Information Advantage, Relationship Advantage and Competition in Banking Industry*

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Abstract

I study the competition between bank bank and FinTech in loan markets. It is said that FinTech erodes the market share of bank bank. This is because by using Big Data or technologies which have not used by bank, FinTech can earn more accurate hard information which is numerical information about firms productivity. By paying additional cost, however, the traditional relationship between bank and customer allows bank to collect soft information which is not obtained as numerical information. I find that as the results of the competition, both can earn positive profit by using the advantage which each have. Comparing with the competition between two incumbent banks, the competition between FinTech and bank improves not only social welfare but also the profit of each agent's welfare.

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1 Introduction

In the past few years, new competitors emerge in financial markets. They are called FinTech (Financial Technology) or FinTech companies. One of the main feature of FinTech is that by using information technology which have not been used by the banks (i.e, Machine Learning, Big Data,), they can collect more accurate information than the banks about firm and consumer and provide services which suit for the type of each firm or consumer. It is said that FinTech will erodes the banks market share so that the banks may not be able to survive at financial markets. But there is a few research which study the effect of entrance of FinTech in financial markets. In this paper, I focus on loan markets and consider the competition between the banks and FinTech, and show the effect of the competition to the social welfare.

In loan markets, how can FinTech collect information about customers and provide loan service? Since 2012, for example, Amazon have started Amazon Lending. In the service, the firm which sells used goods at Amazon Market Place can borrow from Amazon. Since Amazon can observe whole trade between firms and consumers, Amazon can know the corporate performance of those firms and collect the evaluation of those firms by consumer. By using these information, Amazon provides the lending contract suiting to each firm. If a firm have a good corporate performance, he might be able to borrow more money with the lower interest than when he borrows from bank. Furthermore, even though a firm is refused to borrow from a bank, he might be offered loan by Amazon. Like Amazon Lending, the other FinTech which provide lending service also can offer the lending contract suiting to each firm or consumer. Thus the entry of FinTech is probably beneficial for them.

Although the entry of FinTech is beneficial for customer, it may not be beneficial for bank. Because of information technology, FinTech can provide the more attractable contract to consumer and firm so that bank may lose their market share.

However, the banks have other advantage which FinTech does not have. Especially in banking sector, bank traditionally builds the relationship with customer to monitor the performance of customer or to advice and it makes bank collect the different type information; soft information. The Information which collected by FinTech can be classified hard information. Hard information is the information which is easily reduced to number and can transmit and process easily. Newer information technologies always improve the quality of hard information. On the other hands, soft information contains information which is difficult to completely summarize in a numerical source. Thus even though by using newer information technologies, it is very hard for FinTech to collect because it can not be digitized. Of course, bank can use the hard information. But to get more accurate information, bank can choose whether he collect soft information or not. In other wards, bank chooses whether he build relationship with customer or not. Such a relationship leads other advantages to bank and in this paper, I call them relationship advantage.

I consider the competition between bank banks which have the relationship advantage and FinTech

which has the information advantage. The bank banks and FinTech offer loan contract for firms. Each firm has different productivity and it can not be observed by the bank banks and FinTech initially. However, they can know the type roughly as hard information. The hard information which is observed by FinTech is more accurate than that by the bank banks. Thus if they offer a contract based on the hard information, FinTech can design the more attractable contract for the firms. By paying an additional cost, the bank banks have an option of building the relationship with the firms and can know the productivity exactly and the relationship can reduce the cost of lending. While it depends on the cost of building the relationship, they can offer a contract which is preferred by the firms.

What will happen if there exists the contracts which is offered by the banks and FinTech in a loan market? Fist, I consider the competition between bank and FinTech. I find that all firms visit FinTech first and enforce the screening contract with bank and enforce the pooling contract with bank and FinTech. This makes FinTech and bank earn positive profit. And comparing with the case where two banks compete with each other, not only the social welfare but also each agent's welfare improve by the competition.

The rest of the paper is organized as follows. Next subsection introduces related literature. Section 2 lays out the basic model of bank and FinTech. Section 3 analyzes the equilibrium under competition. Sections 4 compares the results with the case there are only banks. Section 5 is conclusion. All proofs are in the Appendix.

Related Literature

Since FinTech appear in the past few years, there is only a few research about FinTech[1]. The argument about the competition of bank and Fintech is considered in (Vives 2016).

Theoretically, this paper relates to the literature about the competition of banks under the information asymmetricity. (Sharpe 1990) and (von Thadden 2004) consider the competition of banks under the information asymmetricity. In their model, if bank has a relationship with a customer, the bank receive a signal about type of the customer. But without the relationship, bank can not receive the signal. They show that at the equilibrium, for a customer, bank with the relationship offers the loan contract based on the signal and uninformed bank uses a mixed strategy to offer the loan contract. The informed bank can get positive payoff but the uninformed bank gets zero profit. (Hauswald and Marquez 2003) endogenous the choice of the accuracy of signal. (Hauswald and Marquez 2006) introduces (Salop 1979) into (Sharpe 1990) and VONTHADDEN2004. They consider the effect of the competition to the market share of each bank or the interest rate. Unlike the above papers, (Dell'Ariccia and Marquez 2004) and (Dell'Ariccia et al. 1999) assume that informative bank can know the type of customer exactly without cost and derive the similar mixed strategy equilibrium.

The above papers assume that customer does not know their type ex-ante, thus their model does

[1]For example, see (Buchak et al. 2017)

not consider the hidden information problem. (Gormley 2014) and (Sengupta 2007) consider the entry of foreign bank and the competition. Their models deal with the hidden information problem. (Gormley 2010), (Gormley 2014) introduce the cost advantage of foreign bank and conclude that because of the advantage, at equilibrium, only high productive firm accept a contract offered by entrant bank, and bank banks and other type firm can enforce a contract. Thus the banks is excluded by the competition. (Sengupta 2007) introduce the information advantage and the cost advantage and show, at equilibrium, when the cost advantage of the foreign bank dominates that of the bank banks, the foreign bank can attract the highly productive firms.

However, their model can not predict the result of the competition of banks and FinTech because their model does not assume the information advantage of foreign bank. Thus, this paper is introduces the information advantage to foreign bank.

2 Model

2.1 Borrower

A firm (the borrower) has an individual project with fixed cost $I > 0$. Since the borrowers have no initial endowment, they can not implement their project by themselves. Thus, they seek a lender to implement the project. The project yields $R > 0$ if the project success, or nothing if the project fail. I define the probability of success by $\theta \in \Theta \equiv [0, 1]$. I denote the distribution function of θ by $F(\cdot)$ and the density function by $f(\cdot)$. θ is can be interpreted as the type of customer, but I assume the type is only observed by lender.

2.2 Lender and information structure

I assume that there are tow type bank (the lender): a traditional bank and a FinTech type bank. The difference between the traditional bank and FinTech type bank is information structure. First, both banks can divide the domain of the type, $\Theta = [0, 1]$, into the small partition. For example, the traditional bank can divide the domain into m parts. Denote the nth partition from the first information partition by $\Theta(m, n) \equiv [\underline{\theta}_n, \overline{\theta}_n)$ where $\underline{\theta}_n = \frac{n-1}{m}$ and $\overline{\theta}_n = \frac{n}{m}$. I assume that the last partition, that is, the m th partiton is defined as $\Theta(m, m) = [\frac{m-1}{m}, 1]$. Hereafter, I call the divided partitions as information partition. When the traditional bank divide the original domain into m parts, the FinTech type bank can divide each information partition finer. Denote the FinTech type bank's information partition by $\Theta_n(m', n')$. This is the n'th information partition of the FinTech type bank when the FinTech type bank divide the traditional bank's information partition, $\Theta(m, n)$, into m' parts. When a firm visit a bank, the bank observes which information partition the firm in. I assume that there is no observation cost. Thus, the finer the information partition is, the more bank can get accurate information. This implies that the FinTech type bank have more accurate information about

the probability of firm than the traditional bank. Note that m and m' is exogenously given so that both banks can not control the accuracy of information partition.

An interpretation of information partition is credit scoring. When firm visits bank, the bank can observe the credit score of the firm and the bank decides the loan contract based on the credit score. The well- known discrimination of customer based on credit scoring are called prime and subprime lending. In consumer lending, the customer whose credit score is more than 300 point can obtain a loan. The customer whose credit score is less than 660 point is called subprime borrower and the customer whose credit score is higher than 660 point is called prime borrower. When $m = 3$, each information partition equates the credit scoring. On the other hand, by using not only credit scoring but also Big data or machine learning technique, the FinTech type bank creates an unique scoring. Thus, the FinTech type bank have finer information partition. These scorings are based on numerical data and the information based on numerical data is called hard information.

Second, the traditional bank has an option to get the exact information about the firm's type. Suppose that a firm visit the traditional bank. If the traditional bank pays a screening cost, $k > 0$, he can observe the firm's type. The traditional bank can decide if he the screening cost. However, the FinTech type bank does not have the option. Thus, the traditional bank has another advantage. The interpretation of this option relates to relationship banking. The cost, k, can be interpreted as the cost for monitoring, screening, or becoming main bank. Through monitoring or the process becoming main bank, bank can obtain information which can not preserve as numerical data. The information is called soft information. Thus, I can say that FinTech type bank has information advantage and traditional bank has relationship advantage.

2.3 Equilibrium contract and Payoff

I impose some assumptions. First each banks can observe the contract which is offered by the opponent bank to a firm which visited the opponent bank before. Next, if the traditional bank pays k for a firm the traditional bank can lock in the firm. Finally, each bank knows the information structure of the other bank. When I denote the expected output by $\mu_\theta = \theta R$, the expected output can be written as $\mu = \int_0^1 \mu_\theta f(\theta) d\theta$. I assume that $\mu - I > 0$, that is, on average, investment is profitable. To access the hard information or soft information is valuable, I assume that there exists a type, θ', such that for all $\theta < \theta'$, $\mu_\theta - I < 0$ holds.

Since the traditional bank can perfectly screen the firm's type when he pays k, the traditional bank can enforce screening contract. That is, the traditional bank can provide the contract which suit for each firm type. On the other hand, the FinTech type bank and the traditional bank without paying k can only obtain rough information about firms. Thus they provide pooling contract, that is, bank provides same contract for an information partition.

The contract specifies repayment for lending. Let $r(\theta)$ be the repayment under screening contract and $r(m, n)$ be the repayment under pooling contract for the information partition, $\Theta(m, n)$ and

$r(m', n')$ be the repayment for the information partition, $\Theta_n(m', n')$. The payoff of a firm whose type is θ is

$$\pi^f(\theta) = \mu_\theta - \theta r. \tag{1}$$

The payoff of a bank from the firm is

$$\pi^t(\theta) = \begin{cases} \theta r(m, n) - I & if\ pooling \\ \theta r(\theta) - k - I & if\ screening \end{cases} \tag{2}$$

2.4 Timing

I construct multi-stage game. The timing of the game is following: First, both banks offer the contract to firms and firms observe the value of the expected payoff and decide which bank they will visit first. Bank observes the firm's type based on his information structure and offers contract. Next firms visit the other bank and are offered contract. If a firm is offered a screening contract, the firm stay at the traditional bank. Otherwise, the firm choose the bank which provide a better pooling contract. I assume that if a firm is offered a contract which give him the same payoff from both banks, then he will randomly decide which bank he will enforce the contract.

Since the firms does not know own type, in the first stage all firm visit same bank by observing the total expected payoff. I assume that the way of the traditional bank to screen their type is as the follow: if the traditional bank pays k,

3 Competiton between the traditional bank and the FinTech type bank

In this section, I analyze the competition between the traditional bank and the FinTech type bank. Since in the first stage the firms observe the total expected payoff under the contract provided by both banks, all firms visit the bank which gives higher total expected payoff. Thus, I can suppose that when all firms visit the traditional bank or the FinTech type bank . I assume that all firms visit the traditional bank initially in proposition 1 and the FinTech type bank in proposition 2. Then, the case which gives higher profit for the firms is supported as an equilibrium.

First, when I assume that all firms visit the traditional bank initially, I obtain the following proposition.

Proposition 1. *Suppose that all firm visit the traditional bank initially. The following holds:*

1. *The screening contract* : *the traditional bank fully extract the firm's surplus,*

2. *The pooling contract* : *For each information partition,* $\Theta_n(m', n')$*, both banks give the firms the maximized expected payoff,*

$$V_{\Theta(m,n)} = \begin{cases} \max\limits_{\theta^*} \int_{[\underline{\theta}_n, \theta^*]} \mu_\theta - If(\theta)d\theta & if\ \theta_n^* \in \Theta(m,n) \\ \int_{\Theta_n(m',n')} \mu_\theta - If(\theta)d\theta & if\ \theta_n^* \notin \Theta(m,n) \end{cases}$$

3. *Let* θ_n^* *be a threshold type. The firms whose type is in* $[\theta_n^*, 1]$ *enforce the screening contract with the traditional bank, and the firms whose type is in* $[\underline{\theta}_n, \theta_n^*]$ *enforce the pooling contract with the FinTech type bank or the traditional bank randomly. The firms whose type is in* $[0, \overline{\theta}]$ *can not enforce any contract with both firms,*

4. *The traditional bank can earn positive profit from the screening contract and under a condition, the FinTech type bank can earn positive profit.*

Proof. See the Appendix. ■

The type, $\overline{\theta}$, is the upper bound threshold such that in all information partition less than $\overline{\theta}$, the average output is less than the average cost. The traditional bank can lock in the firms through screening , that is, the firms can not visit the FinTech type bank by screening. Therefore, the traditional bank can provides the contract which fully extract the firms profit by screening. On the other hand, when the traditional bank does not offer the screening contract, both banks must compete in Bertrand fashion. Thus the pooling contract gives the firms the maximized expected profit. Since the FinTech type bank provides the same expected payoff with the traditional bank in the pooling contract, the pooling value is based on the traditional bank's information partition.

Second, when I assume that all firms visit the FinTech type bank initially, I obtain the following proposition.

Proposition 2. *Suppose that all firms will visit the FinTech type bankinitially. The following holds.*

1. *The screening contract* : *the traditional bank gives the firms the expected payoff,*

$$V_{\Theta_n(m',n')} = \max_{\theta^*} \int_{[\underline{\theta}_{n'}, \theta^*]} \mu_\theta - If(\theta)d\theta$$

2. *The pooling contract* : *For each information partition,* $\Theta_n(m', n')$*, both banks give the firms the maximized expected payoff,*

$$V_{\Theta(m,n)} = \begin{cases} \max\limits_{\theta_n^*} \int_{[\underline{\theta}_n, \theta_n^*]} \mu_\theta - If(\theta)d\theta & if\ \theta_n^* \in \Theta_n(m',n') \\ \int_{\Theta_n(m',n')} \mu_\theta - If(\theta)d\theta & if\ \theta_n^* \notin \Theta_n(m',n') \end{cases}$$

3. *Let $\theta^*_{n'}$ be a threshold type. The firms whose type is in $[\theta^*, \overline{\theta}_{n'}]$ enforce the screening contract with the traditional bank. If a condition holds, the firms whose type is in $[\underline{\theta}_{n'}, \theta^*_{n'}]$ enforce the pooling contract with the FinTech type bank. Otherwise the firms choose bank randomly. The firms whose type is in $[0, \overline{\theta}]$ can not enforce any contract with both firms,*

4. *The traditional bank can earn positive profit from the screening contract and under a condition, the FinTech type bank can earn positive profit.*

Proof. See the Appendix. ■

Unlike proposition 1, the screening contract can not fully extract the firm's surplus. This is because since the firms visit the FinTech type bank initially, they can know their type roughly through the pooling contract and inform the pooling contract offered by the FinTech type bank to the traditional bank. This makes the outside option in the traditional bank's screening contract increase. Thus the traditional bank can not fully extract the firm's surplus. Note that in this propositions both banks can know the FinTech type bank 's information partition, the expected payoff in the pooling contract equals to the maximized expected payoff in $\Theta_(m', n')$.

Now, from the above propositions, I obtain the next corollary.

Corollary 1. *Since all firms visit the FinTech type bank initially, the equilibrium in proposition 2 holds.*

Proof. The threshold type in proposition 1 become lower then the threshold type in proposition 2 and T_f is added the positive expected payoff when they enforce the screening contract. Thus, $T_f > T_t$ holds. This implies that all firms visit the FinTech type bank initially. ■

This corollary is the main result in this paper. The mechanism of the corollary is following. When the firm visit the traditional bank initially, he is provided the screening contract or the pooling contract. But his payoff is fully extracted under the screening contract and and he is locked in the traditional bank. On the other hand, when a firm visit the FinTech type bank, the FinTech type bank can know the firm's type roughly and provide a pooling contract based on the information. This contract makes the firm know his type. After visiting the FinTech type bank, the firm visit the traditional bank. Since the firm already know his type roughly, the traditional bank must provide the contract which gives the firm the higher expected profit. This implies that by visiting the FinTech type bank initially, the firm can obtain a bargaining power to the traditional bank. Thus the firm can earn higher total expected profit in the proposition 2 than the proposition 1 so that he visit the FinTech type bank first. Note that even though under the pooling contract both firms earn zero profit, they can enforce the pooling contract with the firms.

4 Comparison

Here, I compare the above result with the case where there are two traditional banks. First, I analyses the competition with the two traditional banks.

4.1 Competition with the two traditional banks

Suppose that there are two traditional banks, $i = 1, 2$. Because of the symmetricity of the banks, I can assume that the firms will randomly choose which the traditional bank they visit. As the same before, the traditional bank provide the screening contract and the pooling contract. Fist, I consider the pooling contract. For each information partition, to attract the firms the traditional banks offer the pooling contract which satisfies zero profit condition. Thus, the under the pooling contract, the firms in the information partition, $\Theta(m,n)$, obtain the expected payoff, $V_{\Theta(m,n)} = \int_{\Theta(m,n)} \mu_m - If(\theta)d\theta$. Next, the screening contract for each information partition, $\Theta(m,n)$, is derived from the following problem:

$$\max_{r(\theta)} \ \theta r(\theta) - k - I \ s.t \ \mu_\theta - \theta r(\theta) \geq \hat{V}_{\Theta(m,n)}$$

where $\hat{V}_{\Theta(m,n)} = \max\{V^1_{\Theta(m,n)}, V^2_{\Theta(m,n)}\}$ is the value of outside option provided by each traditional bank. Because of the symmetricity, I assume that $V^1_{\Theta(m,n)} = V^2_{\Theta(m,n)} = V_{\Theta(m,n)}$. The equilibrium in the competition between the two traditional bank is explained in the next proposition.

Proposition 3. *Under the competition between the two traditional banks, the equilibrium is the following.*

1. *The screening contract : the traditional bank gives the firms the expected payoff,*

$$V_{\Theta(m,n)} = \max_{\theta^{**}_n} \int_{[\underline{\theta}_n, \theta^{**}_n]} \mu_\theta - If(\theta)d\theta$$

2. *The pooling contract : For each information partition, $\Theta(m,n)$, both banks give the firms the maximized expected payoff,*

$$V_{\Theta(m,n)} = \begin{cases} \max_{\theta^{**}_n} \int_{[\underline{\theta}_n, \theta^{**}_n]} \mu_\theta - If(\theta)d\theta & if \ \theta^{**}_n \in \Theta(m,n) \\ \int_{\Theta(m,n)} \mu_\theta - If(\theta)d\theta & if \ \theta^{**}_n \notin \Theta(m,n) \end{cases}$$

3. *The firms whose type is in $[\theta^{**}_n, \overline{\theta}_n]$ enforce the screening contract, and the firms whose type is in $[\underline{\theta}_n, \theta^{**}_n]$ enforce the pooling contract . The firms whose type is in $[0, \overline{\theta}]$ can not enforce any contract with both firms. The firms which can enforce contract with the both banks, chooses a bank randomly.*

This proposition is similar to proposition 2. Since both banks have the screening option, unlike the situation in proposition 1 both banks can not lock in the firms surely. Thus the firms have the bargaining power to the both banks.

In both cases, the traditional bank can earn profit from the screening contract. Since the FinTech type bank provides the same expected payoff with the expected payoff provided by the traditional bank in pooling contract for the information partition, $\Theta(m, n)$. Thus, in the competition between the traditional bank and the FinTech type bank, the the threshold value for screening contract does not change. But, note that in proposition 3 the firm which enforce the screening contract randomly choose the traditional bank. Thus the profit which each traditional bank can earn from the screening contract is the half of total profit from the screening contract. On the other hand, when the opponent is the FinTech type bank since he can not lock in the firms, the traditional bank can earn all profit from the firms which enforce the screening contract. This argument leads the next proposition.

Proposition 4. *The competition between the traditional bank and FinTech type bank makes the traditional bank earn more profit than the case where two traditional bank compete.*

This proposition says that the entry of the fbank is profitable for the tbank. Since the fbank does not have the lock in option, the tbank can earn higher profit from the competition. This result can be interpreted as the effect of relationship banking, that is, the option to get soft information. It is often said that the entry of the fbank erodes the market share of the tabnk so that the tbank lose the competition. But this proposition says that as long as the tbank has the relationship advantage, he can stile have the room to earn profit from the competition.

4.2 Welfare Analysis

In this subsection, I compare welfare in each cases.First, the payoff of the firms in each information set is same in both case. Second the total profit from screening contract is same in both case. However, in the competition of the tbanks, both banks earn zero profit from the pooling contract. On the other hand, in the competition between the fbank and the tbank, the fbank has the opportunity to earn the positive profit from the pooling contract. Thus, I obtain the next proposition

Proposition 5. *Comparing with the competition of the tbanks, the social welfare may improve in the competition between the tbank and the fbank.*

This implies that in our model, the competition between the tbank and the fbank will not only make the social welfare not be worse off, but also may be better off. The reason of the better off is the informational advantage which the fbank has. From this proposition, I can say that by introducing the more accurate information technology and the competition, our economy will be better off.

5 Conclusion

In this paper, I analyze the competition between bank and FinTech. I obtain the following results through the analysis. When FinTech which have more accurate hard information than bank enter the market, FinTech can earn a positive profit through the competition. On the other hand, bank which have the relationship advantage also can a positive profit. By using the advantage, each survives in the market. And comparing with the case where two banks compete with each other, not only the social welfare but also each agent's welfare improve by the competition. I think that these results provide a helpful perspective about the regulation policy of FinTech in banking industry.

6 Appendix

6.1 Proof of proposition 1

Proof. Suppose that all firms will visit the traditional bank. I derive the equilibrium contract by using backward induction.

(*The FinTech type bank*) After visiting the traditional bank, the firms whose type θ is in $[\theta^*, 1]$ enforce a contract with the traditional bank. Thus, the type of firms who will visit the FinTech type bank is in $[0, \theta^*]$. For each information partition, the FinTech type bank offers a contract. If the average productivity in an information partition is less than the investment cost, FinTech type bank will reject all firms which are in the information partition. First, I consider the case where $\theta^* \notin \Theta_n(m', n')$. If the average productivity in the information partition is higher than the investment cost, FinTech type bank offers a contract. Suppose that for an information partition of the traditional bank, $\Theta(m, n)$, the traditional bank provides a pooling contract which gives the value V to the firms in $\Theta(m, n)$. For the FinTech type bank, there are three cases, (i) $V > \int_{\Theta_n(m',n')} \mu_\theta - If(\theta)d\theta$, (ii) $V = \int_{\Theta_n(m',n')} \mu_\theta - If(\theta)d\theta$, and (iii) $V < \int_{\Theta_n(m',n')} \mu_\theta - If(\theta)d\theta$. In (ii), by providing the contract which leads zero profit condition, the FinTech type bank takes all firm in $\Theta_n(m', n')$ because of assumption. In the case (i), by providing the contract which gives V for the FinTech type bank, the FinTech type bank can take all firm in $\Theta_n(m', n')$. But this leads a loss. Define the difference between V and net profit by $D(V) \equiv \int_{\Theta_n(m',n')} \mu_\theta - I - Vf(\theta)d\theta$. In this case, $D(V)$ becomes negative. On the other hand, in the case (iii), by solving the following problem,

$$\max_{r(m',n')} \int_{\Theta_n(m',n')} \theta r(m', n') - If(\theta)d\theta \ s.t \ \int_{\Theta_n(m',n')} \mu_\theta - \theta r(m', n')f(\theta)d\theta \geq V,$$

the FinTech type bank can get positive profit, $D(V) > 0$ and since this contract can attract the firms in $\Theta_n(m', n')$, the FinTech type bank can take them from the traditional bank. Define $L \equiv \{\Theta_n(m', n') | D(V) < 0\}$ and $G \equiv \{\Theta_n(m', n') | D(V) > 0\}$. L is the set of information partition such that $D(V)$ is negative and G is the set of information partition such that $D(V)$ is positive. If the

difference between total loss and the total gain,

$$T(V) \equiv \sum_{G} D(V) - \sum_{L} D(V)$$

is positive, since the FinTech type bank can compensate the loss and can take all firms in $\Theta(m,n)$. Suppose that $T(V)$ is negative. Then, by ignoring the information partition and providing the same contract as the traditional bank for the firms in $\Theta(m,n)$, the FinTech type bank can take all firms.

Next consider the case where $\theta^* \in \Theta_n(m',n')$. Since the firms whose type is in $[\theta^*, \overline{\theta}_n]$ stay at the traditional bank, the firms whose type is in $[\underline{\theta}_n, \theta^*)$ visit the FinTech type bank. The traditional bank offers a pooling contract for $[\underline{\theta}_n, \theta^*)$ and I assume that the contract gives the firms the payoff V_{θ^*}. In this case, by the same argument if $T(V_{\theta^*}) > 0$, the FinTech type bank can take the firms randomly and earn positive profit. On the other hand by offering the same contract with the traditional bank, the FinTech type bank earn zero profit.

(*The traditional bank*) Hereafter, I consider the optimal behavior of the traditional bank. First, I derive the optimal pooling contract. Given the FinTech type bank's behavior, the all firms for which the traditional bank offers a pooling contract will visit the FinTech type bank and will stay at the FinTech type bank. Even though all firm will be taken, to attract the firms, the traditional bank will provide the most attractive contract and the contract gives the traditional bank zero profit. Thus, for each information partition, the traditional bank offers the pooling contract satisfying

$$\int_{\Theta(m,n)} \theta r(m,n) - I f(\theta) d\theta = 0 \Longrightarrow r(m,n) = \frac{I}{E[\theta | \theta \in \Theta(m,n)]}.$$

This contract gives the firm in $\Theta(m,n)$ the value, $V = \int_{\Theta(m,n)} \mu_\theta - I f(\theta) d\theta$. If the threshold type θ^* is in a information partition $\Theta(m,n)$, the traditional bank offer the pooling contract for an interval $[\underline{\theta}_n, \theta^*]$.

Next consider the optimal screening contract. Since the traditional bank can lock in firms if he pay k, the optimal screening contract is driven by the following problem:

$$\max_{r(\theta)} \ \theta r(\theta) - k - I \ s.t \ \mu_\theta - \theta r(\theta) \geq 0.$$

Thus, the threshold type, θ^*, is determined by the following equation,

$$\mu_{\theta^*} - k - I = 0 \Longrightarrow \theta^* = \frac{k+I}{R}.$$

(*Payoff*) At this equilibrium, the traditional bank enforces the screening contract with the firms whose type is in $[\theta^*, 1]$ and the FinTech type bank enforces the pooling contract with the firms whose type is in $[\underline{\theta}, \theta^*]$. Since the traditional bank fully extract the firm's surplus, the firm's expected payoff

from the screening contract is zero. On the other hand, when the firm's type is in $[\underline{\theta}, \theta^*]$, they enforce the pooling contract with the FinTech type bank so that the total expected profit is

$$T_t = \sum_{\Theta_n(m',n') \in [\underline{\theta}, \theta^*]} V_{\Theta(m,n)} = \sum_{\Theta_n(m',n') \in [\underline{\theta}, \theta^*]} \int_{\Theta(m,n)} \mu_\theta - If(\theta) d\theta.$$

The traditional bank's payoff is

$$\int_{\theta^*}^{1} \mu_\theta - k - If(\theta) d\theta$$

and the FinTech type bank's payoff is zero. ■

6.2 Proof of proposition 2

Proof. Suppose that all firms will visit the FinTech type bankinitially. I derive the equilibrium contract by using backward induction.

(*The traditional bank*) After visiting the FinTech type bank, all firms visit the traditional bank. Suppose that for each information partition, $\Theta_n(m', n')$, the FinTech type bank gives the firms the payoff, $V_{\Theta_n(m',n')}$, and there exists n^* such that for all $n' \leq n^*$ in the $N(n^*)$ th information partition of the traditional bank and for all $n \leq N(n^*)$, $\int_{\Theta_n(m',n')} \mu_\theta - If(\theta) d\theta < 0$ holds. Since the firms in the information partitions must rejected by the FinTech type bank, the traditional bank also reject to lend.

The traditional bank can know the pooling contract provided by the FinTech type bank, to attract the firms the traditional bank provide the more attractive contract, and so in Bertrand fashion both banks will offer the pooling contract which leads zero profit condition. Thus the screening contract is obtained by the following problem:

$$\max_{r(\theta)} \ \theta r(\theta) - k - I \quad s.t \ \mu_\theta - \theta r(\theta) \geq V_{\Theta_n(m',n')}.$$

The constraint must bind at the equilibrium, the repayment under the screening contract is $r(\theta) = (\mu_\theta - V_{\Theta_n(m',n')})/\theta$. The threshold type θ^* is determined by

$$\mu_\theta - V_{\Theta_n(m',n')} - k - I = 0 \tag{3}$$

For the firm in the information partition, $[\underline{\theta}_n, \theta^*]$, the traditional bank offers a pooling contract giving the value $V_{[\underline{\theta}_n, \theta^*]}$.

(*The FinTech type bank*) First, for all information partition where the average output is less than the investment cost the FinTech type bank will not offer any contract. Thus the rest of the firms will have the opportunity to enforce a contract.

Next, consider the information partition for which the traditional bank will not offer the screening contract. In this case the by the same argument of proposition 1, there is the case where the FinTech

type bank hide the information. If $T(V) > 0$ holds, the FinTech type bank can earn positive profit from the information partition $\Theta(m,n)$. Thus the firms in $\Theta_n(m',n')$ will obtain the expected payoff, $V_{\Theta(m,n)} = \int_{\Theta(m,n)} \mu_\theta - If(\theta)d\theta$.

Lastly, I consider the pooling contract for the information partition in which the traditional bank will offer the screening contract. The equation (3) which characterizes the threshold implies that the expected payoff, $V_{\Theta_n(m',n')}$, which the optimal pooling contract gives to the firms determines the thresholds value, θ^*. The type interval of firm's which the FinTech type bank may able to enforce the contract is $[\underline{\theta}_n, \theta^*]$. The traditional bank will offer the pooling contract which gives the firms the expected payoff, $V_{[\underline{\theta}_n,\theta^*]} = \int_{[\underline{\theta}_n,\theta^*]} \mu_\theta - If(\theta)d\theta$. Therefore, the FinTech type bank should solve the following maximization problem:

$$\max_r \int_{[\underline{\theta}_n,\theta^*]} \theta r - If(\theta)d\theta \ s.t \ \int_{[\underline{\theta}_n,\theta^*]} \mu_\theta - \theta r f(\theta)d\theta \geq \int_{[\underline{\theta}_n,\theta^*]} \mu_\theta - If(\theta)d\theta$$

From the above maximization problem, the repayment is defined so as to hold zero profit condition. Thus the FinTech type bank will offer the pooling contract for the information partition, $\Theta_n(m',n')$ which gives the expected payoff, $V_{\Theta_n(m',n')} = \max_{\theta^*_{n'}} \int_{[\underline{\theta}_n,\theta^*]} \mu_\theta - If(\theta)d\theta$. And to attract the firms, the FinTech type bank chooses the maximum value of $V_{[\underline{\theta}_n,\theta^*]}$ which satisfies the $\theta^* \in \Theta_n(m',n')$.

(*Payoff*) Since zero profit condition holds for any information partition, the FinTech type bank's payoff becomes zero. The traditional bank can only earn positive profit from the screening contract. The expected payoff of the firm is

$$T_f = \sum_{pooling} V_{\Theta_n(m',n')} + \sum_{screening} V_{[\underline{\theta}_{n'},\theta^*]}.$$

■

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