FinTech Lending, Financial Inclusion, and Policy Implications*

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Abstract

We study a setting in which banks originally compete with shadow banks and later FinTech lenders also enter the market. Competition from shadow banks gives rise to a separating equilibrium which does not exist when borrowers only have access to banks. Whether FinTech lenders may improve or harm financial inclusion crucially depends on the FinTech lenders' relative intensity in cream skimming and blacklisting. Cream skimming harms financial inclusion by increasing the breakeven interest rate by traditional lenders, while it improves financial inclusion by making shadow banks more likely to serve borrowers due to a lower deviation profit by banks. Blacklisting gives FinTech lenders the comparative advantage to target the pool of non-blacklisted consumers. Financial inclusion can be further improved if there is a market for FinTech lenders to sell their blacklist to traditional lenders.

Key Words: FinTech, banks, shadow banks, cream skimming, blacklisting

JEL Codes: D82, G21, G23

1 Introduction

In the past decade, we have witnessed dramatic transformation in the financial industry. Two important changes are the emergence of shadow banking and the extensive use of internet and information technol-

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ogy to replace brick and mortar banks in provision of financial services. According to Consultancy.uk, in 2017, \$27.4 billion in venture capital money was invested into FinTech, representing a tremendous growth from one year ago when the figure was \$17.4 billion.[1] Currently, the most innovative FinTech firms are mostly based on China and the United States.[2] Lending was among the first financial services which was subject to the disruption of the technological revolution. Bank lending capacity for small and medium sized enterprises (SMEs) has significantly shrunk following the 2008 financial crisis. Early FinTech lenders entered the market to fill some of the unmet demands for credit by providing supply-chain financing, crowdfunding, and peer-to-peer (P2P) lending platforms which connect borrowers and lenders without banks as middlemen. Initially, lenders on P2P lending platforms screened borrowers and made their own decisions on loans. Interest rates sometimes were determined through auction mechanisms. However, over time, these platforms have taken over activities of traditional banks, such as loan screening, evaluation, and pricing, using their proprietary software (e.g., Mores, 2015, Balyuk and Davydenko, 2018, and Ryan and Zhu, 2018). Many describe the earlier development of P2P lending platforms as disintermediation and the current trend as reintermediation.

Considering the rapid development of FinTech lending around the world, it is imperative for governments to formulate effective financial regulation (or deregulation) and policies to spur FinTech innovations while at the same time maintaining the financial stability of the economy.[3] A major challenge for FinTech policy making is that theoretical research on FinTech is scarce and there are few widely accepted insights on important and practical issues concerning FinTech. This paper aims to fill this important void in the context of FinTech lending, putting emphasis on the impacts of entry of FinTech lenders on the lending markets, financial stability, and consumer welfare.

To analyze the impact of emergence of FinTech lenders, we first consider a game-theoretical model in which traditional banks compete with unregulated lenders or shadow banks, serving borrowers of privately known levels of risks. The banks' competitive advantage over unregulated lenders comes from its lower cost of funds due to their acceptance of deposits and its better ability to screen borrowers' creditworthiness. The unregulated lenders' competitive advantage arises from their superior ability in debt

[1] See Consultancy.uk (2018), "Venture capital investment in FinTech reaches record \$27.4 billion high".

[2] See CNBC.com (2017), "10 of the most innovative FinTech firms right now, according to research".

[3] Accoding to an IMF Staff Discussion Note, He et al. (2017), also point out the need for regulatory authorities "to be assured that risks to stability and integrity—including from cyberattacks, money-laundering and terrorism financing—can be effectively managed without stifling innovation."

collection. We assume their tactic of debt collection comes with a social cost. According to Bloomberg (2018), "Shadow banking is a catchall phrase that encompasses risky investment products, pawnshop and loan-shark operations and so-called peer-to-peer lending between individuals and businesses." It is not uncommon to find reports that shadow banks use questionable collection tactics such as harassing the borrowers with numerous call and using false threats of lawsuits.[4] These tactics can be effective in debt recovery but also imposes a cost on the borrower. The cost may be incurred when the borrower sells his assets at a loss to make debt repayments or simply psychological.[5]

In the benchmark case, some intuitive findings follow naturally. Banks capture the borrowers whom they identify as low-risk and compete for their business by charging them a low loan rate. Competition from shadow banks makes it harder for banks to serve unidentified borrowers. On the other hand, shadow banks may promote financial inclusion by giving rise to a separating equilibrium in which only low-risk borrowers are served. When the prior average credit risk of borrowers is high, no pooling equilibria exist. For lower prior average credit risk of borrowers, whether banks or shadow banks have the competitive advantage in serving borrowers with unidentified risks depends on banks' advantage in cost of funds, shadow banks' advantage in debt collection, and social costs of debt collection.

Next, we introduce FinTech lenders into the market. Just like traditional shadow banks, FinTech lenders also do not receive deposits so have a higher cost of funds than banks. Their competitive advantage comes from their superior ability to screen borrowers' creditworthiness. In practice, this is achieved by processing alternative data using proprietary algorithms which leverage big data, artificial intelligence, and machine learning. According to Jagtiani and Lemieux (2017), alternative data sources used by FinTech firms include "utility payments, electronic records of deposit and withdrawal transactions, insurance claims, bank account transfers, use of mobile phones or the Internet, and other personal data such as consumer's occupation or detail about their education."

We pay special attention to the distinction between two types of information acquisition by FinTech

[4] See for example, Reuters (2014), "Payday lender to pay $10 million over collection tactics: CFPB".

[5] Note that the exact details of how to achieve their competitive advantage is not crucial to our analysis. The key to our anlaysis is that shadow banks are more tolerant of risk and that whenever there is a default of loans, there is some social cost that is not fully internalized by the shadow bank and the borrower. We would generate qualitatively similar findings if the higher tolerance for risk is due to the fact that many shadow banks' funds come from institutional investors, and the social cost is in the form of potential risk of a financial crisis.

lenders, *cream skimming* and *blacklisting*. Through cream skimming, FinTech lenders identify some borrowers with low credit risk and this directly generates business for them. However, cream skimming can worse the adverse selection problem faced by banks and shadow banks as the pool of borrowers who cannot borrow money from FinTech lenders have worse credit risk on average. The overall effect of cream skimming on financial inclusion is ambiguous. On one hand, cream skimming enhances financial inclusion by making shadow banks more likely to serve unidentified borrowers because it becomes less profitable for banks to deviate. On the other hand, cream skimming harms financial inclusion by making any pooling equilibria harder to sustain because banks or shadow banks have to charge a higher breakeven interest rate.

Blacklisting, or the activity of identifying borrowers with high credit risk, does not directly generate business for FinTech lenders because they only identify borrowers they do not want to lend money to. However, screening out some high-risk borrowers improves the average credit risk of borrowers who are not blacklisted. This will give FinTech lenders the comparative advantage to serve the pool of non-blacklisted consumers. Jagtiani and Lemieux (2017) found that Lending Club borrowers are, on average, riskier than traditional borrowers given the same FICO scores. This is consistent with our prediction that under certain cases, banks give up unidentified borrowers and these borrowers are served by FinTech firms.

Even if the FinTech lenders do not find it profitable to serve the non-blacklisted borrowers, it is still possible that they improve financial inclusion by selling the blacklist to banks or shadow banks and allowing the latter to profitably lend to non-blacklisted borrowers. We also find that the FinTech lenders' sales of the blacklist may change the relative comparative advantage of banks and shadow banks. Our analysis suggests that policy maker should put emphasis on blacklisting of borrowers and promote sharing or sales of blacklists by FinTech lenders.

2 Technologies behind FinTech Lending

FinTech lending emerged first in the forms of crowdfunding, invoice and supply chain financing. Then it evolved to cover marketplace lending and peer-to-peer lending. In more recent years, they have evolved to take up more and more activities of traditional banks, except that they do so with the help of technologies. FinTech lending companies, different from traditional banks which rely heavily on

FICO scores to access quality and risk of borrowers, rely on their own algorithms to determine loan origination and loan pricing. To use those algorithms effectively, FinTech lending companies commonly adopt technologies such as big data analysis, artificial intelligence and cloud processing.

The main methods FinTech lenders used in big data analysis are classification, regression and similarity matching. They are all part of algorithms to estimate borrowers' expected default rates. Classification is often used to create classes representing users. Using Class Probability Estimation, one could use an individual's characteristics as inputs to predict a distribution of classes within a small error. Regression uses the individual's characteristics to predict likely behavior or outcomes. Similarity matching tries to recognize similarities between individuals based on the premise that if a customer is similar to some customers historically, it will be reasonable to assume that they will behave similarly in the future. On the other hand, the advanced algorithms in big data analysis also enjoy a huge advantage from good data resource. FinTech companies could get more personal information which is hard for people to forge than that they provide to traditional bank.

Artificial intelligence helps FinTech companies solve problems more efficiently. Artificial intelligence mimics the normal intelligence and flexibility of human, while taking advantage of the powerful and efficient operational capability of machines. By machine learning, a subset of artificial intelligence in the field of computer science based on statistical techniques, computers have the ability to "learn" with data and do not have to be programed for each step. For instance, AI could search borrowers' news feed, twitter or even message automatically to analyze whether they have stable income or ability to pay back. AI can also analyze the data and deliver recommendations, which can help humans make better decision. Additionally, AI can process the data in cloud so that FinTech companies can not only drastically accelerate the investigating process, deciding to lend or not within seconds, as compared to several weeks for banks, but also prevent fraud in lending. Since employees of banks will earn bonus if they lend out, in some cases, they may collude with borrowers to cheat on banks, while AI will not do so.

Some papers such as Fuster et al. (2018) use the loan originating process to define FinTech, calling a firm FinTech lender if the loan application and approval is predominantly processed online and using an automated process.[6] We instead define a FinTech lender using its superior ability to screen borrowers'

[6] The defining features of this business model are an end-to-end online mortgage application platform and centralized

credit risk over banks and non-FinTech shadow banks. We believe our characterization captures a more fundamental feature of FinTech lenders. There is ample anecdotal evidence of FinTech firms' ability to more accurately evaluate a borrower's credit risk. For example, Singapore-based Lenddo builds credit scores for loan applicants by accessing their "social media activity, browsing history, geolocation and other smartphone data", and Poland-based FriendlyScore uses the Facebook API exclusively to score users. According to their site: "who you're friends with, what you're interested in, and other habits online can help contribute to a better credit score." Jagtiani and Lemieux (2017) also provide evidence of how remarkably the Lending Club's credit rating grade closely tracks borrowers' actual probability of default. One reason FinTech lenders can process applications online and by automation is because of their superior access to and processing of borrowers' information.

3 Literature Review

Our paper contributes to a burgeoning literature on FinTech lending. Most existing studies in the literature focus on studying peer-to-peer lending marketplace platforms and are empirical in nature. Some examples include Duarte et al. (2012), Morse (2015), Mariotto (2016), Franks et al. (2016), Fenwick et al. (2017), and Tang (2018).[7]

A number of studies have shown that FinTech lenders emerge to meet credit demands banks fail to supply. Ahmed et al. (2015) and Jagtiani and Lemieux (2017) found evidence that online lenders have filled the funding gap when banks retreated loans to SMEs following the 2008 financial crisis, especially in areas with the largest decline in bank branches, and SMEs benefited from increased sales after receiving loans from online lenders. Buchak et al. (2017) also found that increasing regulatory

mortgage underwriting and processing augmented by automation.

[7] Duarte et al. (2012) shows that investors use borrowers' appearance to assess their creditworthiness and make loan decisions based on that. Morse (2015) surveys the literature on peer-to-peer lending and founds P2P allows investors to capture rents associated with the removal of a layer of financial intermediation borrowers to enjoy pricing and/or access benefits. The paper also identify the early reintermediation trend. Mariotto (2016) studies the competition between leading lending platforms in the US, Prosper and LendingClub, and conclude that the two platforms are close substitutes and intensely competing with each other. Franks et al. (2016) studies the effect of an UK P2P platform's switch from auction to posted pricing, revealing that closing price of auction predicts defult risk after controlling for credit score constructed using public information. However, the increasing difficulty to match changes in demand and supply for loans caused the platform to eventually switch to posted pricing.

burden faced by traditional banks and financial technology can account, respectively, for about 55% and 35% of the recent shadow bank (including FinTech bank) growth. De Roure et al. (2018) build a theoretical model which predicts that P2P lending platforms grow when banks face higher regulatory costs, P2P loans are riskier, and that the risk-adjusted interest rates charged by P2P loans are lower.

A number of studies identify FinTech lenders' comparative advantage vis-a-vis traditional banks. Jagtiani and Lemieux (2017) reported evidence that FinTech lenders gain competitive advantage using alternative data. Barlett et al. (2017) showed that FinTech lenders are less likely to discriminate against ethnic minorities due to their use of algorithmic underwriting which is not influenced by human discrimination.

Contrasting most studies of FinTech lending, instead of studying P2P lending platforms, we study FinTech lenders who act like a new intermediary, risking its own funds like banks, except that it gains competitive advantage in borrower screening using technology. Modeling FinTech lenders this way is particularly meaningful, given the current trend of reintermediation of FinTech lenders (see, e.g., Mores, 2015, Balyuk and Davydenko, 2018, and Ryan and Zhu, 2018). To point out a moral-hazard problem of P2P platforms, Balyuk and Davydenko (2018) argue that "in contrast to banks, lending platforms typically have little or no skin in the game, bearing little of the credit risk of the loans they help originate." To address this moral hazard issue, FinTech lenders have to operate even more like traditional banks.

Closest to our paper in terms of main research questions addressed are papers which study how competition from FinTech lenders impact the traditional banking sector. Balyuk (2017) finds evidence that when borrowers gain access to Prosper Marketplace, they also enjoy additional credit from banks. Buchak et al. (2017) found that more regulatory constraints caused banks to retreat, allowing FinTech and non-FinTech shadow banks to enter the residential lending market. They also found that controlling for the same level of regulatory restrictions, on-line origination technology was an important force in the decline of traditional banks during the last decade.

Our paper is also related to the theoretical literature of endogenous adverse selection induced by more sophisticated investors' cream skimming (e.g., Glode, Green and Lowery , 2012 , Biais, Foucault and Moinas, 2015, Fishman and Parker, 2015, Bolton, Santos and Scheinkman, 2016, Yang and Zeng, 2017, and Valle and Zeng, 2018). According to these theories, when firms or individual investors (such as speed traders) with informational advantage screen (cream-skim) securities or loans, it creates an adverse selection for securities or loans they do not buy. This would offset investment by competitors and possibly lead to collapse of the market. The idea that cream-skimming may give rise to endogenous adverse selection is more well known in the literature of health economics (see e.g., van de Ven and Ellis, 2000 for a review). Closest to ours among these papers, Valle and Zeng (2018) embed this trade-off in a P2P lending platform design problem and solve for the level of platform prescreening and information sharing which generates the largest volume of lending on the platform. Prescreening and information sharing allow sophisticated investors to select creditworthy borrowers but leave the remaining borrowers to pay a higher interest rate and underserved. Our FinTech lender is not a P2P platform and our research interest is in the impact of FinTech entry on financial inclusion and overall financial stability. Also contrasting the above mentioned papers on cream skimming of investors, we also study the welfare-enhancing role of blacklisting high-risk borrowers. Unlike cream skimming, blacklisting improves the average creditworthiness of the non-blacklisted pool of borrowers, whether the FinTech lenders utilize the blacklist themselves or sell the blacklist to traditional financial institutions. To the best of our knowledge, *we are the first to distinguish between two types of borrower screening by FinTech lenders, cream skimming and blacklisting.* In our setting, due to the presence of shadow banks, there also exist separating equilibria. In this case, worsen adverse selection due to cream skimming improves financial inclusion, and this is also new to the literature.

In terms of modeling FinTech lenders' competitive advantage, this paper focuses on their superior ability over banks in overcoming asymmetric information of borrowers. We abstract away from other advantages of FinTech lenders such as their lower cost and faster speed of processing loan application online and through automation, which is the focus of Buchak et al. (2017) and Fuster et al. (2018). When modeling regulated lenders' competitive advantage, we focus on their lower cost of capital compared to unregulated lenders and FinTech lenders, and relative advantage over traditional unregulated lenders in terms of having some information about the borrowers. On the other hand, we abstract away from other advantages such as relational banking which Jakšič and Marinč (2018) focus on.

Our setting is reminiscent of Buchak et al. (2017) as Buchak et al. (2017) also include a discrete-choice model of competition between two types of traditional lenders and FinTech lenders to help interpret their empirical findings, but our models are very different. Adverse selection of borrowers and FinTech lenders' informational advantage are the key features of our models and our analysis is game-theoretic, but they do not model adverse selection and they perform reduced-form supply-demand analysis. To the best of our knowledge, we are the *first theoretical analysis of competition among FinTech lenders, traditional shadow banks and banks based on a game-theoretical model* with borrowers' private information of risk levels, lenders' screening and competition among differentiated lenders.

4 Model

A continuum of borrowers each needs a \$1 loan to invest in a project. There are two types of borrowers, low-risk (type L) and high-risk (type H) borrowers, i.e., $t \in \{L, H\}$. Type L's investment project pays $1 + y^L$ with probability $\left(1 - d^L\right)$ and 0 with probability d^L. Type H has an investment project that pays $1+y^H$ with probability $\left(1 - d^H\right)$ and 0 with probability d^H, where $0 \leq d^L < d^H$ and $0 \leq y^L < y^H$.

Suppose

$$\begin{aligned}
\left(1 - d^H\right)\left(1 + y^H\right) &< 1 < \left(1 - d^L\right)\left(1 + y^L\right) \\
\frac{d^L}{1 - d^L} &< y^L < y^H < \frac{d^H}{1 - d^H}
\end{aligned}$$

So it is socially efficient to invest in low-risk projects but socially inefficient to invest in high-risk projects. The borrower's type is *private information* to himself. Here d^L and d^H can be interpreted as default risks of the borrowers. The prior probability of type H is θ, and that of type L is $(1 - \theta)$, where $0 < \theta < 1$.

There are two types of traditional lenders. Regulated (type R) lenders (e.g., banks) can only collect up to what remains in the investment project. Unregulated (type U) lenders (e.g., shadow banks) can use alternative collection tactics (e.g., threat, intimidation, or even violence) to enforce repayment. Each lender R receives a noisy signal, σ_R of each borrower's type but lender U does not.[8] Let

$$\begin{aligned}
\Pr\left(\sigma_R = N | H\right) &= 1 \\
\Pr\left(\sigma_R = L | L\right) &= p \in (0.5, 1)
\end{aligned}$$

where N means "no signal". Let the interest cost of capital of lender R be normalized to 0 and that of lender U be i.[9]

[8] This assumption captures an important role of banks as an intermediary which mitigates asymmetric information between investors (depositors) and borrowers (Diamond, 1984).

[9] Regulated lenders enjoy lower costs of capital because they can receive deposits.

Let the interest rates charged by the two types of lenders be denoted by r_R and r_U, respectively. If an investor borrows from a lender R, the repayment is $(1 + r_R)$ when the project succeeds and zero when the project fails. If an investor borrows from a lender U, the repayment is $(1 + r_U)$ when the project succeeds. If the project fails, the borrower pays $c(1 + r_U) + \lambda$ and lender U receives $c(1 + r_U)$. Here c captures lender U's capacity in debt collection and λ captures the social *loss* due to alternative debt collection tactic, where $0 < c \leq 1$ and $\lambda > 0$. We assume that the lenders' types are *publicly observable*. Suppose there is a continuum of each type of lenders so that we can focus on the competitive market outcome. Borrowers have limited liability when they borrow from regulated lenders and FinTech lenders, while they have unlimited liability when they borrow from unregulated lenders due to the latter's superior collection tactics. Each borrower borrows if and only if there exists a contract which gives her a strictly positive expected payoff.

FinTech lenders are denoted by type F. Let lender F's interest cost of capital be i, just as that of lender U. Suppose all FinTech lender receives a signal σ_F and that σ_F is more informative than σ_R.[10] In other words, FinTech lenders have the signal regulated lenders receive and are able to identify additional low-risk borrowers that regulated lenders cannot.[11]

$$\begin{aligned} \Pr(\sigma_F = L|L) &= \left\{ \begin{array}{cc} 1 & \text{if } \sigma_R = L \\ q \in (0.5, 1) & \text{if } \sigma_R = N \end{array} \right\} \\ \Pr(\sigma_F &= H|H) = k \in (0, 1) \end{aligned}$$

where N means "no signal". Specifically, when the borrower is type L, FinTech lenders either get a L signal or no signal; when the borrower is type H, FinTech lenders either get a H signal or no signal.

[10] This assumption is consistent with Balyuk and Davydenko's (2018) finding in the context of P2P lending. FinTech lender Proper's in-house credit score is much more informative than FICO, which traditional lenders rely on, in predicting borrowers' credit risk. It is also consistent with the finding of Fuster et al. that after including the largest set of controls in their study, default rates for FinTech-originated loans are about 25% lower.

[11] Our assumption that fintech lenders are able to more accurately assess borrowers' creditworthiness is consistent with Jagtiani and Lemieux's (2018) finding that the correlation between Lending Club's lending grades and the FICO scores has decreased over the years, indicating that "that the Lending Club is relying more on additional information." Further supporting this view, Jagtiani and Lemieux cited Ron Suber, president of Prosper Marketplace, stating that "Prosper gets 500 pieces of data on each borrower; the FICO score is just one data point." FinTech lenders also claim that they have more efficient profiling algorithms than the traditional banking system (Mariotto, 2016).

This implies that, without conditioning on σ_R,

$$\Pr(\sigma_F = L|L) = p + (1-p)\,q \in (p,1)$$

5 Analysis

5.1 Traditional Credit Market

In this subsection, we consider the traditional credit market without FinTech lenders. A fraction p of type L borrowers have their type identified by regulated lenders. Let r_R^L be regulated lenders' interest rate for type L borrowers which can be identified by regulated lenders. Let r_U and r_R be unregulated and regulated lenders' interest rate for unidentified borrowers respectively. The following lemma shows that identified type L borrowers always borrow from regulated lenders in equilibrium.

Define d^P as the average credit risk of the pool of type H borrowers and unidentified type L borrowers, where

$$1 - d^P = \frac{\theta\left(1-d^H\right) + (1-\theta)(1-p)\left(1-d^L\right)}{1-(1-\theta)\,p}$$

Lemma 1 *In the traditional credit market, identified type L borrowers borrow from regulated lenders at the interest rate $r_R^L = \frac{d^L}{1-d^L}$.*

A fraction $1-p$ of type L borrowers who are unidentified and all type H borrowers are pooled together. The following lemma shows that unidentified type L borrowers are more attracted to unregulated borrowers.

Lemma 2 *In the traditional credit market, if type H borrowers prefer borrowing from unregulated lenders to borrowing from regulated lenders, then unidentified type L borrowers must also prefer borrowing from unregulated lenders.*

We first consider separating equilibria.

Lemma 3 *In the traditional credit market, any separating equilibrium must have the following properties:*

(i) Type H borrowers are not served.

(ii) Unidentified type L borrowers are served by unregulated lenders.

Lemma 3 shows that no lenders will knowingly lend to high-risk borrowers because such transaction would be socially inefficient. Furthermore, it is impossible to have an equilibrium in which regulated lenders knowingly lend to the low-risk borrowers although such transaction would be socially efficient. It is not because there does not exist a mutally agreeable interest rate between the regulated lenders and the low-risk borrowers. It is rather because high-risk borrowers always find it profitable to mimic the low-risk borrowers.

Proposition 1 *In the traditional credit market, if*

$$\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} \leq \frac{(1-c)\,d^L+i}{1-(1-c)\,d^L} < \frac{(1-d^L)y^L-(c+\lambda)d^L}{1-(1-c)d^L}$$

and

$$\frac{(1+\lambda)\,d^L+i}{1-d^L} \leq \frac{d^P}{1-d^P}$$

then there exists a separating equilibrium with the following properties:

(i) Unidentified type L borrowers are served by unregulated lenders.

(ii) Type H borrowers are not served.

(iii) Regulated lenders refuse to serve unidentified borrowers.

(iv) Unregulated lenders set the interest rate for unidentified borrowers at

$$r_U = \frac{(1-c)\,d^L+i}{1-(1-c)\,d^L}$$

In the competition between banks and shadow banks, under some plausible conditions, there exists a separating equilibrium in which all low-risk borrowers are served by the shadow banks. It is interesting to note that such separating equilibrium would not exist if only banks compete in the market, according to Lemma 3. This suggests that although shadow banks have no information about borrowers' risk and their cost of fund is higher, they can still enhance financial inclusion and improve the efficiency of the market. However, this comes at a cost as socially inefficient debt collection tacits will be applied against the borrowers whose projects fail.

For a separating equilibrium to exist, the prior probability of high-risk borrowers θ cannot be too low so that d^P is sufficiently large. The reason is that when a regulate lender deviates to attract unidentified type L borrowers, they unavoidably attracts the type H borrowers, as Lemma 2 shows. Thus, a worsened pool of borrowers lowers the regulated lender's deviation profit and makes the separating equilibrium easier to sustain.

Next we consider pooling equilibria.

Proposition 2 *In the traditional credit market, if*

$$\frac{d^P}{1-d^P} < y^L$$

and

$$\frac{d^P}{1-d^P} \leq \frac{(1+\lambda)\, d^L + i}{1-d^L}$$

then there exists a pooling equilibrium with the following properties:

(i) Type H borrowers and unidentified type L borrowers are served by regulated lenders.

(ii) Regulated lenders set the interest rate for unidentified borrowers at

$$r_R = \frac{d^P}{1-d^P}$$

(iii) Unregulated lenders refuse to serve unidentified borrowers.

Proposition 3 *In the traditional credit market, if*

$$\frac{(1-c)\, d^P + i}{1-(1-c)\, d^P} < \min\{\frac{(1-d^H)y^H - (c+\lambda)d^H}{1-(1-c)d^H}, \frac{(1-d^L)y^L - (c+\lambda)d^L}{1-(1-c)d^L}\}$$

and

$$\frac{(c+\lambda)d^L}{1-d^L} + \frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\, d^P + i}{1-(1-c)\, d^P} \leq \frac{d^P}{1-d^P}$$

then there exists a pooling equilibrium with the following properties:

(i) Type H borrowers and unidentified type L borrowers are served by unregulated lenders.

(ii) Regulated lenders refuse to serve unidentified borrowers.

(iii) Unregulated lenders set the interest rate for unidentified borrowers at

$$r_U = \frac{(1-c)\, d^P + i}{1-(1-c)\, d^P}$$

For a pooling equilibrium to exist, the prior probability of high-risk borrowers θ cannot be too high so that d^P is sufficiently small and borrowers' participation constraints are satisified. Furthermore, θ cannot be too low so that d^P is sufficiently large for unregulated lenders to serve unidentified borrowers in a pooling equilibrium. Suppose at the beginning of the game, there are only regulated lenders in the traditional market and we consider the impact of the entry of unregulated lenders. First, competition from unregulated lenders makes the pooling equilibrium in which unidentified borrowers are served by regulated lenders less likely to sustain. Moreover, we can draw the implication that the entry of unregulated lenders may only hurt financial inclusion when θ is moderately low. The intuition is as follows. For high enough θ, unregulated lenders give rise to the separating equilibrium by Proposition 1. For low enough θ, unidentified borrowers can rely on a pooling equilibrium in which unidentified borrowers are served by regulated lenders. However, for an intermediate level of θ, either this pooling equilibrium may be replaced by a less efficient pooling equilibrium in which unidentified borrowers are served by unregulated lenders, or neither type of lenders may serve unidentified borrowers.

The following lemma shows that whether regulated lenders or unregulated lenders can serve unidentified borrowers for a wider range of θ depends on the value of i and λ.

Lemma 4 *(i) The pooling equilibrium in which regulated lenders serve unidentified borrowers arises for a wider range of θ when i is higher and λ is higher.*

(ii) The pooling equilibrium in which unregulated lenders serve unidentified borrowers arises for a wider range of θ when i is lower and λ is lower.

5.2 Credit Market with FinTech Entry

We solve the equilibrium after the entry of FinTech lenders. A fraction p of type L borrowers have their type identified by both regulated lenders and FinTech lenders. A fraction $(1-p)q$ of type L borrowers have their type identified by only FinTech lenders. A fraction k of type H borrowers have their type identified by FinTech lenders, which will never be served by FinTech lenders due to inefficiency. We call these borrowers *blacklisted borrowers.* As in the original model, we have the following lemma characterizing the equilibrium strategy of identified type L borrowers.

Lemma 5 *In the credit market with FinTech lenders,*

(i) The type L borrowers identified by both regulated and FinTech lenders borrow from regulated lenders at the interest rate $r_R^L = \frac{d^L}{1-d^L}$.

(ii) The type L borrowers identified only by FinTech lenders never borrow from unregulated lenders.

(iii) The type L borrowers identified only by FinTech lenders borrow from FinTech lenders if unidentified type L borrowers borrow from unregulated lenders or FinTech lenders.

A fraction $(1-p)(1-q)$ of type L borrowers who are unidentified and all type H borrowers are pooled together. We first consider separating equilibria.

Lemma 6 *In the credit market with FinTech lenders, any separating equilibrium must have the following properties:*

(i) Type H borrowers are not served.

(ii) Unidentified type L borrowers are served by unregulated lenders.

As in the traditional credit market, no lenders will knowingly lend to high-risk borrowers because such transaction would be socially inefficient. Both banks and FinTech lenders cannot survive in a separating equilibrium because high-risk borrowers always find it profitable to mimic the low-risk borrowers. By Lemma 5 and 6, in any separating equilibrium, the type L borrowers identified only by FinTech lenders are served by FinTech lenders.

Proposition 4 *In the credit market with FinTech lenders, if*

$$\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} \leq \frac{(1-c)\,d^L+i}{1-(1-c)\,d^L} < \frac{(1-d^L)y^L-(c+\lambda)d^L}{1-(1-c)d^L}$$

$$\frac{(1+\lambda)\,d^L+i}{1-d^L} \leq \min\{\frac{\widetilde{d}^P}{1-\widetilde{d}^P}, \frac{i+d^B}{1-d^B}\}$$

and

$$\frac{i+d^L}{1-d^L} \leq \frac{d^P}{1-d^P}$$

then there exists a separating equilibrium with the following properties:

(i) The type L borrowers identified only by FinTech lenders are served by Fintech lenders at

$$r_F^L = \frac{i+d^L}{1-d^L}$$

(ii) Unidentified type L borrowers are served by unregulated lenders.

(iii) Type H borrowers are not served.

(iv) Unregulated lenders set the interest rate for unidentified borrowers at

$$r_U = \frac{(1-c)\,d^L+i}{1-(1-c)\,d^L}$$

(v) Regulated lenders and FinTech lenders refuse to serve unidentified borrowers.

The impact of the entry of FinTech lenders on the existence of separating equilibria depends on their relative intensity in cream skimming and blacklisting. In the absence of blacklisting, a separating equilibrium may become easier to sustain because regulated lenders face a worsened pool of borrowers when they deviate to attract unregulated lenders' customers. In this case, FinTech firms profit even less from deviation than regulated lenders due to a higher cost of capital. However, when FinTech lenders' blacklisting is sufficiently more intense than cream skimming, they can deviate by targetting a more favorable pool of unidentified borrowers, making a separating equilibrium harder to sustain.

Next we consider pooling equilibria. Define $\widetilde{d}^P$ as the average credit risk of the pool of type H borrowers and unidentified type L borrowers, where

$$1-\widetilde{d}^P=\frac{\theta\left(1-d^H\right)+(1-\theta)\left[1-p-(1-p)q\right](1-d^L)}{1-(1-\theta)\left[p+(1-p)q\right]}<1-d^P$$

Define d^B as the average credit risk of the pool of type H borrowers which are not blacklisted and unidentified type L borrowers, where

$$1-d^B\equiv\frac{\theta(1-k)(1-d^H)+(1-\theta)[1-p-q(1-p)](1-d^L)}{\theta(1-k)+(1-\theta)[1-p-q(1-p)]}>1-\widetilde{d}^P$$

Define $\widetilde{d}^B$ as the average credit risk of the pool of blacklisted borrowers and unidentified type L borrowers:

$$1-\widetilde{d}^B\equiv\frac{\theta k(1-d^H)+(1-\theta)[1-p-q(1-p)](1-d^L)}{\theta k+(1-\theta)[1-p-q(1-p)]}>1-\widetilde{d}^P$$

Define $\widehat{d}^B$ as the average credit risk of the pool of blacklisted borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders:

$$1-\widehat{d}^B\equiv\frac{\theta k(1-d^H)+(1-\theta)(1-p)(1-d^L)}{\theta k+(1-\theta)(1-p)}>1-\widetilde{d}^B$$

By Lemma 5, if the pool of unidentified borrowers are served by unregulated lenders or FinTech lenders, the type L borrowers identified only by FinTech lenders must be served by FinTech lenders. Otherwise, the type L borrowers identified only by FinTech lenders may be served by regulated lenders or FinTech lenders. The following propositions characterize the pooling equilibrium in which unidentified borrowers are served by regulated lenders, unregulated lenders and FinTech lenders respectively.

Proposition 5 *In the credit market with FinTech lenders, if*

$$\frac{\widetilde{d}^P}{1-\widetilde{d}^P}<y^L$$

$$\frac{i+d^L}{1-d^L}\leq\frac{d^P}{1-d^P}$$

and

$$\frac{\widetilde{d}^P}{1-\widetilde{d}^P}\leq\min\{\frac{(1+\lambda)\,d^L+i}{1-d^L},\frac{i+d^B}{1-d^B}\}$$

then there exists a pooling equilibrium with the following properties:

(i) The type L borrowers only idenfitied by FinTech lenders are served by FinTech lenders at

$$r_F^L = \frac{i + d^L}{1 - d^L}$$

(ii) Type H borrowers and unidentified type L borrowers are served by regulated lenders.

(iii) Regulated lenders set the interest rate for unidentified borrowers at

$$r_R = \frac{\widetilde{d}^P}{1 - \widetilde{d}^P}$$

(iv) Unregulated lenders and FinTech lenders refuse to serve unidentified borrowers.

Proposition 6 *In the credit market with FinTech lenders, if*

$$\frac{d^P}{1 - d^P} < y^L$$

and

$$\frac{d^P}{1 - d^P} \leq \frac{i + d^L}{1 - d^L}$$

then there exists a pooling equilibrium with the following properties:

(i) Type H borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders are served by regulated lenders.

(ii) Regulated lenders set the interest rate for unidentified borrowers at

$$r_R = \frac{d^P}{1 - d^P}$$

(iii) Unregulated lenders refuse to serve unidentified borrowers.

(iv) FinTech lenders refuse to serve the type L borrowers identified only by FinTech lenders and unidentified borrowers.

The entry of FinTech lenders makes the pooling equilibrium in which unidentified borrowers are served by regulated lenders harder to sustain. When the type L borrowers identified only by FinTech lenders are served by FinTech lenders, the breakeven interest rate by regulated lenders is higher because of a worsened pool of borrowers due to cream skimming. In this case, borrowers are less likely to participate and unregulated lenders are more tempted to deviate. Furthermore, FinTech lenders may profit even more from deviation than unregulated lenders because of the information advantage due to blacklisting. Moreover, when the type L borrowers identified only by FinTech lenders are served by regulated lenders, FinTech lenders are more tempted to deviate by targeting these borrowers.

Proposition 7 *In the traditional credit market, if*

$$\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P} < \min\{\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}, \frac{(1-d^L)y^L-(c+\lambda)d^L}{1-(1-c)d^L}\}$$

$$\frac{(c+\lambda)d^L}{1-d^L} + \frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P} \leq \min\{\frac{\widetilde{d}^P}{1-\widetilde{d}^P}, \frac{i+d^B}{1-d^B}\}$$

and

$$\frac{i+d^L}{1-d^L} \leq \frac{d^P}{1-d^P}$$

then there exists a pooling equilibrium with the following properties:

(i) The type L borrowers only idenfitied by FinTech lenders are served by FinTech lenders at

$$r_F^L = \frac{i+d^L}{1-d^L}$$

(ii) Type H borrowers and unidentified type L borrowers are served by unregulated lenders.

(iii) Regulated and FinTech lenders refuse to serve unidentified borrowers.

(iv) Unregulated lenders set the interest rate for unidentified borrowers at

$$r_U = \frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P}$$

The entry of FinTech lenders has an ambiguous effect on the pooling equilibrium in which unidentified borrowers are served by unregulated lenders. First, the breakeven interest rate by unregulated lenders is higher because of a worsened pool of borrowers due to cream skimming, making borrowers are less likely to participate. On the other hand, cream skimming contributes to detering regulated lenders' deviation because regulated lenders face a worsened pool of borrowers. With significant blacklisting, FinTech lenders' incentive to deviate may become binding.

Proposition 8 *In the credit market with FinTech lenders, if*

$$\frac{i+d^B}{1-d^B} < y^L$$

$$\frac{i+d^B}{1-d^B} \leq \frac{\widetilde{d}^P}{1-\widetilde{d}^P}$$

$$\frac{i+d^L}{1-d^L} \leq \frac{d^P}{1-d^P}$$

and either of following conditions holds:

(i)

$$\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L} + \frac{(c+\lambda)d^L}{1-d^L} < \frac{i+d^B}{1-d^B} \leq \frac{(1+\lambda)\,d^L+i}{1-d^L}$$

(ii)

$$\frac{i+d^B}{1-d^B} \leq \frac{1-(1-c)d^L}{1-d^L}\max\{\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}, \frac{(1-c)\,\widetilde{d}^B+i}{1-(1-c)\widetilde{d}^B}\}+\frac{(c+\lambda)d^L}{1-d^L}$$

$$\frac{i+d^B}{1-d^B} < \frac{i+(1-c-\lambda)d^L}{1-(1-c)d^L}\frac{1-(1-c)d^H}{1-d^H}+\frac{(c+\lambda)d^H}{1-d^H}$$

$$\frac{i+d^L}{1-d^L} \leq \frac{(1-c)\,\widehat{d}^B+i}{1-(1-c)\widehat{d}^B}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}$$

(iii)

$$\frac{i+(1-c-\lambda)d^L}{1-(1-c)d^L}\frac{1-(1-c)d^H}{1-d^H}+\frac{(c+\lambda)d^H}{1-d^H} \leq \frac{i+d^B}{1-d^B}$$

$$\leq \frac{1-(1-c)d^L}{1-d^L}\max\{\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}, \frac{(1-c)\,\widetilde{d}^B+i}{1-(1-c)\widetilde{d}^B}\}+\frac{(c+\lambda)d^L}{1-d^L}$$

$$\frac{i+d^L}{1-d^L} \leq \frac{(1-c)\,d^P+i}{1-(1-c)d^P}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}$$

then there exists a pooling equilibrium with the following properties:

(i) Type H borrowers which are not blacklisted, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders are served by FinTech lenders.

(ii) Blacklisted borrowers are not served.

(iii) Regulated lenders and unregulated lenders refuse to serve unidentified borrowers.

(iv) FinTech lenders set the interest rate for unidentified borrowers and the type L borrowers identified only by FinTech lenders respectively at

$$r_F = \frac{i+d^B}{1-d^B}$$

and

$$r_F^L = \frac{i+d^L}{1-d^L}$$

In the following we draw some conclusions on the impact of the entry of FinTech lenders. When FinTech lenders enter the credit market, their identification of low-risk borrowers which regulated lenders cannot identify obviously enhances financial inclusion. Also, cream skimming enhances financial inclusion by making unregulated lenders more likely to serve unidentified borrowers because it becomes less profitable for regulated lenders to deviate. However, consistent with the literature, cream skimming harms financial inclusion by making any pooling equilibria harder to sustain because regulated or unregulated lenders have to charge a higher breakeven interest rate. Finally, FinTech lenders may lead to more financial inclusion by serving unidentified borrowers which are not served by traditional lenders, which is only possible when FinTech lenders do enough blacklisting. Without blacklisting, the pooling equilibrium in which FinTech lenders serve unidentified borrowers (excluding blacklisted borrowers) does not exist. Moreover, if there is a market for FinTech lenders to sell the blacklist to regulated or unregulated lenders, then it is even more likely that FinTech lenders' borrower screening leads to more financial inclusion. This is an issue we will explore in the next subsection.

5.3 Selling of Blacklist

In this subsection, we consider the case where FinTech lenders can sell the blacklist to traditional lenders. The price of the blacklist should be zero due to competition among FinTech lenders.

Define $\widehat{d^P}$ as the average credit risk of the pool of type H borrowers which are not blacklisted, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders:

$$1-\widehat{d^P}=\frac{\theta(1-k)\left(1-d^H\right)+(1-\theta)\,(1-p)\left(1-d^L\right)}{\theta(1-k)+(1-\theta)\,(1-p)}$$

Proposition 9 *In the credit market with FinTech lenders, if*

$$\frac{d^B}{1-d^B}<y^L$$

$$\frac{i+d^L}{1-d^L}\leq\frac{\widehat{d^P}}{1-\widehat{d^P}}$$

and either of following conditions holds:

(i)

$$\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}<\frac{d^B}{1-d^B}\leq\frac{(1+\lambda)\,d^L+i}{1-d^L}$$

(ii)

$$\frac{d^B}{1-d^B}\leq\frac{1-(1-c)d^L}{1-d^L}\max\{\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H},\frac{(1-c)\,\widetilde{d^B}+i}{1-(1-c)\widetilde{d^B}}\}+\frac{(c+\lambda)d^L}{1-d^L}$$

$$\frac{d^B}{1-d^B}<\frac{i+(1-c-\lambda)d^L}{1-(1-c)d^L}\frac{1-(1-c)d^H}{1-d^H}+\frac{(c+\lambda)d^H}{1-d^H}$$

$$\frac{i+d^L}{1-d^L}\leq\frac{(1-c)\,\widehat{d^B}+i}{1-(1-c)\widehat{d^B}}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}$$

(iii)

$$\frac{i+(1-c-\lambda)d^L}{1-(1-c)d^L}\frac{1-(1-c)d^H}{1-d^H}+\frac{(c+\lambda)d^H}{1-d^H}\leq\frac{d^B}{1-d^B}$$

$$\leq\frac{1-(1-c)d^L}{1-d^L}\max\{\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H},\frac{(1-c)\,\widetilde{d^B}+i}{1-(1-c)\widetilde{d^B}}\}+\frac{(c+\lambda)d^L}{1-d^L}$$

$$\frac{i+d^L}{1-d^L} \leq \frac{(1-c)\,d^P+i}{1-(1-c)d^P}\frac{1-(1-c)d^L}{1-d^L} + \frac{(c+\lambda)d^L}{1-d^L}$$

then there exists a pooling equilibrium with the following properties:

(i) FinTech lenders sell the blacklist to regulated lenders at zero price.

(ii) The type L borrowers identified only by FinTech lenders are served by FinTech lenders at

$$r_F^L = \frac{i+d^L}{1-d^L}$$

(iii) Type H borrowers which are not blacklisted and unidentified type L borrowers are served by regulated lenders.

(iv) Blacklisted borrowers are not served.

(v) FinTech lenders and unregulated lenders refuse to serve unidentified borrowers.

(vi) Regulated lenders set the interest rate for unidentified borrowers at

$$r_R = \frac{d^B}{1-d^B}$$

Proposition 10 *In the credit market with FinTech lenders, if*

$$\frac{\widehat{d}^P}{1-\widehat{d}^P} < y^L$$

$$\frac{\widehat{d}^P}{1-\widehat{d}^P} \leq \frac{i+d^L}{1-d^L}$$

and either of following conditions holds:

(i)

$$\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L} + \frac{(c+\lambda)d^L}{1-d^L} < \frac{\widehat{d}^P}{1-\widehat{d}^P} \leq \frac{(1+\lambda)\,d^L+i}{1-d^L}$$

(ii)

$$\frac{\widehat{d}^P}{1-\widehat{d}^P} \leq \frac{1-(1-c)d^L}{1-d^L}\max\{\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}, \frac{(1-c)\,\widehat{d}^B+i}{1-(1-c)\widehat{d}^B}\} + \frac{(c+\lambda)d^L}{1-d^L}$$

then there exists a pooling equilibrium with the following properties:

(i) FinTech lenders sell the blacklist to regulated lenders at zero price.

(ii) Type H borrowers which are not blacklisted, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders are served by regulated lenders.

(iii) Blacklisted borrowers are not served.

(iv) Unregulated lenders refuse to serve unidentified borrowers.

(v) FinTech lenders refuse to serve the type L borrowers identified only by FinTech lenders and unidentified borrowers.

(vi) Regulated lenders set the interest rate for unidentified borrowers at

$$r_R = \frac{\widehat{d}^P}{1 - \widehat{d}^P}$$

Proposition 11 *In the credit market with FinTech lenders, if*

$$\frac{(1-c)\,d^B + i}{1-(1-c)\,d^B} < \min\{\frac{(1-d^H)y^H - (c+\lambda)d^H}{1-(1-c)d^H}, \frac{(1-d^L)y^L - (c+\lambda)d^L}{1-(1-c)d^L}\}$$

$$\frac{(c+\lambda)d^L}{1-d^L} + \frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^B + i}{1-(1-c)\,d^B} \leq \min\{\frac{\widetilde{d}^P}{1-\widetilde{d}^P}, \frac{i+d^B}{1-d^B}\}$$

and

$$\frac{i+d^L}{1-d^L} \leq \frac{d^P}{1-d^P}$$

then there exists a pooling equilibrium with the following properties:

(i) FinTech lenders sell the blacklist to unregulated lenders at zero price.

(ii) The type L borrowers only idenfitied by FinTech lenders are served by FinTech lenders at

$$r_F^L = \frac{i+d^L}{1-d^L}$$

(iii) type H borrowers which are not blacklisted and unidentified type L borrowers are served by unregulated lenders.

(iv) Blacklisted borrowers are not served.

(v) FinTech lenders and regulated lenders refuse to serve unidentified borrowers.

(vi) Unregulated lenders set the interest rate for unidentified borrowers at

$$r_U = \frac{(1-c)\,d^B + i}{1-(1-c)\,d^B}$$

Blacklisting may not improve financial inclusion if FinTech lenders still find it unprofitable to serve the non-blacklisted borrowers. Nevertheless, selling the blacklist to traditional lenders may create social value if it allows the latter to profitably lend to non-blacklisted borrowers. That is because traditional lenders have more competitive advantage when they have the blacklist: FinTech lenders lose out to regulated lenders because of higher cost of funds and they lose out to unregulated lenders because they are less effective in debt collection. Therefore, the equilibrium in which traditional lenders serve unidentified borrowers may arise for a wider range of θ compared to case without FinTech lenders if traditional lenders can also utilize the blacklist.

6 Unobservable Lender Type

(TBA) Suppose borrowers cannot distinguish between FinTech lenders and traditional shadow banks. In this case, shadow banks which rely on aggressive collection tactics may pretend to be FinTech lenders. This setting has real-life relevance. Assume the prior probability of FinTech lenders is ρ, and that of unregulated lenders is $1-\rho$, where $0<\rho<1$. Other elements of the model remain the same as in the main analysis. We solve the equilibrium after the entry of FinTech lenders.

7 Conclusion

Our analysis generates some new applied insights. First, competition from shadow banks may improve financial inclusion by giving rise to a separating equilibrium whose existence requires bad enough borrower composition. Second, a pooling equilibrium with unidentified borrowers served by shadow banks or FinTech lenders requires an intermediate average credit risk of borrower composition, but a pooling equilibrium with unidentified borrowers served by banks requires good enough borrower composition. Thrid, the relative intensity of cream skimming and blacklisting and sales of the blacklist affect the impact of FinTech entry. Too much cream skimming may harm financial inclusion by increasing the average default risk of unidentified borrowers and making the market collapse.[12] FinTech lenders can use the blacklist to improve the average credit risk of the borrowers whose type they cannot identify. Whether they use the blacklist themselves or sell the blacklist to other lenders, the blacklist may enhance the financial inclusion of unidentified borrowers. This also implies that cooperation between FinTech firms and traditional financial institutions should be enhanced. One of the top trends in FinTech is FinTech firms' transition from industry disruptors to industry enablers.[13]

We can compare the efficiency of equilibria in our model. For example, in the pooling equilibria, the efficiency is higher when unidentified borrowers are served by banks than FinTech lenders, and the efficiency is higher when unidentified borrowers are served by FinTech lenders than shadow banks. The separating equilibrium with unidentified type L borrowers served by shadow banks is more efficient than

[12] For regulatory discussion, see Fenwick et al. (2017) which examines regulatory responses in FinTech in 17 jurisdictions.

[13] https://www.startupbootcamp.org/blog/2017/10/disruptors-enablers-top-5-fintech-cybersecurity-startup-trends-watch-2018-infographics/

https://www2.deloitte.com/us/en/pages/financial-services/articles/the-next-phase-of-fintech-evolution.html the pooling equilibrium with unidentified borrowers served by shadow banks. Therefore, we can make equilibrium selection and search for the optimal equilibrium.

For future research, one extension is to consider the possibility that FinTech lenders sign code to lift transparency. Six FinTech start-ups that lend to small business have signed a "code of lending practice", a move the small business ombudsman says will improve transparency and protect SMEs by requiring the online lenders to disclose standardized pricing and fairly resolve disputes. Furthermore, it would be interesting to introduce moral hazard on the borrowers' side as well as the FinTech lenders' incentive for information acquisition. Moreover, some assumptions can be relaxed in the analysis to get more general results. For example, we can consider continuous types rather than discrete types of borrowers, and derive semi-pooling equilibria in which some borrowers are indifferent between different types of lenders. Finally, one related topic is InsurTech. Consider a model in which there are high-risk and low-risk consumers where levels of risks are privately known. It is socially optimal to insure both, but it may not be jointly optimal between the insurer and the high-risk consumers. The policy objective is to have a pooling equilibrium in which both types are insured. The analysis may be similar but we believe we can draw new insights due to the difference between the lending and insurance business.

Appendix: Proofs

Proof for Lemma 1: Suppose there exists equilibrium in which unregulated lenders serve the identified type L borrowers. Let $\overline{d}_U$ be the average default risk of borrowers who borrow from unregulated lenders in equilibrium. Since unregulated lenders break even,

$$
\begin{aligned}
(1-\overline{d}_U)(1+r_U)+\overline{d}_U c(1+r_U) &= 1+i \\
r_U &= \frac{(1-c)\overline{d}_U+i}{1-(1-c)\overline{d}_U}
\end{aligned}
$$

When any regulated lender deviates to offer a price r' to identified type L borrowers, they will visit him if and only if

$$
\begin{aligned}
d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U &> (1-d^L)r' \\
r' &< \frac{d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U}{1-d^L}
\end{aligned}
$$

A regulated lender can deviate to offer a price r_R^L arbitrarily close to $\frac{d^L[c(1+r_U)+\lambda]+(1-d^L)r_U}{1-d^H}$ to attract identified type L borrowers, and to deter such deviation, we must have

$$\begin{aligned} (1-d^L)(1+\frac{d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U}{1-d^L}) &\leq 1 \\ \frac{(1-c)\overline{d}_U+i}{1-(1-c)\overline{d}_U} &\leq \frac{(1-c-\lambda)d^L}{1-(1-c)d^L} \end{aligned}$$

which is impossible since $\overline{d}_U \geq d^L$.

Now suppose there exists equilibrium in which the identified type L borrowers are not served. When any regulated lender deviates to offer a price r' to identified type L borrowers, they will visit him if and only if

$$r' < y^L$$

A regulated lender can deviate to offer a price r_R^L arbitrarily close to y^L to attract identified type L borrowers, and to deter such deviation, we must have

$$\begin{aligned} (1-d^L)(1+y^L) &\leq 1 \\ y^L &\leq \frac{d^L}{1-d^L} \end{aligned}$$

which is impossible by assumption.

Therefore in equilibrium the identified type L borrowers must be served by regulated lenders, which break even:

$$\begin{aligned} (1-d^L)(1+r_R^L) &= 1 \\ r_R^L &= \frac{d^L}{1-d^L} \end{aligned}$$

■

Proof for Lemma 2: For unidentified type H borrowers to prefer borrowing from unregulated lenders to borrowing from regulated lenders:

$$d^H[c\,(1+r_U)+\lambda]+(1-d^H)r_U \leq (1-d^H)r_R$$
$$\frac{d^H}{1-d^H}[c\,(1+r_U)+\lambda]+r_U \leq r_R$$

Since $d^L < d^H$, we must have

$$\frac{d^L}{1-d^L}[c\,(1+r_U)+\lambda]+r_U \leq r_R$$
$$d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U \leq (1-d^L)r_R$$

So, if type H borrowers prefer borrowing from unregulated lenders, then type L must also prefer borrowing from unregulated lenders. ■

Proof for Lemma 3: We first prove (i). When regulated lenders serve type H borrowers in equilibrium, they break even:

$$\begin{aligned}\left(1-d^H\right)(1+r_R) &= 1 \\ r_R &= \frac{d^H}{1-d^H}\end{aligned}$$

For borrowing to be profitable for type H borrowers:

$$\begin{aligned}(1-d^H)(y^H-r_R) &> 0 \\ \frac{d^H}{1-d^H} &< y^H\end{aligned}$$

This cannot be satisfied by assumption.

Similarly, when unregulated lenders serve type H borrowers in equilibrium, they break even:

$$\begin{aligned}\left(1-d^H\right)(1+r_U)+d^H c\,(1+r_U) &= 1+i \\ r_U &= \frac{(1-c)\,d^H+i}{1-(1-c)\,d^H}\end{aligned}$$

For borrowing to be profitable for type H borrowers:

$$\begin{aligned}d^H[c\,(1+r_U)+\lambda]+(1-d^H)r_U &< (1-d^H)y^H \\ \frac{(1-c)\,d^H+i}{1-(1-c)\,d^H} &< \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\end{aligned}$$

This cannot be satisfied because

$$\frac{(1-c)\,d^H+i}{1-(1-c)\,d^H} > \frac{(1-c)\,d^H}{1-(1-c)\,d^H} > \frac{d^H-(c+\lambda)d^H}{1-(1-c)\,d^H} = \frac{(1-d^H)\frac{d^H}{1-d^H}-(c+\lambda)d^H}{1-(1-c)\,d^H} > \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)\,d^H}$$

We then prove (ii). Suppose in equilibrium type H borrowers are not served and unidentified type L borrowers are served by regulated lenders.

For borrowing to be unprofitable for type H borrowers and profitable for unidentified type L borrowers:

$$\begin{aligned}(1-d^H)(y^H-r_R) &\leq 0<(1-d^L)(y^L-r_R) \\ y^H &\leq r_R<y^L\end{aligned}$$

This cannot be satisfied by assumption. ■

Proof for Proposition 1: Unregulated lenders break even:

$$\begin{aligned}\left(1-d^{L}\right)(1+r_{U})+d^{L}c(1+r_{U}) &= 1+i \\ r_{U} &= \frac{(1-c)\,d^{L}+i}{1-(1-c)\,d^{L}}\end{aligned}$$

For borrowing to be unprofitable for type H borrowers:

$$\begin{aligned}d^{H}[c(1+r_{U})+\lambda]+(1-d^{H})r_{U} &\geq (1-d^{H})y^{H} \\ \frac{(1-d^{H})y^{H}-(c+\lambda)d^{H}}{1-(1-c)d^{H}} &\leq \frac{(1-c)\,d^{L}+i}{1-(1-c)\,d^{L}}\end{aligned}$$

For unidentified type L borrowers to prefer borrowing from unregulated lenders:

$$\begin{aligned}d^{L}[c(1+r_{U})+\lambda]+(1-d^{L})r_{U} &< (1-d^{L})y^{L} \\ \frac{(1-c)\,d^{L}+i}{1-(1-c)\,d^{L}} &> \frac{(1-d^{L})y^{L}-(c+\lambda)d^{L}}{1-(1-c)d^{L}}\end{aligned}$$

When any regulated lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers will visit him if and only if

$$\begin{aligned}d^{L}[c(1+r_{U})+\lambda]+(1-d^{L})r_{U} &> (1-d^{L})r' \\ r' &< \frac{(1+\lambda)\,d^{L}+i}{1-d^{L}}\end{aligned}$$

Type H borrowers will visit him if and only if

$$\begin{aligned}(1-d^{H})y^{H} &> (1-d^{H})r' \\ r' &< y^{H}\end{aligned}$$

Type H borrowers have more incentive to borrow from regulated lenders than unidentified type L borrowers.

The best deviation strategy for any regulated lender is to offer a price arbitrarily close to $\frac{(1+\lambda)d^{L}+i}{1-d^{L}}$ for unidentified borrowers such that both types of borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-d^{P})[1+\frac{(1+\lambda)\,d^{L}+i}{1-d^{L}}] &\leq 1 \\ \frac{(1+\lambda)\,d^{L}+i}{1-d^{L}} &\leq \frac{d^{P}}{1-d^{P}}\end{aligned}$$

■

Proof for Proposition 2: Regulated lenders break even:

$$\left(1-d^P\right)(1+r_R) = 1$$
$$r_R = \frac{d^P}{1-d^P}$$

For borrowing to be profitable for both types of borrowers,

$$r_R < \min\{y^L, y^H\}$$
$$r_R < y^L$$

When any unregulated lender deviates to offer a price r', unidentified type L borrowers will visit him if and only if

$$d^L[c(1+r')+\lambda]+(1-d^L)r' < (1-d^L)r_R$$

Type H borrowers will visit him if and only if

$$d^H[c(1+r')+\lambda]+(1-d^H)r' < (1-d^H)r_R$$

Since unidentified type L borrowers have more incentive to borrow from unregulated lenders than type H borrowers, it is sufficient to deter the deviation that attract only type L borrowers at a price arbitrarily close to r' where r' satisfies

$$d^L[c(1+r')+\lambda]+(1-d^L)r' = (1-d^L)r_R$$
$$r' = \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}$$

To deter such deviation, it requires that

$$\left(1-d^L\right)(1+r')+d^L c(1+r') \leq 1+i$$
$$\frac{d^P}{1-d^P} \leq \frac{(1+\lambda)\,d^L+i}{1-d^L}$$

■

Proof for Proposition 3: Unregulated lenders break even:

$$\left(1-d^P\right)(1+r_U)+d^P c(1+r_U) = 1+i$$
$$r_U = \frac{(1-c)\,d^P+i}{1-(1-c)\,d^P}$$

For borrowing to be profitable for both types of borrowers,

$$\begin{aligned} d^H[c\,(1+r_U)+\lambda]+(1-d^H)r_U &< (1-d^H)y^H \\ r_U &< \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} \end{aligned}$$

$$\begin{aligned} d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U &< (1-d^L)y^L \\ r_U &< \frac{(1-d^L)y^L-(c+\lambda)d^L}{1-(1-c)d^L} \end{aligned}$$

When any regulated lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers will visit him if and only if

$$\begin{aligned} d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U &> (1-d^L)r' \\ r' &< \frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^P+i}{1-(1-c)\,d^P} \end{aligned}$$

Type H borrowers will visit him if and only if

$$\begin{aligned} d^H[c\,(1+r_U)+\lambda]+(1-d^H)r_U &> (1-d^H)r' \\ r' &< \frac{(c+\lambda)d^H}{1-d^H}+\frac{1-(1-c)d^H}{1-d^H}\frac{(1-c)\,d^P+i}{1-(1-c)\,d^P} \end{aligned}$$

Type H borrowers have more incentive to borrow from regulated lenders than unidentified type L borrowers.

The best deviation strategy for any regulated lender is to offer a price arbitrarily close to $\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)d^P+i}{1-(1-c)d^P}$ for unidentified borrowers such that both types of borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned} (1-d^P)[1+\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^P+i}{1-(1-c)\,d^P}] &\leq 1 \\ \frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^P+i}{1-(1-c)\,d^P} &\leq \frac{d^P}{1-d^P} \end{aligned}$$

■

Proof for Lemma 5: The proof of (i) and (ii) is almost the same as the proof of Lemma 1. The identified type L borrowers will never borrow from unregulated lenders since they are dominated by either regulated lenders or FinTech lenders. The type L borrowers identified by both regulated and FinTech lenders borrow from regulated lenders because FinTech lenders have a higher interest rate cost than regulated lenders while they have the same collection tactics. We now prove (iii).

First, suppose in equilibrium unidentified type L borrowers borrow from unregulated lenders,

$$d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U \leq (1-d^L)r_R$$

This condition also implies that the type L borrowers identified only by FinTech lenders will prefer unregulated lenders to regulated lenders. Therefore, in equilibrium these borrowers cannot be served by regulated lenders. By (ii), these borrowers must be served by FinTech lenders.

Then suppose in equilibrium unidentified type L borrowers borrow from FinTech lenders,

$$r_F \leq r_R$$

Let $\overline{d}_F$ be the average default risk of unidentified borrowers who borrow from FinTech lenders in equilibrium. Since FinTech lenders break even,

$$\begin{aligned}(1-\overline{d}_F)(1+r_F) &= 1+i \\ r_F &= \frac{i+\overline{d}_F}{1-\overline{d}_F}\end{aligned}$$

Then we have

$$r_R \geq \frac{i+\overline{d}_F}{1-\overline{d}_F} > \frac{i+d^L}{1-d^L}$$

since $\overline{d}_F > d^L$[14].

If the type L borrowers identified only by FinTech lenders are served by regulated lenders, for any FinTech lender to attract them, he has to charge a price r_F^L such that

$$r_F^L < r_R$$

A FinTech lender can deviate to offer a price r_F^L arbitrarily close to r_R for the type L borrowers identified only by FinTech lenders such that these borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-d^L)(1+r_R) &\leq 1+i \\ r_R &\leq \frac{i+d^L}{1-d^L}\end{aligned}$$

which leads to contradiction.

[14] $\overline{d}_F = d^L$ cannot hold in equilibrium because in any separating equilibrium unidentified type L borrowers are served by unregulated lenders, which is shown by Lemma 6 in the following.

Therefore, if in equilibrium unidentified type L borrowers are served by FinTech lenders, the type L borrowers identified only by FinTech lenders cannot be served by regulated lenders. By (ii), these borrowers must be served by FinTech lenders. ■

Proof for Lemma 6: The proof of this lemma is almost the same as the proof of Lemma 3 so it is omitted. Type H borrowers are not served without being pooled with unidentified type L borrowers because it is not socially efficient to serve type H borrowers. To prove (ii), we only need to show there does not exist any separating equilibrium in which unidentified type L borrowers are served by regulated lenders or FinTech lenders. ■

Proof for Proposition 4: FinTech lenders break even:

$$r_F^L = \frac{i + d^L}{1 - d^L}$$

Unregulated lenders break even:

$$\begin{aligned} \left(1 - d^L\right)(1 + r_U) + d^L c\,(1 + r_U) &= 1 + i \\ r_U &= \frac{(1 - c)\, d^L + i}{1 - (1 - c)\, d^L} \end{aligned}$$

For borrowing to be unprofitable for type H borrowers:

$$\begin{aligned} d^H [c\,(1 + r_U) + \lambda] + (1 - d^H) r_U &\geq (1 - d^H) y^H \\ \frac{(1 - d^H) y^H - (c + \lambda) d^H}{1 - (1 - c) d^H} &\leq \frac{(1 - c)\, d^L + i}{1 - (1 - c)\, d^L} \end{aligned}$$

For unidentified type L borrowers to prefer borrowing from unregulated lenders:

$$\begin{aligned} d^L [c\,(1 + r_U) + \lambda] + (1 - d^L) r_U &< (1 - d^L) y^L \\ \frac{(1 - c)\, d^L + i}{1 - (1 - c)\, d^L} &< \frac{(1 - d^L) y^L - (c + \lambda) d^L}{1 - (1 - c) d^L} \end{aligned}$$

For the type L borrowers identified only by FinTech lenders to prefer borrowing from FinTech lenders:

$$(1 - d^L) r_F^L \leq d^L [c\,(1 + r_U) + \lambda] + (1 - d^L) r_U$$

When any regulated lender deviates to offer a price r' for unidentified borrowers, unidentified type

L borrowers will visit him if and only if

$$\begin{aligned} d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U &> (1-d^L)r' \\ r' &< \frac{(1+\lambda)\,d^L+i}{1-d^L} \end{aligned}$$

Type H borrowers will visit him if and only if

$$\begin{aligned} (1-d^H)y^H &> (1-d^H)r' \\ r' &< y^H \end{aligned}$$

The type L borrowers identified only by FinTech lenders will visit him if and only if

$$\begin{aligned} (1-d^L)r_F^L &> (1-d^L)r' \\ r' &< r_F^L \end{aligned}$$

Type H borrowers have more incentive to borrow from regulated lenders than unidentified type L borrowers and the type L borrowers identified only by FinTech lenders.

The best deviation strategy for any regulated lender is one of the following: a regulated lender can deviate to offer a price arbitrarily close to $\frac{(1+\lambda)d^L+i}{1-d^L}$ for unidentified borrowers such that type H borrowers and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned} (1-\widetilde{d}^P)[1+\frac{(1+\lambda)\,d^L+i}{1-d^L}] &\leq 1 \\ \frac{(1+\lambda)\,d^L+i}{1-d^L} &\leq \frac{\widetilde{d}^P}{1-\widetilde{d}^P} \end{aligned}$$

Alternatively, a regulated lender can deviate to offer a price arbitrarily close to r_F^L for unidentified borrowers such that type H borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned} (1-d^P)[1+\frac{i+d^L}{1-d^L}] &\leq 1 \\ \frac{i+d^L}{1-d^L} &\leq \frac{d^P}{1-d^P} \end{aligned}$$

When any FinTech lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers will visit him if and only if

$$\begin{aligned} d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U &> (1-d^L)r' \\ r' &< \frac{(1+\lambda)\,d^L+i}{1-d^L} \end{aligned}$$

Unidentified type H borrowers will visit him if and only if

$$\begin{aligned}(1-d^H)y^H &> (1-d^H)r' \\ r' &< y^H\end{aligned}$$

Unidentified type H borrowers have more incentive to borrow from FinTech lenders than unidentified type L borrowers.

The best deviation strategy for any FinTech lenders is to offer a price arbitrarily close to $\frac{(1+\lambda)d^L+i}{1-d^L}$ for unidentified borrowers such that both types of unidentified borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-d^B)[1+\frac{(1+\lambda)\,d^L+i}{1-d^L}] &\leq 1+i \\ \frac{(1+\lambda)\,d^L+i}{1-d^L} &\leq \frac{i+d^B}{1-d^B}\end{aligned}$$

When any unregulated deviates to offer a price r', the type L borrowers identified only by FinTech lenders will visit him if and only if

$$\begin{aligned}d^L[c\,(1+r')+\lambda]+(1-d^L)r' &< (1-d^L)r_F^L \\ r' &< \frac{(1-c-\lambda)\,d^L+i}{1-(1-c)d^L}\end{aligned}$$

An unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-c-\lambda)d^L+i}{1-(1-c)d^L}$ such that at least unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, it is sufficient that

$$(1-d^L)[1+\frac{(1-c-\lambda)\,d^L+i}{1-(1-c)d^L}]+d^Lc[1+\frac{(1-c-\lambda)\,d^L+i}{1-(1-c)d^L}]\leq 1+i$$

which must hold. ■

Proof for Proposition 5: Regulated lenders break even:

$$\begin{aligned}\left(1-\widetilde{d}^P\right)(1+r_R) &= 1 \\ r_R &= \frac{\widetilde{d}^P}{1-\widetilde{d}^P}\end{aligned}$$

FinTech lenders break even:

$$\begin{aligned}\left(1-d^L\right)\left(1+r_F^L\right) &= 1+i \\ r_F^L &= \frac{i+d^L}{1-d^L}\end{aligned}$$

For borrowing to be profitable for both types of unidentified borrowers,

$$\begin{aligned} r_R &< \min\{y^L, y^H\} \\ r_R &< y^L \end{aligned}$$

For the type L borrowers identified only by FinTech lenders to borrow from FinTech lenders,

$$\begin{aligned} r_F^L &\leq r_R \\ \frac{i+d^L}{1-d^L} &\leq \frac{\widetilde{d}^P}{1-\widetilde{d}^P} \end{aligned}$$

When any unregulated lender deviates to offer a price r', unidentified type L borrowers will visit him if and only if

$$d^L[c\,(1+r')+\lambda]+(1-d^L)r' < (1-d^L)r_R$$

The type L borrowers identified only by FinTech lenders will visit him if and only if

$$d^L[c\,(1+r')+\lambda]+(1-d^L)r' < (1-d^L)r_F^L$$

Type H borrowers will visit him if and only if

$$d^H[c\,(1+r')+\lambda]+(1-d^H)r' < (1-d^H)r_R$$

Since unidentified type L borrowers have more incentive to borrow from unregulated lenders than type H borrowers, it is sufficient to deter the deviation that attract only type L borrowers at a price arbitrarily close to r' where r' satisfies

$$\begin{aligned} d^L[c\,(1+r')+\lambda]+(1-d^L)r' &= (1-d^L)r_R \\ r' &= \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L} \end{aligned}$$

To deter such deviation, it requires that

$$\begin{aligned} \left(1-d^L\right)(1+r')+d^L c\,(1+r') &\leq 1+i \\ \frac{\widetilde{d}^P}{1-\widetilde{d}^P} &\leq \frac{(1+\lambda)\,d^L+i}{1-d^L} \end{aligned}$$

When any FinTech lender deviates to offer a price r' for unidentified borrowers, both types of unidentified borrowers will visit him if and only if

$$r' < r_R$$

A FinTech lender can deviate to offer a price arbitrarily close to r_R for unidentified borrowers such that both types of unidentified borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-d^B)(1+r_R) &\leq 1+i \\ r_R &\leq \frac{i+d^B}{1-d^B}\end{aligned}$$

When any regulated lender deviates to offer a price r' for unidentified borrowers, the type L borrowers identified only by FinTech lenders will visit him if and only if

$$r' < r_F^L$$

A regulated lender can deviate to offer a price arbitrarily close to r_F^L for unidentified borrowers such that both types of unidentified borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-d^P)(1+r_F^L) &\leq 1 \\ r_F^L &\leq \frac{d^P}{1-d^P}\end{aligned}$$

■

Proof for Proposition 6: Regulated lenders break even:

$$\begin{aligned}\left(1-d^P\right)(1+r_R) &= 1 \\ r_R &= \frac{d^P}{1-d^P}\end{aligned}$$

For borrowing to be profitable for both types of unidentified borrowers,

$$\begin{aligned}r_R &< \min\{y^L, y^H\} \\ r_R &< y^L\end{aligned}$$

When any unregulated lender deviates to offer a price r', unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will visit him if and only if

$$d^L[c\,(1+r')+\lambda]+(1-d^L)r' < (1-d^L)r_R$$

Type H borrowers will visit him if and only if

$$d^H[c\,(1+r')+\lambda]+(1-d^H)r' < (1-d^H)r_R$$

Since unidentified type L borrowers and the type L borrowers identified only by FinTech lenders have more incentive to borrow from unregulated lenders than type H borrowers, it is sufficient to deter the deviation that attract only type L borrowers at a price arbitrarily close to r' where r' satisfies

$$\begin{aligned} d^L[c(1+r')+\lambda]+(1-d^L)r' &= (1-d^L)r_R \\ r' &= \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L} \end{aligned}$$

To deter such deviation, it requires that

$$\begin{aligned} \left(1-d^L\right)(1+r')+d^Lc(1+r') &\leq 1+i \\ \frac{d^P}{1-d^P} &\leq \frac{(1+\lambda)\,d^L+i}{1-d^L} \end{aligned}$$

When any FinTech lender deviates to offer a price r' for unidentified borrowers and the type L borrowers identified only by FinTech lenders, these borrowers will visit him if and only if

$$r' < r_R$$

A FinTech lender can deviate to offer a price r_F^L arbitrarily close to r_R for the type L borrowers identified only by FinTech lenders such that these borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned} (1-d^L)(1+r_R) &\leq 1+i \\ \frac{d^P}{1-d^P} &\leq \frac{i+d^L}{1-d^L} \end{aligned}$$

■

Proof for Proposition 7: FinTech lenders break even:

$$r_F^L = \frac{i+d^L}{1-d^L}$$

Unregulated lenders break even:

$$\begin{aligned} (1-\widetilde{d}^P)(1+r_U)+\widetilde{d}^Pc(1+r_U) &= 1+i \\ r_U &= \frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P} \end{aligned}$$

For borrowing to be profitable for both types of unidentified borrowers,

$$\begin{aligned} d^H[c(1+r_U)+\lambda]+(1-d^H)r_U &< (1-d^H)y^H \\ r_U &< \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} \end{aligned}$$

$$
\begin{aligned}
d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U &< (1-d^L)y^L \\
r_U &< \frac{(1-d^L)y^L-(c+\lambda)d^L}{1-(1-c)d^L}
\end{aligned}
$$

For the type L borrowers identified only by FinTech lenders to borrow from Fintech lenders,

$$
(1-d^L)r_F^L \leq d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U
$$

When any regulated lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers will visit him if and only if

$$
\begin{aligned}
d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U &> (1-d^L)r' \\
r' &< \frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P}
\end{aligned}
$$

Unidentified type H borrowers will visit him if and only if

$$
\begin{aligned}
d^H[c\,(1+r_U)+\lambda]+(1-d^H)r_U &> (1-d^H)r' \\
r' &< \frac{(c+\lambda)d^H}{1-d^H}+\frac{1-(1-c)d^H}{1-d^H}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P}
\end{aligned}
$$

The type L borrowers identified only by FinTech lenders will visit him if and only if

$$
r' < r_F^L
$$

Unidentified type H borrowers have more incentive to borrow from regulated lenders than unidentified type L borrowers and the type L borrowers identified only by FinTech lenders.

The best deviation strategy for any regulated lender is one of the following: a regulated lender can deviate to offer a price arbitrarily close to $\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\widetilde{d}^P+i}{1-(1-c)\widetilde{d}^P}$ for unidentified borrowers such that both types of unidentified borrowers will be attracted, and to deter such deviation, we must have

$$
\begin{aligned}
(1-\widetilde{d}^P)[1+\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P}] &\leq 1 \\
\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P} &\leq \frac{\widetilde{d}^P}{1-\widetilde{d}^P}
\end{aligned}
$$

Alternatively, a regulated lender can deviate to offer a price arbitrarily close to r_F^L for unidentified borrowers such that both types of unidentified borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$
\begin{aligned}
(1-d^P)(1+r_F^L) &\leq 1 \\
\frac{i+d^L}{1-d^L} &\leq \frac{d^P}{1-d^P}
\end{aligned}
$$

When any FinTech lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers will visit him if and only if

$$\begin{aligned} d^L[c(1+r_U)+\lambda]+(1-d^L)r_U &> (1-d^L)r' \\ r' &< \frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P} \end{aligned}$$

Unidentified type H borrowers will visit him if and only if

$$\begin{aligned} d^H[c(1+r_U)+\lambda]+(1-d^H)r_U &> (1-d^H)r' \\ r' &< \frac{(c+\lambda)d^H}{1-d^H}+\frac{1-(1-c)d^H}{1-d^H}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P} \end{aligned}$$

Unidentified type H borrowers have more incentive to borrow from FinTech lenders than unidentified type L borrowers.

The best deviation strategy for any FinTech lender is to offer a price arbitrarily close to $\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\widetilde{d}^P+i}{1-(1-c)\widetilde{d}^P}$ for unidentified borrowers such that both types of unidentified borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned} (1-d^B)[1+\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P}] &\leq 1+i \\ \frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,\widetilde{d}^P+i}{1-(1-c)\,\widetilde{d}^P} &\leq \frac{i+d^B}{1-d^B} \end{aligned}$$

When any unregulated lender deviates to offer a price r', the type L borrowers identified only by FinTech lenders will visit him if and only if

$$\begin{aligned} d^L[c(1+r')+\lambda]+(1-d^L)r' &< (1-d^L)r_F^L \\ r' &< \frac{(1-c-\lambda)\,d^L+i}{1-(1-c)\,d^L} \end{aligned}$$

An unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-c-\lambda)d^L+i}{1-(1-c)d^L}$ such that both types of unidentified borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned} d^P c[1+\frac{(1-c-\lambda)\,d^L+i}{1-(1-c)\,d^L}]+(1-d^P)[1+\frac{(1-c-\lambda)\,d^L+i}{1-(1-c)\,d^L}] &\leq 1+i \\ \frac{(1-c-\lambda)\,d^L+i}{1-(1-c)\,d^L} &\leq \frac{(1-c)d^P+i}{1-(1-c)d^P} \end{aligned}$$

which must hold by assumption. ■

Proof for Proposition 8: FinTech lenders break even:

$$\left(1-d^{B}\right)\left(1+r_{F}\right) = 1+i$$
$$r_{F} = \frac{i+d^{B}}{1-d^{B}}$$

$$\left(1-d^{L}\right)\left(1+r_{F}^{L}\right) = 1+i$$
$$r_{F}^{L} = \frac{i+d^{L}}{1-d^{L}}$$

For borrowing to be profitable for both types of unidentified borrowers,

$$r_{F} < \min\{y^{L}, y^{H}\}$$
$$r_{F} < y^{L}$$

When any unregulated lender deviates to offer a price r', unidentified type L borrowers will visit him if and only if

$$d^{L}[c(1+r')+\lambda]+(1-d^{L})r' < (1-d^{L})r_{F}$$
$$r' < \frac{(1-d^{L})r_{F}-(c+\lambda)d^{L}}{1-(1-c)d^{L}}$$

The type L borrowers identified only by FinTech lenders will visit him if and only if

$$d^{L}[c(1+r')+\lambda]+(1-d^{L})r' < (1-d^{L})r_{F}^{L}$$
$$r' < \frac{(1-d^{L})r_{F}^{L}-(c+\lambda)d^{L}}{1-(1-c)d^{L}}$$

Type H borrowers which are not blacklisted will visit him if and only if

$$d^{H}[c(1+r')+\lambda]+(1-d^{H})r' < (1-d^{H})r_{F}$$
$$r' < \frac{(1-d^{H})r_{F}-(c+\lambda)d^{H}}{1-(1-c)d^{H}}$$

Blacklisted borrowers will visit him if and only if

$$d^{H}[c(1+r')+\lambda]+(1-d^{H})r' < (1-d^{H})y^{H}$$
$$r' < \frac{(1-d^{H})y^{H}-(c+\lambda)d^{H}}{1-(1-c)d^{H}}$$

Note that unidentified type L borrowers have more incentive to borrow from unregulated lenders than type H borrowers which are not blacklisted and the type L borrowers identified only by FinTech lenders. We have three cases:

Case 1: suppose that

$$\begin{aligned}\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} &< \frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L} \\ \frac{i+d^B}{1-d^B} &> \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

such that unidentified type L borrowers have more incentive to borrow from unregulated lenders than blacklisted borrowers.

Then it is sufficient to deter the deviation that attract only type L borrowers at a price arbitrarily close to r' where r' satisfies

$$\begin{aligned}d^L[c(1+r')+\lambda]+(1-d^L)r' &= (1-d^L)r_F \\ r' &= \frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L}\end{aligned}$$

To deter such deviation, it requires that

$$\begin{aligned}\left(1-d^L\right)(1+r')+d^Lc(1+r') &\leq 1+i \\ \frac{i+d^B}{1-d^B} &\leq \frac{(1+\lambda)\,d^L+i}{1-d^L}\end{aligned}$$

Case 2: suppose that

$$\begin{aligned}\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} &\geq \frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L} \\ \frac{i+d^B}{1-d^B} &\leq \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

and

$$\begin{aligned}\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L} &> \frac{(1-d^H)r_F-(c+\lambda)d^H}{1-(1-c)d^H} \\ \frac{i+d^B}{1-d^B} &< \frac{i+(1-c-\lambda)d^L}{1-(1-c)d^L}\frac{1-(1-c)d^H}{1-d^H}+\frac{(c+\lambda)d^H}{1-d^H}\end{aligned}$$

such that blacklisted borrowers have more incentive to borrow from unregulated lenders than unidentified type L borrowers, and the type L borrowers identified only by FinTech lenders have more incentive to borrow from unregulated lenders than the type H borrowers which are not blacklisted.

The best deviation strategy of any unregulated lender is one of the following: an unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L}$ such that both blacklisted borrowers and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-\widetilde{d}^B)[1+\frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L}]+\widetilde{d}^B c[1+\frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i\\ \frac{i+d^B}{1-d^B} &\leq \frac{(1-c)\,\widetilde{d}^B+i}{1-(1-c)\widetilde{d}^B}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

Alternatively, an unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}$ such that blacklisted borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-\widehat{d}^B)[1+\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}]+\widehat{d}^B c[1+\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i\\ \frac{i+d^L}{1-d^L} &\leq \frac{(1-c)\,\widehat{d}^B+i}{1-(1-c)\widehat{d}^B}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

Case 3: suppose that

$$\begin{aligned}\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} &\geq \frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L}\\ \frac{i+d^B}{1-d^B} &\leq \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

and

$$\begin{aligned}\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L} &\leq \frac{(1-d^H)r_F-(c+\lambda)d^H}{1-(1-c)d^H}\\ \frac{i+d^B}{1-d^B} &\geq \frac{i+(1-c-\lambda)d^L}{1-(1-c)d^L}\frac{1-(1-c)d^H}{1-d^H}+\frac{(c+\lambda)d^H}{1-d^H}\end{aligned}$$

such that blacklisted borrowers have more incentive to borrow from unregulated lenders than unidentified type L borrowers, and the type H borrowers which are not blacklisted have more incentive to borrow from unregulated lenders than the type L borrowers identified only by FinTech lenders.

The best deviation strategy of any unregulated lender is one of the following: an unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L}$ such that both blacklisted borrowers and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-\widetilde{d}^B)[1+\frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L}]+\widetilde{d}^B c[1+\frac{(1-d^L)r_F-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i\\ \frac{i+d^B}{1-d^B} &\leq \frac{(1-c)\,\widetilde{d}^B+i}{1-(1-c)\widetilde{d}^B}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

Alternatively, an unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}$ such that type H borrowers, unidentified type L borrowers and the type L borrowers identified only by

FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-d^P)[1+\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}]+d^Pc[1+\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i \\ \frac{i+d^L}{1-d^L} &\leq \frac{(1-c)\,d^P+i}{1-(1-c)d^P}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

When any regulated lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers and type H borrowers which are not blacklisted will visit him if and only if

$$r' < r_F$$

Blacklisted borrowers will visit him if and only if

$$r' < y^H$$

The type L borrowers identified only by FinTech lenders will visit him if and only if

$$r' < r_F^L$$

The best deviation strategy of any regulated lender is one of the following: a regulated lender can deviate to offer a price arbitrarily close to r_F for unidentified borrowers such that type H borrowers and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}\left(1-\widetilde{d}^P\right)(1+r_F) &\leq 1 \\ \frac{i+d^B}{1-d^B} &\leq \frac{\widetilde{d}^P}{1-\widetilde{d}^P}\end{aligned}$$

Alternatively, a regulated lender can deviate to offer a price arbitrarily close to r_F^L for unidentified borrowers such that type H borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned}\left(1-d^P\right)\left(1+r_F^L\right) &\leq 1 \\ \frac{i+d^L}{1-d^L} &\leq \frac{d^P}{1-d^P}\end{aligned}$$

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Proof for Proposition 9: Regulated lenders break even:

$$\begin{aligned}\left(1-d^B\right)(1+r_R) &= 1 \\ r_R &= \frac{d^B}{1-d^B}\end{aligned}$$

FinTech lenders break even:

$$\begin{aligned}\left(1-d^L\right)\left(1+r_F^L\right) &= 1+i \\ r_F^L &= \frac{i+d^L}{1-d^L}\end{aligned}$$

For borrowing to be profitable for both types of unidentified borrowers,

$$\begin{aligned}r_R &< \min\{y^L, y^H\} \\ r_R &< y^L\end{aligned}$$

For the type L borrowers identified only by FinTech lenders to borrow from Fintech lenders,

$$\begin{aligned}r_F^L &\leq r_R \\ \frac{i+d^L}{1-d^L} &\leq \frac{d^B}{1-d^B}\end{aligned}$$

When any unregulated lender deviates to offer a price r', unidentified type L borrowers will visit him if and only if

$$\begin{aligned}d^L[c(1+r')+\lambda]+(1-d^L)r' &< (1-d^L)r_R \\ r' &< \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}\end{aligned}$$

The type L borrowers identified only by FinTech lenders will visit him if and only if

$$\begin{aligned}d^L[c(1+r')+\lambda]+(1-d^L)r' &< (1-d^L)r_F^L \\ r' &< \frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}\end{aligned}$$

Type H borrowers which are not blacklisted will visit him if and only if

$$\begin{aligned}d^H[c(1+r')+\lambda]+(1-d^H)r' &< (1-d^H)r_R \\ r' &< \frac{(1-d^H)r_R-(c+\lambda)d^H}{1-(1-c)d^H}\end{aligned}$$

Blacklisted borrowers will visit him if and only if

$$\begin{aligned}d^H[c(1+r')+\lambda]+(1-d^H)r' &< (1-d^H)y^H \\ r' &< \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\end{aligned}$$

Note that unidentified type L borrowers have more incentive to borrow from unregulated lenders than type H borrowers which are not blacklisted and the type L borrowers identified only by FinTech lenders. We have three cases:

Case 1: suppose that

$$\begin{aligned}\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} &< \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L} \\ \frac{d^B}{1-d^B} &> \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

such that unidentified type L borrowers have more incentive to borrow from unregulated lenders than blacklisted borrowers.

Then it is sufficient to deter the deviation that attract only type L borrowers at a price arbitrarily close to r' where r' satisfies

$$\begin{aligned}d^L[c(1+r')+\lambda]+(1-d^L)r' &= (1-d^L)r_R \\ r' &= \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}\end{aligned}$$

To deter such deviation, it requires that

$$\begin{aligned}\left(1-d^L\right)(1+r')+d^Lc(1+r') &\leq 1+i \\ \frac{d^B}{1-d^B} &\leq \frac{(1+\lambda)\,d^L+i}{1-d^L}\end{aligned}$$

Case 2: suppose that

$$\begin{aligned}\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} &\geq \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L} \\ \frac{d^B}{1-d^B} &\leq \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

and

$$\begin{aligned}\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L} &> \frac{(1-d^H)r_R-(c+\lambda)d^H}{1-(1-c)d^H} \\ \frac{d^B}{1-d^B} &< \frac{i+(1-c-\lambda)d^L}{1-(1-c)d^L}\frac{1-(1-c)d^H}{1-d^H}+\frac{(c+\lambda)d^H}{1-d^H}\end{aligned}$$

such that blacklisted borrowers have more incentive to borrow from unregulated lenders than unidentified type L borrowers, and the type L borrowers identified only by FinTech lenders have more incentive to borrow from unregulated lenders than the type H borrowers which are not blacklisted.

The best deviation strategy of any unregulated lender is one of the following: an unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}$ such that both blacklisted borrowers and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-\widetilde{d}^B)[1+\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}]+\widetilde{d}^B c[1+\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i \\ \frac{d^B}{1-d^B} &\leq \frac{(1-c)\,\widetilde{d}^B+i}{1-(1-c)\widetilde{d}^B}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

Alternatively, an unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}$ such that blacklisted borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-\widehat{d}^B)[1+\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}]+\widehat{d}^B c[1+\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i \\ \frac{i+d^L}{1-d^L} &\leq \frac{(1-c)\,\widehat{d}^B+i}{1-(1-c)\widehat{d}^B}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

Case 3: suppose that

$$\begin{aligned}\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} &\geq \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L} \\ \frac{d^B}{1-d^B} &\leq \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

and

$$\begin{aligned}\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L} &\leq \frac{(1-d^H)r_R-(c+\lambda)d^H}{1-(1-c)d^H} \\ \frac{d^B}{1-d^B} &\geq \frac{i+(1-c-\lambda)d^L}{1-(1-c)d^L}\frac{1-(1-c)d^H}{1-d^H}+\frac{(c+\lambda)d^H}{1-d^H}\end{aligned}$$

such that blacklisted borrowers have more incentive to borrow from unregulated lenders than unidentified type L borrowers, and the type H borrowers which are not blacklisted have more incentive to borrow from unregulated lenders than the type L borrowers identified only by FinTech lenders.

The best deviation strategy of any unregulated lender is one of the following: an unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}$ such that both blacklisted borrowers and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-\widetilde{d}^B)[1+\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}]+\widetilde{d}^B c[1+\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i \\ \frac{d^B}{1-d^B} &\leq \frac{(1-c)\,\widetilde{d}^B+i}{1-(1-c)\widetilde{d}^B}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

Alternatively, an unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}$ such that type H borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned}(1-d^P)[1+\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}]+d^P c[1+\frac{(1-d^L)r_F^L-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i \\ \frac{i+d^L}{1-d^L} &\leq \frac{(1-c)\,d^P+i}{1-(1-c)d^P}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

When any FinTech lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers and type H borrowers which are not blacklisted will visit him if and only if

$$r' < r_R$$

A FinTech lender can deviate to offer a price arbitrarily close to r_R for unidentified borrowers such that type H borrowers which are not blacklisted and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned}\left(1-d^B\right)(1+r_R) &\leq 1+i \\ \frac{d^B}{1-d^B} &\leq \frac{i+d^B}{1-d^B}\end{aligned}$$

which must hold.

When any regulated lender deviates to offer a price r' for unidentified borrowers, the type L borrowers identified only by FinTech lenders will visit him if and only if

$$r' < r_F^L$$

A regulated lender can deviate to offer a price arbitrarily close to r_F^L for unidentified borrowers such that type H borrowers which are not blacklisted, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned}\left(1-\widehat{d^P}\right)\left(1+r_F^L\right) &\leq 1 \\ \frac{i+d^L}{1-d^L} &\leq \frac{\widehat{d^P}}{1-\widehat{d^P}}\end{aligned}$$

■

Proof for Proposition 10: Regulated lenders break even:

$$\begin{aligned}\left(1-\widehat{d}^P\right)(1+r_R) &= 1\\ r_R &= \frac{\widehat{d}^P}{1-\widehat{d}^P}\end{aligned}$$

For borrowing to be profitable for both types of unidentified borrowers and the type L borrowers identified only by FinTech lenders,

$$\begin{aligned}r_R &< \min\{y^L, y^H\}\\ r_R &< y^L\end{aligned}$$

When any unregulated lender deviates to offer a price r', unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will visit him if and only if

$$\begin{aligned}d^L[c(1+r')+\lambda]+(1-d^L)r' &< (1-d^L)r_R\\ r' &< \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}\end{aligned}$$

Type H borrowers which are not blacklisted will visit him if and only if

$$\begin{aligned}d^H[c(1+r')+\lambda]+(1-d^H)r' &< (1-d^H)r_R\\ r' &< \frac{(1-d^H)r_R-(c+\lambda)d^H}{1-(1-c)d^H}\end{aligned}$$

Blacklisted borrowers will visit him if and only if

$$\begin{aligned}d^H[c(1+r')+\lambda]+(1-d^H)r' &< (1-d^H)y^H\\ r' &< \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\end{aligned}$$

Note that unidentified type L borrowers and the type L borrowers identified only by FinTech lenders have more incentive to borrow from unregulated lenders than type H borrowers which are not blacklisted. We have two cases:

Case 1: suppose that

$$\begin{aligned}\frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} &< \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}\\ \frac{\widehat{d}^P}{1-\widehat{d}^P} &> \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L}\end{aligned}$$

such that unidentified type L borrowers and the type L borrowers identified only by FinTech lenders have more incentive to borrow from unregulated lenders than blacklisted borrowers.

Then it is sufficient to deter the deviation that attract only type L borrowers at a price arbitrarily close to r' where r' satisfies

$$\begin{aligned} d^L[c(1+r')+\lambda]+(1-d^L)r' &= (1-d^L)r_R \\ r' &= \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L} \end{aligned}$$

To deter such deviation, it requires that

$$\begin{aligned} \left(1-d^L\right)(1+r')+d^L c(1+r') &\leq 1+i \\ \frac{\widehat{d}^P}{1-\widehat{d}^P} &\leq \frac{(1+\lambda)\,d^L+i}{1-d^L} \end{aligned}$$

Case 2: suppose that

$$\begin{aligned} \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H} &\geq \frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L} \\ \frac{\widehat{d}^P}{1-\widehat{d}^P} &\leq \frac{(1-d^H)y^H-(c+\lambda)d^H}{1-(1-c)d^H}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L} \end{aligned}$$

such that blacklisted borrowers have more incentive to borrow from unregulated lenders than unidentified type L borrowers and the type L borrowers identified only by FinTech lenders.

The best deviation strategy of any unregulated lender is to offer a price arbitrarily close to $\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}$ for unidentified borrowers such that blacklisted borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned} (1-\widehat{d}^B)[1+\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}]+\widehat{d}^B c[1+\frac{(1-d^L)r_R-(c+\lambda)d^L}{1-(1-c)d^L}] &\leq 1+i \\ \frac{\widehat{d}^P}{1-\widehat{d}^P} &\leq \frac{(1-c)\,\widehat{d}^B+i}{1-(1-c)\widehat{d}^B}\frac{1-(1-c)d^L}{1-d^L}+\frac{(c+\lambda)d^L}{1-d^L} \end{aligned}$$

When any FinTech lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers and type H borrowers which are not blacklisted will visit him if and only if

$$r' < r_R$$

A FinTech lender can deviate to offer a price arbitrarily close to r_R for unidentified borrowers such that type H borrowers which are not blacklisted and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned} \left(1-d^B\right)(1+r_R) &\leq 1+i \\ \frac{\widehat{d}^P}{1-\widehat{d}^P} &\leq \frac{i+d^B}{1-d^B} \end{aligned}$$

which must hold.

When any FinTech lender deviates to offer a price r' to the type L borrowers identified only by FinTech lenders, these borrowers will visit him if and only if

$$r' < r_R$$

A FinTech lender can deviate to offer a price arbitrarily close to r_R for the type L borrowers identified only by FinTech lenders such that these borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned} \left(1-d^L\right)(1+r_R) &\leq 1+i \\ \frac{\widehat{d}^P}{1-\widehat{d}^P} &\leq \frac{i+d^L}{1-d^L} \end{aligned}$$

■

Proof for Proposition 11: FinTech lenders break even:

$$r_F^L = \frac{i+d^L}{1-d^L}$$

Unregulated lenders break even:

$$\begin{aligned} (1-d^B)(1+r_U) + d^B c(1+r_U) &= 1+i \\ r_U &= \frac{(1-c)\,d^B + i}{1-(1-c)\,d^B} \end{aligned}$$

For borrowing to be profitable for both types of unidentified borrowers,

$$\begin{aligned} d^H[c(1+r_U)+\lambda] + (1-d^H)r_U &< (1-d^H)y^H \\ r_U &< \frac{(1-d^H)y^H - (c+\lambda)d^H}{1-(1-c)d^H} \end{aligned}$$

$$\begin{aligned} d^L[c(1+r_U)+\lambda] + (1-d^L)r_U &< (1-d^L)y^L \\ r_U &< \frac{(1-d^L)y^L - (c+\lambda)d^L}{1-(1-c)d^L} \end{aligned}$$

For the type L borrowers identified only by FinTech lenders to borrow from Fintech lenders,

$$(1-d^L)r_F^L \leq d^L[c(1+r_U)+\lambda] + (1-d^L)r_U$$

which must hold.

When any regulated lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers will visit him if and only if

$$\begin{aligned} d^L[c(1+r_U)+\lambda]+(1-d^L)r_U &> (1-d^L)r' \\ r' &< \frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^B+i}{1-(1-c)\,d^B} \end{aligned}$$

The type L borrowers identified only by FinTech lenders will visit him if and only if

$$r' < r_F^L$$

Type H borrowers which are not blacklisted will visit him if and only if

$$\begin{aligned} d^H[c(1+r_U)+\lambda]+(1-d^H)r_U &> (1-d^H)r' \\ r' &< \frac{(c+\lambda)d^H}{1-d^H}+\frac{1-(1-c)d^H}{1-d^H}\frac{(1-c)\,d^B+i}{1-(1-c)\,d^B} \end{aligned}$$

Blacklisted borrowers will visit him if and only if

$$r' < y^H$$

Type H borrowers have more incentive to borrow from regulated lenders than unidentified type L borrowers and the type L borrowers identified only by FinTech lenders.

The best deviation strategy for any regulated lender is one of the following: a regulated lender can deviate to offer a price arbitrarily close to $\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)d^B+i}{1-(1-c)d^B}$ for unidentified borrowers such that type H borrowers and unidentified type L borrowers will be attracted, and to deter such deviation, we must have

$$\begin{aligned} (1-\widetilde{d}^P)[1+\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^B+i}{1-(1-c)\,d^B}] &\leq 1 \\ \frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^B+i}{1-(1-c)\,d^B} &\leq \frac{\widetilde{d}^P}{1-\widetilde{d}^P} \end{aligned}$$

Alternatively, a regulated lender can deviate to offer a price arbitrarily close to r_F^L for unidentified borrowers such that type H borrowers, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$\begin{aligned} (1-d^P)(1+r_F^L) &\leq 1 \\ \frac{i+d^L}{1-d^L} &\leq \frac{d^P}{1-d^P} \end{aligned}$$

When any FinTech lender deviates to offer a price r' for unidentified borrowers, unidentified type L borrowers will visit him if and only if

$$
\begin{aligned}
d^L[c\,(1+r_U)+\lambda]+(1-d^L)r_U &> (1-d^L)r' \\
r' &< \frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^B+i}{1-(1-c)\,d^B}
\end{aligned}
$$

Unidentified type H borrowers will visit him if and only if

$$
\begin{aligned}
d^H[c\,(1+r_U)+\lambda]+(1-d^H)r_U &> (1-d^H)r' \\
r' &< \frac{(c+\lambda)d^H}{1-d^H}+\frac{1-(1-c)d^H}{1-d^H}\frac{(1-c)\,d^B+i}{1-(1-c)\,d^B}
\end{aligned}
$$

Unidentified type H borrowers have more incentive to borrow from FinTech lenders than unidentified type L borrowers.

The best deviation strategy for any FinTech lender is to offer a price arbitrarily close to $\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)d^B+i}{1-(1-c)d^B}$ for unidentified borrowers such that both types of unidentified borrowers will be attracted, and to deter such deviation, we must have

$$
\begin{aligned}
(1-d^B)[1+\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^B+i}{1-(1-c)\,d^B}] &\leq 1+i \\
\frac{(c+\lambda)d^L}{1-d^L}+\frac{1-(1-c)d^L}{1-d^L}\frac{(1-c)\,d^B+i}{1-(1-c)\,d^B} &\leq \frac{i+d^B}{1-d^B}
\end{aligned}
$$

When any unregulated lender deviates to offer a price r', the type L borrowers identified only by FinTech lenders will visit him if and only if

$$
\begin{aligned}
d^L[c\,(1+r')+\lambda]+(1-d^L)r' &< (1-d^L)r_F^L \\
r' &< \frac{(1-c-\lambda)\,d^L+i}{1-(1-c)\,d^L}
\end{aligned}
$$

An unregulated lender can deviate to offer a price arbitrarily close to $\frac{(1-c-\lambda)d^L+i}{1-(1-c)d^L}$ such that both type H borrowers which are not blacklisted, unidentified type L borrowers and the type L borrowers identified only by FinTech lenders will be attracted, and to deter such deviation, we must have

$$
\begin{aligned}
\widehat{d^P}c[1+\frac{(1-c-\lambda)\,d^L+i}{1-(1-c)\,d^L}]+(1-\widehat{d^P})[1+\frac{(1-c-\lambda)\,d^L+i}{1-(1-c)\,d^L}] &\leq 1+i \\
\frac{(1-c-\lambda)\,d^L+i}{1-(1-c)\,d^L} &\leq \frac{(1-c)\widehat{d^P}+i}{1-(1-c)\widehat{d^P}}
\end{aligned}
$$

which must hold by assumption. ■

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