Incentive regulation of banks on third party logistics enterprises in principal-agent-based inventory financing

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Abstract In inventory financing, asymmetric information between banks and the third party logistics enterprises may incur moral risks, often causing economic losses of banks. To effectively solve this problem, a pure incentive scheme and a regulatory incentive scheme are designed with the principal-agent theory. By comparison, it is found that the pure incentive model is not applicable to practical conditions, and regulatory incentive model can not only solve practical problems substantially but also outbalance pure incentive model under certain conditions. The research results from example analysis given in this paper offer theoretical instruction and a practical method for effective regulation of banks.

Keywords Inventory financing · Asymmetric information · Principal-agent · Regulatory incentive

1 Introduction

In comparison with large enterprises, the small and medium enterprises have relative advantages in creating job opportunities, promoting technical progress, accelerating regional

economic recovery and other aspects. However, the small and medium enterprises commonly encounter financing difficulties in both developing countries with financial repression and imperfect financial system and the developed countries with financial liberalization and sound financial system. Most scholars consider information asymmetry as an important cause for hindering the financing of the small and medium enterprises, among which Stiglitz and Weiss [1] are the most influential. There are two options for the small and medium enterprises when making financing decisions: providing true information or false information. However, once the information asymmetry occurs, these enterprises tend to choose the latter. Hence, the borrower in an information advantage can often utilize such advantage to seek the opportunity benefits, which may present in following typical ways. The first is fraudulent bankruptcy and true debt avoidance, thus seeking the opportunity benefits from the “bankruptcy”. The characteristics of the small and medium enterprises determine their stronger incentive on investing the high-risk projects at the cost of debt financing. If the projects succeed, the high yield will belong to the enterprises. If fail, the loss will be passed on to the capital providers. The second typical way is to offer “inflated” collateral security for seeking the opportunity benefits. Third, the borrower conceals the real operating conditions of enterprises via false financial statements to mislead the banks to offer the loans. Forth, the borrower may utilize the information advantage to change the use of funds after getting loans. In addition, the fifth typical way is seeking the opportunity benefits through “interpersonal relationship”. Similarly, due to information asymmetry, the ethical risk may occur after the investment contract is entered into, i.e., the financing party will be engaged in the activities in its own interest but deviate the interests of investors under the shield of the information asymmetry.

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Whereas small and medium enterprises may play a dominant role in promoting the economic development, experts and scholars all over the world have emphasized the research on financing problems very much. Thus a great number of valuable research literatures have sprung up. Jensen and Meckling created the contract theory on the financing structure, based on which the incentive theory, signaling theory and theory of control right incentive on the financing structure of enterprises have been developed in Ref. [2]. The pecking order theory proposed by Myers is the earliest research on the financing structures under the condition of the asymmetric information [3, 4].

Many scholars deemed that the bank loan was the first and foremost channel for small and medium enterprises to finance [5–7]. The research by Bernanke and Blinder [8] also showed that the traditional bank loan remained to be the most important external financing channel of the small and medium enterprises. Therefore, the core subject in terms of the financing of the small and medium enterprises mainly focuses on the bank credit based on the information asymmetry.

The bank credit is the main financing channel for small and medium enterprises. However, the prior adverse selection and the post ethical risk resulting from the information asymmetry are the main obstacles of the credit financing of the small and medium enterprises. Such situation was relieved to a large extent until the logistics financial businesses were undertaken in the 1990s. The development of the logistics financial industry underwent three phases: (i) In the middle and earlier stage of 19th century, the logistics finance was characterized in rote supervision, single-link inventory pledge and less involvement of logistics enterprises; (ii) In the second phase from the middle of 19th century to the 1970s, the changes rested on that the logistics enterprises became more involved in the businesses. As with the involvement, the logistics finance mode turned into a mode in which the inventory pledge is given priority to and the pledge for accounts receivable is supplementary. The supervision model is relatively flexible; (iii) The third phase started from the 1980s to now, literatures on the practice and research from the perspective of supply-chain finance became the main stream, of which the research content mainly focused on “financing”, “risk”, “profit” and “contract”.

With respect to the research on the logistics finance, a great number of valuable research literatures and application cases have sprung up all over the world. For example, in terms of business evolution, Friedman, Albert, Eisens-taedt, Raymond and Dunham summed up legal support, business models, storage methods, supervision methods and procedures of inventory pledge financing and accounts receivable financing in the logistics finance [9–13]. Rut-berg taking UPS as an example, elucidated the main characteristics of the innovation model of the logistics

finance [14]. Barnett and Biederman conducted the relevant research on the current situation and development tendency of the logistics finance [15]. Pillai [16] thought that the goods market and warehouse financing were two tools for providing the price exploration and risk mitigation to farmers by deeply researching the various aspects of the warehouse financing in India. After analyzing the conflicts in the inventory interests between participants in the supply chains, Erik Hofmann put forward the concept of inventory financing for logistics service providers and stated out the influencing factors. In addition, Hofmann [17] applied hedging to the provider financing to avoid the business risk. By taking Bank of America for example, Dan [18] expressed that the financial supply chain was managed by means of electronic payment through the integration of logistics and cash flows, under the premise that the procedures and characteristics of supply chains were comprehensively mastered. Gonzalo and Mariana researched the short-term supply-chain management integrating the production and the enterprise financing plan and deemed that the reasonable supply-chain management mode might influence the operation and financing of enterprises to increase the overall revenues [19].

In practice, foreign financial institutions, such as BNP Paribas, Mees Pierson Bank and Citibank N.A., etc., had cooperation with the logistics warehousing enterprises, developed logistics financial business, and even established a special pledge bank. In 1999, America Morgan Stanley invested \$350 million to the listed company Redwood Trust to develop the logistics financial business. In the same year, American Package Delivery Company UPS, the world’s largest express & logistics giant, purchased the first international bank and set up a special UPS financial corporation which could blend the logistics, capital flow and information flow effectively to provide financing products and services for customers and develop logistics financial service in all around manner.

China scholars, represented by Yi-Xue Li, Xiang-Feng Chen and Xiang Liu, made their research emphasis on the cost/profit, price/capital constraint model, information system and dissipative structure theory [20–24].

Seen from the developmental trajectory of Chinese logistics finance, Huai Chen from the Renmin University of China had made an assumption of establishing a material bank as early as in 1987. In the early 1990s, there were also some scholars who published the papers to discuss material bank operations. However, “material bank” at that time was intensely tinted with planned economy color and mainly discussed the regulation and swap of the materials by material bank. In April 1998, Wen-Chao Ren, former general manager of Shanxi Qin-ling Zengs Non-ferrous Metals Co., Ltd. at that time, explored to use the “material bank” to solve the chain debt problems of the enterprises, making a

breakthrough for the concept. In 1999, China Material Storage & Transportation Company and the bank launched the first inventory business in Wuxi, which officially fostered the development of the China's logistics financial business.

In February 2002, Qi Luo and Dao-Li Zhu et al. from School of Management, Fudan University put forward the concept and operation mode of "financing warehouses". In 2004, Xiao-Peng Zou and Yuan-Qi Tang from School of Economics, Zhejiang University first proposed the concept of "logistics finance", of which the connotation and denotation were defined. Thereby "logistics finance" was formally regarded as a new research platform.

Since 2004, the concept, mode and application of "logistics finance" have been the focuses of the research. The results of theory research promoted the development of bank related business: China Guangfa Bank and China Construction Bank first launched "logistics bank" business in 2004; China Pudong Development Bank first regarded the logistics finance as a new profit growth point in 2005. By 2007, several banks including ICBC, CCB, ABC, China CITIC Bank and Shenzhen Development Bank had provided logistics financial products.

With the expansion of logistics financial business of each bank, the risk has aroused most scholars' attention. For the research of risk prevention, Coulter and Onumah [25] believed that the short-term risk of chattel inventory financing came from the price fluctuation of the pledges. John and Rachel analyzed the inventory management under the condition of pledge financing [26]. Barsky and Catanach [27] believed that logistics finance was different from the traditional credit loan. Thus in practice, the business control should turn the concept of risk control based on the main-part access into the concept of risk management based on the process control. Diercks [28] believed that logistics financial business must be monitored closely, and introduced some concrete control methods, and at the same time, discussed the necessity for the third party logistics enterprises to participate in the monitoring activity. Nevilie [29] researched how to value the inventory in financing and gave the operating precautions in 2008.

The above research shows that although "risk" is a hot-spot of the research, yet from the developing process of bank "logistics finance" business, research points are concentrated on profit calculation and risk prevention in advance, including the design of the loan contract and the confirmation for the ratio of pledge. Researches on the business monitoring during the process and exit mechanism after the business are insufficient. As the scope of "logistics finance" business is expanded constantly, various good cheats and robbery occur frequently. A loan repayment storm in Shanghai steel trade market in 2012 let the banks lose trust in steel trade enterprises. The major banks shrank their credit scale, which made gloomy steel market even worse. In 2011,

the total amount of bank financing credit by Shanghai steel trade enterprises was up to RMB 151 billion Yuan. The steel trade guarantee corporations held the balance of RMB 28.9 billion Yuan. The steel trade enterprises needed to burden nearly RMB 25 billion Yuan of interests and fees in one year. According to statistics, the financing cost of the steel trade enterprises was as high as 37 %. However the steel trade enterprises could not afford such a huge amount due to the recent depressed industry market. Surprisingly, the steel trade enterprises made large loans from banks again and again by the way of "joint guaranty" between them in the case that they knew they were unable to pay back the loans. After careful investigation, 80 % of Shanghai steel trade merchants were found to be Zhouning people in Fujian. Some steel trade merchants set up their own guarantee corporations. Then steel trade merchants ganged up for applying for loans from banks by mutual guarantee. In addition, non-standard warehouse receipts were given for steel pledge, and the supervision existed in name only and repeated pledge was serious. In the whole pledge financing business, banks did not fully investigate the real strength of these companies before lending and were blinded by the superficial phenomenon of "joint liability guaranty". Among the banks, guarantee corporations and steel trade merchants, it was obvious that the interest of guarantee corporations was consistent with that of the steel trade merchants, so the banks were clearly at a disadvantage.

Therefore, banks and the third party logistics enterprises have been troubled by such problems as how to monitor the goods in real time, how to determine the value of the goods, and when to make an inventory of the warehouses. This paper sets up a model for such sorts of problems and mainly analyzes how the banks seize the power of control in the trilateral cooperation, solve the interest conflicts of three parties, and take reasonable incentive measures to make the third party logistics control enterprises actively perform their duties.

Inventory pledge can be simply explained as that enterprises borrow money from financial institutions with the inventory as the pledge. To realize transferred possession of the pledged property, the bank entrusts a logistics enterprise or an asset management company as the third party enterprise to monitor and store the pledged inventory. There are relations among the banks, the enterprise, the third party logistics enterprise (see Fig. 1): (i) the enterprise borrows money from the bank with the inventory as the pledge; (ii) the bank entrusts the third party enterprise to monitor and store the goods; (iii) the bank generally requires the third party logistics enterprise to make credit guaranty for the loan enterprise in order to dodge risks. The biggest risk of inventory financing businesses does not simply lie in internal control of credit loan approval. Violation operation or illegal behaviors in the management

Fig. 1 Tripartite relation in stock pledge

of each party after loaning also pose great threat to banks, that is, asymmetric information leads to moral risks. The informationization of the third party logistics enterprise is low and the information exchange between the bank and customers is asymmetric or opaque, so each party driven by interests may fall into violent operation and further cause moral risks in case of such weak internal management.

Principal-agent relations in economics generally refer to a transaction pertaining to asymmetric information in which the one is agent while the other is principal. Personal information (behaviors or knowledge) of an agent has an influence on the principal, in other words, a principal has to take risks of an agent's behaviors. Principal-agent theory model poses the following question: how can a principal punish or reward the agent based on observation or external random factors so as to prompt the agent to take actions that are the most favorable to the principal?

Former researches in contract designing did not consider that an agent (the third party logistics enterprise) might get "grey interest" which might influence their effort extent. On the basis of former studies, this paper intends to design a new contract to combine the bank's supervision, punishment and reward mechanism by taking into consideration the fact that the third party logistics enterprise might get grey interests. By comparison between the pure incentive contract and the example analysis, it is found that this new contract is more close to the reality, which enables each party to get utmost interests and effectively lowers moral risks taken by the bank. The solution of contract model sheds light on the relations between the third party logistics enterprise's effort and the bank's incentive. This paper also analyzes its influencing factors.

2 Model establishment and solution

The bank in the inventory pledge process entrusts part of the businesses to the third party logistics enterprise, which can save costs and increase efficiency both. However due

to asymmetric information of both sides, the bank may take moral risks caused by pursuit of interests of the third party logistics enterprise. In addition, the loan enterprise often instigates the third party to cover its rule-violating operations, which further increases moral risks of the bank in inventory pledge. This paper puts forward that the bank should supervise the third party logistics enterprise on the basis of incentive and consider punishment-reward factors.

2.1 Principal-agent model when the bank only takes incentive method for the third party logistics enterprise

In the contract design of this model, the bank only takes incentive method to prevent immoral behaviors between the third party logistics enterprise and the loan enterprise. Set J as all the effort levels of the third party logistics enterprise, $a \in J$ as a certain effort level of the third party logistics enterprise. For the sake of simplification, suppose a is a one-dimensional continuous variable representing how strictly the third party logistics enterprise performs contract and refuses to collude with the loan enterprise. Set $a \in [0, 1]$, the increasing of a indicates that the third party works harder and does not collude; θ is an external random factor immune to influences from the bank and the third party logistics enterprise, which is called natural condition. Suppose θ is submissive to normal distribution with the average of 0 and variance of σ^2 , and higher θ represents a more favourable natural condition.

The loan enterprise once has the motivation of refusing to pay back the loans, opportunistic behavior will occur. To achieve the utmost satisfaction, they generally will give the third party logistics enterprise "grey interests" so that the third party will cover their rule-violating behaviors. $(1 - a)$ indicates the covering degree of the third party logistics enterprise, then the function of "grey interests" of the third party logistics enterprise is $Q(a) = q(1 - a)$, and q is the coefficient relevant to the grey interests given by the loan enterprise to the third party logistics enterprise.

Here the production function of the third party logistics enterprise is

$$\pi = (A - h)a + \theta, \quad (1)$$

where π represents value appreciation brought by the third party logistics enterprise services; A represents influence coefficient of effort level variable on service value appreciation, that is, the third party logistics enterprise's service capability coefficient which is generally determined by management, assets scale, etc.; h is the influence coefficient generated by impact of the loan enterprise's "grey interests" on service capability of the third party logistics enterprise.

Contracts where the bank pays incentive rewards to the third party logistics enterprise take linear forms:

$$s(\pi) = \alpha + \beta\pi, \quad (2)$$

where α the fixed income gotten by the third party logistics enterprise, β the incentive reward degree coefficient, $0 \leq \beta \leq 1$.

According to basic theories of microeconomics, effort cost $c(a)$ and marginal cost $c'(a)$ will increase with effort level a , that is, $c'(a) > 0$, $c''(a) > 0$. This paper applies the function $c(a) = \frac{1}{2}ba^2$ to represent the third party's effort level; b is the cost coefficient and the value of b decreases with the increase of the third party logistics enterprise's capability.

Suppose the bank has a neutral risk, and the third party logistics enterprise intends risk aversion with invariable risk aversion feature. $\rho = -\frac{u''}{u'} > 0$ represents Arrow-Pratt absolute risk aversion degree of the third party logistics enterprise; in utility function $u = -e^{\rho w}$, where w represents the actual monetary income of the third party logistics enterprise.

When the risk of the bank is neutral, its expected utility equals the expected income:

$$Ev(\pi - s(\pi)) = E(\pi - \alpha - \beta\pi) = (1 - \beta)(A - h)a - \alpha. \quad (3)$$

The actual income of the third party logistics enterprise is

$$w = s(\pi) - c(a) + Q(a) = \alpha + \beta\pi - \frac{1}{2}ba^2 + q(1 - a). \quad (4)$$

According to Arrow-Pratt conclusion, risk cost of the third party logistics enterprise is $\frac{1}{2}\rho\beta^2\sigma^2$ and its definite equivalence income is

$$Ew - \frac{1}{2}\rho\beta^2\sigma^2 = \alpha + \beta(A - h)a - \frac{1}{2}ba^2 + q(1 - a) - \frac{1}{2}\rho\beta^2\sigma^2. \quad (5)$$

For the maximum expected utility equivalence, the third party logistics enterprise is equivalent to the maximum definite equivalent, and we replace expected utility with definite equivalent income.

Set $\bar{w}$ as the reserve income level of the third party logistics enterprise. When the definite equivalence income is lower than $\bar{w}$, the third party logistics enterprise will not accept the contract. Therefore, participation constraint (that is, personal rational constraint IR) of the logistics service supplier is

$$\alpha + \beta(A - h)a - \frac{1}{2}ba^2 + q(1 - a) - \frac{1}{2}\rho\beta^2\sigma^2 \geq \bar{w}. \quad (6)$$

The bank makes equal sign tenable under the optimal condition.

In the bank's principal-agent relations, the bank has no way to observe effort level of the third party logistics enterprise due to asymmetric information. However the rational third party logistics enterprise might make use of information advantage to choose an effort level achieving the maximum interests and further damaging the bank's interests. Therefore, the third party should also meet incentive compatible constraint (IC), that is

$$\begin{aligned} \alpha + \beta(A - h)a - \frac{1}{2}ba^2 + q(1 - a) - \frac{1}{2}\rho\beta^2\sigma^2 \\ \geq \alpha + \beta(A - h)a' - \frac{1}{2}b(a')^2 + q(1 - a') - \frac{1}{2}\rho\beta^2\sigma^2, \end{aligned} \quad (7)$$

where a' represents other effort level chosen by the third party. Thus incentive compatible constraint equals

$$\max_a \left\{ \alpha + \beta(A - h)a - \frac{1}{2}ba^2 + q(1 - a) - \frac{1}{2}\rho\beta^2\sigma^2 \right\}. \quad (8)$$

Model 1 is established as follows:

$$\max_{\alpha, \beta, a} \{ (1 - \beta)(A - h)a - \alpha \}, \quad (9)$$

$$\text{s.t. (IR)} \quad \alpha + \beta(A - h)a - \frac{1}{2}ba^2 + q(1 - a) - \frac{1}{2}\rho\beta^2\sigma^2 \geq \bar{w}, \quad (10)$$

$$\text{(IC)} \quad \max_a \left\{ \alpha + \beta(A - h)a - \frac{1}{2}ba^2 + q(1 - a) - \frac{1}{2}\rho\beta^2\sigma^2 \right\}. \quad (11)$$

The optimal solution when the bank only adopts incentive method for the third party logistics enterprise:

$$a_1 = \frac{\beta_1(A - h) - q}{b}, \quad (12)$$

$$\beta_1 = \frac{1}{1 + \rho b \sigma^2 / (A - h)^2}. \quad (13)$$

This contract touches upon "grey interests" in actual operations of the three parties and is believed that the "grey interests" have negative influences on whether the third party operates legally. Known from the above results, the effort level of the third party logistics enterprise is positively correlated with the bank incentive coefficient and the

third party's capability, that is, the higher the bank incentive level is, the stronger the third party's capability will be. However it is negatively correlated to "grey interests", that is, the more "grey interests" the third party gets, the more likely the third party may choose to cover up the loan enterprise. The bank incentive coefficient is positively correlated to the third party's capability and is negatively correlated to the third party's risk aversion degree and external indefinite factors. That is, if the third party has strong capability, small risk aversion degree, fewer indefinite factors, the bank will provide more incentives.

2.2 Principal-agent model when the bank adopts incentive, supervision and punishment-reward method for the third party logistics enterprise

The bank may consider using a supervision and punishment-reward mechanism on the basis of incentive to restrain the third party from collusion behaviors, impel them to work harder and further to reduce losses caused by moral risks. Suppose $P \in [0, 1]$, which represents the supervision level of the bank on the third party, can be understood as that the bank discovers the third party failing to meet scheduled standards (that is, rule-breaking rate). Being the same as the third party's effort cost, suppose the supervision cost function as $c_2(P) = \frac{1}{2}dP^2$, in which d is the coefficient of bank supervision cost. At this time, the service capability coefficient of the third party logistics enterprise will change with the bank supervision. To put it simple, suppose the changed capability coefficient under the bank supervision influence as kP , so the production function of the third party logistics enterprise is

$$\begin{aligned}\pi &= (A + kP - h(1 - p))a + \theta \\ &= (A + kP + hP - h)a + \theta.\end{aligned}\quad (14)$$

If job performance π of the third party reaches or surpasses the expected standard π_0 in bank examination, they will not be punished. Otherwise, the bank punishes them to some extent. Suppose the punishment value as $(\pi_0 - \pi)F_0$, the punishment function on the third party logistics enterprise by the bank can be represented

$$F(\pi) = \begin{cases} 0 & \pi \geq \pi_0, \\ (\pi_0 - \pi)F_0 & \pi < \pi_0, \end{cases}\quad (15)$$

where π_0 represents the expected standard of job performance which can be accepted by the bank; F_0 represents the corresponding punishment coefficient, and $F_0 > 0$. In this case, the expected value in which the third party is punished by the bank can be represented as

$$\begin{aligned}E(F(\pi)) &= E((1 - P) \times 0 + P \times (\pi_0 - \pi)F_0) \\ &= P(\pi_0 - (A + kP + hP - h)a)F_0.\end{aligned}\quad (16)$$

The loss expectation when illegal behaviors occur but the bank fails to discover them can be represented as

$$El = (1 - P)(\pi_0 - (A + kP + hP - h)a). \quad (17)$$

Contract commission, that is the commission given by the bank to the third party logistics enterprise, is

$$s(\pi) = \alpha + \beta\pi. \quad (18)$$

When the risk of the bank is neutral, expected utility equals expected returns, so

$$\begin{aligned}Ev &= E(\pi - s(\pi)) - c_2(P) + E(F(\pi)) - El \\ &= (1 - \beta)(A + kP + hP - h)a - \alpha - \frac{1}{2}dP^2 \\ &\quad + P(\pi_0 - (A + kP + hP - h)a)F_0 \\ &\quad - (1 - P)(\pi_0 - (A + kP + hP - h)a).\end{aligned}\quad (19)$$

The actual income of the third party logistics enterprise is

$$w = s(\pi) + Q(a) - c(a) - F(\pi). \quad (20)$$

The definite equivalence income of the third party logistics enterprise is

$$\begin{aligned}Ew - \frac{1}{2}\rho\beta^2\sigma^2 &= \alpha + \beta(A + kP + hP - h)a + q(1 - a) - \\ &\quad \frac{1}{2}ba^2 - P(\pi_0 - (A + kP + hP - h)a) \\ &\quad F_0 - \frac{1}{2}\rho\beta^2\sigma^2.\end{aligned}\quad (21)$$

Model 2 can be rephrased as follows:

$$\begin{aligned}\max_{\alpha, \beta, a} &\{(1 - \beta)(A + kP + hP - h)a - \alpha - \\ &\frac{1}{2}dP^2 + P(\pi_0 - (A + kP + hP - h)a)F_0 \\ &- (1 - P)(\pi_0 - (A + kP + hP - h)a)\}, \\ \text{s.t. (IR)} &\quad \alpha + \beta(A + kP + hP - h)a + q(1 - a) - \frac{1}{2}ba^2 - \\ &\quad P(\pi_0 - (A + kP + hP - h)a)F_0 - \frac{1}{2}\rho\beta^2\sigma^2 \geq \bar{w},\end{aligned}\quad (22)$$

$$\begin{aligned}\max_a &\{\alpha + \beta(A + kP + hP - h)a + q(1 - a) - \frac{1}{2}ba^2 \\ \text{(IC)} &- P(\pi_0 - (A + kP + hP - h)a)F_0 - \frac{1}{2}\rho\beta^2\sigma^2\}.\end{aligned}\quad (23)$$

The solution is

$$a_2 = \frac{(A + kP + hP - h)(\beta_2 + PF_0) - q}{b}, \quad (25)$$

$$\beta_2 = \frac{2 - P - PF_0}{1 + \rho b \sigma^2 / (A + kP + hP - h)^2}. \quad (26)$$

From the balanced results of this contract, the effort level of the third party logistics enterprise is not only positively correlated with the bank incentive coefficient and the third party's capability yet negatively correlated to their "grey income", but also positively correlated with the bank supervision and punishment degree. That is, the more serious the bank supervision and punishment is, the more efforts the third party will make to avoid illegal operation. The bank incentive coefficient is positively correlated to the third party's capability and negatively correlated to the third party's risk aversion degree and external indefinite factors as well as punishment degree. That is, the more serious the bank punishment is, the fewer incentives the bank is likely to give the third party logistics enterprise. In terms of the supervision degree, when the value of P is extremely big or small, the bank incentive will diminish in the same way.

3 Model analyses

By analyzing balanced results of contract 1 (model 1) and contract 2 (model 2), it is found that the bank in contract 1 only adopts incentive method to prevent illegal operations from the third party while the bank in contract 2 takes supervision and punishment measures in addition to incentive measures to prevent illegal operations.

As far as the bank incentive coefficient is concerned, the third party hopes the bigger the better. In line with the balanced results of the contract, through comparing Eqs. (13) and (26), if $2 - PF_0 - P \geq 1$, the bank incentive coefficient in contract 1 is sure to be bigger than that in contract 1. That is, if $\beta_2 > \beta_1$, the unnecessary and sufficient condition requires $F_0 \leq \frac{1-P}{P}$, indicating the third party hopes that punishment coefficient set by the bank will not exceed the ratio of supervision-null degree to supervision degree. The stronger the supervision is, the smaller punishment coefficient will be. "Small amount, multiple times" supervision model is what we experience in reality, that is, supervise frequently but punish slightly when discovering problems. In case of light supervision from the bank, punishment can be strengthened accordingly. In reality, we often see that they will experience bankruptcy when these things occur. But supervision strengthening will increase supervision cost, and strong supervision is hard to achieve and fails to mend. Thus a proper supervision and punishment degree will be good for both the bank and the third party logistics enterprise.

The bank hopes that the third party logistics enterprise makes greater efforts. Seen from Eqs. (12) and (25), when $\beta_2 > \beta_1$, $a_2 > a_1$, that is, when the bank sets a reasonable degree of punishment and supervision, $\beta_2 > \beta_1$ and further $a_2 > a_1$ is sure to be realized. This is the results satisfying both the bank and the third party logistics enterprise. The third party logistics enterprise will get more incentives while the bank will benefit from the third party's efforts. To summarize the analyses above, in case of asymmetric information, supervision from the bank is vitally important but supervision degree will also influence the cooperation of both parties.

4 Example analyses

To prove the superiority of the new contract, to further illustrate the optimal rewards given by the bank to the third party logistics enterprise and the optimal effort level made by the third party (the third party operating illegally and do not collude with loan enterprise), and to illustrate changing conditions between the third party's effort level and the bank incentive coefficient, this study demonstrates corresponding numerical example.

Suppose cost coefficient $b = 100$; the self-supervision capability of the third party $A = 150$; the third party's capability coefficient which changes with the influence of grey interests $h = 50$; risk aversion degree $\rho = 1$; coefficient of grey interests given by the loan enterprise to the third party logistics enterprise $q = 5$; θ complies with normal distribution $N(0, 900)$. Fill the above data into Eqs. (12) and (13) and we can get

$$a_1 = \frac{\beta_1(A - h) - q}{b} = 0.05, \quad (27)$$

$$\beta_1 = \frac{1}{1 + \rho b \sigma^2 / (A - h)^2} = 0.1. \quad (28)$$

To illustrate it simply, suppose in the third party's capability coefficient kP which changes with the bank supervision, $k = h = 50$; if punishment degree $F_0 = 0.25$ and that bank chooses a proper degree of supervision $P = 0.6$, fill the values into Eqs. (25) and (26), we can get

$$a_2 = \frac{(A + kP + hP - h)(\beta_2 + PF_0) - q}{b} = 0.633, \quad (29)$$

$$\beta_2 = \frac{2 - P - PF_0}{1 + \rho b \sigma^2 / (A + kP + hP - h)^2} = 0.277. \quad (30)$$

From results in contract 1 and contract 2, we can get

$$\frac{\beta_2}{\beta_1} = 2.77, \quad \frac{a_2}{a_1} = 12.66. \quad (31)$$

We can first conclude from the data above if the bank supervision and punishment is not considered in contract designing, that is, the third party logistics enterprise in contract 1 generally gets fewer incentives from banks, and the third party is apt to collude with the loan enterprise to cheat loans out of the bank under no supervision. Secondly, supervision measures taken by the bank, which are cost-consuming, will increase risk cost of the third party logistics enterprise. However proper input will increase incentives gotten by the third party logistics enterprise by almost three times. The bank can even get 13 times that of the original effort level from the third party logistics enterprise. Advantages outweigh disadvantages for both parties. It can be seen that proper supervision and punishment measures taken by the bank will both increase incentives for the third party and decrease the possibility that the third party colludes with the loan enterprise, thus lowering down moral risks taken by the bank.

5 Conclusions

This paper analyzes principal-agent issue between the bank and the third party logistics enterprise in inventory pledge and designs two contract models. Comparison of the two models and example analysis are carried out. In contract 1, given that the third party will get “grey interests” from the loan enterprise and the bank only takes incentive measures to prevent the third party taking illegal behaviors, the effect is trivial. The third party is apt to operate illegally with few bank incentives and moral risks cannot be effectively prevented. Therefore, contract 1 cannot be widely applied in reality. Contract 2 that adopts a supervision and punishment mechanism on the basis of the bank incentives is formulated. Under contract 2, the bank incentive level and the third party’s effort level will increase significantly, which can solve practical problems and prevent banks’ moral risks more effectively.

Principal-agent model in this study provides an improved thinking yet shortcomings still exist. Many questions such as optimal supervision rate, agent cost, etc., in reality are to be studied in the future.

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