



## Research on the Negotiation Decision-Making Model Based on Concession Strategy in the Artificial Credit Market

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**Abstract.** This paper which introduces the transaction concession strategy expands the artificial credit market model based on agent. First, through the investment and financing decision model, analysis the feasible set of the loan interest rate pricing in credit market. Second, proposed the bargaining decision mechanism of credit market based on concession strategy. Then we carried out simulation experiments on the artificial credit market based on concession strategy. The bilateral financial contract bargaining pricing mechanism under single issue frame in this paper provides fundamental ideas for optimizing the operation mechanism of credit market and improving credit market performance.

### 1. Introduction

With the Internet technology and information processing technology more and more widely available, the internet banking is booming. If financial transactions, especially financing transactions completely online, the internet lending platform will become a huge public exchange. First, the traditional financial intermediaries, such as SMEs and individuals can be directly involved in the transaction, because the lenders and borrowers of internet financial is point to point, grid interconnection and sharing, not for special subject. Second, the internet financial is brokered transactions and credit first. In a large number of supply and demand information, pairs with the evaluation of information of both sides and the borrower's credit evaluation, borrowers can directly involved in the credit evaluation of the lender. Third, the transaction is flexibility and diversity. In the Internet lending platform, the needs of lender and borrower are diverse, need negotiation, running, synergy and matching, and form diversified product features, especial market-oriented rate. The existing empirical studies(Wang and Zhang,2014) also demonstrated that borrowers with some features have stronger bargaining power in the real credit market.

Stahl (1972) and Rubinstein (1985) put forward the concept of bargaining zone of single issue, they believe both parties have their own bottom line price. The bargaining process is a game process that

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the both sides of the transaction finding final transaction point in the bargaining interval formed by the respective bottom line price. The main goal of the game is to maximize their utility. But the existing loan pricing model of artificial credit markets have been often ignored the bargaining behavior between the agents. Giulia(2009) suppose the borrower and lender both take the mini-max loan pricing strategy, that is to maximize market share and taking the lowest interest rates. The multi-bank relationship lending market model constructed by Liu (2010) given the borrowers specific parameters of the bargaining power, the greater the parameter value, the stronger bargaining power. However, as Stahl et al (1972) pointed out, bargaining is a dynamic process of a multi round, sequential or stage.

Based on previous study, this paper further extends the existing basis of artificial credit market model, constructed the bargaining model based on transaction concession strategy. In order to describe the self learning adaptive behavior of artificial credit market gradually. The following of this paper is: the second section summarized the researches about the credit market bargaining power, the third section discussed the artificial credit market decision-making model in detail, the fourth section simulation experiment based on artificial credit market, the fifth section summarizes the conclusion and puts forward the prospect of research.

## 2. Literature review

Bargaining power is the power that agents agree on a (some) issues by compromise in certain circumstances. The early studies focused on the bargaining of labor unions, such as the employee and the employer bargaining for compensation and other conditions, they believe bargaining is the process of mutual information manipulation, is a kind of game behavior, the more abundant the strategy, the stronger bargaining power.

Stahl(1972) and Rubinstein (1985) pointed out bargaining is a typical inverse dynamic process of bid and counter bid. They considered the bargaining under complete information, and realized sequential bargaining produces a Pareto efficient game result, bargainer wont argue endlessly after the agreement. In recent years, as a kind of coordination mechanism of the interests of all parties, bargaining was focused on the study of electronic commerce, cloud business and supply chain(Sucky,2006;Crook and Combs,2007;Hua and Li,2008 etc.). The same, the study about bargaining power of SMEs in credit market has become a hot topic of theoretical research.

In general, determinants of bargaining power of SMEs mainly from four aspects: borrower, lender relationship and macroeconomic (such as competition, economic cycle).

Study on the bargaining power of bank credit business began in Rudolph(2006) bargaining power effects in financial contracting. Rudolph(2006) constructed a principal-agent model of bank and enterprise, analyses the important role of bargaining behavior bilateral financial contract making.

Hirofumi(2006) find that the lender or the borrower, usually incurs a shoe-leather cost when they have contact. The proxy is regressed on three types of variables that can potentially determine distribution: first, lender's competition, second, the degree of informational asymmetry between the two parties, and third the borrower performance.

Cerqueiro, Degryse and Ongena(2011) propose a heteroscedastic regression model to identify the determinants of the dispersion in interest rates on loans granted to small and medium sized enterprises. Proposed the rule and discretion in loan pricing of SMEs. Verified the adaptive behavior of commercial bank in SMEs loan pricing. The adaptive behavior is an important factor affecting the SME loan interest rates.

Grunert and Norden(2012) investigate the relationship between borrower risk and loan maturity in small business lending using a rich dataset on new loans extended to German firms. They find a robust, significantly positive, monotonic risk-maturity relation, and this relation becomes stronger when asymmetric information is high and weaker when borrower bargaining power is high, and that borrower bargaining power affects the risk-maturity relation differently depending on whether asymmetric information is high or low.

Cosci, Meliciani and Sabato(2009) and Santikian(2009) find that the relationship between banks and enterprises is valuable. This largely from two aspects: first aspect is information channel, financial services

products, such as Basic settlement account and cash management system provided by commercial banks make the transmission of information between the bank and the enterprise more effective. Through continuous monitoring of cash flows, can effectively alleviate the adverse selection and moral hazard problems. The second aspect is profit channel. The non-credit services cross-sold to the borrower, and the additional bank clients referred by the borrower can increase the income of commercial banks. In addition, Kirschenmann(2010), Gropp, Gruendl and Guettler(2011), Kirschenmann and Norden(2012) proposed the other representative research.

In recent years, the rapid development of artificial intelligence technology makes dynamic bargaining experiments possible. Study on the artificial credit market bargaining decision is yet to be a breakthrough. In order to simplify the modeling and solving, Giulia (2009) and Liu (2010) simplified the bilateral negotiation decision to single individual decision. Obviously, this exogenous decision mechanism based on the researcher need further enrich and deepen.

### 3. Bargaining decision model of artificial credit market

#### 3.1. The basic assumption

There are  $f$  borrowers and  $b$  lenders in the credit market. All of the borrowers and lenders are risk neutral. Suppose the bargaining periods is, if more than, the bargaining will be canceled. Borrower can invest in ventures use own capital or lend from the lender. The lender can access the information of borrower without costs. The bargaining cost is 0. Time is precious to both sides of the bargaining.

#### 3.2. Basic process of the model

The bargaining process of artificial credit market consists of three stages:

First, the borrower makes investment decision. He can use his own funds to obtain risk-free return, use his own funds for venture, or apply for a loan to make up for the shortfall in funds then invest in risky projects.

Second, the lender makes lending decision. He calculates the potential risk and returns then determine the floor price.

Third, The borrower and lender negotiation to determine the final rate, then extend a loan.

#### 3.3. The investment and financing decision

##### 3.3.1. The decision of the borrower

There are  $f$  borrowers in artificial credit market, indicate with  $i(i=1,2,3\dots f)$ . At beginning, the initial asset of borrower is  $A_i$ , can invest in risk-free asset with yields of  $r_f$  or investing in risky projects. The chance of risky project is  $p$ , if success the yield rate is  $\rho_i$ , otherwise the yield rate is 0.

Suppose the investment of borrower is  $h_i$ , the earning of bank deposits is  $R_i = h_i * (1 + r_f)$ . The earning of inventing in risk project is:

$$I_i = \begin{cases} (1 + \rho_i) * h_i & \text{the probability is } p \\ h_i & \text{the probability is } 1 - p \end{cases} \quad (1)$$

The expected revenue is  $E(I_i) = h_i(1 + \rho_i) * p + h_i * (1 - p)$ . when  $E(I_i) \geq R_i$ , the borrower will inventing in risky project. so  $p\rho_i \geq r_f$ , that means the minimum expected return rate of risk project investment should be higher than the current deposit interest rate. Without loss of generality, let:

$$\rho_i = k_i * \frac{r_f}{p} \quad (2)$$

If  $k_i \geq 1$ , the borrower will invest in risky project.  $k_i$  can understood as influence factors of yield risk of the project, such as management ability, implementation and strategies. In this paper we define  $k_i$  as the feature information of borrower.

In addition, when and only when the earnings from risky project with borrowed fund  $E(\widetilde{W}_i)$  more than the earnings from risky project with own fund, the borrower whose  $k_i \geq 1$  will submit a loan application. Suppose the lending quota is  $L_i$ , the lending rate is  $r_i$ . If the risky project failed, the lender will recover  $B_i$ . These constraints can be described as:

$$\begin{cases} E(W_i) = [(1 + \rho_i) * (A_i + L_i) - L_i * (1 + r_i)] * p + (A_i - B_i) * (1 - p) \\ E(\widetilde{W}_i) = A_i * (1 + \rho_i) * p + A_i(1 - p) \\ E(W_i) \geq E(\widetilde{W}_i) \end{cases} \quad (3)$$

then we can get:

$$\begin{cases} (\rho_i - r_i) * p * \lambda_i - \beta_i * (1 - p) \geq 0 \\ \lambda_i = \frac{L_i}{A_i} \\ \beta_i = \frac{B_i}{A_i} \end{cases} \quad (4)$$

$\lambda_i$  is the leverage ratio of borrower,  $\beta_i$  is the mortgage rates of borrower. The boundary conditions that the borrower submit a loan application is:

$$r_i \leq \rho_i - \frac{1 - p}{p} * \frac{\beta_i}{\lambda_i} \quad (5)$$

### 3.3.2. The decision-making of lender

In the artificial credit market model constructed in this paper, the lenders are risk neutral. Generally, the premise of loans is that the lender has enough liquidity, but we wont consider the liquidity constrained situation. The decision-making principle is the expected return greater or equal to 0. The expected return can be expressed as:

$$E(V_i) = (1 + r_i) * L_i * p + B_i * (1 - p) - L_i * (1 + r_f) \quad (6)$$

$$\text{If } E(V_i) \geq 0, 1 + r_i \geq \frac{1 + r_f}{p} * \frac{B_i}{L_i} \quad (7)$$

According to the definition of (4), it can be rewritten as:

$$1 + r_i \geq \frac{1 + r_f}{p} - \frac{1 - p}{p} * \frac{\beta_i}{\lambda_i} \quad (8)$$

Therefore, the boundary condition for the loan is:

$$r_i \geq \frac{r_f}{p} + \frac{1 + p}{p} * (1 - \frac{\beta_i}{\lambda_i}) \quad (9)$$

Combined (2), (5) and (9), it is not difficult to find the rate subset that the borrower can afford is:

$$k_i \geq 1 + \frac{1 - p}{r_f} \quad (10)$$

Obviously, the interest rate range of the borrower and lender is:

$$\frac{r_f}{p} + \frac{1 - p}{p} * (1 - \frac{\beta_i}{\lambda_i}) \leq r_f \leq \rho_i - \frac{1 - p}{p} * \frac{\beta_i}{\lambda_i} \quad (11)$$

### 3.4. The bargaining Decision

Negotiation is agents consensus on something through compromise. Faratin, Sierra and Jennings(1998), Fatima, Wooldridges and Jennings(2002), Osepay, shvils and Wellman(2002), Lai, Lis and Sycara (2008) studied on the negotiation between agents. Agent bargaining behavior in this paper chiefly rely on the study of Faratin, Sierras and Jennings(1998), Rens and Zhang(2013). But the difference is this paper fully consider the investment and financing boundary of borrower and lender. To avoid the problem of the arbitrariness of choice parameters, this is closer to real market.

#### 3.4.1. Agents reacts to market shifts

According to the first basic assumptions, there are  $b$  lenders and  $f$  borrowers. Define the initial offer as  $r_{ini}$ . Define the desire to complete the transaction of agent as  $d(0 \leq d \leq 1)$ , if  $d=0$ , the agents have no sincerity for concluding a deal; if  $d=1$ , the agents have sincerity for concluding a deal. Define  $\tau$  as the term of bargaining. Define  $\alpha$  as the role of agent in the credit markets, if  $\alpha = -1$ , the agent is borrower; if  $\alpha = 1$ , the agent is lender. Define  $\delta$  as the concession strategy of agents, define  $\pi$  as the reaction coefficient of changes in market to every agent, the credit market supply-demand relationship can be expressed as:

$$\phi(b, f, \alpha) = \frac{f - b}{f + b} * \alpha, -1 \leq \phi \leq 1 \tag{12}$$

When  $0 \leq \phi \leq 1$ , it is more beneficial for agent whose  $\alpha = 1$ . When  $-1 \leq \phi \leq 0$ , it is more beneficial for agent whose  $\alpha = -1$ . When  $\phi = 0$ , supply and demand have come to balance in credit market.

According to the study of Ren and Zhang (2013), there are three types of the reaction coefficient of changes in market( $\pi$ ).

First, the cautious( $\pi > 1$ ). When the market to break the balance and turn to buyer’s market or seller’s market, these agents are not sensitive to the subtle changes in the early, but sensitive to the dramatic change in market.

Second, the general type( $\pi = 1$ ). The reaction of agent with changes in market supply and demand is linear.

Third, radical type( $0 < \pi < 1$ ). When the market to break the balance of supply and demand and turn to buyer’s market or seller’s market, these agents are sensitive to the subtle changes in the early, but not sensitive to the dramatic change in market.

So the reaction coefficient of changes in market can express as:

$$I_i = \begin{cases} \phi(b, f, \alpha)^\pi, \phi(b, f, \alpha) \geq 0 \\ -[-\phi(b, f, \alpha)]^\pi, \phi(b, f, \alpha) < 0 \end{cases} \tag{13}$$

#### 3.4.2. The utility of agent to the count-partys offer

Define  $r_g$  as offer of the count-party,  $r_{int}$  as the initial offer of the agent, the utility of agent to the count-partys quote can be formulated as:

$$\Lambda(r_g, r_{int}, \alpha) = th\left(\frac{r_g - r_{int}}{r_{int}} * \alpha\right) + 1, \Lambda \in (0, 2) \tag{14}$$

It can be understood as the utility of the count-partys offer. If  $r_g = r_{int}$ ,  $\Lambda = 1$ , that means the count-partys offer meet the Price expectation of agent exactly. If  $r_g > r_{int}$ ,  $0 \leq \Lambda < 1$ , that means the count-partys offer only meet the price expectation of agent partly. If  $r_g < r_{int}$ ,  $1 < \Lambda < 2$ , means the count-partys offer exceed the price expectation of agent, the agent can get extra yield from count-party.

It is worth saying, the definition of is:

$$th(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} \tag{15}$$

### 3.4.3. The synthetic utility

Formula(14) chiefly studied the utility of agent from the aspect of the count-partys offer. However, disruptions of supply and demand may have a major impact on agents. So when we study the utility of agent to the count-partys offer, we need to consider the supply and demand in the credit markets, and consider the reaction of agent to market shift. So the synthetic utility evaluation function is:

$$\Theta(r_g, b, f, r_{int}, \alpha, \pi) = \Lambda(r_g, r_{int}, \alpha) * (1 - \psi(b, f, a, \pi)) \tag{16}$$

It took into account under the utility of agent to the count-partys offer under the right circumstances. Only when the supply and demand balance on the credit market ( $\psi = 0, \Theta = \Lambda$ ), estimation of the utility of quotation14 is unbiased.

### 3.4.4. Anti proposed Decision

Anti proposed decision (counter-offer) is an important part of the credit market bargaining behavior. Anti propose decision (counter-offer) also need to take into account the credit supply and demand in the market and count-party quote.

Define  $R_t$  as a collection of competitors offer in round of t,  $r_{b,t}(r_{b,t} \in R_t)$ as the best offer in round of t ,which maximizes the expected utility of the agent. Define  $r_{b,t}^e$  as the best offer of count-party estimated by agent in round of t+1.

$$r_{b,t}^e = r_{b,t} + \Psi(b, f, \alpha, \pi) * std(R_t) * \alpha \tag{17}$$

$std(R_t)$ is The standard deviation of offers in round t. In round t+1, the anti proposed decision(counter-offer) of agent  $r_{c,t+1}$  can be express as:

$$r_{c,t+1} = \begin{cases} r_{int} & t = 0 \\ r_{c,t} + (r_{b,t+1}^e - r_{c,t}) * (\frac{t}{\tau})^\delta & 0 < t \leq \tau \end{cases} \tag{18}$$

As defined,  $\delta$  is the concession strategy of agents. According to the study of Faratin, Sierra and Jennings (1998), the concession strategy can be used is:

First, when  $\delta > 1$ , the agent is on the defensive. First, their utility remains at a high level, when the bargaining time comes, then decreased rapidly.

Second, when  $\delta = 1$ , the agent chooses a linear strategy. The utility of agent level decreased with the time constantly.

Third, when  $\delta < 1$ , the agent is more progressive. First, there utility decrease rapidly then remained at a high level.

### 3.4.5. The description of bargaining process

As discussed above, the bargaining process can be simply summarized as follows:

First, the initialization of bargaining. Distribute parameter to agent, such as the initial offer as  $r_{int}$ , the demand d, the bargaining period  $\tau$ , the role of the market  $\alpha$ , the market reaction coefficient  $\pi$ , concession strategy  $\delta$ .

Second, according to the collection of quotations  $R_t$ , the agents make anti proposed decision(counter-offer), and waiting for a response.

Third, if the count-party to accept the (counter-offer, a deal was struck, and Exit the bargaining process. Otherwise, if  $t > \delta$ , to forth step; if  $t \leq \delta$ , to fifth step.

Forth, if  $t > \delta$ , the lender and borrower both have no time to negotiate. Agent will make decision at the last period  $r_{b,t}$ . If  $\Theta(r_{b,t}, b, f, r_{int}, \alpha, \pi) \geq 1 - d$ , the agent will accept the offer of last period  $r_{b,t}$ , or the bargaining failure.

Fifth, if  $t \leq \tau$ , the borrowers and lenders still have opportunities, the Agent will give counter-offer in the next round. If  $\max(\Theta(r_{b,t}, \Theta(r_c, t + 1), 1 - d) = \Theta(r_{b,t})$ , agent will accept the optimal bidding in this round. If  $\max(\Theta(r_{b,t}, \Theta(r_c, t + 1), 1 - d) = \Theta(r_{b,t+1})$ , to sixth step. If  $\max(\Theta(r_{b,t}, \Theta(r_c, t + 1), 1 - d) = 1 - d$ , the agent will exit the bargaining process, the bargaining failure.

Sixth update to t+1, back to second step.

#### 4. The experimental design and results analysis

##### 4.1. The basic parameters of the experimental

In order to simulate the supply and demand in the credit market, we introduce four agents, contain two borrowers ( $f_1, f_2$ ) and two lenders ( $b_1, b_2$ ). The lenders  $k=30$ . All the borrowers want a one unit of loans; all lenders each have one unit of loans. In order to simplify the experiment, let the bargaining period  $\tau = 10$ , all agents concession strategy is linear, that means  $\delta = 1$ . Suppose the credit environment of the market is: the borrowers mortgage rate  $\beta = 1$ , the leverage ratio  $\lambda = 1$ , the risk free interest rate  $r_f = 0.05$ , the chance of success of the risk project  $p=0.8$ . Especially, the lender use the bargaining model that have considered the relationship between supply and demand, the rest of the agents use the model of Faratin, Sierras and Jennings(1998). For  $f_1$ , according to the(11), let its initial offer as  $r_{int} = \frac{r_f}{p}$ , and its  $d = \pi = 1, a = -1$ . In order to ensure that the agent will not leave during negotiation process. Parameters of Other agents is shown in table 1. We will study the agents bargaining behavior in three types of market environment: short supply, the balance of supply and demands and oversupply.

It is worth saying, the bargaining model in this paper is fundamentally different from the model of Faratin, Sierra and Jennings(1998). Their model requires market participants to set a final reservation utility before the bargaining process, the final reservation utility is directly related to the final price. But as described by Ren and Zhang(2013), the supply and demand of market is changing, market participants may not uphold its final reservation utility in any market situation. When the supply and demand changes, participants should timely adjust the reservation utility, or will lose the opportunity to clinch a deal.

Table 1: the parameters of  $f_2, b_1$  and  $b_2$

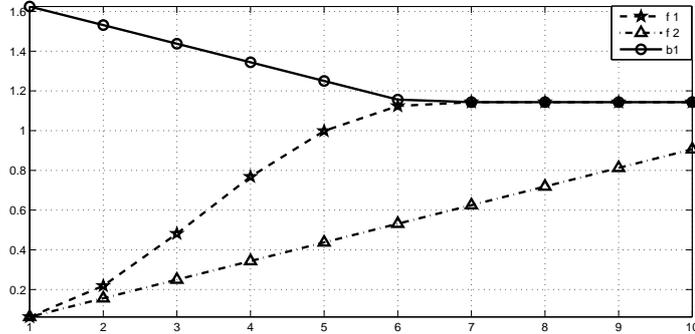
Agent	$r_{ini}$	$u$	$\tau$	$\delta$	$\alpha$
$f_2$	0.0625	0.4	10	1	-1
$b_1$	1.6250	0.4	10	1	1
$b_2$	1.3000	0.4	10	1	1

##### 4.2. The experimental results

###### 4.2.1. in the inferior market

Suppose there are  $f_1, f_2$  and  $b_1$  in the market, borrower  $f_1$  and  $f_2$  compete for one unit of credit resource from lender  $b_1$ . The experimental results is shown in figure 1. Obviously, in the sellers (supply) market environment, in order to occupy scarce credit resources. The bid of  $f_1$  is higher than that of  $f_2$  in each round. Finally in the seventh round, borrower  $f_1$  and lender  $b_1$  reached an agreement, the bid is 1.1242. we can conclude that first, borrower  $f_1$  note that the credit market supply-demand relationship disadvantage to him. In order to make a deal, borrower  $f_1$  give more concessions to lender. Second, this experiment made the borrowers ( $f_1$ ) transaction will as 1, so the borrower  $f_1$  will not out of the market in the bargaining process. When we reduce the borrowers ( $f_1$ ) transaction will, if the adverse conditions aggravated, the borrower  $f_1$  will out of the market.

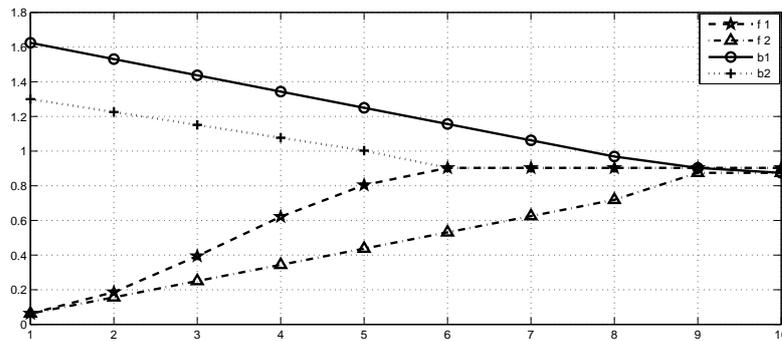
Figure 1: Bargaining in the inferior market



4.2.2. In the equitable market

Suppose there are  $f_1, f_2$  and  $b_1, b_2$  in the market. The experimental results is shown in figure 2. In market equilibrium, borrower  $f_2$  find that there are less competition in the market, the bid of  $f_1$  is higher than that of  $f_2$  in each round. Finally, in the seventh round of bargaining, borrower  $f_1$  and lender  $f_2$  reached an agreement, the bid is 0.9034. Notably, borrower  $f_2$  and lender  $b_2$  reached an agreement in the last round, the bid is 0.875, lower than borrower  $f_1$ . Based on the seventh assumptions, borrower  $f_1$  make a deal in fourth round, pay a high price but certainly saves time. But borrower  $f_2$  make a deal in the last round, devoted time but pay a lower price. So in a real-world market, the systematized, borrower and lender should trade-off between fairness and efficiency.

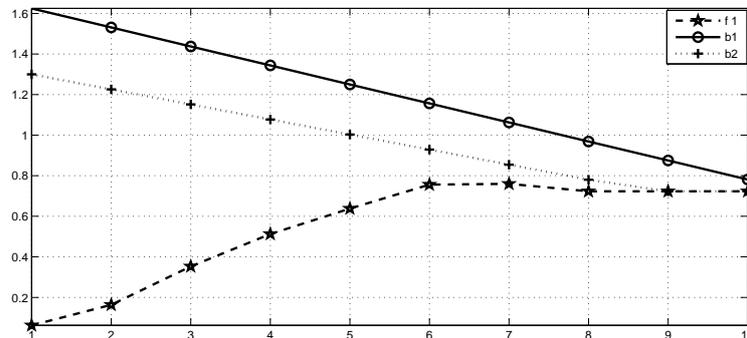
Figure 2: Bargaining in the inferior market



4.2.3. In the beneficial market

Suppose there are  $f_1$  and  $b_1, b_2$ , in the market. The experimental results is shown in figure 3. The market is more conducive to the borrower. Because the lender  $b_1$  and  $b_2$  should compete for the only borrower  $f_1$  and lender  $b_2$  reached an agreement in the price 0.7231, lower than the price of first two cases. Because the borrower  $f_1$  finds that the relationship between supply and demand is on his side. He becomes more aggressive in the bargaining.

Figure 3: Bargaining in the inferior market



## 5. The conclusion

In this study, we propose an artificial credit market in which contains the transaction bargaining mechanism. By choosing the parameters of these agents, we illustrate experimental results of the proposed model in different market situations, including the inferior market for buyers, the equitable market and the beneficial markets. We find that in the inferior (beneficial) market, the agent who takes both objective and subjective considerations into account may make the bargaining negotiation process more efficient; however, we find that the agent has to make choices between efficiency and impartiality in the equitable market.

First, in the inferior seller's (supply) market, the borrower  $f_1$  will note that the credit market supply-demand relationship disadvantage to him in order to make a deal, borrower  $f_1$  give more concessions to lender  $b_1$ .

Second, in the equitable market, the borrower  $f_1$  has to make choices between efficiency and impartiality.

Third, in the beneficial market, the lenders should compete for the only borrower. The borrower becomes more aggressive in the bargaining, the turnover rate lower than the inferior sellers (supply) market and the equitable market.

## Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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