

## Analysis of the Financing Mode of Small and Medium-Sized Enterprises Under the DC/EP Platform Based on a Comparison with the Traditional Bank Financing Mode

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**Abstract** As a legal currency with the credit endorsement of the Chinese government, DC/EP has many advantages and special characteristics. Based on the application of DC/EP in the financing of small- and medium-sized enterprises (SMEs), this paper studies the optimal financing decisions of SMEs under both the traditional financing mode and the DC/EP financing mode. Considering the construction and use costs of DC/EP and the role of DC/EP credit traceability in improving mortgage rates, this paper explores the feasible range for SMEs to select DC/EP financing. It is found that mortgage rates affect the returns of SMEs when they take on loans; under different credit strategies, the pledge rate set by the bank will affect the financing willingness of SMEs. The participants had different optimal mortgage rates to optimize the returns of borrowers and banks. High-quality SMEs are more willing to use the DC/EP platform for financing. With the increase in default costs, banks will be more inclined to use DC/EP, while enterprises will be inclined to utilize the traditional financing mode. Through the comparative analysis of the two financing modes, the default cost range that neither banks nor borrowers are willing to use DC/EP is found. This study provides theoretical support and management inspiration for scientific decision-making to solve the financing problems of SMEs by using DC/EP.

**Keywords** DC/EP; small and medium-sized enterprises; financing; mortgage rate

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# 1 Introduction

As an important part of China's substantial economy, small- and medium-sized enterprises (SMEs) have made outstanding contributions to high-quality economic development, expanding employment, improving people's livelihoods and promoting entrepreneurship and innovation. By the end of 2020, the number of SMEs in operation in China had exceeded 42 million, accounting for 98.5% of the total number of enterprises in China (more than 43 million), contributing to more than 50% of national taxes, more than 60% of GDP, more than 70% of technological innovation, and more than 80% of urban employment. However, the problem of the difficulty and costliness of obtaining financing has always been one of the biggest problems hindering the development of SMEs. Based on the proportion of GDP and tax revenue of SMEs and the financing situation of large- and medium-sized enterprises, the loan space of small and medium-sized enterprises is estimated to be 1.5~2.3 times the actual loan balance by the end of 2020<sup>[1]</sup>.

The development and continuous application of 5G, blockchain, big data, cloud computing, and artificial intelligence technologies in the financial field provide technical support for the emergence and promotion of digital currency<sup>[2]</sup>. Bitcoin heralded the beginning of digital currency, and digital currency officially entered public view<sup>[3]</sup>. Since the establishment of the Digital Currency Research Group in 2014, China has introduced relevant policies for the pilot and application of the digital RMB. In the 14th Five-Year Plan, China's digital RMB "10+1" pilot cities actively issued policies to promote the development of digital RMB. At the same time, the corresponding industry report in the market, "China Digital RMB Industry Market Prospect and Investment Strategic Planning Analysis Report", jointly verified the necessity of researching digital RMB. In 2017, the People's Bank of China officially launched the digital currency/electronic payment (DC/EP) project<sup>[4]</sup>. DC/EP combines the advantages of physical RMB and electronic payment tools, which not only have the characteristics of physical RMB payment, i.e., settlement and anonymity, but also have the characteristics of electronic payment tools, such as low cost, strong portability, high efficiency, and difficulty to counterfeit<sup>[5]</sup>. Meanwhile, on April 23, 2021, Shandong Guosheng microfinance Co., Ltd. and the ICBC Qingdao branch jointly completed the pilot application of DC/EP online microfinance scenario, which is the first closed-loop application of DC/EP in the financing scenario of financial institutions<sup>[6]</sup>. The technical characteristics of DC/EP are naturally suitable for solving SMEs' financing problems. Therefore, the study of DC/EP has important practical significance for these problems.

Scholars have conducted extensive research on SME financing and fintech-enabled SME financing. It was found that among the reasons for the difficulty and high cost of financing for SMEs are poor management ability<sup>[7]</sup>, short duration<sup>[8]</sup>, small scale<sup>[9]</sup>, lack of effective collateral<sup>[10]</sup>, low degree of information transparency<sup>[11]</sup>, and asymmetric financing information<sup>[12]</sup>. However, bank loans are characterized by slow approval, large amounts, and strict risk management, which is contrary to the financing characteristics of SMEs<sup>[13, 14]</sup>. Chen<sup>[15]</sup> believed that the hidden barriers of banks in loan approval have caused financing-related discrimination against SMEs. Xiao<sup>[16]</sup> found that China's financial system is singular, and there are few small- and medium-sized financial institutions that conform to the financing characteristics of SMEs. Yang and Huang<sup>[17]</sup> believed that any enterprise has adverse selection and

moral hazard problems, and the credit rationing of commercial banks to SMEs is a reasonable way to achieve effective resource allocation. Stiglitz, et al.<sup>[18]</sup> further studied credit rationing in markets with imperfect information; they found that financial institutions will reduce credit support for SMEs on the basis of considering information asymmetry and agency costs from the perspective of profit maximization. Yang and Li<sup>[19]</sup> analyzed the role of banks in the financing of SMEs and believed that China's SMEs were facing financing problems, such as credit discrimination, unreasonable corporate governance structure, poor social credit, and so on. Most existing studies focus on the impact of blockchain technology in financial technology on the financing of SMEs. Wang, et al.<sup>[20]</sup> believed that blockchain-embedded credit systems can help SMEs that cannot provide the necessary collateral to obtain bank loans. Gong, et al.<sup>[21]</sup> built a digital supply chain financial model based on blockchain technology to study the impact of the number of chain enterprises and information quality on banks' willingness to adopt blockchain technology. Combined with supply chain financial factoring business and blockchain technology, Zheng, et al.<sup>[22]</sup> analyzed the optimization effect of smart contract technology on the decision-making behavior of each entity in the supply chain. Chod, et al.<sup>[23]</sup> studied the optimal contract and quantity decision-making of the supply chain supported by the traditional supply chain and the blockchain by using the revenue sharing contract in the supply chain selling fashion products, and analyzed how the revenue sharing contract coordinates the two types of supply chains.

The DC/EP based on blockchain technology can be regarded as a weak "decentralized" digital currency, which provides a new idea for alleviating the financing problems of SMEs<sup>[2]</sup>. Huang, et al.<sup>[4]</sup> introduced the development process of DC/EP and its impact on the existing monetary system. He and Yao<sup>[5]</sup> analyzed the possible impact of the legalization of RMB digital currency on traditional payment, monetary policy and money market, financial stability, banking system, and financial technology, and put forward a series of policy suggestions conducive to the issuance and promotion of RMB legal digital currency. DC/EP is endorsed by national credit and has the attribute of currency, which can assume the monetary functions of payment means, value scale, circulation means, and value storage<sup>[6]</sup>. The point-to-point payment and settlement feature of DC/EP will speed up the currency circulation, fully activate the stock capital, and improve capital turnover speed<sup>[5]</sup>. In addition, the DC/EP is essentially an encrypted digital code that has the ability to forcibly control the flow of funds through special restrictions. The central bank can set up that loans issued in digital currency can be activated only after they are transferred to the accounts of specific small- and medium-sized enterprises. Therefore, the aid funds for SMEs specially allocated by state finance can be fully earmarked, making the transmission effect of monetary policy more effective<sup>[24]</sup>. With the help of DC/EP, financial institutions can monitor every financing fund issued by them throughout the process so that it can be used 100% in specified projects instead of being invested by borrowers in high-risk industries and projects, helping financial institutions achieve "accurate investment"<sup>[25]</sup>, improving the security of funds, effectively reducing bad debt rate, and significantly reducing the performance risk<sup>[26]</sup>. Zhang<sup>[27]</sup> believes that digital RMB can help solve the financing problem of SMEs by establishing a credit assessment mechanism, improving the financing environment and promoting the development of supply chain finance. Hu<sup>[28]</sup> believes

that legal digital currencies become the mainstream of digital currencies to play its application advantages and control the risks of digital currencies. Although some research on DCEP has emerged, there are fewer modeling or empirical studies on financing with DCEP.

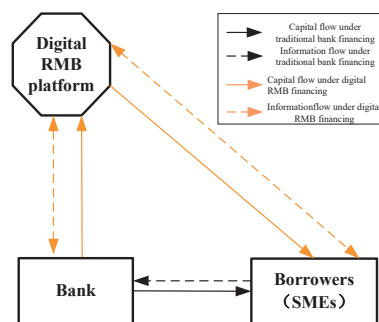
Because of its technical characteristics, DC/EP can improve the digitalization of SME assets, enhance the transparency of enterprise capital flows, improve the ability of enterprise self-credit, and enhance the ability of enterprise financial management.

However, as an emerging product, DC/EP is still in the testing period. From the perspective of theory and technology, it has great potential and advantages in improving SME financing, but its application in real scenarios is in the exploratory stage. Meanwhile, there is even less academic research on the topic. Therefore, this study innovatively investigates this topic from an academic perspective based on real-world problems. In order to make up for the above research gap, this study builds a financing game model composed of banks, SMEs, and the DC/EP platform under the credit financing scenario and explores the possibility and feasibility of DC/EP to improve the financing difficulties and high financing costs of SMEs. After considering the credit endorsement function and cost of DC/EP, this paper discusses the conditions for the application of DC/EP. This study on DC/EP provides theoretical support and managerial insights for scientific decision-making in solving SME financing problems.

## 2 Problem Description and Model Assumptions

### 2.1 Problem Description

By referring to the basic modeling ideas of credit models<sup>[1-5]</sup>, this study constructed the traditional small- and medium-sized enterprises (SMEs) credit model and the SME credit model under the background of DC/EP. The model considers that the DC/EP can be traced through transaction records to improve the credit level of SMEs and enhance their ability to pay mortgages at high rates. By analyzing the returns of each credit participant, solving the optimal solution in each scenario, and comparing the two scenarios, this study aims ascertain the optimal decision in the two scenarios and the conditions of SMEs that adopt DC/EP for financing, as shown in Figure 1 below.



**Figure 1** Traditional financing mode and DC/EP financing mode

Figure 1 shows two different financing models for SMEs: The traditional financing model and the DC/EP financing model. More specifically, in the traditional financing model, the

SME applies for a loan directly from the bank, where the information about the SME is verified through the bank's pre-lending investigation; then the bank deliberates on whether to provide the SME with credit support. In the DC/EP financing model, SMEs' daily settlements are conducted through the DC/EP. Banks obtain information from the DC/EP platform and then decide whether to provide credit support in DC/EP, thus achieving accurate loan placement and controlled use.

## 2.2 Variable Description and Model Assumptions

**Table 1** Description of parameters and variables

Symbol	Description
$B$	The financing principal required by the borrower
$p$	The borrower investment success probability under traditional financing model
$p^D$	The borrower investment success probability under DC/EP financing model
$X$	The borrower operating income
$W$	The value of assets that SMEs can use as collateral
$\gamma$	The Mortgage rates
$\beta$	The discount rate of collateral assets required for DC/EP financing
$K$	The credit default cost based on DC/EP technology platform
$C_E$	The infrastructure costs for SMEs using DC/EP
$BR$	The bank loan income $R > 1$
$C_B$	The cost of building a DC/EP technical financing platform for banks
$C_P$	The fixed cost of building a DC/EP platform
$I$	The social welfare effect coefficient of using DC/EP

In order to study the nature of the problem, the model analysis is simplified, and the following model assumptions are proposed:

1) Based on blockchain technology, a series of data, such as credit records and payment records, will be saved, making the DC/EP more transparent as to the flow of corporate capital. Moreover, the distributed ledger technology of blockchain enables each participant to obtain all transaction information, providing an equal cooperation platform for all parties involved. Therefore, a bank providing credit can obtain such information to make credit decisions, and the cost of information collection is 0<sup>[6]</sup>.

2) Assume that when carrying out DC/EP loan, the cost of upgrading the corresponding platform of the bank is  $C_B$ <sup>[7]</sup>. However, at present, because DC/EP is still in its pilot stage, there will be some limitations in the actual use of DC/EP. Therefore, it is assumed that the cost of holding and using DC/EP for SMEs is  $C_E$ <sup>[8]</sup>. As the DC/EP platform is free to use, its income mainly comes from the rational use effect of national funds  $I$  brought by the targeted investment of credit funds<sup>[9]</sup>.

3) Assume that the borrowers (SMEs) have no own capital and that the mortgageable asset is  $W$ <sup>[10–13]</sup>. The probability of success and return of the investment project are expressed as  $(p, X)$ , and the probability of failure and return of that is  $(1-p, 0)$ <sup>[14]</sup>. In the traditional mode, banks set the mortgage rate  $\gamma$  according to the mortgage assets  $W$  and use the mortgage assets to obtain financing. In the process of using the DC/EP platform, a portion of the assets can be pledged to obtain the same loan amount  $B$ <sup>[15]</sup>.

### 3 Model Setting and Analysis

**Table 2** Setting of traditional financing mode and DC/EP financing mode

	Traditional financing mode	DC/EP financing mode
Probability, return, rate of return	$(p, X, R)$	$(p^D, X, R) (p^D \geq p)$

#### 3.1 Traditional Financing Mode

Under the traditional bank financing mode, the expected returns of SMEs and banks are as follows:

$$\begin{aligned}\Pi^E &= p(X - BR) - (1-p)\gamma W, \\ \Pi^B &= pBR + (1-p)\gamma W - B.\end{aligned}$$

**Proposition 1** When  $0 < \gamma < \bar{\gamma} = \frac{p(X-BR)}{(1-p)W}$ , the income of borrower is directly proportional to the probability of investment success, and the income of SMEs is  $\Pi^E \geq 0$ .

When the mortgage rate is  $0 < \gamma < \bar{\gamma} = \frac{p(X-BR)}{(1-p)W}$ , SMEs always profit. In order to control risks, commercial banks often need to provide sufficient collateral for providing credit, which sets a high threshold for SME financing<sup>[16–18]</sup>. However, SMEs generally have insufficient collateral, which leads to financing difficulties.

**Proposition 2** (a) In an imperfectly competitive market,  $0 < \gamma < \bar{\gamma} = \frac{BR}{W}$ , the income of bank  $\Pi^B$  is directly proportional to the success probability of SMEs investment  $p$ <sup>[19–21]</sup>. When  $\gamma \geq \bar{\gamma}$ , the income of the bank is inversely proportional to its success probability. Therefore, the optimal asset collateral ratio of banks is  $\gamma^* = \frac{BR}{W}$ , and the return of SMEs and bank is  $\Pi^E = pX - BR$  and  $\Pi^B = B(R-1)$ , respectively.

(b) In a perfectly competitive market, the asset collateral ratio of banks is  $\gamma^* = \frac{B(1-pR)}{W(1-p)}$ <sup>[22]</sup>. When the probability of investment success is  $p > \frac{B}{X}$ , SMEs can profit.

In the imperfectly competitive market, when the mortgage rate of the bank meets  $0 < \gamma < \bar{\gamma} = \frac{BR}{W}$ , the income of the bank is positively correlated with the probability of investment<sup>[23]</sup>. When the mortgage rate is high, the bank's income is negatively correlated with the success probability of investment. Therefore, the existence of an optimal mortgage rate maximizes the income of the bank. When a bank is in perfect competition, the success probability of borrower investment should be greater than the threshold value  $\frac{B}{X}$ .

**Table 3** Comparison of the traditional financing mode and the DC/EP financing mode

Case	Imperfectly competitive market	Perfectly competitive market
Traditional financing mode	$\gamma^* = \frac{BR}{W}$	$\gamma^* = \frac{B(1-pR)}{W(1-p)}$
	$\Pi^{E*} = pX - BR$	$\Pi^{E*} = pX - B$
	$\Pi^{B*} = B(R - 1)$	
The DC/EP financing mode	$\gamma^{D*} = \frac{BR-K}{\beta W}$	$\gamma^{D*} = \frac{B(1-p^D R) - (1-p^D)K + C_B}{\beta W(1-p^D)}$
	$\Pi^{DE*} = p^D X - BR - C_E$	$\Pi^{DE*} = p^D X - B - C_B - C_E$
	$\Pi^{DB*} = BR - B - C_B$	

### 3.2 The DC/EP Financing Mode

Under the DC/EP financing mode, SMEs use DC/EP for daily settlement. The bank makes decisions based on the daily transaction settlement record of the borrower on the DC/EP platform, and the loan is issued using DC/EP. The expected investment returns of SMEs, the banks, and financing platforms of DC/EP financing mode are as follows:

$$\begin{aligned}\Pi^{DE} &= p^D(X - BR) - (1 - p^D)(K + \gamma\beta W) - C_E, \\ \Pi^{DB} &= p^D BR + (1 - p^D)(K + \gamma\beta W) - B - C_B, \\ \Pi^{DP} &= IB - C_P.\end{aligned}$$

**Proposition 3** (a) In the imperfectly competitive market,  $0 < \gamma < \bar{\gamma}^D = \frac{BR^D - K}{\beta W}$ , the income of bank  $\Pi^{DB}$  is directly proportional to the success probability of SMEs investment  $p^D$ . When  $\gamma \geq \bar{\gamma}^D$ , the income of bank is inversely proportional to the success probability  $p^D$ . Therefore, the optimal asset collateral ratio of banks  $\gamma^{D*} = \frac{BR^D - K}{\beta W}$ , and the return of SMEs and bank is  $\Pi^{DE*} = p^D X - BR - C_E$  and  $\Pi^{DB*} = BR - B - C_B$ , respectively.

(b) In a perfectly competitive market, the asset collateral ratio of banks is

$$\gamma^{D*} = \frac{B(1 - p^D R) - (1 - p^D)K + C_B}{\beta W(1 - p^D)}.$$

When the probability of investment success is  $p^D > \frac{B + C_B + C_E}{X}$ , SMEs can profit.

In an imperfectly competitive market, when the mortgage rate of the bank meets  $0 < \gamma < \bar{\gamma}^D = \frac{BR - K}{\beta W}$ , the income of the bank is positively correlated with the success probability of the project. In this case, the higher the success probability of the project, the higher the bank's income. When the mortgage rate is high, that is,  $\gamma \geq \bar{\gamma}^D$ , the income of bank is negatively correlated with the success probability of the project. Therefore, the bank sets an optimal mortgage rate to ensure income maximization. When the bank is in perfect competition, SMEs will choose financing and profit from the project only when the success probability of the project is greater than  $\gamma^{D*} = \frac{BR - K}{\beta W}$ .

**Proposition 4** In an imperfectly competitive market, the DC/EP information construction platform will be profitable only when the amount of financing demand meets  $B > \frac{C_F}{1}$ , or

the social welfare coefficient of the DC/EP platform reaches a certain threshold  $I > \frac{C_E}{B}$ . In an imperfectly competitive market, the profit of DC/EP platform is not considered.

**Proposition 5** When the mortgage rate (the threshold of the mortgage rate is set according to the construction cost, default cost, probability of investment success, and the expected returns of loans of SMEs using the DC/EP) meets  $0 < \gamma < \bar{\gamma}^D = \frac{p(X-BR)-K(1-p^D)-C_E}{(1-p^D)\beta W}$ , the income of SMEs is directly proportional to the success probability of financing, and the income of SMEs is  $\Pi^{DE} \geq 0$ .

When the mortgage rate meets  $0 < \gamma < \bar{\gamma}^D = \frac{p(X-BR)-K(1-p^D)-C_E}{(1-p^D)\beta W}$ , SMEs can always make a profit. When  $\frac{C_E+K(1-p^D)}{(1-p^D)W} \geq 0$ , this indicates that the construction cost of SMEs using DC/EP is higher than the default cost. Thus, compared to the case of ordinary financing, the implementation of digital RMB guarantees the profitability of SMEs in a wider range of mortgage rate<sup>[24, 25]</sup>. At this time, the risk control of commercial banks makes use of the credit provided by DC/EP, reducing the financing threshold of SMEs. When  $\frac{C_E+K(1-p^D)}{(1-p^D)\beta W} \leq 0$ , this indicates that the default cost of SMEs using digital RMB is high, compared with the situation of traditional financing, the use of the digital RMB strengthens the control of corporate risks.

**Proposition 6** (a) When  $K \geq \frac{C_B}{1-p^D} + (1-\beta)\gamma W$ ,  $\Pi^{DB} \geq \Pi^B$ ; When  $K \leq -BR + \gamma W + \frac{C_B}{(1-p)}$ ,  $\Pi^{DB} \leq \Pi^B$ .

(b) When  $K \leq (1-\beta)\gamma W - \frac{C_E}{1-p^D}$ ,  $\Pi^{DE} \geq \Pi^E$ ; When  $K \geq X - BR + \gamma W - \frac{C_E}{1-p^D}$ ,  $\Pi^{DE} \leq \Pi^E$ .

(c) When  $X - BR + \gamma W - \frac{C_E}{1-p^D} \leq K \leq -BR + \gamma W + \frac{C_B}{1-p}$ ,  $\Pi^{DE} \leq \Pi^E$  and  $\Pi^{DB} \leq \Pi^B$ .

**Table 4** Comparison of bank and enterprises' profits

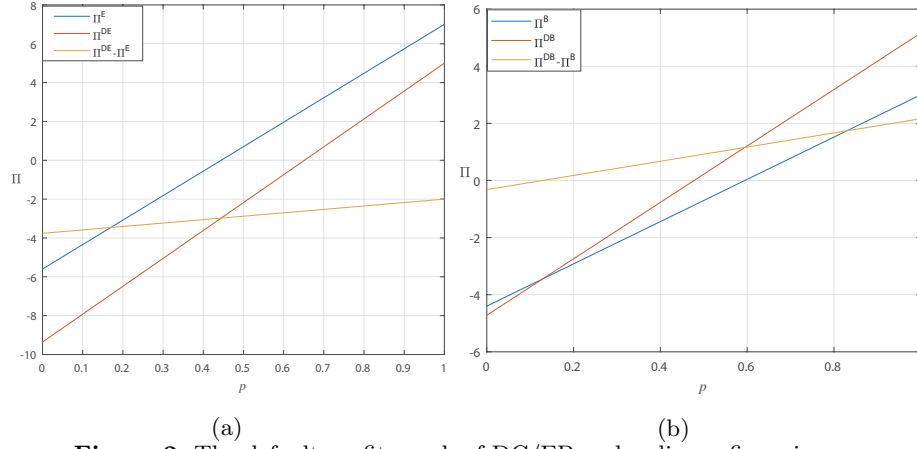
Case	$K$	$\Pi$
Bank	$K \geq \frac{C_B}{1-p^D} + (1-\beta)\gamma W$	$\Pi^{DB} \geq \Pi^B$
	$K \leq -BR + \gamma W + \frac{C_B}{(1-p)}$	$\Pi^{DB} \leq \Pi^B$
Enterprise	$K \leq (1-\beta)\gamma W - \frac{C_E}{1-p^D}$	$\Pi^{DE} \geq \Pi^E$
	$K \geq X - BR + \gamma W - \frac{C_E}{1-p^D}$	$\Pi^{DE} \leq \Pi^E$
$X - BR + \gamma W - \frac{C_E}{1-p^D} \leq K \leq -BR + \gamma W + \frac{C_B}{1-p}$		$\Pi^{DE} \leq \Pi^E$ and $\Pi^{DB} \leq \Pi^B$

As shown in Figure 2(a), (b), the blue line and the orange line represent the earnings of SMEs (Proposition 2(a), Proposition 5) and banks (Proposition 2(b), Proposition 3(a)) under the condition of ordinary bank financing and DC/EP platform financing, respectively. The yellow line represents the income difference between SMEs and banks under DC/EP platform financing and ordinary bank financing.

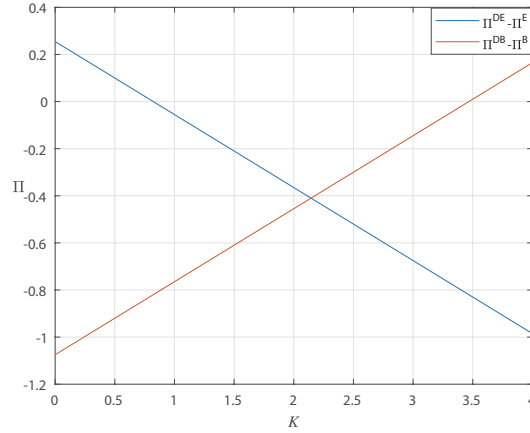
In Proposition (a), when the default cost meets  $K \geq \frac{C_B}{1-p^D} + (1-\beta)\gamma W$ , the returns of the bank under the DC/EP are higher than ordinary bank financing. When the default cost meets  $K \leq -BR + \gamma W + \frac{C_B}{1-p}$ , the earnings of banks under the DC/EP are not as good as those under the traditional bank financing mode<sup>[26]</sup>. In Proposition (b), when the default cost meets  $K \geq X - BR + \gamma W - \frac{C_E}{1-p^D}$ , the earnings of SMEs under the DC/EP are not as high as those under ordinary bank financing mode. When the default cost meets  $K \leq (1-\beta)\gamma W - \frac{C_E}{1-p^D}$ ,



that is, the default cost is low, the earnings of SMEs under the DC/EP are better than those under ordinary bank financing, as shown in Figure 3.



**Figure 2** The default-profit graph of DC/EP and ordinary financing



**Figure 3** The default-profit graph of DC/EP and ordinary financing

In Proposition (c), when  $K$  meets  $X - BR + \gamma W - \frac{C_E}{1-p^D} \leq K \leq -BR + \gamma W + \frac{C_B}{1-p}$ , the use of DC/EP cannot bring better returns to SMEs. The main reason is that the infrastructure construction costs and default costs of the platform are increased using DC/EP. Meanwhile, the reduced amount of mortgage assets is not enough to offset the increased cost, thus increasing the successful pressure of investment. When the default occurs in ordinary bank financing, the default cost  $K$  is about 20%~30% of the loan principal<sup>[1]</sup>. In Figure 3, when the DC/EP platform is used for financing, the default cost is relaxed to 0%~40%.

## 4 Conclusions

In sum, the DC/EP is an inevitable outcome of the development of human society. It can not only increase payment diversity, but also help solve the financing problems of SMEs. This study considers financing models constructed by banks, SMEs, and DC/EP platforms and researches the influence of DC/EP platform cost and credit traceability on the choice of financing methods.

The main findings of this study are as follows: 1) When the banks' credit targets differ, the factors influencing SMEs' financing decisions also vary. More specifically, when banks target profit maximization, the factor that influences these banks' decisions is the optimal collateral rate under which SME decide whether to finance. When banks target inclusive financing, SMEs choose to finance only when the probability of business success is greater than the target threshold. We also find that the collateral rate directly affects the returns of SMEs when they lend. 2) In the DC/EP financing mode, we can obtain a similar conclusion as in the traditional mode, indicating that the use of DC/EP does not affect the decision-making goals of SMEs and banks. However, when banks implement an inclusive finance policy and the probability of successful investment of SMEs in the DC/EP scenario is greater than that in the traditional scenario, SMEs will choose to conduct financing. This result indicates that high-quality SMEs are more willing to use DC/EP-platform financing. 3) As the default costs rise, banks will prefer to use the DC/EP, while firms will prefer the traditional financing model. Meanwhile, this paper finds the range of default costs that both banks and borrowers are reluctant to use DC/EP by comparing these two financing models. Currently, DC/EP is still in the pilot stage, and application scenarios are still being enriched and need to be improved in practice. This paper makes the following recommendations: 1) Increase the popularity of digital RMB. As the digital RMB scenario is enriched and the volume of enterprises and individuals adopting digital RMB settlement increases, the information transfer and trade flow contained in digital RMB is improved and can clearly reflect enterprise funds and trade transactions, making it easy for banks to conduct pre-loan investigations and simplifying the processes necessary for SMEs to raise funds. 2) The existing digital RMB loan products are relatively single, and the utilization of digital RMB advantages is limited. Commercial banks should innovatively develop DC/EP-based supply chain finance solutions to solve SMEs' financing problems. 3) The government and the central bank should formulate supportive policies such as subsidies and tax breaks to reduce the costs for banks to set up DC/EP technology financing platforms and encourage SMEs to use digital RMB for transaction settlement. This paper is definitely not without its shortcomings. First, it considers certain factors in constructing the digital RMB scenario; in reality, however, there are many factors that affect a loan, and additional factors can be added in the future to construct a more systematic model. Second, because of the role digital RMB plays in each loan process, the effect of digital RMB pre-loan, mid-loan, and post-loan could be considered more systematically in the future. Finally, this paper only compares digital RMB loans with traditional loans, which can be compared with platform-based financing (similar to Alibaba borrowing) in the future.

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## Appendix 1

### Proof of Proposition 1

$$\Pi^E = p(X - BR) - (1 - p)\gamma W,$$

$$\Pi^B = pBR + (1 - p)\gamma W - B.$$

$$\Pi^E > 0 \Rightarrow \gamma < \frac{p(X - BR)}{(1 - p)W}.$$

1) When  $X - BR > 0$ ,

$$\left\{ \gamma \mid \gamma > 0 > \frac{BR - X}{W} \right\} \cap \left\{ \gamma \mid 0 < \gamma < \frac{p(X - BR)}{(1 - p)W} \right\} = \left\{ \gamma \mid 0 < \gamma < \frac{p(X - BR)}{(1 - p)W} \right\}.$$

2) When  $X - BR < 0$ ,  $\left\{ \gamma \mid \gamma > \frac{BR - X}{W} > 0 \right\} \cap \left\{ \gamma \mid \gamma < \frac{p(X - BR)}{(1 - p)W} < 0 \right\} = \emptyset$ .

### Proof of Proposition 2

$$\Pi^E = p(X - BR) - (1 - p)\gamma W,$$

$$\Pi^B = pBR + (1 - p)\gamma W - B.$$

$$(a) \frac{\partial \Pi^B}{\partial p} = BR - \gamma W \begin{pmatrix} > \\ = \\ < \end{pmatrix} 0 \Rightarrow \gamma \begin{pmatrix} < \\ = \\ > \end{pmatrix} \frac{BR}{W} \Rightarrow \gamma^* = \frac{BR}{W}.$$

$$(b) \Pi^B = pBR + (1 - p)\gamma W - B = 0 \Rightarrow \gamma^* = \frac{B(1 - pR)}{W(1 - p)}. \quad \Pi^E = p(X - BR) - (B - pBR) = pX - B > 0 \Rightarrow p > \frac{B}{X}.$$

### Proof of Proposition 3

$$\Pi^{DE} = p^D(X - BR) - (1 - p^D)(K + \gamma\beta W) - C_E,$$

$$\Pi^{DB} = p^D BR + (1 - p^D)(K + \gamma\beta W) - B - C_B,$$

$$\Pi^{DP} = IB - C_P.$$

$$(a) \frac{\partial \Pi^{DB}}{\partial p} = BR - (K + \gamma\beta W) \begin{pmatrix} > \\ = \\ < \end{pmatrix} 0 \Rightarrow \gamma \begin{pmatrix} < \\ = \\ > \end{pmatrix} \frac{BR - K}{\beta W} \Rightarrow \gamma^{D*} = \frac{BR - K}{\beta W}.$$

$$\Pi^{DE} = p^D(X - BR) - (1 - p^D)BR - C_E = p^D X - BR - C_E, \quad \Pi^{DB} = p^D BR + (1 - p^D)BR - B - C_B = BR - B - C_B.$$

$$(b) \Pi^{DB} = p^D BR + (1 - p^D)(K + \gamma\beta W) - B - C_B = 0 \Rightarrow \gamma^{D*} = \frac{B(1 - p^D R) - (1 - p^D)K + C_B}{\beta W(1 - p^D)}.$$

$$\Pi^{DE} = p^D(X - BR) - B + p^D BR - C_B - C_E = p^D X - B - C_B - C_E > 0 \Rightarrow p^D > \frac{B + C_B + C_E}{X}.$$

### Proof of Proposition 4

$$\Pi^{DP} = IB - C_P \begin{pmatrix} > \\ = \\ < \end{pmatrix} 0 \Rightarrow B \begin{pmatrix} > \\ = \\ < \end{pmatrix} \frac{C_P}{I}, \quad I \begin{pmatrix} > \\ = \\ < \end{pmatrix} \frac{C_P}{B}.$$

**Proof of Proposition 5**

$$\begin{aligned} \frac{\partial \Pi^{\text{DE}}}{\partial p} &= X - BR + (K + \gamma\beta W) \begin{pmatrix} > \\ = \\ < \end{pmatrix} 0 \Rightarrow \gamma \begin{pmatrix} < \\ = \\ > \end{pmatrix} \frac{BR - X - K}{\beta W}, \\ \Pi^{\text{DE}} &= p^D(X - BR) - (1 - p^D)(K + \gamma\beta W) - C_E \begin{pmatrix} > \\ = \\ < \end{pmatrix} 0 \\ &\Rightarrow \gamma \begin{pmatrix} < \\ = \\ > \end{pmatrix} \frac{p^D(X - BR) - (1 - p^D)K - C_E}{(1 - p^D)\beta W}. \end{aligned}$$

1) When  $X - BR + K > 0$ ,

$$\begin{aligned} &\left\{ \gamma \mid \gamma > 0 > \frac{BR - X - K}{\beta W} \right\} \cap \left\{ \gamma \mid \gamma < \frac{p^D(X - BR) - (1 - p^D)K - C_E}{(1 - p^D)\beta W} \right\} \\ &= \left\{ \gamma \mid 0 < \gamma < \frac{p^D(X - BR) - (1 - p^D)K - C_E}{(1 - p^D)\beta W} \right\}. \end{aligned}$$

2) When  $X - BR + K < 0$ .

$$\left\{ \gamma \mid \gamma > 0 > \frac{BR - X - K}{\beta W} \right\} \cap \left\{ \gamma \mid \frac{p^D(X - BR) - (1 - p^D)K - C_E}{(1 - p^D)\beta W} < 0 < \gamma \right\} = \emptyset.$$

**Proof of Proposition 6**

(a)

$$\begin{aligned} \Pi^B &= pBR + (1 - p)\gamma W - B, \\ \Pi^{\text{DB}} &= p^D BR + (1 - p^D)(K + \gamma\beta W) - B - C_B, \\ BR - \gamma W &\geq 0, \\ \Pi^{\text{DB}} - \Pi^B &= p^D BR + (1 - p^D)(K + \gamma\beta W) - B - C_B - (pBR + (1 - p)\gamma W - B) \\ &= (p^D - p)BR + (1 - p^D)K + (1 - p^D)\gamma\beta W - (1 - p)\gamma W - C_B \\ &= (p^D - p)(BR - \gamma W) + (1 - p^D)K - (1 - p^D)(1 - \beta)\gamma W - C_B \\ &\geq (1 - p^D)K - (1 - p^D)(1 - \beta)\gamma W - C_B, \\ \Pi^{\text{DB}} - \Pi^B &\geq (1 - p^D)K - (1 - p^D)(1 - \beta)\gamma W - C_B \geq 0, \\ K &\geq (1 - \beta)\gamma W + \frac{C_B}{(1 - p^D)}, \end{aligned}$$

$$\begin{aligned}
\Pi^{\text{DB}} - \Pi^B &= p^D BR + (1 - p^D)(K + \gamma\beta W) - B - C_B - (pBR + (1 - p)\gamma W - B) \\
&= (p^D - p)BR + (1 - p^D)K + (1 - p^D)\gamma\beta W - (1 - p)\gamma W - C_B \\
&= (p^D - p)(BR - B\gamma W) + (1 - p^D)K - (1 - p)(1 - \beta)\gamma W - C_B \\
&\leq (1 - p)(BR - \beta\gamma W) + (1 - p)K - (1 - p)(1 - \beta)\gamma W - C_B, \\
\Pi^{\text{DB}} - \Pi^B &\leq (1 - p)(BR - \beta\gamma W) + (1 - p)K - (1 - p)(1 - \beta)\gamma W - C_B \leq 0, \\
K &\leq -BR + \gamma W + \frac{C_B}{(1 - p)}, \\
(1 - p^D)K - (1 - p^D)(1 - \beta)\gamma W - C_B \\
&\leq \Pi^{\text{DB}} - \Pi^B \\
&\leq (1 - p)(BR - \beta\gamma W) + (1 - p)K - (1 - p)(1 - \beta)\gamma W - C_B, \\
\text{When } p^D = p, \Pi^{\text{DB}} &\begin{pmatrix} \geq \\ < \end{pmatrix} \Pi^B, K \begin{pmatrix} \geq \\ < \end{pmatrix} \frac{C_B}{1 - p} + (1 - \beta)\gamma W.
\end{aligned}$$

(b)

$$\begin{aligned}
\Pi^E &= p(X - BR) - (1 - p)\gamma W, \\
\Pi^{\text{DE}} &= p^D(X - BR) - (1 - p^D)(K + \gamma\beta W) - C_E, \\
X - BR &\geq 0, \\
\Pi^{\text{DE}} - \Pi^E &= p^D(X - BR) - (1 - p^D)(K + \gamma\beta W) - C_E - [p(X - BR) - (1 - p)\gamma W] \\
&= (p^D - p)(X - BR) - (1 - p^D)K - (1 - p^D)\gamma\beta W + (1 - p)\gamma W - C_E \\
&= (p^D - p)(X - BR + \gamma W) - (1 - p^D)K + (1 - p^D)(1 - \beta)\gamma W - C_E \\
&\geq (1 - p^D)(1 - \beta)\gamma W - (1 - p^D)K - C_E, \\
\Pi^{\text{DE}} - \Pi^E &\geq (1 - p^D)(1 - \beta)\gamma W - (1 - p^D)K - C_E \geq 0, \\
K &\leq (1 - \beta)\gamma W - \frac{C_E}{(1 - p^D)}, \\
\Pi^{\text{DE}} - \Pi^E &= p^D(X - BR) - (1 - p^D)(K + \gamma\beta W) - C_E - [p(X - BR) - (1 - p)\gamma W] \\
&= (p^D - p)(X - BR) - (1 - p^D)K - (1 - p^D)\gamma\beta W + (1 - p)\gamma W - C_E \\
&= (p^D - p)(X - BR + \beta\gamma W) - (1 - p^D)K + (1 - p)(1 - \beta)\gamma W - C_E \\
&\leq (1 - p)(X - BR + \beta\gamma W) + (1 - p)(1 - \beta)\gamma W - (1 - p^D)K - C_E, \\
\Pi^{\text{DE}} - \Pi^E &\leq (1 - p)(X - BR + \beta\gamma W) + (1 - p)(1 - \beta)\gamma W - (1 - p^D)K - C_E \leq 0, \\
K &\geq \frac{(X - BR + \gamma W)(1 - p)}{(1 - p^D)} - \frac{C_E}{(1 - p^D)} \\
&\geq X - BR + \gamma W - \frac{C_E}{(1 - p^D)}, \\
(1 - p^D)(1 - \beta)\gamma W - (1 - p^D)K - C_E &\leq \Pi^{\text{DE}} - \Pi^E \\
&\leq (1 - p)(X - BR + \beta\gamma W) + (1 - p)(1 - \beta)\gamma W - (1 - p)K - C_E.
\end{aligned}$$

When

$$p^D = p, \quad \Pi^{\text{DE}} \begin{pmatrix} \geq \\ < \end{pmatrix} \Pi^E, \quad K \begin{pmatrix} \leq \\ > \end{pmatrix} (1 - \beta)\gamma W - \frac{C_E}{1 - p}.$$

(c)  $X - BR + \gamma W - \frac{C_E}{1 - p^D} \leq K \leq -BR + \gamma W + \frac{C_E}{1 - p}$ ,  $\Pi^{\text{DE}} \leq \Pi^E$  and  $\Pi^{\text{DB}} \leq \Pi^B$ .  
 When  $p^D = p$ ,  $(1 - \beta)\gamma W - \frac{C_E}{1 - p} \leq K \leq (1 - \beta)\gamma W + \frac{C_E}{1 - p}$ ,  $\Pi^{\text{DE}} \leq \Pi^E$  and  $\Pi^{\text{DB}} \leq \Pi^B$ .

## Appendix 2

$$\Pi^E = p(X - BR) - (1 - p)\gamma W,$$

$$\Pi^B = pBR + (1 - p)\gamma W - B^+,$$

$B^+$  represents the cost of the bank that contains the cost of information collection. Similar to proof of Proposition 1, we could get similar results to the main model.

In the DC/EP financing mode, the application of fintech does not incur information collection cost, so it is consistent with the results of the existing model.