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Credit Rationing in Small and Micro Enterprises: A Theoretical Analysis

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Abstract: One of the features of credit markets is that borrowers are sometimes rationed in the amount that they can borrow, which differentiates them from other markets. Small and micro enterprises (SMEs) are more likely to be eliminated than large and medium-sized enterprises under credit rationing. However, SMEs play a significant role in employment creation and growth of gross domestic products in developing countries. So, it is of great significance to study the reasons why SMEs are more vulnerable to credit constraints. By considering the differences in characteristics between SMEs and large and medium-sized enterprises, we established a theoretical model with endogenous enterprise size, and by considering banks' screening principles before and after the loan approval, we have analyzed the micro-mechanism in which there are significant differences in credit availability between SMEs and large and medium-sized enterprises. Our conclusion indicates that credit rationing in SMEs is the result of the rational choice by banks for the purpose of profit maximization.

Keywords: financing constraint; asymmetric information; small and micro enterprises; credit rationing; big data

1. Introduction

SMEs refer to natural person enterprises and legal person enterprises with small production scale, small number of employees and assets, including small enterprises, micro-enterprises, family-workshop enterprises as well as individual industrial and commercial households. In the economic society, SMEs play an irreplaceable role in increasing employment, improving people's livelihood and promoting economic growth [1,2]. Financing is the basic work of enterprise management. The establishment, survival, and development of any enterprise need financing. However, financing obstacles inhibited the efficiency of operation and the growth of enterprises. The major source of financing obstacles for enterprises is credit rationing, which refers to a situation that among observationally identical loan applicants, some get a loan whereas others are denied credit, and those who do not have access to loans will not be able to borrow even if they are willing to pay higher interest rates; in another case, no matter how adequate the supply of loans, there are always some borrowers can't get access to loans at any level of interest rate [3].

Enterprise size is considered to be one of the priority indicators to judge the financing obstacles of enterprises [4]. Zott and Amit (2007) contend that Large enterprises have more resources to undertake new products or projects which, if successful, can be implemented on a larger scale and made profitable through better access to large markets [5,6]. But, Uhlaner et al. (2012) argue that SMEs are more flexible, and managers are closer to operational levels, being able to make decisions more dynamically [7–10]. Gou Q et al. (2014) found that the smaller the enterprise size, the higher the probability of being rationed [11]. By cross-country evidence, Demirguckunt et al. (2010) show that small enterprises are

more constrained in their operation and growth than large enterprises and access to financial services features importantly among the constraints [12]. Beck et al. (2006) also indicate that small enterprises consistently report higher financing obstacles than large and medium-sized enterprises [13]. Small enterprises do not only report higher financing obstacles but also more adversely affected by these obstacles. Beck, Demirgüç-Kunt, and Maksimovic (2004) find that small enterprises' financing obstacles have almost twice the effect on their growth that large enterprises' financing obstacles do [14].

In response to this situation, governments and financial institutions of many countries have taken a lot of measures to deal with the financing constraints in SMEs. However, the effect of these measures is quite limited, for more than a decade, credit availability of SMEs also reflected that the financing problems of SMEs in developing countries have not been well solved [15–17].

Research on the mechanism of credit rationing in SMEs is still in its infancy. Baltensperger (1978) and Stiglits & Weiss (1981) explored the financing difficulties of borrowers from the perspective of credit rationing, considered that credit rationing comes from adverse selection and moral hazard caused by asymmetric information, so even though borrowers are willing to pay the non-price and price terms in the contract, their loan demand will still not be met [3,18]. Yang (2012) also believes that the main reasons why it is difficult for SMEs to obtain loans are information asymmetry, high cost, and credit rationing [19]. Demirgüç-Kunt and Maksimovic (1998) find that financing constraints are lower in countries with more efficient legal systems [20]. Laeven (2003) and Gelos and Werner (2002) find that financial liberalization relaxes financing constraints of enterprises, in particular for smaller enterprises [21,22].

For the consideration of the enterprise size, Coase (1937) indicate that enterprise boundaries could affect the allocation of Resources [23]. This has received much attention in theoretical and empirical studies in economics and finance [24–27]. Traditionally, in China, the classification of the enterprise by size was based on production capacity rather than on sales or the number of employees, as in western countries [28–30]. Dang et al. (2018) employed natural logarithm forms of total assets, total sales, and market value of equity to measure the enterprise size [31]. Smyth et al. (1975) also use employment, invested capital, and net assets (capital employed) as alternative measures of enterprise size [32].

However, research on financing constraints of SMEs in foreign academic circles began in the 1990s. After many years of study, rich results have been accumulated, but the financing market system and policy support system, as well as the institutional environment in developed countries, have been relatively perfect, therefore, scholars pay more attention to the financing constraints of SMEs under perfect market conditions, the theoretical explanation put forward by them are not completely suitable for the actual situation in developing countries. SMEs in developing countries are facing more serious financing constraints. The theoretical and empirical research on financing constraints of SMEs has not been carried out in depth yet. In addition, although some scholars have used the credit rationing theory to explain the financing constraints of borrowing enterprises, they have not considered the variable of enterprise size, so they can not accurately explain the problem of "financing is difficult and expensive" for SMEs.

Therefore, on the basis of summarizing existing literatures, by considering the main disadvantages of SMEs which distinguished them from large and medium-sized enterprises, that is, by characterizing the differences between SMEs and large and medium-sized enterprises in terms of their project success probability and capital appreciation ability, we have introduced the variable of enterprise size into the traditional credit rationing model. We contend that, with other things being equal, the average success probability of SMEs' projects is lower than that of large and medium-sized enterprise, and in the case of success, the average return of SMEs' projects is less than that of large and medium-sized enterprise. In light of these problems caused by the enterprise size factor, we systematically analyzed banks' screening principles before and after the loan approval. According to the analysis, we explained the internal mechanism of credit rationing in SMEs under imperfect market conditions.

The research finds that, before making a loan, banks will comprehensively assess the risk of the borrowing enterprises, SMEs' initial asset size is usually below the critical collateral value, which

made them unable to transmit their risk levels, and SMEs' loan size is usually below the minimum loan size, which would cause higher costs to banks. Besides, compared with large and medium-sized enterprises, SMEs lack tangible assets as collateral, have a lower proportion of public property rights, and exists a greater degree of information asymmetry with banks. After the loan has been made, SME at lower living standards have a stronger incentive to increase current consumption at the expense of future investment returns, and the increased credit diversion will decrease borrowing enterprise's project expected returns. All these factors resulting in lower expected bank profits. Considering this, banks will apply strict credit rationing to prevent credit risk, thus leading to the financing constraints in SMEs.

We highlight several empirical implications. First, our measurement of the enterprise size provides some insights to business finance researchers and bank credit decision makers who need quantify the factor of enterprise size in their work. Second, it pushes forward researchers' understanding of the reasons why the barriers of the accessibility to credit for SMEs are greater. Finally, our work could help banks and government and other institutions to apply appropriate methods to ease enterprise financing constraint problems. However, the limitation of this article is that we just did a theoretical analysis, what should be further done is an empirical test with data.

This paper is organized as follows: the second part presented the relevant hypotheses and established the model, and the third part analyzed the main disadvantages of SMEs as compared with large and medium-sized enterprises. Section IV described the screening mechanism before the loan issuance. Section V analyzed the risk prevention mechanism after the loan issuance and the resulting credit rationing. The last section summarized this article and puts forward the policy recommendations for alleviating the financing constraints in SMEs.

2. The Model

2.1. Assumptions about Enterprises

Suppose in a competitive credit market, there are a number of banks and enterprises. These enterprises are of different sizes, which can be divided into two groups — SMEs and large and medium-sized enterprises, represented by $i = 1, 2$ respectively. The initial asset size of SMEs are W_1, and the initial asset size of large and medium-sized enterprises are W_2, where $W_1 < W_2$, that is, the asset size of SMEs is smaller than that of large and medium-sized enterprises. Each enterprise needs to finance a project that requires a fixed amount of investment L, where $W_i < L$, as a result, each enterprise could provide collateral with a positive value, however, the initial assets are not sufficient to cover the cost of the investment project. The average success probability of group i's project is p_i, and get a positive return $G_i(K)$ once successful, where $G'_i(K) > 0, G''_i(K) < 0$ and K is the aggregated value of inputs, which is less than or equal to the loan amount L, the probability of failure is $1 - p_i$, and get *0* in case of failure, where $p_i \in (0, 1)$. Assume that as long as the project is successful and G_i is high enough, the enterprise will repay the loan, that is, there is no possibility of intentional default. Enterprise's preferences are described by the Von Neumann-Morgenstern utility function of their ultimate wealth, denoted by U, where $U' > 0$, assume that the borrowing enterprises are all risk-neutral, that is $U'' = 0$, and satisfying the assumption that its utility is negative infinity when their property of individual rationality is zero, which means $U(0) = -\infty$.

2.2. Assumptions about Banks

Suppose that each bank has enough capital, that is, there is no shortage of funds in the credit market, and the deposit interest rate (opportunity cost) of the bank is μ. Banks compete in the credit market by offering credit contracts (L, r, C), where the terms L, r, C represent loan size, interest rate, and collateral requirement respectively, they are all non-negative and $r > \mu$. The contract should satisfy the feasibility constraints at the same time, that is, the principal and interest to be repaid are greater than the level of collateral, namely, $L(1 + r) \geq C$. It is assumed that banks can costlessly divide

borrowing enterprises into SMEs group and large and medium-sized enterprises group. Banks know the average success probability of each group, but for each specific size group, banks are not aware of the success probability for each particular enterprise, moreover, the cost of supervising the behavior of the enterprise after the loan issuance for the bank is enormous. Assume that the loan review costs to banks are $c = f(\eta, \sigma)$, where η indicates the proportion of public property rights of the borrowing enterprise and σ indicates the degree of information asymmetry between the borrowing enterprise and the bank, it is obvious that $f'(\eta) < 0, f'(\sigma) > 0$, which means that the larger the proportion of public property rights of the borrowing enterprise, the smaller the loan review costs of the bank, and that the greater the degree of information asymmetry between the borrowing enterprise and the bank, the greater the loan review costs of the bank.

The use of collateral generally involves various costs, which include costs of necessary legal documentation, regulatory or insurance costs of the asset to maintain the value of the collateral at the agreed level, as well as implicit costs of the borrower being forced to relinquish discretionary use of the asset. Denote these costs by $Q(C)$ with $Q(0) = 0$ and $Q'(C) > 0$. Assume that $Q(C) = \xi C$ and these costs will be paid by the borrower (In general, $Q(C)$ will be shared by the borrower and lender, say, the borrower pay αQ and the lender $(1–\alpha Q)$. However, if lender and borrower can negotiate on α, Yuk-Shee Chan et al. (1985) indicated that the optimal solution will be $\alpha = 1$ [33]. Therefore, we suppose the bank will choose to assume all these costs here to simplify the exposition.). Suppose that the liquidation value of each unit of the collateral is δ times the original value, that is, the assets realization ratio of the collateral is δ, in which $0 < \delta < 1$.

Based on the above assumptions, expected bank profits ($E\pi$) and expected enterprise utility (ρ) are as follows:

$$E\pi = p_i L(1 + r) + (1 - p_i)\delta_i C - f(\eta, \sigma) - L(1 + \mu) \quad (1)$$

$$\rho = p_i U[G_i(K) - L(1 + r) + W_i] + (1 - p_i)U[W_i - (1 + \xi)C] - U(W_i) \quad (2)$$

3. Disadvantages of SMEs

Although SMEs have their own advantages and importance, they also have distinctive defects which made their financing more restricted relative to large and medium-sized enterprises. In this section, we will analyze the main disadvantages of SMEs which distinguished them from large and medium-sized enterprises.

A common problem in SMEs is that the proportion of fixed assets to total assets is too low. The core competitiveness of SMEs is often manifested in intangible assets such as intellectual property rights and brand value, thus lack of valid and collateralizable fixed assets. Fixed assets such as business premises and equipment are mainly obtained by renting or leasing. Even if these SMEs own the equipment themselves, the liquidity of their equipment are generally poor and are of low assessment value, thus unable to meet the standard of bank's collateral requirements, it is, therefore, difficult to meet the contractual terms of banks [34–36]. As a result, banks are unable to effectively control the credit risk. But in practice, banks mainly use mortgages or secured loans to lend to SMEs, for lack of valid assets as collateral, even SMEs have strong growth potential, it is difficult for them to obtain credit or other financial support through formal channels, such as banks, consequently turn into the main victim in credit rationing.

On the other hand, most SMEs are in highly competitive industries, they are vulnerable to the market environment and national policies, as well as economic cycle fluctuations [37–39]. SMEs are generally newly established enterprises with few employees and limited initial development funds, as a result, their production scale is small, their market competitiveness is weak, and their ability to resist risks is poor [40,41]. SMEs also lack detailed credit histories, therefore, banks are unable to accurately identify their credit's status and operational risks. Moreover, SMEs loans generally have "small loan scale", "short loan period" as well as "urgent and frequent loan demand", banks are faced with higher transaction costs when lending to SMEs with smaller capital needs [42]. Based on the above analysis, the rest of this section mathematically characterized the differences between

SMEs and large and medium-sized enterprises in terms of their project success probability and capital appreciation ability.

Suppose banks are able to correctly recognize that there are two differences in the average characteristics of SMEs and large and medium-sized enterprises. Firstly, other things being equal, the average risk of SMEs is greater than that of large and medium-sized enterprises, in other words, the average success probability of SMEs' projects is lower than that of large and medium-sized enterprises:

$$p_1 < p_2 \tag{3}$$

Secondly, under the same external environment and production inputs, once successful, the average return of SMEs' projects is less than that of large and medium-sized enterprises:

$$G_1(K) \leq G_2(K) \ \ \forall \mathrm{K} \tag{4}$$

For enterprises of different sizes, the difference between the average success probability of their projects implied by (3) reflects the low diversification of SME resources. Microenvironmental events can easily affect the overall operation of SMEs, whereas large and medium-sized enterprises are better able to eliminate the volatility in their production processes. For the difference between the average return of their projects in the case of success, firstly, it may reflect some scale economy in the production process, perhaps large and medium-sized enterprises can obtain better quality and more timely inputs. Secondly, it may reflect the greater experience and skill of large and medium-sized enterprises in using modern techniques.

Based on the above assumptions that the average success probability of SMEs' projects is lower than that of large and medium-sized enterprises and that the average return of SMEs' projects in the event of success is less than that of large and medium-sized enterprises, by considering the impact of these differences on expected bank profits, it is easy to demonstrate that, for given contract terms $(\overline{L}, \overline{C}, \overline{r})$, expected bank profits are higher on loans to large and medium-sized enterprises than on loans to SMEs (Here, our implicit assumption is that banks have the same review costs for loans to all enterprises. In fact, these costs would be relatively higher per yuan loaned to SMEs. Inclusion of these costs will only widen the gap in the expected profits of lending to large and medium-sized enterprises and to SMEs. As a result, it could lead SMEs to self-select out of the credit market at lower rates of interest.),

$$E\pi(\overline{L}, \overline{C}, \overline{r}|G_2, p_2) - E\pi(\overline{L}, \overline{C}, \overline{r}|G_1, p_1) \geq 0. \tag{5}$$

First of all, it is easy to demonstrate that expected bank profits are greater on loans to enterprises with higher capital appreciation capacity when average project success probability is held constant across enterprises. In other words, suppressing the notation indicating the fixed contract terms,

$$E\pi(|G_2, \overline{p}) - E\pi(|G_1, \overline{p}) \geq 0, \tag{6}$$

where, $G_2 \geq G_1$.

Secondly, expected bank profits are greater on loans to enterprises with higher average project success probability when capital appreciation capacity is held constant across enterprises,

$$E\pi(|\overline{G}, p_2) - E\pi(|\overline{G}, p_1) \geq 0, \tag{7}$$

where, $p_2 > p_1$.

This latter proposition can be demonstrated by substituting in the expression for expected bank profits given fixed contract terms $\overline{L}, \overline{C}, \overline{r}$,

$$\begin{array}{c} \left[p_2\overline{L}(1+\overline{r}) + (1-p_2)\delta\overline{C} - f(\eta,\sigma) - \overline{L}(1+\mu)\right] \\ -\left[p_1\overline{L}(1+\overline{r}) + (1-p_1)\delta\overline{C} - f(\eta,\sigma) - \overline{L}(1+\mu)\right], \end{array} \tag{8}$$

which is non-negative by condition (3), therefore, the above conclusion can be obtained.

The initial proposition of the differential expected bank profits of loans to enterprises of different sizes can now be seen by rewriting (5) as:

$$[E\pi(|G_2, p_2) - E\pi(|G_2, p_1)] + [E\pi(|G_2, p_1) - E\pi(|G_1, p_1)]. \tag{9}$$

by (6) and (7), both expressions in square brackets are positive, so that expected bank profits are in fact higher on large and medium-sized enterprises if contract terms are identical. Therefore, we have the following proposition:

Proposition 1. *With other things being equal, the average success probability of SMEs' projects is lower than that of large and medium-sized enterprise, and once successful, the average return of SMEs' projects is less than that of large and medium-sized enterprise. As a result, expected bank profits are higher on loans to large and medium-sized enterprises than on loans to SMEs.*

However, when loan demand is greater than supply, banks will choose from borrowing enterprises that, for any given contract terms, will yield the highest risk-adjusted expected net return. To select such enterprises, banks will compare: (1) cost of granting loans to enterprises of different sizes; (2) difference in expected returns across these enterprises that banks consider to be equally risky; and (3) differences in risks and willingness to pay across these enterprises that banks consider to be of equal expected returns. Therefore, it is just these flaws in SMEs themselves put them in a disadvantaged place in credit markets. In the following two parts, we analyzed the signaling mechanism of borrowing enterprises and the screening mechanism of banks before and after the loan issuance.

4. Signaling and Screening Mechanism before Lending

Before the loan transaction, borrowing enterprises send signals to banks by selecting contract terms, which can reflect their risk preference and level of credibility. And banks screen borrowing enterprises by making incentive compatible contract terms based on profit maximization principle. This section analyzed borrowing enterprises' signaling mechanism and banks' screening mechanism under ex-ante information asymmetry.

4.1. Conditions for Banks to Grant Loans to Enterprises

Bank loans should meet the following constraint:

$$E\pi = p_i L(1+r) + (1-p_i)\delta_i C - f(\eta, \sigma) - L(1+\mu) \geq 0 \tag{10}$$

In the equilibrium of competitive credit markets, expected bank profit is 0, thus we assume that expected bank profits on any loan are constant at 0. Differentiating expression (10) according to the implicit function derivation rule, the marginal substitution rate between the interest rate and the collateral requirement is

$$\frac{dr}{dC} = -\delta \frac{1-p_i}{p_i L} < 0 \tag{11}$$

Differentiating (11) with respect to p_i, we have

$$\frac{d}{dp_i}[\frac{dr}{dC}] = \frac{\delta}{L}\frac{1}{p_i^2} > 0 \tag{12}$$

Differentiating (10) with respect to p_i, we have

$$\frac{dE\pi}{dp_i} = L(1+r) - \delta C > 0 \tag{13}$$

According to expression (11) and (12), we get the iso-expected profit curve of the bank for collateral C and interest rate r $--\overline{E\pi}(L,C,r)--$ when the credit market is in equilibrium, as shown in Figure 1.

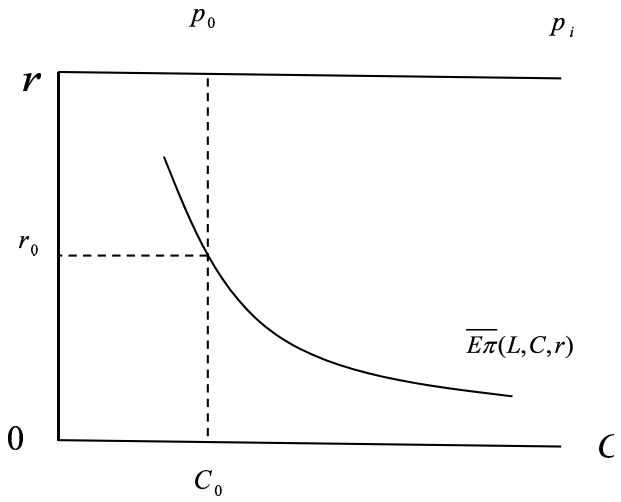

Figure 1. The iso-expected profit curve of the bank. Where, r: interest rate; C: collateral requirement; p_i: average success probability of group i's project; $\overline{E\pi}(L,C,r)$ the iso-expected profit curve of the bank for collateral c and interest rate r when the credit market is in equilibrium; r_0: credit rationing equilibrium interest rate; C_0: collateral requirement corresponding to r_0 on the iso-expected profit curve; p_0: borrowing enterprise's project success probability corresponding to r_0 on the iso-expected profit curve.

As we can see from Figure 1, the slope of $\overline{E\pi}(L,C,r)$ increases gradually with the increase of collateral requirement C and the decrease of interest rate r, which indicate that the slope of $\overline{E\pi}(L,C,r)$ increases with the project success probability of borrowing enterprises. Therefore, in equilibrium, banks are willing to provide low-interest rate and high collateral requirement contracts for enterprises with higher project success probability, while providing high-interest rates and low collateral requirement contracts for enterprises with lower project success probability.

In the light of theorem 1, theorem 2 and theorem 5 in the paper of Stiglitz, Weiss (1981) [3], we can see that, under information asymmetry, as the interest rate exceeds the credit rationing equilibrium interest rate r_0, expected bank profit of each loan will decrease with the interest rate. Therefore, as the interest rate $r > r_0$, expected bank profit must be less than that on the iso-expected profit curve in equilibrium. Suppose the collateral requirement corresponding to r_0 on the iso-expected profit curve is C_0, and the corresponding project success probability of the borrowing enterprise is p_0, then in equilibrium, on the iso-expected profit curve, expected bank profit must satisfy the condition that $C \geq C_0$. That is, in Figure 1, any point lies in the region where $C < C_0$ will not be a loan contract designed by banks for borrowing enterprises. Since expected bank profit in equilibrium is 0, according to formula (1), the expression of C_0 is

$$C_0 = \frac{L(1+\mu) + f(\eta,\sigma) - p_0(1+r_0)}{(1-p_0)\delta} \tag{14}$$

where, C_0 is the minimum collateral value for banks to screen borrowing enterprises. However, since the asset size of the borrowing enterprise needs to meet the condition $W_i - C_i > 0$, as a result, the amount of collateral provided by the enterprise that $W_i < C_0$ is limited by the total amount of its collateralizable assets, hence C_0 is also the critical asset size of enterprises entering credit market. Nevertheless, as we've expounded before, the asset size of SMEs are smaller than that of large and medium-sized enterprises, consequently, due to lack of collateralizable assets, SMEs are more likely to be suffered from credit rationing.

In addition, since for banks, there is a cost of making a loan, so there is a break-even point in the loan size, that is, there are a minimum loan size and a capital preservation interest profit. According to condition (10) and holding other variables constant, we have

$$L_0 = \frac{(p_i - 1)\delta C + f(\eta, \sigma)}{p_i(1 + r) - \mu - 1} \tag{15}$$

$$L \geq L_0 \tag{16}$$

where L_0 represent the minimum loan size of a single loan of banks, rL_0 is the capital preservation interest profit of banks. However, for SMEs, their capital demand size tend to be lower, generally smaller than the critical loan size of banks, banks obtain relatively low profits from such enterprises, as a result, banks are reluctant to lend to SMEs. To sum up, we have the following proposition:

Proposition 2. *Borrowing enterprises whose initial asset size below the critical collateral value are unable to transmit their risk levels and borrowing enterprises whose loan size below the minimum loan size cause higher costs to banks. But SMEs tend to have lower initial asset size and tend to borrow less, which could not meet the profit maximization goal of banks, therefore, they are more likely to be suffered from credit rationing.*

4.2. Conditions for Enterprises to Apply for Loans

Borrowing enterprise should meet the following constraints in applying for a loan:

$$\rho = p_i U[G_i(K) - L(1 + r) + W_i] + (1 - p_i)U[W_i - (1 + \xi)C] - U(W_i) \geq 0 \tag{17}$$

Differentiating expression (17) according to the implicit function derivation rule, borrowing enterprise's marginal substitution rate between the interest rate and the collateral requirement is

$$\frac{dr}{dC} = -\frac{(1 + \xi)(1 - p_i)U'[W_i - (1 + \xi)C]}{Lp_i U'[G_i(K) - L(1 + r) + W_i]} < 0 \tag{18}$$

Differentiating (18) with respect to p_i, we have

$$\frac{d}{dp_i}[\frac{dr}{dC}] = \frac{(1 + \xi)U'[W_i - (1 + \xi)C]}{Lp_i^2 U'[G_i(K) - L(1 + r) + W_i]} > 0 \tag{19}$$

According to inequality (18), r varies inversely with C, which indicates that, for any borrowing enterprise, they are willing to pay lower interest rate when banks demand higher collateral, while they are willing to offer less collateral when banks demand higher interest rate. As $p_1 < p_2$, we have $\frac{d}{dp_1}[\frac{dr}{dC}] < \frac{d}{dp_2}[\frac{dr}{dC}]$, that's to say, compared with SMEs, large and medium-sized enterprises are willing to offer more collateral in exchange for bank's interest concessions, because they are more likely to recover their collateral. However, SMEs with higher average risks are just the opposite case.

4.3. The Influence of Each Variable on Expected Bank Profits

We've analyzed the influence of borrowing enterprises' risk level and capital appreciation capacity on expected bank profits. Now we continue to discuss the impact of other variables on expected bank profits and how these impacts affect the credit availability of borrowing enterprises.

4.3.1. The Proportion of Public Property Rights of Borrowing Enterprises

Differentiating $E\pi$ with respect to η and according to the condition that $f'(\eta) < 0$, we have

$$\frac{\partial E\pi}{\partial \eta} = -f'(\eta) > 0 \tag{20}$$

That is to say, expected bank profits vary directly with the proportion of borrowing enterprise's public property rights, that is, the higher the proportion of borrowing enterprise's public property rights, the higher the expected bank profits. However, public property rights of SMEs have are generally low. Therefore, private property rights is an extremely significant factor that affects the credit availability of SMEs in developing countries.

4.3.2. The Degree of Information Asymmetry between Banks and Borrowing Enterprises

Differentiating $E\pi$ with respect to σ and according to the condition that $f'(\sigma) > 0$, we have

$$\frac{\partial E\pi}{\partial \sigma} = -f'(\sigma) < 0 \tag{21}$$

Which means that, expected bank profits vary inversely with the degree of information asymmetry between borrowing enterprises and banks, that is, the higher the degree of information asymmetry between borrowing enterprises and banks, the lower the expected bank profits. However, compared with large and medium-sized enterprises, there is generally a greater degree of information asymmetry between SMEs and banks, so the degree of information asymmetry between enterprises and banks is another important factor that affects the credit availability of SMEs in developing countries.

4.3.3. Different Types of Collateral

As we've noted before, the core competitiveness of SMEs is manifested in intangible assets, thus lack collateralizable fixed assets for financing. What would happen to SMEs if they rely on intangible assets to apply for loans?

Suppose borrowing enterprises can be divided into two groups according to the types of their collateralizable assets, one group uses intangible assets as collateral, the other group uses traditional tangible assets as collateral (denoted by i = 1, 2 respectively). Assume that for given contract terms (L, C, r), their assets realization ratio of the collateral are δ_1, δ_2 respectively. Owing to the fact that compared with traditional tangible collateral, the loan trading market with intangible assets as collateral is not very perfect yet, the process of disposal and realization of intangible assets is very complicated, banks face many obstacles in getting loan repayment by disposing of intangible assets, it is difficult for banks to recover funds timely by means of asset auctions, leases, transfers, etc. Therefore, we assume that $\delta_1 < \delta_2$.

Differentiating $E\pi$ with respect to δ_i, we have

$$\frac{\partial E\pi}{\partial \delta_i} = (1 - p_i)C > 0, \tag{22}$$

which indicate that, the higher the assets realization ratio of the collateral, the higher the expected bank profits. However, for two types of collateral with the same risk level, $\delta_1 < \delta_2$, as a result, $E\pi_1 < E\pi_2$, consequently, banks are more willing to lend to borrowing enterprises that provide traditional tangible collateral.

In the actual loan business, value determination cost and assets realization ratio of the traditional tangible collateral (such as land, real estate, machinery equipment etc.) are relatively stable, for banks that lack experience in intangible asset lending, the variance in the assets realization ratio of collateral $\delta_1 - \delta_2$ and the difference in expected bank profits $E\pi_1 - E\pi_2$ are even greater. This partly explains that, when borrowing enterprise uses intangible assets as collateral, even they have good reputation and profitability, most inexperienced banks still choose to lend to borrowing enterprises who can provide traditional tangible collateral, which lead to more serious credit rationing, and it is more difficult for SMEs to obtain credit funds. In summary, we have the following proposition:

Proposition 3. *Compared with large and medium-sized enterprises, SMEs lack tangible assets as collateral, have a lower proportion of public property rights, and exists a greater degree of information asymmetry with banks, all these factors resulting in lower expected bank profits, thus exacerbating credit rationing in SMEs.*

5. Moral Hazard Inhibition Mechanism after Lending

After a borrowing enterprise obtains a loan, it may also have "moral hazard" problem because of bank's inability to supervise its behavior, this problem may be manifested in the transfer of credit funds from the project to non-productive uses. The investment decision made by the enterprise after obtaining loans will affect the project success probability and the expected enterprise returns, thus affect the expected bank profits, this stage of decision embodies the incentive effect. Considering this moral hazard problem caused by the ex-post asymmetric information, banks would impose stricter credit rationing on borrowing enterprises ex-ante. In this section, we assume that borrowing enterprises can freely allocate the credit funds they receive between production and consumption purposes, and then we have explained how this autonomy affects the behavior of borrowing enterprises and, in turn, the credit decisions of banks.

5.1. Incentive Effects of Borrowing Enterprises

Assume that risk-neutral borrowing enterprise chooses to invest K in the project, which is less than the loan size, L, that is, the amount of credit $L - K$ will be transferred by the borrowing enterprise for consumption uses. The expected utility of the borrowing enterprise is the sum of the utility of the credit diversion $L - K$ plus the utility of the investment return ρ. Given loan contract terms, borrowing enterprise's optimization problem is to choose the funds K invested in the project to satisfy

$$\begin{aligned} &\max_{K}\{U(L-K)+\rho\}, \\ s.t. \quad &\\ &eq.(2), \\ &K \leq L. \end{aligned} \tag{23}$$

For this optimization problem, by Lagrange multiplier method, we have the following first-order condition:

$$p_i U'[G_i(K) - L(1+r) + W_i]G'(K) \geq U'(L-K) \tag{24}$$

where $K = L$ if the strong inequality holds.

Denote the solution to this problem as $K*(r)$, as (24) shows, $K*(r)$ is selected by comparing the expected marginal return to investing borrowed funds in the project with their marginal utility of funds for consumption uses. No analytically useful expression can be given for conditions under which the solution to (23) is an interior maximum and diversion of credit to consumption uses occurs (i.e., $K* < L$). Nonetheless, given contract conditions, as K approaches L, expected enterprise utility is almost certainly concave in K, and may be decreasing. (Differentiation of the first order condition (24) with respect to K yields $p_i U'[G_i(K) - L(1+r) + W_i]G''(K) < 0$. Thus, the expected enterprise return has a concave portion with respect to K, and has a turning point.)

Now we can see the incentive effect of raising interest rates on the behavior of borrowing enterprise. As r increases, the level of average success probability p_i and average project return in the event of success $G_i(K)$ needed for the enterprise to repay the loan increases, expected returns to investment subsequently decline, and as the left-hand side of condition (24) decreases, incentives for credit diversion increase. Actual credit diversion will increase if the solution to (23) is, or becomes, an interior one. Other things equal, increased credit diversion will decrease $G_i(K)$ and expected bank profits. However, banks can diminish incentive effects by restricting loan size so that marginal returns to investment funds $G_i{}'(K)$ remain high.

5.2. Credit Rationing in SMEs under Incentive Effects

The above analysis shows that, from the bank's point of view, as the interest rate increases, borrowing enterprise autonomy in credit use can cause average borrowing enterprises characteristics to worsen. Banks in our model face a situation similar to that in the Stiglitz-Weiss model. After some critical interest rates r_i*, expected bank profits per loan to borrowing enterprise in the group i begin to decrease in r. So how does this functional relationship affect the credit market equilibrium?

Even if banks treat all borrowing enterprises as identical if there is excess demand for loans at $r*$, it would be better for banks to arbitrarily rations credit to borrowing enterprises at $r*$ than if it raises the interest rate to eliminate the excess demand. At interest rates $r*$ where excess credit demand exists, banks can still make the same amount of loans that it could at a higher interest rate. Average bank profits per loan made will be higher at $r*$ even though banks arbitrarily select borrowing enterprises to grant loans. In other words, banks would find it profit maximizing to impose an interest rate restriction.

However, in general, banks can distinguish between large and medium-sized enterprise group and SMEs group, and have transaction records of each large and medium-sized enterprise, thus could design specific credit contracts for large and medium-sized enterprises, so the problem of credit rationing in large and medium-sized enterprises would disappear. It has been proved that for given contract terms, expected bank profits on loans to large and medium-sized enterprises exceeds that to SMEs. Even if the incentive effect were identical on large and medium-sized enterprises and SMEs (i.e., $r_1* = r_2*$), this differential expected profitability alone could cause SMEs to be eliminated from the credit market. As shown in Figure 2, at the endogenous interest rate ceiling of $r*$, it would always be more profitable to lend to large and medium-sized enterprises. Only after the interest rate had been lowered to $\hat{r}$, and all large and medium-sized enterprises desiring loans at $\hat{r}$ had been given credit, would it be possible for any SME to receive credit.

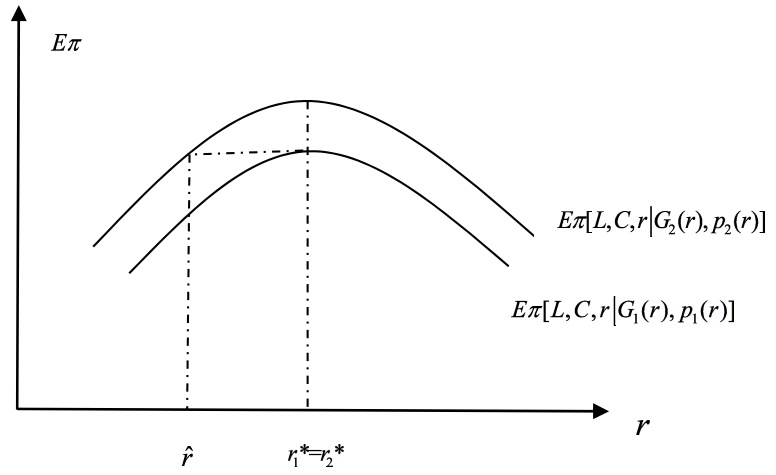

Figure 2. Endogenous interest rate restrictions and equilibrium credit rationing. (Where, r: interest rate; $E\pi$: expected bank profit; $E\pi[L, C, r|G_1(r), p_1(r)]$: expected bank profits on loans to SMEs; $E\pi[L, C, r|G_2(r), p_2(r)]$: expected bank profits on loans to large and medium-sized enterprises; r_1*: interest rate that maximizes expected bank profits on loans to SMEs; r_2*: interest rate that maximizes expected bank profits on loans to large and medium-sized enterprises; $\hat{r}$: interest rate that lower than r_1* and r_2*.).

In fact, the situation is likely to be even less favorable for SMEs than Figure 2 shows. Because funds available for self-consumption is likely to be relatively lower on SMEs, incentives for credit diversion are likely to be even higher. Greater risk and output variability on SMEs would further heighten relative SMEs adverse incentive effects. More severe incentive effects on loans to SMEs would imply that per-loan expected profits begin to diminish at a lower interest rate on SMEs ($r_1* < r_2*$),

Figure 3 illustrates this situation. At best, in an adverse incentive constrained equilibrium, SMEs will now only be rationed credit after all large and medium-sized enterprises desiring credit at interest rate $\hat{r}'$ receive loans. For a given opportunity cost and supply of loanable funds, it becomes more likely that SMEs will be completely rationed out from formal credit markets.

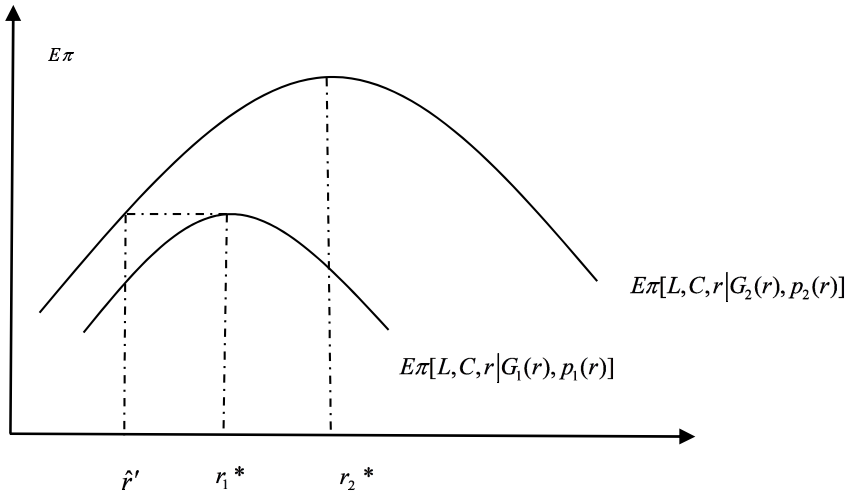

Figure 3. Credit rationing when incentive effects are more severe on SMEs.

Above all, we have the following proposition:

Proposition 4. *Compared with large and medium-sized enterprises, SMEs at lower living standards (with higher $U'(L-K)$) have a stronger incentive to increase current consumption at the expense of future investment returns. With other things being equal, increased credit diversion will decrease borrowing enterprise's project expected returns and thus decrease expected bank profits. Considering this, banks will apply stricter credit rationing to reduce this incentive effect, thus making the financing constraints of SMEs more severe.*

6. Conclusions and Remarks

Although there has been substantial research on the problem of borrowers' financing constraints at home and abroad, the enterprises' size has not been taken into account yet. The research on the causes of financing barriers of SMEs is not systematic and deep enough. In order to explain the formation mechanism of credit rationing in SMEs, by considering the differences between SMEs and large and medium-sized enterprises in terms of their project success probability and capital appreciation ability, we have established a comprehensive credit rationing model of endogenous enterprise size. And by considering banks' screening principles before and after the loan approval, this paper systematically analyzed the internal mechanism of credit rationing in SMEs.

The conclusion shows that, the main reason why it is more difficult for SMEs to obtain credit funds in the formal credit market lies in that, before approving the loan, SMEs are unable to transmit their risk levels, as their initial asset size are generally below the critical collateral value, and loan to SMEs cause higher costs to banks, as their loan size are generally below the minimum loan size. SMEs also lack tangible assets as collateral, exists a lower proportion of public property rights, and have a greater degree of information asymmetry with banks. Besides, after approving the loan, SMEs at lower living standards have a stronger incentive to increase current consumption at the expense of future investment returns, which would decrease borrowing enterprise's project expected returns. All these factors resulting SMEs loan less profitable for banks, considering this, the rational choice of profit maximization banks is to ration credit on SMEs.

This kind of credit market equilibrium reduced the allocation efficiency of credit resources and distorted the Pareto optimization of the whole society. Ration credit on SMEs with relatively high

productivity and relatively low risk hampered the use of credit, and other things equal, distorted equilibrium credit allocation away from SMEs.

This study has important implications, especially for banks and governments. According to the results of the theoretical analysis, in order to correct this distortion phenomenon and fundamentally solve the credit rationing problem, thereby increasing the credit availability of SMEs and improve the sustainability of credit market's stable development. On one hand, being able to analyze and predict market and customer behavior with Big Data is a new paradigm shift for SMEs [43]. The core features of big data can be characterized by "volume, velocity, variety" [44]. Using credit technology based on big data, commercial banks can efficiently analyze more than trillion bytes of relevant information, which can improve the loan approval efficiency and reduce the degree of information asymmetry between SMEs and banks. Therefore, banks should use big data to carry out credit technology innovation, based on the quantitative information which resides in the bank management information system to predict risk and identify loan applicants, instead of making credit decisions based on the qualitative characteristics of loan applicants.

On the other hand, the failure of the market to solve the problem provides a justification for government intervention. The aim of government support for SMEs is to ultimately establish, without governmental financial aid, viable, competitive, and innovative SMEs [45]. Governments can provide a variety of support services for SMEs. These include provisions for targeted and quality business support services; immediate, technical, and managerial training programs; the cutting of administrative costs and burdens of SMEs; building network cross sectors and cross borders; provisions for financial incentives and assistance; and legal framework reinforcement [46,47]. The government can also compensate banks for risk losses, and banks grant loans to SMEs. These measures can increase the credit availability of SMEs, thus alleviate the financing constraints of SMEs. Therefore, the sustainability of the national economy and the healthy development of SMEs need the joint efforts of all parties.

This study presents some limitations. First, in the analysis of moral hazard inhibition mechanism after lending, we assume that borrowing enterprises are all risk-neutral, in fact, we can prove that even if borrowing enterprises are assumed to be risk averse, banks still potentially face adverse incentive and selection effects, thus we can obtain the same conclusions as in risk-neutral situations. Future research can discuss this situation in detail. In addition, this paper theoretically analyzed the formation mechanism of credit rationing in SMEs, but all the propositions have not been tested empirically. Future research can use credit data from enterprises and banks for empirical testing. These data can be obtained from bank financial statements and questionnaires on borrowing enterprises.

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