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Blockchain, bank credit and SME financing

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Abstract
Blockchain is an emerging decentralized architecture and distributed computing paradigm and has recently attracted intensive attention from all sectors of society. This paper sets up a theoretical model to analyze a new credit pattern that allows small and medium-sized enterprises (SMEs) assessing bank loans through the blochchain technology. Theoretical analysis demonstrates that the blockchain technology enables the decentralized consensus recording of success of debt repayment or debt default rendered by verifying and validating certain lending and borrowing activities in distributed ledgers. In the newly proposed blockchain embedded credit system, SMEs with low-risk and high-quality could display their credibility and risk class through information distribution. They are more likely to access bank loans even if they are not able to provide collateral. Results derived from the theoretical model present two main findings. First, the alleviation of information asymmetry and credit rationing problems can be achieved through decentralized consensus and information distribution among all participants. Second, the risk sharing mechanism involving government, banks and firms, will not only make the establishment of such an innovative system possible, but also create risk pool for the blockchain based lending and borrowing.

Keywords Blockchain · Credit rationing · Information asymmetry · SMEs financing

JEL Classification G21 · G30 · O33

1 Introduction

The ability to access credit for small and medium-sized enterprises (SMEs) has restricted the growth and development of SMEs in many countries. There are two main reasons that it is not easy for SMEs to get loans. The first difficulty is serious

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information asymmetry between banks and enterprises. Adverse selection coming with the asymmetric information makes credit rationing a rational choice for banks (Stiglitz and Weiss 1981). Lack of sufficient collateral for most of the SMEs is the second difficulty. Many high-quality and low-risk SMEs are unable to effectively display their credit quality, and therefore, are subject to the bank's credit rationing (Bester 1987).

With the popularity of next-generation information technologies such as big data, cloud computing, and mobile internet, human society has entered into a stage of transition from the traditional information society to the smart information society. Blockchain, one of the most important and innovative technologies developed in recent years, has shown an explosive growth, and as many would agree, will have great potential for application (Peters and Panayi 2016; Pilkington 2016). Originally used for crypto currency trading, blockchain establishes a decentralized public ledger that provides a secure infrastructure for transactions among unfamiliar parties without a central authority (Dai and Vasarhelyi 2017). Recently, blockchain has broadened its technical foundation to support various businesses, such as voting systems, leasing contracts, insurance, government services and banking.

Having considered the difficulties of SMEs to get credit and the characteristics of blockchain technology, this paper propose a theoretical model to address some important questions in this field. For example, to what extent the adoption of blockchain technology in the credit system could effectively alleviate the financing difficulties of SMEs? What is the mechanism that enables blockchain technology to mitigate the information asymmetry and credit rationing between lenders and borrowers?

The theoretical model proposed in the present paper shows that the function of increasing the default cost of an enterprise by blockchain can serve as a screening mechanism. When the default cost of an enterprise increases, enterprises with higher risks are more reluctant to use the blockchain for financing because they are more likely to bear the cost of default. With the help of blockchain, SMEs that with low-risk and high-quality can show their credibility and risk type through blockchain, even if they were not able to obtain bank loans under the traditional loan model. In terms of risk sharing, as the proportion of government funding in the risk pool increases, more low-risk SMEs will have access to bank credit. This provides a theoretical basis for the government to support the development of new channels for SMEs through blockchain platforms.

As one of the first papers addressing the adoption of blockchain technology in reshaping the traditional credit system, our study represents two advances over existing literature. First, recent studies of the application of blockchain technology have focused on other fields rather than information asymmetry and credit rationing problems. Cong and He (2018) analyze how decentralization improves consensus effectiveness using a standard dynamic industrial organization model. Cong et al. (2018) study the centralization and decentralization forces in the creation and competition of cryptocurrency-mining activities. The second contribution of the present study is to reveal the mechanism that enables blockchain technology to mitigate the information asymmetry and credit rationing between lenders and borrowers. This could be viewed as an enrichment and supplement to the existing credit rationing theory.

The remainder of this paper is structured as follows: Sect. 2 illustrates the background of blockchain technology and possible roles that blockchain technology played in credit market. Section 3 reviews related literature. Section 4 analyzes blockchain embedded credit model. The discussions are displayed in Sect. 5. Section 6 concludes.

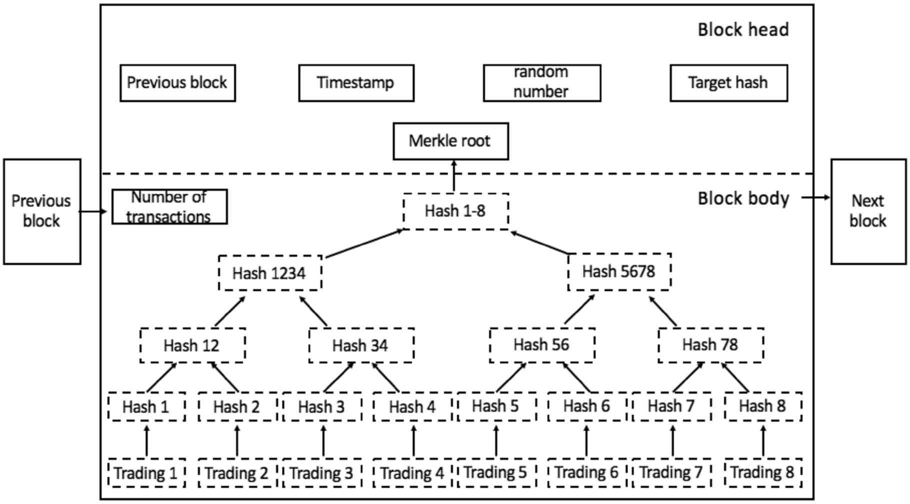


Fig. 1 The structure of blocks

2 Background

The concept of blockchain was proposed and initiated by Nakamoto (2008) in his paper "Bitcoin: A Peer-to-Peer Electronic Cash System". The generalized blockchain technique refers to a new decentralized computational paradigm that uses the encrypted chained block structure to verify and store data and utilize distributed node consensus algorithms to generate and update data. The narrow blockchain is the data book shared by each node of the decentralized system (Fanning and Centers 2016; Yermack 2017). The structure of the blockchain is shown in Fig. 1. The blockchain data storage process involves technical elements such as block, chain structure, hash algorithm, Merkle tree and timestamp. Each distributed node can encapsulate the transaction data received over a period of time into a time-stamped data block and link to the current main blockchain through a specific hash algorithm and a Merkle tree data structure. Each block is connected to form a longest main chain from the creation block to the current block, thus recording the complete history of the data and providing data traceability and positioning functions.

The main characteristics of the blockchain include decentralization, strong authentication and tamper-resistance. Decentralization means that all nodes in the system have access to the entire list of transactions. Such access allows nodes to both verify and publish new transaction records onto blocks, which are then periodically added to the end of the main blockchain with a time stamp (Nakamoto 2008). The system is also able to verify the identity of every payer and payee involved based on a public-key cryptography system (Diffie 1988). Moreover, blockchain technology uses asymmetric cryptography to encrypt data while using the workload of each node of the distributed system proves that the powerful algorithm formed by the consensus algorithm can resist external attacks, ensuring that the blockchain data can not be falsified and unforgeable, and therefore has high security. These characteristics indicate that financial transactions through the blockchain can greatly reduce transaction costs, shorten transaction processing time, and improve the security of transaction information.

Based on the decentralized characteristics of storing data and recording transactions, any data of any enterprise will be stored in an encrypted manner. More specifically, the assets, profitability, and investment status of an enterprise are recorded in blocks at different times. Therefore, in the absence of collateral, all the conditions of the enterprise can be tracked by the bank in real time and thus the information asymmetry in the traditional credit market can be mitigated with the use of blockchain technology.

In addition, on the basis of information sharing, once the firm breaches the contract, the default information will be transmitted and published to all banks and enterprises accessing the blockchain at once. Therefore, the introduction of blockchain has increased the default cost of companies, which can be viewed as the cost of deteriorating reputation and credit damage in the company's future operations.

Moreover, the development and operation of blockchain require very large computing resources, and blockchain ledgers should be allocated to avoid collusion and destruction, which may bring heavy overheads. Hence, it is necessary to bring together government, banks, and companies to build a blockchain platform together, to share construction costs on the one hand, and to prevent the risks caused by blockchain on the other. Hence, in our model, we assume banks, government, and firms jointly implement risk sharing by establishing a "risk pool". Once the firm defaults, the loss of bank credit will be compensated through the risk pool. Compared with traditional bank financing, this risk-sharing mechanism reduces the risk of bank credit losses.

Building upon the above-mentioned characteristics and role of the blockchain, this paper proposes a theoretical model considering information asymmetry. On the basis of relevant literature, we first describe the assumptions and models, and discuss that traditional credit contracts with which banks choose collateral and interest payments cannot completely solve the problem of information asymmetry. Then, we introduce blockchain into the traditional bank-enterprise financing to analyze how it may mitigate the information asymmetry between banks and enterprises and eliminate credit rationing by increasing corporate default costs, obtaining corporate information and implementing risk sharing. We show that even without collateral, the introduction of blockchain will enable firms that previously faced credit rationing to obtain bank financing.

3 Literature review

Previously published literature related to this paper mainly deal with two aspects of our topic. The first category of literature focuses on the credit rationing and collateral. The fundamental one on credit rationing is Stiglitz and Weiss (1981). They believe that the origin of credit rationing is the adverse selection caused by information asymmetry. More specifically, banks are reluctant to raise interest rates to avoid serious adverse selection, making some corporate credit needs unsatisfied and thus generates credit rationing. On this basis, Wette (1983) and Chan and Kanatas (1985) further explore the role of collateral. Bester (1985) proves that if banks could use interest rates and collateral as screening mechanisms at the same time, credit rationing can be eliminated to some extent because borrowers with different risks have different marginal rates of interest rate and collateral. Bester (1987) further points out that credit rationing occurs only if the borrowers' collaterizable wealth is too small to allow perfect sorting or to create sufficiently strong incentives. It has been widely believed that in the traditional Stiglitz–Weiss model, firm size plays an important role in influencing credit rationing. For instance, Cenni et al. (2015) argue that the effects of relationship lending on rationing are not identical for different firm size groups and multiple-banking increases the probability of rationing for small and large firms.

Another category of literature deals with the role of guarantee institutions in addressing corporate collateral shortages. Smith and Warner (1979) first introduce mortgage guarantees into the moral hazard model, arguing that the guarantee could prevent the borrowers from "using the project loans for other purposes" or "consuming the assets used as collateral guarantees" to play the role of supervising the borrowers. On this basis, Watson (1984) argues that the incentive effect of guarantees on borrowers is reflected in the extent of the borrower's efforts to invest in the project. Besanko and Thakor (1987) further analyze the nature of equilibrium under different credit market structures and discussed that when the company's own collateral is insufficient, the guarantee institution can eliminate credit rationing and improve social welfare by providing guarantees for low-risk enterprises. Ono and Uesugi (2009) examine the different role of collateral and guarantees played in relationship lending using empirical data from Japan's SME loan market.

It is worth noting that there is a prominent difference between the role of guarantee institutions and blockchain played in alleviating the financing difficulties of SMEs. The profit model of the guarantee institution is to provide a financial advantage to replace the SMEs to provide guarantees to the bank and to collect a certain percentage of premiums according to the guarantee amount. Once the enterprise defaults, the collateral will be taken over by the bank. Through blockchain and corporate cooperation, banks will mostly take the form of credit loans without mortgage guarantee. And banks rely on the credit records of enterprises in the blockchain platform to make lending decisions, by increasing the company's default costs and establishing risk pools to control loan risk. In addition, each loan through a guarantee institution is required to provide collateral to the bank, and the cost of auditing and mortgage is difficult to disperse by increasing the number of guarantee companies. However, blockchain has achieved economies of scale and saved costs by leveraging the advantages of its network platform.

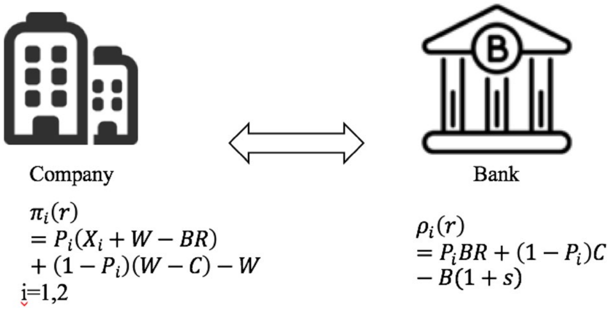
Most existing studies on blockchain focus on real world implications given the functionality blockchain provides. For instance, Raskin and Yermack (2016) discuss how digital currencies and decentralized ledgers based on blockchain technology may reshape the future of central banking. Cong et al. (2018) examine the centralization and decentralization forces in the creation and competition of cryptocurrency-mining activities. Cong and He (2018) study how decentralization improves consensus effectiveness and how the quintessential features of blockchain reshape industrial organization and the landscape of competition. We add by exploring the mechanism that enables blockchain technology to mitigate the information asymmetry and credit rationing between lenders and borrowers.

4 Blockchain embedded credit model

4.1 Model setup

We consider a credit market with two types of entrepreneurs, $i = 1, 2$. Each entrepreneur has the opportunity to undertake in a project with a fixed investment of B. To simplify the model, we assume that one firm is low-risk and the other is high-risk. Firm i's project succeeds with probability p_i and yields the positive return X_i, while the probability of failure is $1 - P_i$ with zero return. We further assume that the probability of the success of the low-risk firm is P_1, and that of the high-risk firm is P_2, $P_2 > P_1$. Following

Fig. 2 Expected returns in traditional financing model



Stiglitz and Weiss (1981) and Bester (1985), we assume $p_i X_i = p_j X_j$ according to a mean preserving spread of returns. Both entrepreneurs have the same positive amount of initial wealth W, where $0< W<B$. Such initial wealth can be used as collateral but is insufficient to cover the costs of the investment project.

If the entrepreneur i obtains loans from the bank and the investment is successful, it gains the revenue X_i, but pays the interest BR to the bank (R indicates the gross interest rates, where; C is the amount of collateral that the company needs to provide, where $0 \le C \le W$). If the entrepreneur's projects fails, the return is zero, and he loses the collateral C. Therefore, the expected return of firm i under contract $r=(R, C)$ is:

$$\pi_i(r) = P_i\left(X_i + W - BR\right) + \left(1 - P_i\right)(W - C) - W \tag{1}$$

Banks finance their credit offers by funds from depositors with deposit rate s. Assume that credit market is competitive and the bank is risk neutral. The bank finances corporate projects through interest rate and collateral contract $r=(R, C)$. Assume that the bank and entrepreneurs have the same evaluation of collateral. Therefore, the expected return for the bank that provides loans to firm i with contract $r=(R, C)$ is:

$$\rho_i(r) = P_i BR + \left(1 - P_i\right)C - B(1 + s) \tag{2}$$

Figure 2 illustrates the expected returns of both company and banks under the traditional credit model. Banks cannot directly distinguish enterprises with different risks because of information asymmetry (Stiglitz and Weiss 1981). The only thing they can use is the loan contract containing interest rate and collateral amount as the mechanism for self-selection. With complete information, when there is no collateral, the bank will ask high-risk firm for higher interest rate. When information is asymmetric, high-risk firm is always motivated to imitate low-risk firm to obtain lower interest rate. Therefore, the bank can only differentiate firms of different risk types by requiring them to provide collateral.

According to Spence (1973) and Berger et al. (2011), firms could get lower interest rate R by increasing the amount of collateral. In other words, when lenders provide sufficient collateral, banks can differentiate various types of firms by designing different loan contracts. However, when low-risk firm is unable to provide sufficient collateral to display its type of risk, credit rationing occurs due to asymmetric information. In this occasion, bank lends to those firms with high-risk but are able to provide collateral, while firms with low-risk but no collateral are expelled from the market. Figure 3 illustrates those enterprises that are able to provide collateral can obtain bank loans under the traditional financing model.

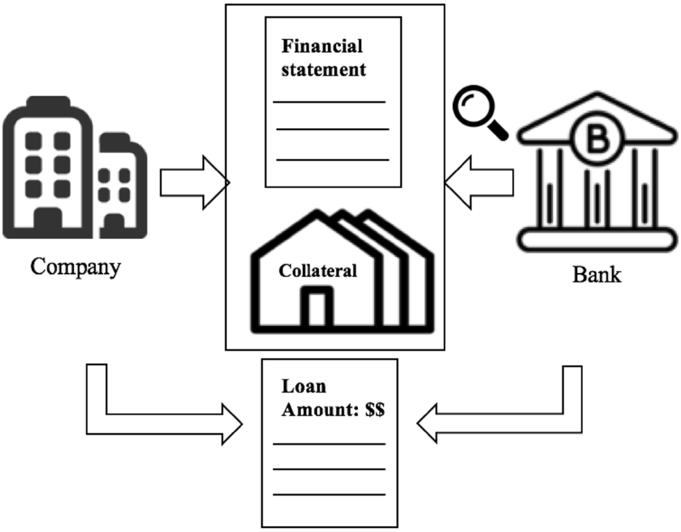


Fig. 3 Traditional financing model

4.2 The role of blockchain

It is worth noting that the blockchain is a technology that cannot directly provide loans to enterprises. When the blockchain is embedded into the credit system, firms will be given the option to choose either the traditional banking channel or borrowing from banks through the blockchain embedded system. If a firm chooses the latter, providing collateral becomes unnecessary. Achieving decentralized consensus in the blockchain embedded credit system requires distributing information to some minimum degrees for verification (Cong and He 2018). Through information distribution in the blockchain, lenders could monitor real-time corporate and credit information of borrowers. In order to use the blockchain embedded system to get more accurate information with the help of decentralized record-keepers and fast developing real-time communication technologies, lender bears the user cost, g, while borrower pays the usage fee, f. If the borrower defaults, the loss would be D for the borrower, while the amount compensated to the lender would be B.

The investment portion on the blockchain embedded credit system from banks, firms and the government are a, b and $1 - a - b$, respectively, as we assume this system is jointly funded by them. Figure 4 illustrates an example where a company without collateral can borrow from bank through the blockchain embedded credit system. Roles that blockchain played in this innovative credit system can be summarized as follows:

First, the information distribution brought along with the decentralized consensus could greatly reduce the information asymmetry in the blockchain embedded system. The alleviation of information asymmetry will inevitably make the lending and borrowing activities more effectively.

Second, the blockchain technology may help to reduce the incentive of individual and/or corporate borrowers to manipulate and tamper their information in the credit system. The tamper-proof and algorithmic executions characteristics of the blockchain technology may also enhance the reliability of conventional credit system and contractibility on contingencies that were difficult to contract traditionally.

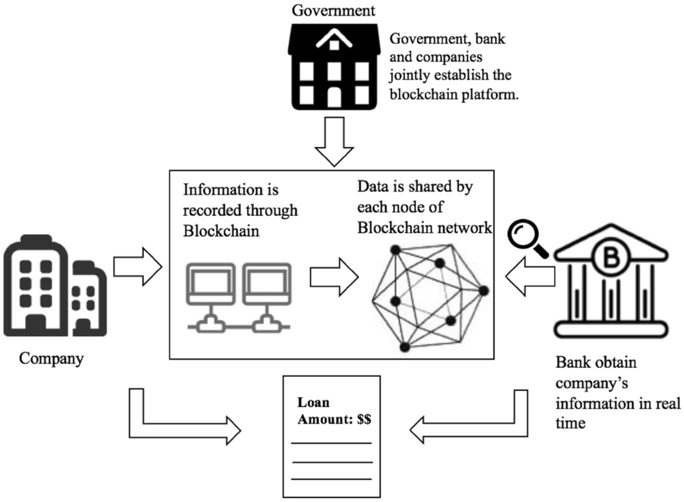


Fig. 4 Blockchain embedded credit system

4.3 Blockchain embedded model

In this section, we focus on the role of the blockchain in relieving the financing difficulties of low-risk firm. Assume that the low-risk firm is financed from bank through the blockchain channel, while the high-risk firm borrows from bank through the traditional manner. Unlike the benchmark model, the expected benefit of the low-risk firm becomes:

$$\pi_1(r) = P_1\left(X_1 + W - BR_1\right) + \left(1 - P_1\right)(W - D) - W - f = X_0 - \left(1 - P_1\right)D - P_1BR_1 - f \tag{3}$$

The expected benefit of bank providing loans to low-risk firm through blockchain channel is:

$$\rho_1(r) = P_1BR_1 + \left(1 - P_1\right)(1 - a)B - B(1 + s) - g \tag{4}$$

The expected benefit of blockchain platform for providing bank loans to low-risk firm is:

$$\delta_1(r) = f + g - \left(1 - P_1\right)bB \tag{5}$$

Figure 5 illustrates the expected returns of both company and bank under the traditional credit model.[1] The assumption of banks getting zero profit under competitive market conditions was made following Acharya and Naqvi (2012).[2]

$$P_1BR_1 + f = B(1 + s) - \left(1 - P_1\right)(1 - a - b)B \tag{6}$$

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[1] Please be noted that only low-risk company ($i = 1$) will borrow through the blockchain channel in this case.

[2] In the real market, this assumption was partially supported by a number of corporate social responsibility (CSR) studies. For instance, Wu and Shen (2013) argue that CSR sacrifice profit for social benefits and the effect of CSR on profit is positive for strategic banks and close to zero for altruistic banks. We are grateful for an anonymous referee pointing out this in the referee report.

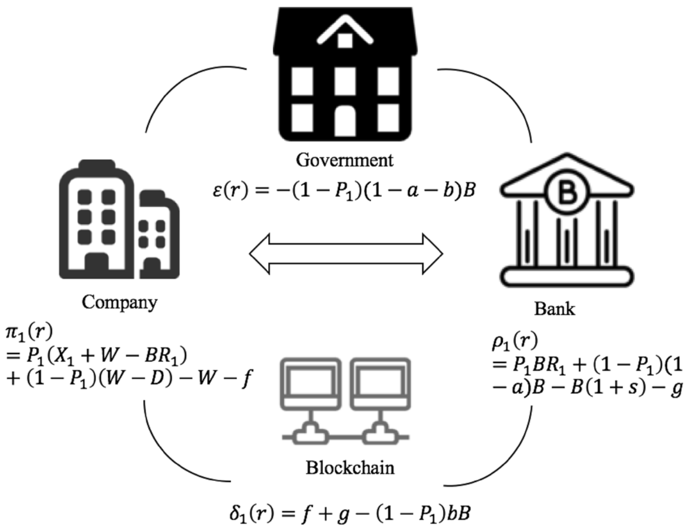

Fig. 5 Expected returns in blockchain-based financing model

Under competitive market conditions, firms maximize their own revenues, and in combination with the above formula, the expected benefit of low-risk firm through blockchain channel can be written as:

$$\begin{aligned} \pi_1(r) &= X_0 - \left(1 - P_1\right)D - P_1BR_1 - f \\ &= X_0 - \left(1 - P_1\right)D + \left(1 - P_1\right)(1 - a - b)B - B(1 + s) \end{aligned} \tag{7}$$

If the high-risk firm imitates a low-risk firm (financing through blockchain at *R1* interest rate), its expected profit becomes:

$$\begin{aligned} \pi_2(r) &= X_0 - \left(1 - P_2\right)D - P_2BR_1 - f \\ &= X_0 - \left(1 - P_2\right)D - f - \frac{P_2}{P_1}\left(B(1 + s) - \left(1 - P_1\right)(1 - a - b)B - f\right) \end{aligned} \tag{8}$$

If distributed information in the blockchain embedded system can distinguished high- and low-risk enterprises, the benefit that low-risk firm could obtained through blockchain channel would be positive, and the benefit achieved by high-risk company through imitating its low-risk counterpart should be lower than the benefit derived from traditional manner. Thus, we have:

$$\begin{aligned} &X_0 - \left(1 - P_1\right)D + \left(1 - P_1\right)(1 - a - b)B - B(1 + s) > 0 \\ &X_0 - \left(1 - P_2\right)D - f - \frac{P_2}{P_1}\left(B(1 + s) - \left(1 - P_1\right)(1 - a - b)B - f\right) < \mathrm{X}_0 - \mathrm{B} \end{aligned} \tag{9}$$

After calculation, we get:

$$\frac{(P_2(1-P_1)(1-a-b)+P_1-P_2)B+(P_2-P_1)f-P_2S}{P_1(1-P_1)} < \mathrm{D} < \frac{X_0+(1-P_1)(1-a-b)B-B(1+s)}{(1-P_1)} \tag{10}$$

In other words, as long as the parameters satisfy:

$$\frac{(P_2(1-P_1)(1-a-b)+P_1-P_2)B+(P_2-P_1)f-P_2S}{P_1(1-P_1)} < \frac{X_0+(1-P_1)(1-a-b)B-B(1+s)}{(1-P_1)} \tag{11}$$

The blockchain embedded credit system will determine a suitable default cost D so that low-risk firm is willing to switch to the blockchain channel, while high-risk firm will continuously use traditional system. In this occasion, the integration of blockchain into credit system effectively enables the screening of information with the help of decentralized consensus and information distribution, and therefore mitigating credit rationing problem.

Proposition 1 *Under certain conditions (i.e., Eq. 11), information distribution helps to differentiate enterprises with different types of risks by adjusting the default cost of enterprises. Low-risk enterprises are willing to borrow through the blockchain channel, while high-risk enterprises will stay within the traditional system.*

It has been noted that in the traditional credit system, banks are reluctant to provide loans to low-risk SMEs mainly because these firms couldn't present sufficient collateral. This has excluded many SMEs getting loans from banks. In the blockchain embedded credit system, however, these low-risk SMEs will have greater opportunity to disclose their credit information to the lenders through the information distribution. The information asymmetry problem is somehow alleviated between the borrowers and lenders.

A recent development of blockchain technology is the creation of smart contracts, originally envisioned by Szabo in 1994 (Cong and He 2018). The core functionality of smart contracts is contracting on contingencies on a decentralized consensus and on low-cost and algorithmic execution. In order to achieve decentralized consensus and information distribution in the blockchain embedded credit system, a distribution ledger is needed and it has to be self-executing so that automated execution is feasible if a borrower defaults. By adopting the smart contracts in the innovative credit system, the blockchain technology can enhance contractibility and enforceability in contingent occasion that facilitate exchanging loan principal, interest, penalty, cost in an algorithmically automated manner. In other words, the added contractibility and enforceability comes at the expense of greater information distribution addressed in Proposition 1.

Proposition 2 *The blockchain embedded credit system helps to lower fraud loss, enforcement costs, and transaction costs. But the added contractibility and enforceability increase the default cost of borrowers at the expenses of greater information distribution. The cost of default lies within a certain range (that is, the interval of Eq. 10).*

If the cost of default is higher than the upper bound of Eq. (10), low-risk companies will not switch to the blockchain embedded system as they would be better of staying within the traditional system. If the cost of default is less than the lower bound of Eq. (10), high-risk companies will have incentives to imitate low-risk companies and borrow through blockchain channel as well. In this occasion, it is not possible to distinguish between different risk types of enterprises and the information asymmetry and credit rationing problem remains.

A brief transformation of Eq. (11) shows that as the *(1 − a − b)* increases, the inequality will relax. So we can get the following proposition:

Proposition 3 *As the proportion of government investment in the risk pool (1-a-b) increases), the role of blockchain played in mitigating information asymmetry and credit rationing would be more pronounced.*

The government's capital injection in the risk pool is equivalent to subsidizing low-risk companies to finance through blockchain embedded system. This could motivate more low-risk companies borrowing through the blockchain channel. At the same time, due to the scale advantage of blockchain technology and smart contracts adopted in the innovative system, related costs for both lenders and borrowers would be reduced and decentralized consensus and information distribution would become more effective.

4.4 Warfare analysis

As described in the aforementioned model, low-risk firm is able to borrow from the bank with no collateral or with insufficient collateral if such an innovative blockchain system exists. Nevertheless, the creation of this system will certainly increase the costs that both lenders and borrowers need to bear. It makes sense to examine whether the adoption of blockchain technology and associated smart contracts improves the welfare of society or not.

Again we assume that banks getting zero profit in a competitive market following Acharya and Naqvi (2012). The expected return of the government in the blockchain embedded credit system is:

$$\varepsilon(r) = -\left(1 - P_1\right)(1 - a - b)B \tag{12}$$

The expected benefit of low-risk company is

$$\pi_1(r) = X_0 - \left(1 - P_1\right)D - P_1 B R_1 - f \tag{13}$$

High-risk firm's welfare is not affected by the adoption of the blockchain technology as it continuously borrows through traditional platform. Therefore, the change in total welfare income in the whole society becomes:

$$\Delta W = X_0 - \left(1 - P_1\right)D - B(1 + s) \tag{14}$$

When $\Delta W > 0$,

$$D < \frac{X_0 - B(1 + s)}{1 - P_1} \tag{15}$$

Equation (15) indicates that if the default cost D meets the above condition, the total social welfare after the adoption of the blockchain technology would be improved.

5 Discussion

The collateral and credit rationing problem faced by SMEs has long been recognized in the literature (Steijvers and Voordeckers 2009). In the traditional bank credit system, providing collateral to the bank can have a mitigating effect on the informational asymmetries that SMEs normally have and thus solve the credit rationing problem. Steijvers and Voordeckers (2009) argue that even though collateral is already a widespread debt contract feature, it will become even more important for informationally opaque firms in the future. However, in a blockchain embedded credit system, we prove in the aforementioned model that SMEs with low-risk but no collateral or insufficient collateral will have the opportunity to borrow from the banks.

In the traditional credit theory, each lender only observes his/her own borrowers and associated credit history and information. With the help of a centralized trustworthy arbitrator or third party, such as credit rating agencies, some large borrowers are able to provide signal (credit rating) on the true state of their credit history and information (Bolton et al. 2012). An alternative method of mitigating the information asymmetry is pledging collateral (Berger et al. 2011). However, neither getting a credit rating nor pledging collateral is possible for many SMEs as both are too costly.

The blockchain technology enables the decentralized consensus recording of success of debt repayment or debt default rendered by verifying and validating certain lending and borrowing activities in distributed ledgers.

As Yermack (2017) summarizes, all blockchains in the distributed ledgers aim at creating a database system in which participants can jointly maintain and edit in a decentralized manner, with no individual exercising central control. One defining feature of the blockchain embedded credit system introduced in the previous sections is thus its ability to distinguish borrowers with different risk classes and maintain the functionality in a relatively more effective manner. By giving all participants, lenders and borrowers, equal access to the transaction and default records, the innovative system also facilitates faster verification and authentication, thereby reducing uncertainties and improving financing efficiency.

The risk-sharing benefit of establishing such an innovative system is also large. Government could encourage banks providing loans to those low-risk SMEs with no or insufficient collateral through the blockchain channel while the risk pool created collectively with banks and firms working as the buffer. If the aggregate default costs could be controlled in a certain level, as indicated in Eq. (15), total social welfare would be improved having considered that the information asymmetry and credit rationing problems are alleviated in the blockchain embedded credit system.

6 Conclusions

We propose a blockchain embedded credit model which could help mitigating the information asymmetry and credit rationing problems widely existed in the traditional credit system. Theoretical analysis demonstrates that the blockchain technology and associated smart contracts enable the decentralized consensus recording of success of debt repayment or debt default rendered by verifying and validating certain lending and borrowing activities in distributed ledgers. In the newly proposed blockchain embedded credit system, SMEs with low-risk and high-quality could display their credibility and risk class through information distribution. They are more likely to access bank loans even if they are not able to provide collateral.

Results derived from the theoretical model have following implications. First, the alleviation of information asymmetry and credit rationing problems can be achieved through decentralized consensus and information distribution among all participants. The blockchain embedded credit model presents a new channel for screening corporate information and collateralized physical assets become unnecessary. Second, the risk sharing mechanism involving government, banks and firms, will not only make the establishment of such an innovative system possible, but also create risk pool for the blockchain based lending and borrowing. This innovative model provides a new approach for the government promoting inclusive SME finance and gives those SMEs with no or insufficient collateral an alternative channel getting access to finance.

As one of the first papers analyzing the application of blockchain technology and smart contracts in reshaping the traditional credit system, we have to leave many interesting topics to future research. For example, we do not take into account the cost of obtaining corporate information in the blockchain platform and the possibility of feeders of collateral information from the offline world. Another interesting direction for future research would be to incorporate smart contracts into the study of information asymmetry and credit rationing of SME financing.

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