r_f, r_b\}]].$$

Here the only difference, compared to the baseline model, is that when the fintech also makes an offer, there is a chance of ξ that the borrower only takes the fintech's offer. Using the fact that

$$\mathbb{E}[r_f] + (1 - \xi)\mathbb{E}[\min\{r_f, r_b\}] = \underline{r} + \int_{\underline{r}}^{\bar{r}} \bar{F}_f(r)\phi(r, x_f)dr,$$

we can derive that the above expected payment equals

$$\underline{r} + (\bar{r} - \underline{r})\phi(\bar{r}, x_f)\frac{1 - \xi}{1 - \xi\phi(\bar{r}, x_f)}.$$

Then we have

$$V_h(x_f; \xi) = (\bar{r} - \underline{r})\frac{1 - \phi(\bar{r}, x_f)}{1 - \xi\phi(\bar{r}, x_f)}.$$

Since both \underline{r} and $\phi(\bar{r}, x_f)$ decrease in x_f , V_h increases in x_f . It is also clear that V_h increases in ξ given \underline{r} is independent of ξ , and so $V_h(x_f; \xi) > V_h(x_f; 0)$.

Case 2. $x_f \in [\hat{x}_f, \hat{\hat{x}}_f]$. (If $\hat{x}_f = \hat{\hat{x}}_f$ which holds when $\hat{x}_f \geq \tilde{x}_f$, this case is empty and we directly jump to Case 3.) This case holds when $\hat{x}_f < \tilde{x}_f$ so that $\hat{x}_f < \hat{\hat{x}}_f$, and for $x_f \in [\hat{x}_f, \hat{\hat{x}}_f]$ we have

$$\frac{1 - \xi}{1 - \xi\phi(\bar{r}, x_f)} \leq \frac{p_{HL}}{p_{LH}} \tag{IA.3}$$

and

$$\xi \leq 1 - \frac{p_{HL}}{p_{LH}}\phi(\bar{r}, x_f). \tag{IA.4}$$

The key condition (IA.4) follows from the definition of $\tilde{x}_f(\xi)$ in (IA.1).

We construct the following equilibrium with $\pi_b = 0 < \pi_f$. The indifference conditions

are:

$$p_{HH}(1 - \xi)\bar{F}_f(r)[\mu_{HH}(1 + r) - 1] - p_{HL} = 0,$$

and

$$p_{HH}[1 - (1 - \xi)m_b + (1 - \xi)m_b\bar{F}_b(r)][\mu_{HH}(1 + r) - 1] - p_{LH} = \pi_f.$$

When the fintech makes an offer, it competes with the bank only when the bank also makes an offer (which happens with probability m_b) and the borrower is not hit by the preference shock (which happens with probability $1 - \xi$); otherwise, it is the monopoly lender. Then it is straightforward to derive

$$\phi(\underline{r}, x_f) = (1 - \xi)\frac{p_{LH}}{p_{HL}} \quad (\text{IA.5})$$

and $\pi_f = \frac{p_{HL}}{1 - \xi} - p_{LH}$, which must be positive under (IA.3). The fintech's interest follows a distribution with survival function

$$\bar{F}_f(r) = \frac{\phi(r, x_f)}{\phi(\underline{r}, x_f)},$$

and it has a mass point at the top with a size of $\lambda_f = \frac{p_{HL}}{p_{LH}} \frac{\phi(\bar{r}, x_f)}{1 - \xi}$. And, the bank makes an offer, upon seeing a good signal, with probability m_b which solves

$$\xi + (1 - \xi)(1 - m_b) = \frac{\phi(\bar{r}, x_f)}{\phi(\underline{r}, x_f)},$$

with bank's interest rate survival function being $\bar{F}_b(r) = \frac{\phi(r, x_f) - \phi(\bar{r}, x_f)}{\phi(\underline{r}, x_f) - \phi(\bar{r}, x_f)}$. This is well-defined if $\frac{\phi(\bar{r}, x_f)}{\phi(\underline{r}, x_f)} \leq 1$.

But under condition (IA.4), we can show that $\underline{r} < \bar{r}$ hence $m_b < 1$, and $\lambda_f = \frac{p_{HL}}{p_{LH}} \frac{\phi(\bar{r}, x_f)}{1 - \xi} \in (0, 1)$; therefore the constructed equilibrium bank strategy is well-defined. To show this, it suffices to ensure that in Eq. (IA.5), we have

$$\phi(\underline{r}, x_f) = (1 - \xi)\frac{p_{LH}}{p_{HL}} \geq \phi(r, x_f) \geq \phi(\bar{r}, x_f) = \frac{p_{LH}}{p_{HH}[\mu_{HH}(1 + \bar{r}) - 1]}.$$

This requires that $1 - \xi \geq \frac{p_{HL}}{p_{HH}[\mu_{HH}(1+\bar{r})-1]}$ which is equivalent to

$$\xi \leq 1 - \frac{p_{HL}}{p_{LH}} \frac{p_{LH}}{p_{HH}[\mu_{HH}(1+\bar{r})-1]} = 1 - \frac{p_{HL}}{p_{LH}} \phi(\bar{r}, x_f).$$

This is exactly the condition in (IA.4), which also ensures $\lambda_f = \frac{p_{HL}}{p_{LH}} \frac{\phi(\bar{r}, x_f)}{1-\xi} \in (0, 1)$.

Under this equilibrium, the expected payment of the high-type is

$$\begin{aligned} & [\xi + (1 - \xi)(1 - m_b)]\mathbb{E}[r_f] + (1 - \xi)m_b\mathbb{E}[\min\{r_f, r_b\}] \\ &= \underline{r} + \int_{\underline{r}}^{\bar{r}} \bar{F}_f(r)[1 - (1 - \xi)m_b + (1 - \xi)m_b\bar{F}_b(r)]dr \\ &= \underline{r} + \int_{\underline{r}}^{\bar{r}} \left(\frac{\phi(r, x_f)}{\phi(\underline{r}, x_f)} \right)^2 dr, \end{aligned}$$

where the second equality used the fact the square-bracket term equals $\frac{\phi(r, x_f)}{\phi(\underline{r}, x_f)}$, which is from the fintech's indifference condition. Then we have the high-type's value to be

$$V_h = \int_{\underline{r}}^{\bar{r}} \left(1 - \left(\frac{\phi(r, x_f)}{\phi(\underline{r}, x_f)} \right)^2 \right) dr.$$

Notice that \underline{r} solves $\phi(\underline{r}, x_f) = (1 - \xi) \frac{x_b(1-x_f)}{x_f(1-x_b)}$ and $\phi(r, x_f)$ is a decreasing function in r .

It is then easy to see that \underline{r} increases in both x_f and ξ . On the other hand, we have

$$\frac{\phi(r, x_f)}{\phi(\underline{r}, x_f)} = \frac{\frac{\tau}{1-x_f}r - 1 + x_b}{\frac{\tau}{1-x_f}\underline{r} - 1 + x_b}.$$

Given \underline{r} increases in x_f , one can check that this expression increases in x_f ; given \underline{r} increases in ξ , this expression also increases in ξ . Therefore, V_h decreases in both x_f and ξ .

Case 3. When $x_f \in (\hat{x}_f, 1]$, we have (IA.4) fails, so that the bank exits, i.e., $m_b = 0$, given the argument in Case 2. As a result, the fintech will charge the monopoly interest rate \bar{r} and the equilibrium $V_h(x_f; \xi) = 0$, which is weakly decreasing in x_f . And, since $V_h(x_f; 0) > 0$ for all x_f in the baseline as shown in Eq. (18), we have the desired claim $V_h(x_f; \xi) < V_h(x_f; 0)$.

Scenario 2. Suppose that $\tilde{x}_f > 1$. Then, $\hat{x}_f \equiv \max(\hat{x}_f, \tilde{x}_f) > 1$. Therefore Case 1 remains unchanged, while for Case 2 we have $x_f \in [\hat{x}_f, 1]$, and Case 3 is void. All the proofs in Scenario 1 go through. Q.E.D.

B Two Fintech Lenders

B.1 Asymmetric Fintechs

Lemma 1. *Suppose that there are lenders with asymmetric screening abilities $x_s > x_m > x_w$ (subscripts denote the strong, medium, and weak lender respectively), then there are only two active lenders.*

Proof. Lender profit (as evaluated at the lowest interest rate \underline{r}) is¹

$$\pi_j = p_{HHH} [\mu_{HHH} (1 + \underline{r}) - 1] - \mathbb{P}(S_j = H, S_{-j} \neq HH) = \theta \underline{r} - (1 - \theta) (1 - x_j).$$

Hence,

$$\pi_s > \pi_m > \pi_w.$$

If all lenders are present with positive probability, then $\pi_w \geq 0$. It follows that $\pi_s > \pi_m > 0$, and the medium and strong lenders never withdraw upon good signal, i.e., $m_m = m_s = 1$. For them to be indifferent at $r = \bar{r}$, both must have a mass point at the top. Take the strong lender as an example (with $\frac{1}{2}$ as the tie-breaking rule),

$$\pi_s(\bar{r}) = p_{HHH} (1 - m_w + m_w \lambda_w) \lambda_m \cdot \frac{1}{2} [\mu_{HHH} (1 + \bar{r}) - 1] - p_{HLH} - p_{HHL} - p_{HLL} > 0 \Rightarrow \lambda_m > 0.$$

Contradiction. Hence, $\pi_w < 0$ and the weak lender exits the market. \square

¹We focus on the well-behaved equilibria with smooth pricing strategies over common interval support.

B.2 Symmetric Fintechs

Now consider the case where there is one bank, and two fintechs with symmetric screening abilities both before and after open banking. Consistent with our two-lender discussion, we consider

$$x'_f > x_b > x_f.$$

Before open banking, there exists an equilibrium in which fintechs make zero profits and the bank makes positive profit

$$\pi_b > 0 = \pi_f.$$

After open banking, the bank leaves the market, and two fintechs make zero profit

$$\pi_{f'} = 0.$$

We make the following assumptions to further simplify the analysis. To eliminate the effects of screening efficiency and focus on the number of lenders, suppose

$$x_f \nearrow x_b \nearrow x_{f'} \equiv x. \tag{IA.6}$$

We assume that $\delta \rightarrow 0$: this does not affect the equilibrium that arises, and simplifies calculating the high-type surplus.

Competition Equilibrium Characterize the competitive equilibrium before open banking. Let $S_b S_f S_f$ denote the signal sequence. The bank's indifference condition is given by

$$\pi_b(r) = p_{HHH} \underbrace{\left[1 - m_f + m_f \bar{F}_f(r)\right]^2}_{\text{winning both competitors}} [\mu_{HHH}(1+r) - 1] \tag{IA.7}$$

$$- 2 \underbrace{p_{HHL}}_{\text{b and one f make mistakes}} \underbrace{\left[1 - m_f + m_f \bar{F}_f(r)\right]}_{\text{bank wins over competing f}} - p_{HLL} \tag{IA.8}$$

Fintech's indifference condition

$$\pi_f(r) = p_{HHH} \underbrace{\left[1 - m_f + m_f \bar{F}_f(r)\right] \bar{F}_b(r)}_{\text{winning both competitors}} [\mu_{HHH}(1+r) - 1] \quad (\text{IA.9})$$

$$- \underbrace{p_{LHH} \left[1 - m_f + m_f \bar{F}_f(r)\right] - p_{HHL} \bar{F}_b(r) - p_{LHL}}_{\text{fintech and its one competitor make mistake}}. \quad (\text{IA.10})$$

The lowest interest rate pinned down by fintechs' zero profit is given by

$$\underline{r} = \frac{1 - x_f}{\tau}.$$

Accordingly, the bank's profit is given by

$$\pi_b(\underline{r}) = \underbrace{\theta(1 + \underline{r})}_{\text{payoff from } h} - \underbrace{\theta - (1 - \theta)(1 - x_b)}_{\text{\$1 lent upon } S_b=H} = (1 - \theta)(x_b - x_f).$$

Hence, the interest rate range and lender profits are the same as in our baseline model.

As for the lender's pricing, the symmetric condition for two lenders fails

$$1 - m_f + m_f \bar{F}_f(r) \neq \bar{F}_b(r).$$

With three players, there is a new event: one of the competitors makes the same mistake and may burden the l borrower. As the bank and fintechs differ in screening abilities, we no longer have the shifted CDF ($m_w F_w = F_s$). Due to the complexity in lender strategy, later the borrower surplus is characterized by subtracting lender profits from total welfare.

Borrower Surplus From our two-lender analysis, the perverse effect depends on whether high types are hurt. As $\delta \rightarrow 0$,

$$\begin{aligned}
V_h^{before} &= \text{Total Welfare} - \pi_b \\
&= \theta \bar{r} - (1 - \theta) \left\{ \underbrace{(1 - x_b)}_{b \text{ offers}} + \underbrace{x_b}_{b \text{ rejects}} \left[\underbrace{(1 - x_f) m_f}_{\text{first } f \text{ offers}} + \underbrace{(1 - (1 - x_f) m_f)}_{\text{first } f \text{ doesn't offer}} (1 - x_f) m_f \right] \right\} - \pi_b \\
&= \theta \bar{r} - (1 - \theta) \{ (1 - x_f) + x_b (1 - x_f) m_f (2 - m_f + x_f m_f) \}
\end{aligned}$$

After mandatory open banking, there are three equilibria, but borrower surplus are equivalent when $\delta \rightarrow 0$.² For the calculation, we use the asymmetric equilibrium. Let m' denote the probability that fintech makes an offer after mandatory open banking, then

$$V_h^{after} = \text{Total Welfare} = \theta \bar{r} - (1 - \theta) \left\{ \underbrace{1 - x_{f'}}_{\text{first } f \text{ offers}} + \underbrace{x_{f'}}_{\text{first } f \text{ doesn't offer}} \underbrace{(1 - x_{f'}) m'}_{\text{second } f \text{ offers}} \right\}.$$

Under the parameter setting (IA.6), h -type surplus depends on the relative relationship between m' and $m_f (2 - m_f + x m_f)$.

The bank's profits before open banking and the fintechs' profits after open banking show the following relationships between m_f , m' , and x :

$$\begin{aligned}
\pi_b &= p_{HHH} (1 - m_f)^2 [\mu_{HHH} (1 + \bar{r}) - 1] - 2p_{HHL} (1 - m_f) - p_{HLL} \rightarrow 0 \\
&\Rightarrow (1 - m_f)^2 \frac{\bar{r}}{x} - 1 + (1 - x) m_f (2 - m_f + m_f x) \rightarrow 0; \tag{IA.11}
\end{aligned}$$

²In the symmetric equilibrium, withdrawing with probability $1 - m$ loses the NPV from h type

$$\theta \bar{r} \cdot (1 - m)^2$$

but avoids loss from l type

$$(1 - \theta) \cdot \left[\underbrace{(1 - x) (1 - m) + x}_{\text{Other fintech not serving}} \right] \underbrace{(1 - x) (1 - m)}_{\text{withdraw upon } H}.$$

In equilibrium these two effects cancel out exactly

$$(1 - m) \cdot \{ \theta \bar{r} (1 - m) - (1 - \theta) (1 - x) (1 - m + x m) \} = 0.$$

$$\begin{aligned}
\pi_f &= p_{HH} (1 - m') [\mu_{HH} (1 + \bar{r}) - 1] - p_{HL} = 0 \\
&\Rightarrow (1 - m') \frac{\bar{r}}{r} - 1 + m' (1 - x) = 0.
\end{aligned} \tag{IA.12}$$

We can rearrange the above two equations (\underline{r} are the same as $x_f \nearrow x_b \nearrow x_{f'} \equiv x$),

$$\underbrace{(1 - m_f)^2 \left[\frac{\bar{r}}{r} - (1 - x) \right] - x + m_f^2 x (1 - x)}_{LHS \text{ from (IA.11)}} \rightarrow \underbrace{(1 - m') \left[\frac{\bar{r}}{r} - (1 - x) \right] - x}_{LHS \text{ from (IA.12)}} = 0,$$

which implies

$$(1 - m_f)^2 < (1 - m').$$

Plug this back into (IA.11) and (IA.12), we have

$$m' < m_f (2 - m_f + x m_f) \Leftrightarrow V_h^{before} < V_h^{after}.$$

Therefore, high types always benefit from mandatory open banking. Our analysis also implies that total welfare is higher in the case of two lenders than with three lenders. This results from our bad-news information structure: l types are more likely to receive an offer with more lenders. One can verify that the total welfare with a monopolist lender is even higher (high types are better off with two lenders as compared with one monopolist due to competition).