Research on the Choice of Logistics Financial Contract Model Based on Game Theory

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Abstract. Logistics enterprises should not only consider the pursuit of their profit maximization with the rapid development of China's logistics and financial cooperation, but also consider their income distribution and other enterprises' income distribution mutual influence, in order to stabilize the operation and development of enterprises. Based on the analysis of the cooperation and game between logistics and financial enterprises, this paper studies and discusses the operation game analysis of logistics finance by taking the contract selection of game theory as the fulcrum, establishes the contract selection mechanism and model for China's logistics financial operation, and provides a better tool for analyzing the income distribution of logistics finance.

Introduction

The emergence and development of financial logistics cannot be separated from the demand of the external market. The realization ability of movable property such as assets, vehicles, and materials of logistics enterprises is relatively weak, while the exclusive right of trademark and patent can be transferred according to law, which is difficult to determine the valuation of products. Therefore, the process for financial institutions to provide financing is very cautious and lengthy. If the logistics enterprise succeeds in financing and the logistics pay back the loan, the financial institution can only control its movable property or control and supervise its warehousing and operating materials. It is very difficult for financial institutions to find the suitable provision of collateral supervision and warehouse management services for every enterprise. However, if the rights of collateral supervision and warehouse management services are given freely to borrowers themselves, the risks of financial institutions cannot be effectively controlled. Based on convenient financing, logistics enterprises hope to have as little impact as possible on the daily operational efficiency.[1] Therefore, they also hope to provide quality supervision and warehouse management services to effectively integrate into supply chain finance.

In the current popular mode of inventory impawn financing is refers to the need of financing enterprises (debit), do the pledged property, its stock (i.e., lenders) pledge to funding enterprises, at the same time the pledged property to have legal custody of the logistics enterprises (mediator) of qualification of the inventory custody, in order to obtain credit loan business activities, is the logistics enterprises to participate in the chattel pledge business.

Analysis of Basic Conditions of Logistics Financial Game

The game is composed of three elements: players, strategy set, and players benefit from the game. From the analysis of the income distribution finance-transportation learn that participating in income distribution of finance-transportation companies make up the game of the participants: each participant will be according to their needs, as well as the external judgment, form a favourable allocation strategy, enterprise produced by the different allocation strategy together to form the strategy of the game. Because the profit of logistics enterprises is different in the financing warehouse, it constitutes the basic condition of their benefit function and game. [2]

Game theory is the study of the decision-making when the behavior of decision-making groups directly interact with each other and the equilibrium problem of such decision-making, the game is
basically between logistics and financial enterprises by the participants, the policy set, as well as participants in the game who benefit form, from the perspective of the analysis of income distribution finance-transportation and participating in income distribution of finance-transportation companies make up the game of the participants, they will demand, according to their corporate earnings judgment of external environment, the architecture of this enterprise allocation strategy, so as to make up the logistics financial enterprises game respective benefit function.

The players in the game are represented by “I”. The benefit of all players in the game of logistics and financial enterprises refers to that for each group of possible decision choices of each player, there should be a result that represents the gain or loss of each player under the strategy combination. Both logistics and financial enterprises have their own game strategies, which constitute their own game strategy sets. Each strategy set \( S_i \) should have at least two different strategies, because a single strategy cannot enter the game strategy set. In the game strategy set, \( S_{ij} \) is used to represent the i strategy of the game party j. For \( S_{ij} \in S_i \), the "benefit" of each game party in the corresponding situation is called the quantitative value of the result in the game. In different game processes, the positive and negative benefits are random, and the contract selection process of logistics finance plays an important role.

**Analysis of Game Contract Conditions of Logistics Finance**

A complete financing contract of a logistics enterprise should consider the whole circulation link of the logistics operation of the pledged goods, including the warehousing of the pledged goods, the storage of the pledged goods, the taking of the goods, the addition of the pledged goods, the realization of the pledge right and the termination of the contract. In the design of loan contracts for logistics enterprises, special attention must be paid to the risk points. The key risk points control indicators in the loan contracts for logistics enterprises include: pledge rate, loan interest rate and loan cycle.

Loan-to-value ratio. Logistics enterprise loan contract in the loan-to-value ratio is the ratio of loans and stock pledge value indicators, is the pledge of stock value and logistics enterprise, corporate default probability, and loan interest rates are closely related to regulatory way, can comprehensively reflect the enterprise inventory impawn financing risk factors, is the core of inventory impawn financing risk control indicators.

Loan interest rate. Mainly in the design of logistics enterprises loan contracts require Banks to meet capital adequacy requirements, to effectively control the credit risk, this makes the logistics enterprise inventory impawn financing have the basis for determination of loan interest rates, the loan pricing from return on equity measurement method based on risk adjustment of capital into the yield calculation method, is an important indicator of inventory impawn financing risk control.

Loan cycle. The inventory pledge loans of logistics enterprises mainly rely on the self-compensation sales of inventory to repay the financing loans. The financing loan cycle is closely related to the risk of inventory pledge financing. The mismatch between the loan cycle and the inventory and sales cycle of the borrowing enterprise is likely to cause the default delay of the borrowing enterprise, which causes certain risks to the operation of the financial institution and affects the loan safety of the creditor. Therefore, the loan cycle must be determined according to the actual needs of the borrowing enterprise in the contract.

**Contract Selection between Logistics Enterprises and Financial Institutions**

In the process of contract selection between logistics and financial enterprises, the logistics and financial business carried out by logistics enterprises is the research object, and the basic elements of the contract selection model are warehouse receipt pledge, confirmed warehouse, advance payment collection and letter of credit guarantee. Since the inventory pledge financing business of logistics enterprises is carried out by logistics enterprises and financial institutions, logistics
enterprises must conduct in-depth research on how to implement the inventory pledge business. How to cooperate with financial institutions, profit distribution is the core problem of contract selection [3].

**Conditional Assumptions**

Generally speaking, logistics enterprises only consider the market risk and the risk of the price fluctuation of their pledges, not the legal risk, operational risk and other risks. As the credit party makes the contract with the goal of maximizing the expected interest rate, the borrower can only choose to accept or not to accept, and the loan enterprise chooses to default or repay the loan in a lump sum when the loan is due, which causes the game between the logistics enterprise and the financial institution. Therefore, it can be assumed that the logistics and financial enterprises construct the return function of the credit side: inventory pledge is a two-party behavior, that is, the logistics enterprises and financial institutions are regarded as a whole as the credit side, and the default probability of the borrowing enterprise is endogenous, that is, the borrowing enterprise chooses to default when the market value of the pledge is lower than the sum of the loan interest. At the same time, the pledged property has liquidity risk and is known in advance, that is, in the event of default, the return obtained by the credit party from the realization of the pledged property is less than the market value of the pledged property.

**Model Analysis**

Based on the above assumptions, when a financial institution provides a pledge loan to a logistics enterprise, the random variable of the ending value of the pledged property expected by both parties is $c$. Its general density function is $f(c)$, The standard deviation is $\sigma$, according to the change of the price of pledges in recent years, The mean value $\bar{c}$ of pledges is determined according to the changes in the price of pledges in recent years. Determine loan discount rate $\omega$ and the nominal lending rate $r$ according to certain methods. Determine loan size $L = \omega \cdot \bar{c}$, then the sum of the interest on the loan at maturity $\theta$ is determined by $\theta = L \cdot (1 + r) = \omega \cdot \bar{c} (1 + r)$. As long as the ending value of the pledged property $\bar{c}$ is less than the sum of the interest on maturity $\theta$, the logistics enterprise borrowing may choose to default, then the default probability and the expected value of the pledged property are represented as follows:

$$ p = \int_{0}^{\theta} f(c)dc $$

$$ \bar{c} = \frac{1}{p} \int_{0}^{\theta} c \cdot f(c)dc $$

(1)

The expected interest rate of the logistics enterprises with loans expressed in $r_{b}$ is their loan cost. $r_{b}$ satisfies the following equation:

$$ L \cdot (1 + r_{b}) = L \cdot (1 + r) \cdot (1 - p) + p \cdot \bar{c} $$

(2)

If the realization return of collateral obtained by the credit party under the condition of default is less than its market value and the liquidity risk coefficient is $\lambda : 0 \leq \lambda \leq 1$, then the variable present value obtained by the credit party is $(1 - \lambda) \cdot \bar{c}$. $r_{l}$ represents the expected interest rate of the credit party whose loan yield $r_{l}$ satisfies the following equation:

$$ \frac{\partial r_{l}}{\partial r} = (1 - p) - \lambda \cdot \theta \cdot f(\theta) $$

(3)

If the expected interest rate of the financial institution $r_{l}$ is determined by the discount rate of the initial loan $\omega$, the loan interest rate $r$ can be solved as:
\[
\frac{\partial r}{\partial r} = (1 - p) - \lambda \cdot \theta \cdot f(\theta)
\]

With the above equation as a variable, it can be obtained:

\[
\frac{\partial r}{\partial r_1} = -(1 + \lambda) \cdot f(\theta) \cdot \omega \cdot \bar{c} - \lambda \cdot \theta \cdot f'(\theta) \cdot \omega \cdot \bar{c}
\]

(5)

**Contract Selection Model**

Based on the above hypothesis and theoretical model, this paper interprets the game contract of logistics finance from the following three types: fixed fee contract (the client pays the fixed fee to the agent and has the surplus); A sharing agreement (an agreement between the principal and the agent to share the proceeds in an agreed proportion) and a fixed rent agreement (where the agent pays the principal a fixed rent and has the remainder). [4]

**Fixed Commission Fee Contract.** According to the operation of development needs, under the fixed commission fee contract, financial institutions pay logistics enterprises entrusts M, and entrust with the nature of the fixed cost, in this way, a lower risk of logistics enterprises to take risks, just get a maximum of fixed income M, while the financial institutions risk is bigger, also play gains. Let the expected interest rate yield of a financial institution be:

\[
r_{11} = r - p(1 + r) + (1 - \lambda) \int_0^\theta c \cdot f(c) dc + (1 - v)[p \cdot L - (1 - \lambda) \int_0^\theta c \cdot f(c) dc] - \frac{M}{\omega \cdot \bar{c}}
\]

(6)

Expected interest rate return of logistics enterprises is:

\[
r_{11} = \frac{M}{\omega \cdot \bar{c}}
\]

(7)

Under the circumstance that the financial institution pays the fixed commission fee, the financial institution expects the interest rate yield to be maximized.

**Sharing Agreement.** In order to avoid risks and encourage logistics enterprises to provide real operation information, financial institutions can also take the form of sharing contracts. The game results of benefit sharing and risk sharing between financial institutions and logistics loan enterprises can be established. At the same time, compared with fixed commission fee contracts, logistics loan enterprises can obtain more expected revenue.

Generally speaking, financial institutions believe that if the logistics loan enterprise does not default, it will give the 1-v ratio of the nominal interest rate to the enterprise as the commission fee (where 0<v<1). If the borrower defaults, the logistics company will assume a 1-v ratio of the loss of principal. For financial institutions, their expected interest rate yield is:

\[
L(1 + r_2) = L(1 + vr)(1 - p) + (1 - \lambda) \int_0^\theta c \cdot f(c) dc + (1 - v)[p \cdot L - (1 - \lambda) \int_0^\theta c \cdot f(c) dc]
\]

To make \( L = \omega \cdot \bar{c} \),

\[
r_{12} = v \cdot r \cdot (1 - p) - v \cdot p + v \cdot (1 - \lambda) \int_0^\theta c \cdot f(c) dc
\]

(8)

The derivative of the above equation is:

\[
\frac{\partial r_{12}}{\partial r} = [(1 - p) - \lambda \cdot \theta \cdot f(\theta)] \cdot v, \quad \frac{\partial r_{12}}{\partial r} = [(1 - p) - \lambda \cdot \theta \cdot f(\theta)] \cdot (1 - v)
\]

Therefore, it can be seen that under the condition of sharing contract, it is still the maximum expected interest rate of financial institutions and logistics loan enterprises.

**Fixed Rent Agreement.** Fixed rent as a new form of financing lease, financial institutions and
logistics enterprises in fixed rent contract also can use fixed rent contract, unite by the financial institutions loans to logistics enterprise, logistics enterprise promises according to the contract rate $r_d$ interest paid to financial institutions, as long as $r_d = r$, financial institutions would accept fixed rent contract. The expected interest rate yield of financial institutions is: $r_{3} = r_d$

Under this contract mechanism, the financial institution takes little risk, so the expected interest rate of the financial institution will decrease compared to the sharing contract. Since under this contract, the logistics loan enterprise has the highest expected return due to all the risks. Under this kind of contract, for the logistics loan enterprise, it is necessary to transfer this fund to the borrower in the form of inventory pledge loan, have the residual of the principal and interest of the borrower's loan after deducting $r_d$ rent and bear the default loss, and its expected interest rate income $r_{3}$ is:

$$r_{3} = r - p \cdot (1 + r) + (1 - \lambda) \int_{0}^{\theta} c \cdot f(c) dc \omega \cdot c - r_d$$

(10)

As $1 - p = \lambda \cdot \theta \cdot f(\theta)$ is the basic condition for the maximum expected interest rate of logistics loan enterprises, logistics loan enterprises can obtain a greater expected interest rate yield based on the constant nominal interest rate and loan value ratio.

Conclusion

In the game process of logistics finance, the logistics finance enterprises participating in the income distribution are often very limited. Secondly, there may be information asymmetry among enterprises involved in income distribution in reality. Traditional economics seems to be unable to study this problem, and better distribution results can be obtained by game theory analysis.

At present, the financial institutions to enterprise's financial business is often difficult, because of the enterprise credit rating can't assess, due to various of the information asymmetry and the current financial system shall implement the principle of the system carefully, make the development of logistics enterprises financing difficulties, lose a large part of the logistics enterprises and financial institutions of financial business, as adhesive of logistics companies and financial institutions, logistics enterprises and financial institutions cooperation launched a series of strategies to solve the logistics financial contracts of a certain logistics enterprise financing difficult problem. [5]

Word count: 2604

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