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# Is collective financing feasible for small and micro-sized enterprises? An evolutionary game analysis of the credit market in China

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## ABSTRACT

With regards to the evolutionary game model of collective financing between commercial banks and small and medium-sized enterprises (SMEs), the self-guarantee mechanism formed within the enterprise group is taken as the research background in the paper. Under the circumstances of mortgage assets and unsecured assets, the changing trend of the strategies of both sides in the process of collective financing is made a discussion respectively. Followed by the evolutionary game, it is concluded that under the stable management strategy, commercial banks will offer different loan strategies (collective or separate) after comprehensively judging the repayment probability of enterprises. For SMEs, loans at a reasonable rate can prompt them to pay them back on time, however, high loan costs can lead to the possibility of total financing default and the adverse circumstances of risk diffusion. More importantly, collective financing of unsecured assets does not increase the bank's credit risk, while not only can it help banks reduce the cost of loan review, but also alleviate the problem of information opacity in SMEs, prevent the occurrence of default risk and reduce the threshold for enterprises to obtain funds and also provide a new way to solve the financing problems of SMEs.

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## 1. Introduction

The healthy development of small and micro-sized enterprises plays a decisive role in stabilising economic growth, adjusting industrial structure, and promoting technological innovation. However, these enterprises encounter difficulty in obtaining financial support from commercial banks or other financial institutions due to information transparency problem, lack of accredited mortgages, and vulnerability to external economic environment. Thus, some of these enterprises even resort to private usury. Once these enterprises encounter difficulties in business operation, capital chain rupture will occur, thereby leading them to a capital crisis for failure to repay the loan. Serious social problems may even occur when the capital supplier recovers the loan.

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In 1931, MacMillan (1931), a British scholar, elaborated on the funding gap faced by small and micro-sized enterprises in the process of creation and development, which they referred to as the ‘Macmillan gap’. This finding shows the long-standing problems in the financing difficulty of small and micro-sized enterprises. Advanced economies and emerging market countries are applying different solutions to solve this problem and break the bottleneck that hinders the rapid development of small and micro-sized enterprises. Developed economies in Europe and America commonly adopted financing methods, such as venture capital and GEM listing, to provide financial assistance for small and micro-sized enterprises. These approaches achieved good results. However, this type of direct financing can only serve as reference because China’s capital market is not yet fully developed and some indirect financing models that involve guarantee agencies are gradually developing. The practice of these models shows the limited coverage of guarantee agencies in China. Moreover, the guarantee costs are high and guarantee procedures are complicated. Only a few small and micro-sized enterprises received funding through this model in the actual financing process. However, this type of ‘guarantee and credit enhancement’ financing model is worth exploring. Moreover, many enterprises applied collective financing models, such as the issuance of collective bonds, collective bills, or cluster financing, due to the weak financing capability and high financing cost of individual small and micro-sized enterprises. These models are typical collective financing models. In this type of financing model, the enterprise pool either chooses to use a third-party guarantee agency for guarantee or raise funds in the financial market by virtue of the company’s own ‘core competitiveness’ as guarantee condition (Gao, 2007). The former approach, which can allow multiple companies to jointly search for third-party guarantee agencies, can improve the credit rating of companies in the collective and reduce the financing costs of each enterprise. The latter approach is a self-guarantee model built by enterprises in the group. This approach offers similar advantages, increases the convenience of enterprise asset allocation within the group, and serves as a mutual supervisory role for the enterprises within the group. These advantages facilitate information transparency and enables enterprises to raise funds through financial institutions such as banks.

This study analyzes strategy evolution and change trend in small and micro-sized enterprises and financial institutions. Financial institutions without loss of generality are simplified as commercial banks in this study. The analysis is based on the collective financing model and different loan-constrained conditions, namely, secured and unsecured assets. This study aims to provide a theoretical basis for small and micro-sized enterprises to obtain effective financing channels. The self-guarantee model formed in small and micro-sized enterprises is used as research background with the application of evolutionary game theory.

## **2. Literature review**

### **2.1. Small and medium-sized enterprise loan**

Making a comprehensive survey at the literature on the financial services provided by commercial banks to small and medium-sized enterprises in recent years, most of

them believe that large banks or foreign banks have little interest in providing financial services for small and medium-sized enterprises. However, when providing financial services to small and medium-sized enterprise, small banks or some professional banks can use relational loans to overcome barriers to information opacity, so that they have a comparative advantage. The main types of bank loans are divided into relational loans and trading technical loans (Berger & Udell, 2006), where a relationship loan based on trust has an advantage over long-term co-operation with banks in promoting financial support for small and micro-businesses (Hernández-Cánovas & Martínez-Solano, 2010). This kind of relationship loan, which is established by trust, usually uses 'soft information' for credit review. For example, joint-stock banks can obtain 'soft information' by asking corporate customers, enterprise suppliers, or business partners to lend to small and medium-sized enterprise, thus providing lower loan costs for small and medium-sized enterprise, therefore, such banks are more important for small and medium-sized enterprise in post-transition economies (Bartoli, Ferri, Murro, & Rotondi, 2013), however, large banks and foreign banks will not adopt 'hard information' technologies such as small business rating technology or fixed asset evaluation technology to carry out trading technical loans for small enterprises (Hasan, Jackowicz, Kowalewski, & Kozłowski, 2014). However, small medium-sized enterprise trading technical loans are not without advantages, and small medium-sized enterprise that obtain loans by means of fixed asset mortgages also have an advantage in terms of loan interest rates (Huo, Feng, & Liu, 2015). More generally, when different types of banks have new technologies, new business models, or risk management models, they develop a broad range of financial products and services for small medium-sized enterprise so that access to financing for small medium-sized enterprise is no longer dependent on relational lending (De la Torre, Pería, & Schmukler, 2010). In China, commercial bank lending remains one of the most important sources of financing for most small and medium-sized enterprise that do not have experience in financing. However, there is no significant difference in the risk of default arising from both the general credit loan and the third-party secured mortgage (Song & Zhang, 2018). As a result, the traditional bank loan model still needs to be explored and innovated to provide more diversified financial and credit services for small medium-sized enterprise. For example, the asset mortgage securitisation or collective financing model mentioned below is a change to the traditional loan mode of small and medium-sized enterprise to meet the capital needs of small and medium-sized enterprise at different stages of development.

## **2.2. SPV**

In the face of the global economic crisis (2007–2009) and the European sovereign debt crisis (2011–2013), there has also been a huge shift in the financing model of small medium-sized enterprise in Europe, and innovative financing tools are helping enterprises to get financial support as soon as possible to maintain business operations, Prelipcean and Boscoianu (2014) used SPV multiple times in a hybrid financing framework based on government and special investment funds for small and micro enterprise financing, which can overcome the shortcomings of financing difficulties

in the capital markets of small and medium-sized enterprise and reduce the credit risk of loans, bring stable expected cash flow for small and micro-business loans, which is more common in the European market (Oricchio, Lugaresi, Crovetto, & Fontana, 2017). Even though asset securitisation does counteract the negative impact of information asymmetry (Albertazzi, Bottero, & Gambacorta, 2017). Franke and Krahen (2017) compared the SPV loan model of small and medium-sized enterprise with the collective financing loan model and it's believed that in order to avoid the establishment of too many legal entities, the transaction cost of the collective financing loan model is lower than that of the mortgage asset securitisation model represented by SPV. The repeated communication among the members of the collection reduces the audit cost of the loan collection by the rating agencies, and as a result, it is preferred by the small and medium-sized enterprise.

### **2.3. Social capital**

At present, scholars at home and abroad still have relatively little research on collective financing, and the idea of this financing model can be explained by the concept of social capital. Granovetter (1973) put forward the concept of social capital and defined it as the connection between individuals and groups, which is the social resource brought about by the position of people in the social structure. Montgomery (1996) introduced the concept of social capital into microcredit and explained the restraint effect of social capital on the problem of borrower's malicious arrears. As the joint responsibility generated by the shared social capital in the group has a positive repayment effect on the borrower (Besley & Coate, 1995), the collection financing group will increase the probability of repayment by screening, supervision and execution (Giné & Karlan, 2014). The existence of social capital usually lowers the cost of enterprise financing (Uzzi, 1999) and brings higher benefits (Ghatak, 1999) to borrower groups and when the individual social capital of collective financing is increased, the probability of repayment of collective financing will also be increased (de Quidt, Fetzer, & Ghatak, 2016). It can be said that the study of collective members' social capital provides a detailed theoretical basis for the construction of collective financing of small and medium-sized enterprise.

### **2.4. Collective financing**

Under the credit environment of China, the discussion on collective financing is gradually increasing in, Zhang and Liang (2004) believes that the community credit resources can also be used as an important way to improve the credit level of small and medium-sized enterprises to alleviate the problem of financing difficulties of enterprises. With regards to different types of social credit resources, different social credit cooperation organisations can be constructed to achieve the purpose of sustainable development of microcredit (Wang & Huang, 2006), and typical financing models using social capital, such as enterprise group, supply chain financing, industry chain financing and collective financing, can all play a role in obtaining greater credibility for the members of the participating groups. Such kind of 'group financing,

pooled guarantee' model overcomes the financing defect of small and medium-sized enterprises that credit risk increases due to the defect of enterprise scale (Li, Li, Tang, & Zhao, 2010; Zhang, Chen, & Cai, 2008). Outside China, there are a great number of scholars who have conducted empirical studies on collective financing through sample data from lending institutions, and it's believed that this model is more popular with large banks. By means of peer supervision and joint responsibility, the collective financing model of co-guarantee can be conducive for banks to reduce the information asymmetry of enterprises (Columba, Gambacorta, & Mistrulli, 2010; Bartoli, Ferri, & Murro, 2013). Similarly, from the point of view of loan institutions, Chowdhury (2007) gives the criteria for judging the quality of credit members in collective financing by means of theoretical model analysis. In addition, more and more scholars pay attention to the influence of the size of pooled financing and the background of members on the efficiency of social capital in collective financing (Ahlin, 2015; Mukherjee & Bhattacharya, 2015), all of which provide a theoretical reference for the construction of collective financing portfolio. Some other scholars also have found that increasing the requirement of collateral in the process of collective financing will increase the probability of repayment, while it also reduces the degree of participation in the credit market (Flatnes & Carter, 2016). Therefore, whether the collateral has to exist in the bank collective financing of small medium-sized enterprise is still open to question.

The literature review shows that discussions on commercial bank loans and collective financing of small and micro-sized enterprises are conducted separately. Only a few studies combined jointly analysed this innovative financing model. Several studies also pointed out the insufficient mortgages often encountered in small and micro-sized enterprise loans, but they did not provide an effective solution. The mortgage financing channels of commercial banks failed to alleviate the shortage of funds for small and micro-sized enterprises. Moreover, domestic and foreign studies on collective financing models mainly focused on their advantages. Specific discussions on the interests of both parties in investment and financing were lacking. Thus, the present study constructs collective financing modes under different constraints to examine changes in the strategies of commercial banks and enterprises through evolutionary game theory. This study also provides reasonable suggestions for improving the financing environment of small and micro-sized enterprises.

### **3. The analysis of the collective financing loan model**

Traditional game theory assumes that the player is completely rational and predicts the player's tactical behaviour from a rational perspective under perfect information through Nash equilibrium. Smith (1974) proposed the Evolutionarily Stable Strategy (ESS), which is an important concept in evolutionary game theory that liberated the theory from the perfect rationality hypothesis; ESS facilitated the development of evolutionary game theory. This theory started from a completely new perspective and reasonably assumed the player's bounded rational behaviour. Various factors that affected the player's behaviour were included in the discussion through multiple learning adjustment processes to examine the strategy selection issues of the two

players in the game when the system reached an evolving stable state. Taylor and Jonker (1978) established a dynamic model of imitators in 1978. Under this framework, the core of game analysis was no longer the optimal strategy selection in traditional games, but an analysis of the process, trends, and stability of strategy adjustment of members in a group of bounded rational players (Xie, 2002). At the end of the twentieth century, many economists introduced the theory into economics; evolutionary game theory then started to shift from the research of symmetrical games to the gradually in-depth study of asymmetric games (Selten, 1980, 1983; Friedman, 1991; Taylor, 1979). Since the issuance of small and medium-sized enterprises bonds (bills) in China in 2007, they have received extensive attention from the industry and academia. However, the scale of bond financing is higher, much higher than that of most small and medium-enterprises. Therefore, it's hoped to pay attention to the bank loan model preferred by small enterprises, to pay attention to the crux of the difficulty of small and medium-sized enterprises in bank loans, and to solve the problem of the lack of approved collateral in enterprises, to provide feasible solutions for small and medium-sized enterprises to obtain convenient bank loans, and to expand financing channels for small and medium-sized enterprises. On this basis, the different situations in which enterprises participate in collective financing is designed and studied in the paper, and it makes a classification comparison and reasoning on whether enterprises need to provide mortgage loans or not. In the end, it is concluded that unsecured bank pooled financing loans are also applicable to small and medium-sized enterprises and banks.

This study establishes a replication dynamic model of evolutionary game and applies it to the cooperation between small and micro-sized enterprises and commercial banks in the case of a collective financing model. Given the asymmetry of information, both banks and enterprises are bounded, rational participants. Thus, this issue should be discussed using evolutionary game theory. Commercial banks can gradually understand the strategy selection trend of small and micro-sized enterprises under different loan modes and analyse their policy adjustment process under different policies. After clearly determining the evolutionarily stable strategy of the game player, banks can design loan products suitable for small and micro-sized enterprises and improve their financing products and services.

### ***3.1. Collective financing model that require mortgage***

#### ***3.1.1. Model assumptions***

Taking into account the limitation of bank loan of small and medium-sized enterprises, five assumptions, such as collective financing loan costs (Madajewicz, 2011), bank loan review costs (Madajewicz, 2011), loan interest rates (Kodongo & Kendi, 2013), risk reserve fund of the collective financing group (de Quidt et al., 2016), collateral value ratio (de Quidt et al., 2016), are set up by drawing lessons from the issuance mode and mechanism of small and medium-sized enterprises aggregate bonds, in addition, in this paper, an evolutionary game model for enterprises to obtain bank loans by means of collective financing is constructed, the change of strategy between commercial banks and enterprises are made an analysis and reasonable suggestions



are put forward to improve the financing environment of small and medium-sized enterprises. Commercial banks mostly use mortgage loans to conduct financing services in their actual cooperation with enterprises. The following assumptions are provided given that small and micro-sized enterprises provided banks with recognized mortgages.

**Assumption 1.** *Small and micro-sized enterprise can either form a group with multiple enterprises, negotiate with the bank and obtain loans by collective financing or obtain loans through individual financing if its own mortgages are sufficient. For the two methods, the expenses that the enterprise must pay when it chooses to get loans by individual financing and collective financing are  $c_1$  and  $c_2$ , respectively, which include contingent guarantee fees, handling fees and loan interest expenses.*

**Assumption 2.** *The bank's review costs of individual financing and collective financing for each small and micro-sized enterprise in obtaining loans are  $f_1$  and  $f_2$ , respectively. The loan interest rates are  $r_1$  and  $r_2$ , respectively.*

**Assumption 3.** *In the collective financing group, a total of  $m$  small and micro-sized enterprises exist, and each enterprise's deposit for the collective financing is  $q_i$ . Then, the collective financing group indicates a total deposit of  $Q = \sum_{i=1}^m q_i$  as the risk reserve fund, which can be repaid to the bank in case of default.*

**Assumption 4.** *The values of mortgages that can be provided to the bank when the enterprise obtains loans by individual financing or collective financing are  $M_1$  and  $M_2$ <sup>1</sup>, respectively. The amount of loan that the bank can provide for the enterprise is  $k$  times the amount of the mortgages. However, regular banks indicate a low level of asset recognition for small and micro-sized enterprises; thus,  $0 < k < 1$ . The total amount of funds that for each small and micro-sized enterprise can obtain through individual financing is  $kM_1$ , whereas the financing group will use risk reserve for enterprises that adopt the collective financing method to reimburse the enterprise's contingent default. Thus, banks will upgrade the loan amount to  $n$  times for small and micro-sized enterprises in the collective financing group, which means that the amount of funds that each enterprise in the group can obtain is  $nM_2 (n > 1)$ .*

**Assumption 5.** *If a small and micro-sized enterprise obtains a bank loan and uses it for normal production and operation, the average profit rate that can be achieved is  $l$ .*

On the basis of these assumptions, the proceeds that commercial banks can obtain are  $nr_2kM_2 - f_2$  when banks adopt the collective financing strategy to finance small and micro-sized enterprises if the enterprise can repay loans on schedule after deducting the cost of loan review. The collective financing group will repay the bank for the defaulting enterprise when a small and micro-sized enterprise cannot repay its loans on schedule, thereby controlling the spread of bank's credit risk and ensuring that the bank's proceeds are not affected. The deposit  $q_i$  paid by the enterprise when it participates in collective financing will be acquired by the collective financing group or will be used to compensate for the loss made by the defaulting company through discounted sale, auction and sale of the enterprise to mortgage the bank's assets.



Similarly, when small and micro-sized enterprises obtain funds via the individual financing strategy, the proceeds that the bank can obtain after deducting the cost of the loan review are  $r_1kM_1 - f_1$  if they can repay the loans on schedule. When the company defaults, the proceeds are the earnings of selling the mortgages after deducting the lost principal and loan review costs,  $M_1 - kM_1 - f_1$ .

If small and micro-sized enterprises choose to repay their loans on schedule under the premise of collective financing, the proceeds that the enterprises will receive after deducting the expenses (including interest) paid for bank loans are  $nlkM_2 - c_2$ . The proceeds are  $lkM_1 - c_1$  under the individual financing model.

Under the collective financing model, when small and micro-sized enterprises choose to default, the enterprise needs to deduct the mortgages with a value of  $M_2$  and the deposit  $q_i$  paid to the collective financing group from the original proceeds. Under the individual financing model, the enterprise does not need to deduct the deposit  $q_i$  paid to the collective financing group. When an enterprise defaults, the interest on the fund is owned by the defaulting enterprise regardless of the financing model used to obtain the loan. Thus, the corresponding proceeds of defaulting small and micro-sized enterprises are  $nlkM_2 - c_2 + nr_2kM_2 - M_2 - q_i$  and  $lkM_1 - c_1 + r_1kM_1 - M_1$ , respectively. Table 1 shows the corresponding payoff matrix for commercial banks and small and micro-sized enterprises.

**3.1.2. Model establishment**

The payoff matrix shown in Table 1 is used to jointly build an evolutionary game model. Any strategy may be used by some of the players in the game for a game with bounded rationality. Therefore, random pairs of games may appear between commercial banks and small and micro-sized enterprises. In the commercial bank group, the proportion adopting the ‘collective financing loan’ strategy is  $x(0 < x < 1)$ . The proportion of adopting the ‘individual financing loan’ strategy is  $1 - x$ . The proportion that adopts the ‘default’ strategy is  $1 - y$  if the proportion in the small and micro-sized enterprise group that adopts the ‘repayment on schedule’ strategy is  $y(0 < y < 1)$ . Thus, the expected proceeds of commercial banks in choosing ‘collective financing loan’ and ‘individual financing loan’ players are  $u_{BC}$  and  $u_{BS}$  the average group proceeds  $\bar{u}_B$  are as follows:

$$u_{BC} = y \cdot (nr_2kM_2 - f_2) + (1 - y) \cdot (nr_2kM_2 - f_2)$$

$$u_{BS} = y \cdot (r_1kM_1 - f_1) + (1 - y) \cdot (M_1 - kM_1 - f_1)$$

$$\bar{u}_B = x \cdot u_{BC} + (1 - x) \cdot u_{BS}$$

**Table 1.** Payoff matrix for commercial banks and small and micro-sized enterprises in collective financing with mortgages required.

		Small and micro-sized enterprises ( $y$ )	
		Repayment on schedule	Default
Commercial Bank( $x$ )	Collective financing loan	$nr_2kM_2 - f_2, nlkM_2 - c_2$	$nr_2kM_2 - f_2, nlkM_2 - c_2 + nr_2kM_2 - M_2 - q_i$
	Individual financing loan	$r_1kM_1 - f_1, lkM_1 - c_1$	$M_1 - kM_1 - f_1, lkM_1 - c_1 + r_1kM_1 - M_1$

The expected proceeds of small and micro-sized enterprise groups as game parties that choose to ‘repay on schedule’ and ‘default’ are  $u_{ER}$  and  $u_{ED}$ , respectively, and the average group proceeds  $\bar{u}_E$  are:

$$u_{ER} = x \cdot (nlkM_2 - c_2) + (1-x) \cdot (lkM_1 - c_1)$$

$$u_{ED} = x \cdot (nlkM_2 - c_2 + nr_2kM_2 - M_2 - q_i) + (1-x) \cdot (lkM_1 - c_1 + r_1kM_1 - M_1)$$

$$\bar{u}_E = y \cdot u_{ER} + (1-y) \cdot u_{ED}$$

We then analyse the rate of dynamic changes of different group proportions in the bounded rational parties involved in the small and micro-sized enterprise collective financing game under different types of strategies. The rate of dynamic change of the proportion depends on the speed of learning of the two players, namely, the commercial bank group and the small and micro-sized enterprise group. The rate is related to the ratio of the mock object and its success degree (can be expressed by the extra after the average proceeds are deducted from proceeds of this type). Therefore, based on the replicator dynamics model (Taylor & Jonker, 1978), the following dynamic differential equation can be used to represent the rate of change  $\frac{dx}{dt} = x \cdot (u_{BC} - \bar{u}_B)$  of group proportion  $x$ , which adopts the collective financing loan strategy when the game player is a bank.

This equation is also referred to as the ‘replication dynamic equation’ because it is consistent with the idea of replication dynamics in the natural selection process of biological evolution. The expected proceeds  $u_{BC}$  of commercial banks when choosing the ‘collective financing loan’ strategy and the average proceeds  $\bar{u}_B$  of the group are substituted into the above replication dynamic equation. The bank’s replication dynamic equation can be obtained as:

$$\frac{dx}{dt} = x \cdot (1-x) \cdot [(nr_2kM_2 - f_2 - M_1 + kM_1 + f_1) - y \cdot (r_1kM_1 + kM_1 - M_1)] \quad (1)$$

Similarly, the replication dynamic equation of small and micro-sized enterprises can be obtained as:

$$\frac{dy}{dt} = y \cdot (u_{ER} - \bar{u}_E) = y \cdot (1-y) \cdot [x \cdot (r_1kM_1 - M_1 - nr_2kM_2 + M_2 + q_i) - (r_1kM_1 - M_1)] \quad (2)$$

### 3.1.3. Strategy analysis

After the above model is established, the evolutionarily stable strategy of the game can be discussed further based on the replication dynamic equation.

Firstly, we use Equation (1) to analyse the bank’s strategy. The replication dynamic equation of the bank is  $\frac{dx}{dt} = 0$ . We can obtain three points where a steady state is reached, which are  $x = 0$ ,  $x = 1$ , and  $y^* = \frac{(nr_2kM_2 - f_2 + f_1) - (M_1 - kM_1)}{r_1kM_1 - (M_1 - kM_1)}$ , respectively;

$r_1kM_1 \geq M_1 - kM_1$  will not be discussed because it does not conform to reality. Only the following three possibilities on the premise of  $r_1kM_1 < M_1 - kM_1$  are analysed.

Scenario 1:  $r_1kM_1 < M_1 - kM_1 < nr_2kM_2 - f_2 + f_1$ . At this time,  $y^* \in (-\infty, 0)$  and  $y > y^*$ . Based on the theorem of stability of differential equations,  $x = 1$  is an evolutionarily stable strategy for commercial banks. According to the payoff matrix shown in Table 1, the proceeds ( $r_1kM_1 - f_1$  or  $M_1 - kM_1 - f_1$ ) obtained by the banks via individual financing loans are lower than those by collective financing loans ( $nr_2kM_2 - f_2$ ) whether small and micro-sized enterprises choose to default or not. Thus, after a period of evolution, banks will choose to provide a collective financing loan strategy that does not depend on the choice of enterprise strategy.

Scenario 2:  $r_1kM_1 < nr_2kM_2 - f_2 + f_1 < M_1 - kM_1$ . At this time,  $y^* \in (0, 1)$ . The payoff matrix shown in Table 1 indicates that the proceeds ( $nr_2kM_2 - f_2$ ) of the commercial bank that chooses the collective financing loan strategy are higher than those ( $r_1kM_1 - f_1$ ) when the bank chooses individual financing loan strategy on the premise that small and micro-sized enterprises repay on schedule. By contrast, lower proceeds ( $M_1 - kM_1 - f_1$ ) are obtained in the event that an enterprise defaults. If  $y = y^*$ , all  $x$  are in a stable state; if  $y > y^*$ , then  $x = 1$  is an evolutionarily stable strategy for commercial banks; if  $y < y^*$ , then  $x = 0$  is an evolutionarily stable strategy for commercial banks. That is, when the proportion of enterprises that chooses to repay on schedule is  $y^*$  in the initial state, the bank's strategy will no longer change. In other words, the proceeds will be the same whether the bank chooses to adopt the collective financing strategy. By contrast, when the proportion of enterprises that chooses to repay on schedule is higher than  $y^*$ , the bank will choose to adopt a collective financing loan strategy to serve the enterprise after long-term evolution. When the proportion of enterprises that chooses to repay on schedule is lower than  $y^*$ , the bank will choose to adopt an individual financing loan strategy to serve the enterprise after long-term evolution.

Scenario 3:  $nr_2kM_2 - f_2 + f_1 < r_1kM_1 < M_1 - kM_1$ . At this time,  $y^* \in (1, +\infty)$  and  $y < y^*$ . Based on the stability theorem of differential equations,  $x = 0$  is the evolutionarily stable strategy for commercial banks. The banks' proceeds ( $r_1kM_1 - f_1$  or  $M_1 - kM_1 - f_1$ ) via individual financing are higher than those via collective financing ( $nr_2kM_2 - f_2$ ) regardless of whether small and micro-sized enterprises choose to default. After a period of evolution, banks will all choose the individual financing loan strategy to provide financial support for small and micro-sized enterprises. This strategy does not depend on the enterprise's strategic choices and changes.

The analysis of the three possible strategies of banks shows that the business strategy of commercial banks is centered on maximising profits. However, when considering the safety of funds and risk control issues, the bank will classify strategies based on small and micro-sized enterprise's willingness to repay. When the enterprise's willingness to repay is high, the bank will offer a collective financing loan strategy. When willingness to repay is low, the bank will choose the traditional individual financing loan strategy to prevent the spread of risks.

We then analyse the strategic choices of small and micro-sized enterprises. Let equation (2), i.e., the replication dynamic equation of small and micro-sized enterprises  $\frac{dy}{dt} = 0$ . We can then obtain  $y = 0$ ,  $y = 1$ , and  $x^* = \frac{r_1kM_1 - M_1}{(r_1kM_1 - M_1) - (nr_2kM_2 - M_2 - q_1)}$ .

According to the range of values of  $r_1$  and  $k$ , we can see that  $r_1kM_1 - M_1 < 0$ . Therefore, the issue is discussed in three scenarios.

Scenario 4:  $nr_2kM_2 - M_2 - q_i < r_1kM_1 - M_1 < 0$ . At this time,  $x^* \in (-\infty, 0)$  and  $x > x^*$ . Based on the stability theorem of differential equations,  $y = 1$  is the evolutionarily stable strategy for small and micro-sized enterprises.

Scenario 5:  $r_1kM_1 - M_1 < nr_2kM_2 - M_2 - q_i < 0$ . At this time,  $x^* \in (1, +\infty)$  and  $x < x^*$ .  $y = 1$  is the evolutionarily stable strategy for small and micro-sized enterprises.

Scenario 6:  $r_1kM_1 - M_1 < 0 < nr_2kM_2 - M_2 - q_i$ . At this time,  $x^* \in (0, 1)$ . If  $x = x^*$ , then all  $y$  are in a stable state. By contrast, when  $x > x^*$ ,  $y = 0$  is the evolutionarily stable strategy for small and micro-sized enterprises. When  $x < x^*$ ,  $y = 1$  is the evolutionarily stable strategy for small and micro-sized enterprises.

In both Scenarios 4 and 5,  $nr_2kM_2 - M_2 - q_i < 0$  is satisfied; that is, when  $nr_2kM_2 < M_2 + q_i$ ,  $y = 1$  is the evolutionarily stable strategy of small and micro-sized enterprises. When a bank adopts a collective financing strategy to provide loans for enterprises, enterprises will all choose to repay the bank on schedule instead of default if the loan interest ( $nr_2kM_2$ ) that the enterprise is liable for is less than the value of the enterprise's mortgages and the total deposit ( $M_2 + q_i$ ) paid to the collective financing group, after a period of strategic evolution. This strategy is not affected by the strategy choice of commercial banks.

Scenario 6: solely establishes  $nr_2kM_2 - M_2 - q_i > 0$ , i.e.,  $nr_2kM_2 > M_2 + q_i$ . This finding indicates that when the loan interest that the small and micro-sized enterprise is liable for is greater than the value of the enterprise's mortgages and the total deposit paid to the collective financing group. If the proportion of collective financing provided by the bank to the small and micro-sized enterprise at the initial stage is  $x^*$ , whether the enterprise chooses to repay on schedule or to default, the bank's proceeds will always be the same. If the proportion of collective financing provided by the bank to the small and micro-sized enterprise at the initial stage is higher than  $x^*$ , after a period of strategy evolution, the enterprise's stable strategy is  $y = 0$ . This situation indicates that small and micro enterprises will still choose to default because of high interest rate. If the proportion collective financing provided by the bank to the enterprise at the initial stage is lower than  $x^*$ . After a period of strategy evolution,  $y = 1$  is the stable strategy of small and micro-sized enterprises, which indicates that enterprises that can only choose the individual financing model will still choose to repay on schedule under higher interest rates after considering the credit history of late-stage loans. However, this high enterprise operating cost will affect the sustainable development of the enterprise.

Therefore, even if the bank offers a convenient collective financing method for small and micro-sized enterprises, the enterprises will still collectively take risks and choose to default to maintain their operations in the case that enterprises are liable for higher interest costs. This situation indicates that when the loan interest setting in commercial banks are unreasonable. The innovative financing model is not only unable to solve the fund supply problem for small and micro-sized enterprises, but also engenders potential credit risks. Thus, we set a reference interest rate  $r_2^* = \frac{M_2 + q_i}{nkM_2}$  for banks to use for collective financing by combining the discussion of the above three scenarios. When the commercial bank's actual collective financing lending rate

is smaller than  $r_2^*$  (i.e., Scenarios 4 and 5), small and micro-sized enterprises indicate a smaller risk of default and will repay bank loans on schedule. When the commercial bank's actual collective financing lending rate is greater than  $r_2^*$  (i.e., Scenario 6), small and micro-sized enterprises will choose different strategies according to the financing plan offered by the bank in the initial stage. However, even if the enterprises do not default, they will not be able to generate stable profits to maintain normal corporate operations because of high interest rates.

**3.2. Collective financing model not requiring mortgages**

**3.2.1. Model assumptions**

For most small and micro-sized enterprises, presenting mortgages that are generally recognized by commercial banks is not easy. Therefore, we aim to integrate previous studies on the comparison of mortgages' role in the provision of collective financing loans for small and micro-sized enterprises by banks. The present study assumes that small and micro-sized enterprises that adopted collective financing to get loans no longer present mortgages to commercial banks but only pay deposits to the collective financing group. Deposits from multiple small and micro-sized enterprises constitute the risk reserve of the collective financing group. When a certain enterprise in the group defaults on credit and cannot repay the loan to the bank on schedule, the enterprise's collective financing group will use the risk reserve fund to repay the loan first and assume the responsibility of corporate finance guarantor. Thus, even if the enterprises cannot provide corresponding mortgages, commercial banks can still provide loans for each enterprise in the group. The amount is  $n$  ( $n > 1$ ) times the total amount of deposit paid to the collective financing group, i.e.,  $nq_i$ . This finding is based on the 'intragroup guarantee' model, which is constructed by small and micro-sized enterprises.

Based on the above assumptions, when a bank adopts a collective financing strategy that does not include mortgages, regardless of whether the enterprise defaults, the bank will receive interest income after deducting the loan review cost; that is,  $nr_2q_i - f_2$ . When small and micro-sized enterprises repay loans on schedule, the proceeds obtained by the enterprise will only need to deduct the costs required to apply for the loan (including interest). In the event of default, the enterprise will also lose the deposit paid to the collective financing group. However, for individual financing loan strategy, the proceeds of commercial banks and small and micro-sized enterprises are the same as the loan proceeds in the case of mortgages. The corresponding proceeds of commercial banks and small and micro-sized enterprises when mortgages are not required are shown in Table 2.

**Table 2.** Payoff matrix for commercial banks and small and micro-sized enterprises in collective financing with mortgages not required.

		Small and micro-sized enterprises ( $y$ )	
		Repayment on schedule	Default
Commercial Bank( $x$ )	Collective financing loan	$nr_2q_i - f_2, nq_i - c_2$	$nr_2q_i - f_2, nq_i - c_2 + nr_2q_i - q_i$
	Individual financing loan	$r_1kM_1 - f_1, lkM_1 - c_1$	$M_1 - kM_1 - f_1, lkM_1 - c_1 + r_1kM_1 - M_1$

### 3.2.2. Model establishment

We obtain the expected proceeds  $u'_{BC}$ ,  $u'_{BS}$  and average group proceeds  $\bar{u}'_B$  when commercial banks choose 'collective financing loan' and 'individual financing loan', respectively. We use the payoff matrix shown in Table 2, similar to the loan model of collective financing with mortgages.

$$u'_{BC} = y \cdot (nr_2q_i - f_2) + (1-y) \cdot (nr_2q_i - f_2)$$

$$u'_{BS} = y \cdot (r_1kM_1 - f_1) + (1-y) \cdot (M_1 - kM_1 - f_1)$$

$$\bar{u}'_B = x \cdot u'_{BC} + (1-x) \cdot u'_{BS}$$

The expected proceeds and average group proceeds under the two strategies of 'repayment on schedule' and 'default' in the small and micro-sized enterprise groups are:

$$u'_{ER} = x \cdot (nlq_i - c_2) + (1-x) \cdot (lkM_1 - c_1)$$

$$u'_{ED} = x \cdot (nlq_i - c_2 + nr_2q_i - q_i) + (1-x) \cdot (lkM_1 - c_1 + r_1kM_1 - M_1)$$

$$\bar{u}'_E = y \cdot u'_{ER} + (1-y) \cdot u'_{ED}$$

In the collective financing loan model with mortgages, the replication dynamic equations of banks and small and micro-sized enterprises are:

$$\frac{dx}{dt} = x \cdot (u'_{BC} - \bar{u}'_B) = x \cdot (1-x) \cdot [(nr_2q_i - f_2 - M_1 + kM_1 + f_1) - y \cdot (r_1kM_1 + kM_1 - M_1)] \quad (3)$$

$$\frac{dy}{dt} = y \cdot (u'_{ER} - \bar{u}'_E) = y \cdot (1-y) \cdot [x \cdot (r_1kM_1 - M_1 - nr_2q_i + q_i) - (r_1kM_1 - M_1)] \quad (4)$$

### 3.2.3. Strategy analysis

On the basis of the replication dynamic equations of bank's secured loans and unsecured loans; that is, Equations (1) and (3), we can conclude that bank's strategy choice under unsecured loans is similar to that under secured loans. The following discussion focuses on the strategic choices of small and micro-sized enterprises.

We let Equation (4) be the replication dynamic equation of small and micro-sized enterprises in the case of unsecured asset loans  $\frac{dy}{dt} = 0$ , and  $y = 0$ ,  $y = 1$ , and  $x^* = \frac{r_1kM_1 - M_1}{(r_1kM_1 - M_1) - (nr_2q_i - q_i)}$ . Based on the range of values of  $r_1$  and  $k$  discussed above,  $r_1kM_1 - M_1 < 0$  is always established. The issue will be discussed in the below three scenarios.

Scenario 7:  $nr_2q_i - q_i < r_1kM_1 - M_1 < 0$ . At this time,  $x^* \in (-\infty, 0)$  and  $x > x^*$ . Based on the stability theorem of differential equations,  $y = 1$  is the evolutionarily stable strategy for small and micro-sized enterprises.

Scenario 8:  $r_1kM_1 - M_1 < nr_2q_i - q_i < 0$ . At this time,  $x^* \in (1, +\infty)$ , so  $x < x^*$  and  $y = 1$  is still the evolutionarily stable strategy for small and micro-sized enterprises.

Scenario 9:  $r_1kM_1 - M_1 < 0 < nr_2q_i - q_i$ . At this time,  $x^* \in (0, 1)$ . When  $x < x^*$ ,  $y = 1$  is the evolutionarily stable strategy for small and micro-sized enterprises. When  $x > x^*$ ,  $y = 0$  is the evolutionarily stable strategy for small and micro-sized enterprises.

Based on Scenarios 7 and 8, as long as  $nr_2q_i - q_i < 0$ , that is, the interest paid by small and micro-sized enterprises under collective financing is less than the deposit paid to the collective financing group, after a period of evolution, enterprises will all choose to repay the bank on schedule. By contrast, when  $nr_2q_i - q_i > 0$ ; that is, the interest paid by small and micro-sized enterprises to the bank is more than the deposit that they need to pay, the enterprise's strategy choice is related to the proportion of banks that choose to adopt the collective financing model at the initial stage. When the proportion is less than the critical value  $x^*$  after a period of evolution, small and micro-sized enterprises will choose to repay on schedule. By contrast, the enterprises will choose to default when the proportion is greater than the critical value  $x^*$  after a period of evolution.

Based on the strategic analysis of banks and enterprises in the collective financing model without mortgages, we conclude that the strategy choices of the two are the same as those in the case of secured loans. Therefore, in the enterprise's collective financing model assumed in this paper, whether small and micro-sized enterprises can provide mortgages recognized by commercial banks does not affect the repayment of enterprises. However, if we blindly require small and micro-sized enterprises with insufficient funds to get loans only by mortgages, this requirement will block the financing channels of enterprises. This situation is not conducive to the development of multiple innovative financing models and also introduces difficulties for small and micro-sized enterprises to obtain suitable financial services.

It is worth noting that free riding is common in collective action. However, in order to prevent this from happening, banks still need to conduct detailed credit reviews and assessments of each enterprise involved in pooled financing to ensure that there is no malicious free riding in the aggregate. The adoption of a collective financing model only facilitates small and medium-enterprises with insufficient assets so that they no longer have to provide hard-to-obtain collateral to obtain loans that cannot be obtained with the advantage of the social capital that exists in the cluster. However, the pre-loan review process will not be relaxed in any way, while will make it more difficult, as it will no longer serve as a basis for the results of credit audits based on the quality of collateral, but attention should be paid to the correlation between the development potential of the enterprise and the aggregate of enterprises (because the higher the correlation is, the more likely the collective default is (Huo, Feng, & Li, 2013)). However, as a matter of fact, the design of collective financing mechanism also prevents the occurrence of free riding behaviour of enterprises to a certain extent. As the construction of an enterprise collection requires that when a default occurs, the members of the collection jointly and severally compensate for



breach of contract damages and loan losses (that is, the risk reserve paid at the initial stage of the build-up of the collection referred to in [assumption 4](#)), which constrains the members of the group to select the aggregate members carefully and supervise and restrain each other to prevent loan default and reduce the probability of free riding behaviour.

### **3.3. Further discussion**

In the current environment of China, the collective financing model without mortgage is more suitable for financing loans of small and medium-enterprises. We can draw conclusions from the following four aspects:

The first is availability of financing. Usually, China's small and medium-enterprises have weak capital strength, and tangible fixed assets are relatively lacking. When there is a demand for financing, it is generally preferable to choose non-governmental loans with high interest rates, reflecting that bank loans, which are formal channels of financing, can provide very limited assistance to small and medium-enterprises. Extensively high the mortgage guarantee requirement makes many small and micro enterprises back off, gave up the convenient bank loan, but only look for the financing way with higher cost. However, the way of collective financing solves the inherent problem of small and medium-enterprises lacking mortgage assets, has the mechanism of mutual restraint and supervision within the group, avoids the malpractice of obtaining asymmetric information of enterprises, reduces the threshold of enterprise loan, and promotes the availability of financing.

The second is financing costs. When businesses own collateral and carry out bank mortgages, they may have stronger negotiating terms to lower loan prices and get the money they need and unsecured enterprises need to comply with the bank's loan requirements. Under the collective financing model established in this paper, in addition to the bank interest, it's necessary for each enterprise to pay the default reserve to prevent the intra-group enterprises from defaulting, therefore, the cost of financing seems to be higher. Therefore, setting a reasonable ratio of damages for default can not only ensure that the financing cost of small and medium-enterprises is not raised too high, at the same time, it also plays a role in restricting the repayment of loans by enterprises, which is also the direction that the author needs further research and exploration in the next stage.

The third is financing default risk. It's true that, in the event of a corporate default, mortgages can be compensated by auctioning off bank-approved collateral, with high recovery rate. However, as long as bank-approved collateral is provided, loans can be obtained in such a way that banks will lower their pre-loan audit standards. On the contrary, the hidden danger of financing default is left behind, which is not conducive to the development of the loan business of small and medium-enterprises. In the collective financing mode without collateral, banks need to carry out full due diligence before lending, design a more scientific basis for credit review, and check the occurrence of default risk of enterprises, which is more reasonable than relying on only one kind of collateral as a means of loan review, and the way is conducive to the prevention of the risk of financing default.

The last is audit cost of bank credit. Under the mortgage model, most banks use the provision of approved collateral as the key criterion for credit review. Therefore, the cost of enterprise investigation is small, and the collective financing mode of unsecured loan certainly requires the bank to carry out a detailed investigation in many aspects, such as the operation of individual enterprises, the historical credit situation of enterprises and the degree of correlation among enterprises, etc. Therefore, in the initial stage of this new loan mode, the audit cost of the bank will be a little higher. However, generally speaking, in order to extend loans to multiple enterprises, when it is necessary for banks to develop a more comprehensive credit audit system to ensure higher audit efficiency, reduce the average cost of loan audit, it's also to create convenient conditions for small and medium-enterprises to obtain funds.

#### **4. Conclusion**

When banks or other financial institutions choose a collective financing model to finance small and medium-enterprises, it's conducive for them to reduce the cost of loan review and improve the efficiency of loan approval. At the same time, commercial banks can also provide other financial services for small and medium-sized enterprises, expand the scope of intermediate business of banks, and enhance their own competitiveness. For small and medium-sized enterprises with the same development stage, not only can the collective financing model help banks to reduce the average approval cost and average supervision cost in the later stage of loan, but also helps to improve the financing efficiency of enterprises and standardize the financial system of small and medium-sized enterprises.

From the point of view of current development, the mode of collective financing also has some limitations. On the one hand, in the initial stage of establishment, the collective financing model will absorb the short-funded small and medium-enterprises at a lower threshold to join the portfolio, therefore, the amount of margin paid by each enterprise to the pooled portfolio is generally low. On the other hand, for many small and medium-enterprises with cash flow constraints, they will take a wait-and-see approach to measure this innovative financing model and reduce the number of enterprises that actually participate in the fund-raising model. As a result, the risk reserve of the financing portfolio is limited, and commercial banks will reduce the magnification of the loan limit. Therefore, it will be the further research direction of this problem on how to improve the existing collective financing operation mode, integrate high-quality enterprise resources, improve the operational efficiency, and provide more convenient financing channels for more small and medium-enterprises.

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## Note

1. When assessing mortgages before granting loans, banks will consider the price fluctuations of the enterprise's mortgages via auctions or discount sales in the event of a future default. Therefore, we may assume that the price of assets recognized by the enterprise is the value of assess in future discount sales.

## References

- Albertazzi, U., Bottero, M., & Gambacorta, L. (2017). Asymmetric information and AHE securitization of SME loans. BIS Working Paper No.601, 42.
- Ahlin, C. (2015). The role of group size in group lending. *Journal of Development Economics*, 115, 140–155. doi:10.1016/j.jdeveco.2015.03.001
- Bartoli, F., Ferri, G., Murro, P., & Rotondi, Z. (2013). Bank–firm relations and the role of mutual guarantee institutions at the peak of the crisis. *Journal of Financial Stability*, 9(1), 90–104. doi:10.1016/j.jfs.2012.03.003
- Bartoli, F., Ferri, G., & Murro, P. (2013). SME financing and the choice of lending technology in Italy: Complementarity or substitutability? *Journal of Banking & Finance*, 37(12), 5476–5485. doi:10.1016/j.jbankfin.2013.08.007
- Berger, A. N., & Udell, G. F. (2006). A more complete conceptual framework for SME finance. *Journal of Banking & Finance*, 30(11), 2945–2966. doi:10.1016/j.jbankfin.2006.05.008
- Besley, T., & Coate, S. (1995). Group lending, repayment incentives and social collateral. *Journal of Development Economics*, 46(1), 1–18. doi:10.1016/0304-3878(94)00045-E
- Chowdhury, P. R. (2007). Group-lending with sequential financing, contingent renewal and social capital. *Journal of Development Economics*, 84(1), 487–506. doi:10.1016/j.jdeveco.2006.01.001
- Columba, F., Gambacorta, L., & Mistrulli, P. E. (2010). Mutual guarantee institutions and small business finance. *Journal of Financial Stability*, 6(1), 45–54. doi:10.1016/j.jfs.2009.12.002
- De la Torre, A., Pería, M. S. M., & Schmukler, S. L. (2010). Bank involvement with SMEs: Beyond relationship lending. *Journal of Banking & Finance*, 34(9), 2280–2293. doi:10.1016/j.jbankfin.2010.02.014
- de Quidt, J., Fetzer, T., & Ghatak, M. (2016). Group lending without joint liability. *Journal of Development Economics*, 121, 217–236. doi:10.1016/j.jdeveco.2014.11.006
- Flatnes, J. E., & Carter, M. R. (2016). *A little skin in the microfinance game: Reducing moral hazard in joint liability group lending through a mandatory collateral requirement*. Agricultural and Applied Economics Association 2016 Annual Meeting, July 31–August 2, Boston, MA.
- Franke, G., & Krahn, J. P. (2017). SME funding without banks? On the interplay of banks and markets. SAFE White Paper, 44.
- Friedman, D. (1991). Evolutionary games in economics. *Econometrica*, 59(3), 637–666. doi:10.2307/2938222
- Gao, L. H. (2007). SME Cluster Financing: Model Innovation, Financing Boundary and Competitive Advantage. *Comparative Economic & Social Systems*, 3, 92–97. (in Chinese).
- Giné, X., & Karlan, D. S. (2014). Group versus individual liability: Short and long term evidence from Philippine microcredit lending groups. *Journal of Development Economics*, 107, 65–83. doi:10.1016/j.jdeveco.2013.11.003
- Ghatak, M. (1999). Group lending, local information and peer selection. *Journal of Development Economics*, 60(1), 27–50. doi:10.1016/S0304-3878(99)00035-8
- Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology*, 78(6), 1360–1380. doi:10.1086/225469
- Hasan, I., Jackowicz, K., Kowalewski, O., & Kozłowski, Ł. (2014). *Bank ownership structure, SME lending and local credit markets* (pp. 2–54). Helsinki, Finland: Bank of Finland.

- Hernández-Cánovas, G., & Martínez-Solano, P. (2010). Relationship lending and SME financing in the continental European bank-based system. *Small Business Economics*, 34(4), 465–482. doi:10.1007/s11187-008-9129-7
- Huo, Y. Y., Feng, Z. X., & Li, Y. (2013). Analysis of EDF measurement and its influencing factors of SMEs collective financing: An empirical study based on the data of 40 listed hi-tech enterprises. *Economic Management Journal*, 35(10), 143–155. (in Chinese).
- Huo, Y. Y., Feng, Z. X., & Liu, C. (2015). The effect of collateral security condition on small and micro enterprise loan interest rate: Empiric study based on the two-tier stochastic frontier model. *Journal of Financial Research*, 9, 112–127. (in Chinese).
- Li, H. M., Li, F. H., Tang, S., & Zhao, D. N. (2010). The dilemma of regional economy in the Peal river delta area under the financial crisis and its' solution—A case of the SMEs financing strategy from the view point of the credit community. *China Soft Science*, 2, 107–115. (in Chinese).
- Kodongo, O., & Kendi, L. G. (2013). Individual lending versus group lending: An evaluation with Kenya's microfinance data. *Review of Development Finance*, 3(2), 99–108. doi:10.1016/j.rdf.2013.05.001
- MacMillan, H. P. (1931). Treasury, Committee on Finance and Industry. Report of the Committee of Finance & Industry, No.20. London, UK: HMSO.
- Madajewicz, M. (2011). Joint liability versus individual liability in credit contracts. *Journal of Economic Behavior & Organization*, 77(2), 107–123. doi:10.1016/j.jebo.2008.01.007
- Montgomery, R. (1996). Disciplining or protecting the poor? Avoiding the social costs of peer pressure in micro-credit schemes. *Journal of International Development*, 8(2), 289–305. doi:10.1002/(SICI)1099-1328(199603)8:2<289::AID-JID368>3.0.CO;2-2
- Mukherjee, S., & Bhattacharya, S. (2015). Optimal group size with joint liability group lending strategy. *Indian Growth and Development Review*, 8(1), 2–18. doi:10.1108/IGDR-02-2014-0002
- Oricchio, G., Lugaresi, S., Crovetto, A., & Fontana, S. (2017). *European funding of SMEs through securitization: An introduction of SME funding*. London, UK: Palgrave Macmillan.
- Prelipcean, G., & Boscoianu, M. (2014). A hybrid framework for SME financing based on the mix between governmental support and the use of a specialized investment fund in the actual context of a slow recovery after crises and turbulences. *Procedia Economics and Finance*, 15, 738–745. doi:10.1016/S2212-5671(14)00445-6
- Selten, R. (1980). A note on evolutionarily stable strategies in asymmetric animal conflicts. *Journal of Theoretical Biology*, 84(1), 93–101. doi:10.1016/S0022-5193(80)81038-1
- Selten, R. (1983). Evolutionary stability in extensive two-person games. *Mathematical Social Sciences*, 5(3), 269–363. doi:10.1016/0165-4896(83)90012-4
- Song, Z., & Zhang, X. (2018). Lending technology and credit risk under different types of loans to SMEs: Evidence from China. *International Review of Economics & Finance*, 57, 43–69. doi:10.1016/j.iref.2018.02.012
- Smith, J. M. (1974). The theory of games and the evolution of animal conflicts. *Journal of Theoretical Biology*, 47(1), 209–221. doi:10.1016/0022-5193(74)90110-6
- Taylor, P. D., & Jonker, L. B. (1978). Evolutionary stable strategies and game dynamics. *Mathematical Biosciences*, 40(1–2), 145–156. doi:10.1016/0025-5564(78)90077-9
- Taylor, P. D. (1979). Evolutionarily stable strategies with two types of player. *Journal of Applied Probability*, 16(1), 76–83. doi:10.2307/3213376
- Uzzi, B. (1999). Embeddedness in the making of financial capital: How social relations and networks benefit firms seeking financing. *American Sociological Review*, 64(4), 481–505. doi:10.2307/2657252
- Xie, S. Y. (2002). *Economic game theory*. Shanghai, China: Fudan University Press. (in Chinese).
- Wang, Y., & Huang, L. J. (2006). The role and significance of social credit cooperation organization in microfinance. *Journal of Financial Research*, 6, 117–127. (in Chinese).

- Zhang, J., & Liang, D. (2004). An analysis of the influencing factors of lending constraints on China's SMEs. *Journal of Jinan University (Humanities and Social Sciences, 1)*, 40–44 + 139. (in Chinese).
- Zhang, Q., Chen, X. H., & Cai, S. Y. (2008). Empirical study on the relationship between scale discrimination and SMEs' financing behavior based on the data from Hunan SMEs. *Systems Engineering, 10*, 61–66. (in Chinese).