Analysis on Logistic Contract for FPLs Two-sided Bargaining Game in Agricultural Product Financing

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Abstract

Agricultural product financing has an important practical significance to expand application scope of inventory financing. However, agricultural products are perishable, seasonal, difficult to transport and storage etc., which requires that agricultural product financing depends on higher level logistic service providers. Therefore, this paper introduces the fourth-party logistics (FPLs) with the ability of resource integration and scheme optimization into the model. Aim to price determination of logistics tasks in agricultural product financing, this paper analyzes the issue between FPLs and banks and TPLs (third-party logistics) under asymmetric information by using Rubinstein bargaining game theory. The study finds that FPLs' offer is regardless of their own patience, banks' offer and TPLs' offer are related to their own cost of competing logistics tasks, and FPLs' bargaining order will affect their offer.

Keywords: Agricultural Product Financing, Fourth-Party Logistics (FPLs), Third-Party Logistics (TPLs), Two-Sided Bargain

1. Introduction

Agricultural product financing effectively expand the application scope of inventory financing. However, it needs higher level logistics enterprises--the fourth-party logistics (FPLs) because agricultural products are slow deterioration, seasonal, difficulty for storage, transportation and supervision. FPLs are integrator of a supply chain, and a leading force of supply sides, demand sides and TPLs. It provides a complete set of supply chain solutions in order to obtain a certain profit through using information technology, integration capabilities and other resources. It helps enterprises effectively reduce cost and integrate sources, and provide logistics planning, consulting, logistics information system, supply chain management activities through relying on excellent TPLs and technology providers, management consultant and other value-added service providers (Hertz and Alfredsson 2003, Bhatti et al. 2010).

FPLs can effectively release risks of agricultural product financing because of the ability of powerful resource integration and program optimization, which has an important role to enhance participants' enthusiasm. In the business, FPLs first undertake tasks entrusted by banks, such as value assessment, transportation, storage, distribution, regulation, and then subcontract to TPLs to carry out (Stefansson 2006). The price determination of logistic tasks among banks, FPLs and TPLs is one of the core issues, which determine whether the business can successfully be carried out.

Agricultural product financing is specific application of inventory financing; many scholars studied the related issues from different angles, mainly concentrated on the loan-to-value ratio, credit contract, incentive mechanism etc. Jokivuolle and Peura (2003) constructed debt risk model under the pledge commodity value related to firm default probabilities. Cossin and Hricko(2003) studied the credit risk pricing, and determine discount rate of pledge inventory. Li et al. (2007, 2011) analyzed the loan-to-value ratios applying qualitative and quantitative methods for seasonal inventory financing. Xu et al (2010) researched on incentive and supervision between banks and TPLs under two operational modes. Wang and Xu (2010) put fairness preference behavior into the model, and studied incentive mechanism between banks and TPLs. Bai (2013) researched on financial institutions how to determine value loan ratio. Li et al (2014) analyzed feasible path of agricultural product order financing from two aspects: theoretical analysis and specific practice. Zeng et al (2015) explored the issue how to construct risk assessment of agriculture supply chain finance. These documents above focus on the "inventory" financing, there is little literature

on a specific "agricultural product" and exploring issues of agricultural product financing.

Based on the analysis of current research, the difference for this paper is as following: (1) this paper focuses on "agricultural product financing". The agricultural product financing has important practical significance to broaden the scope of inventory financing and ease the SMEs' financing difficulties related to agriculture. (2) This paper introduces "fourth party logistics (FPLs)" into the model. The particularity of agricultural products decide that agricultural product financing needs higher level logistics service and better pledge scheme, TPLs are not able to meet the need due to lack of the ability of resource integration and scheme optimization. (3) This paper discusses the price determination of logistics tasks outsourcing. FPLs undertake the logistics tasks from banks, and then subcontract to TPLs for competition. The price of logistics tasks is an important issue among them, which is worthy researching and discussing. Therefore, this paper explores the issue using the bargaining game, and discusses it from two aspects: One aspect is that FPLs firstly bargain with banks, and then with TPLs, the other is that FPLs firstly bargain with TPLs, and then with banks. Bargaining order maybe affects the equilibrium results.

This paper is organized as follows. In Section 2, we give some assumptions for model construction. In Section 3, we construct the model about the price determination of logistics tasks and analyze the issue from two aspects. In Section 4, we analyze the results obtained from the model. Finally, Section 5 concludes the paper and gives suggestions: TPLs and banks should try to reduce the cost of competing logistics tasks.

2. Assumption

There are some assumptions for the construction of the model. It is assumed that C_b denotes the cost of banks completing logistics tasks, including the storage, supervision, transportation, value assessment, default disposal etc., and it is banks' private information. C_t is the cost of TPLs completing logistics tasks, and it is TPLs' private information ; C_f denotes the final transaction price between FPLs and banks about logistics tasks. And it is the FPLs and the bank's private information, and it is assumed that $C_f = \eta C_{f0}$, wherein, η denotes the coefficients, C_{f0} is the final transaction price for general "inventory", and assuming C_{f0} is constant. Obviously, $\eta \geq 1$ due to the characteristic of agricultural products, which also can be divided into many categories, such as slow deterioration, improved product, fresh agricultural products etc., the coefficient is different for different types of agricultural products, but for the convenient analysis, we does not make a distinction among them. C_e denotes the final transaction price between TPLs and FPLs about logistics tasks, and it is their private information, It is assumed that $C_e = \tau C_{e0}$, wherein τ means the coefficient, C_{e0} is the final transaction price for general "inventory", assuming it is constant, similarly known, $\tau \geq 1$.

In the process of bargaining game, the two sides do not know each other's type, but can be estimated based on past experience and information. FPLs estimate C_b and C_t all obey the uniform distribution on the interval $[m, n]$, banks estimate C_e to obey the uniform distribution on the same interval, and TPLs estimate C_f to obey the uniform distribution on the same interval. In game process, if $C_b \leq C_f \leq C_e$, the transaction between the participants cannot be achieved, only when $C_b \geq C_f \geq C_e$, the transaction can be reached, the discussion will be meaningful. It is assumed that banks, FPLs and TPLs have learning ability in the process of bargaining game, that is, they constantly change estimates of the cost of opponents based on their bid and behavior. λ_b, λ_f and λ_t respectively is banks, FPLs and TPLs' discount factor, and $0 < \lambda_b, \lambda_f, \lambda_t < 1$, this indicates that the parties involved in the agreement will pay the price if an agreement is reached lately. Otherwise the parties will tend to bargain and late to reach an agreement. λ can be understood as bargaining power or patience for the parties.

It is assumed that FPLs first began to offer price in the game and the offer price is $P_{fi}\ (i = 1,3,5...)$, which denotes the price offered by FPLs to banks, $P_{ei}\ (i = 1,3,5...)$ is offered by FPLs to TPLs. $P_{bj}\ (i = 2,4,6...)$ is the price offered by banks to FPLs, and $P_{tj}\ (i = 2,4,6...)$ is offered by TPLs to FPLs. Because the bargaining model of N stage is too complicated to finish, this paper only discusses the bargaining model in the two stage.

3. Model of Two-Sided Bargaining Game

In the course of the game, FPLs need to bargain with the banks about the price of logistics tasks entrusted by banks, and then subcontract logistics tasks to TPLs for completion, about the price, FPLs also need to bargain with TPLs. Therefore, there are two kinds of situations. The one is that FPLs first bargain with TPLs, and then negotiate with banks. In this case, FPLs know their own cost; the other is that FPLs first bargain with banks, and then with TPLs. In this case, FPLs don't know their costs function.

3.1 FPLs first Bargain with TPLs and then with Banks

3.1.1 Game Model between FPLs and TPLs

We analyze the two stage bargaining game between FPLs and TPLs by using the backward induction method. That's, we begin to analyze the question from second stage of the game. In the second stage, TPLs offer, and FPLs choose, if FPLs refuse the offer, the game ends, their gains are zero. If TPLs' offer ensures FPLs' income is greater than zero, i.e. $\lambda_f \left(C_f - P_{t2}\right) q \geq 0$, FPLs will accept TPLs' quotations, the game ends. Thus:

$$P_{t2} \leq C_f \tag{1}$$

In the course of the game, TPLs know FPLs' selection criterion is based on inequality (1) proved. At this time, TPLs adjust uniform distribution interval of C_f in $\left[P_{ei}, n\right]$. In this case, TPLs will select a suitable offer P_{t2} to maximize their revenue

$$\underset{P_{t2}}{Max}\pi_t = 0 * P_{fr} + \lambda_t \left(P_{t2} - C_t\right) q P_{fa} \tag{2}$$

Wherein, π_t denotes TPLs' revenue, q is the amount of logistics tasks, P_{fa} and P_{fr} denote the probability of FPLs accepting and rejecting TPLs' offer.

$$P_{fa} = P\left(P_{t2} \leq C_f\right) = \left(n - P_{t2}\right) / \left(n - P_{e1}\right) \tag{3}$$

$$P_{fr} = P\left(P_{t2} > C_f\right) = \left(P_{t2} - P_{e1}\right) / \left(n - P_{e1}\right) \tag{4}$$

Put equation (4) and (3) into equation (2), and then

$$\underset{P_{t2}}{Max}\pi_t = \underset{P_{t2}}{Max}\left[\lambda_t \left(P_{t2} - C_t\right) q \left(n - P_{t2}\right) / \left(n - P_{e1}\right)\right]$$

So TPLs' offer P_{t2} is given by

$$P_{t2} = \left(n + C_t\right) / 2$$

That is the best quotation offered by TPLs in the second stage of their game. If FPLs accept the offer, TPLs' benefits is given by $\lambda_t \left(n - C_t\right) q / 2$, and FPLs' is $\lambda_f \left(2C_f - n - C_t\right) q / 2$.

Now back to the first stage of their game, in the first stage, when FPLs' offer is P_{e1}, TPLs' gain is given by $\left(P_{e1} - C_t\right) q$. FPLs know TPLs' choice and gain in the second stage, so in the first phase, FPLs' offer will meet the condition $\left(P_{e1} - C_t\right) q \geq \lambda_t \left(n - C_t\right) q / 2$, that's $C_t \leq \left(2P_{e1} - \lambda_t n\right) / \left(2 - \lambda_t\right)$, TPLs will accept FPLs' offer. In this case, FPLs will choose the best offer P_{e1} to maximize their revenue.

$$\underset{P_{t2}}{Max}\pi_f = \left(C_f - P_{e1}\right) q P_{ta} + \lambda_f \left(2C_f - n - C_t\right) q P_{tra}$$

Where, π_f denotes FPLs' gain, P_{ta} denotes the probability of TPLs accepting FPLs' offer

$$P_{ta} = P\left(C_t \leq \left(2P_{e1} - \lambda_t n\right) / \left(2 - \lambda_t\right)\right) = \left[2\left(P_{e1} - m\right) - \lambda_t \left(n - m\right)\right] / \left(2 - \lambda_t\right)\left(n - m\right) \tag{5}$$

Where P_{tra} denotes the probability of TPLs refusing FPLs' offer in the first stage and FPLs accepting TPLs' offer.

$$P_{tra} = P\left(C_t > \left(2P_{e1} - \lambda_t n\right) / \left(2 - \lambda_t\right)\right) P\left(P_{t2} < C_f\right) = 2\left(n - \lambda_t\right) / \left(2 - \lambda_t\right)\left(n - m\right) \tag{6}$$

So FPLs' best offer P_{e1} in the first stage is given by

$$P_{e1} = \left[2\left(C_f + m\right) + \lambda_t\left(n - m\right)\right] / 4$$

According to the above analysis, equilibrium solution for two stage bargaining game between FPLs and TPLs is as follows:

(1) In the first stage of the game, FPLs' offer is $P_{e1} = \left[2\eta C_{f0} + 2m + \lambda_t\left(n - m\right)\right] / 4$

(2) When $C_t \le \left[2\left(\eta C_{f0} + m\right) - \lambda_t\left(n + m\right)\right] / 2\left(2 - \lambda_t\right)$, TPLs accept FPLs' offer P_{e1}, the game ends, otherwise, the game enters the second stage.

(3) In the second stage of the game, TPLs will provide the offer $P_{t2} = \left(n + C_t\right) / 2$

(4) If $P_{t2} = \left(n + C_t\right) / 2 \le C_f$, FPLs will accept the offer P_{t2}, otherwise, FPLs will refuse.

3.1.2 FPLs Bargain with Banks

In this section, we mainly discuss that TPLs accept FPLs' offer in the first stage of the game, that is, $C_t \le \left[2\left(C_f + m\right) - \lambda_t\left(n + m\right)\right] / 2\left(2 - \lambda_t\right)$. Under the situation, FPLs know the transaction price about logistics tasks, but banks don't know, because it is FPLs' private information. The transaction price can be understood as FPLs' cost function; here we don't consider FPLs' other cost, because FPLs' income mainly depends on the difference of transaction price with banks and TPLs. When FPLs know the cost functions, it will have an impact on strategy choice in the game. We directly give equilibrium result.

(1) FPLs' offer is $P_{f1} = \left[\left(\lambda_t - \lambda_b\right)\left(n - m\right) + 2\left(n + m\right)\right] / 4$ in the first stage of the game

(2) When $C_b \ge \left[2\left(n + m\right) + \left(\lambda_t - \lambda_b\right)\left(n - m\right)\right] / 2\left(2 - \lambda_b\right)$, banks will accept FPLs' offer P_{f1},

and the game ends, otherwise banks refuse, and the game enters the second stage.

(3) In the second stage, banks will choose the offer given by $P_{b2} = \left(C_b + m\right) / 2$.

(4) When $P_{b2} = \left(C_b + m\right) / 2 \ge \left[\lambda_t n + \left(2 - \lambda_t\right) m\right] / 2$, FPLs accept banks' offer P_{b2}, otherwise refuse.

3.2 FPLs first Bargain with Banks and then with TPLs

3.2.1 FPL Bargain with banks

Under the situation, FPLs undertake logistics tasks from banks and bargain with them about the price, and then subcontract these tasks to TPLs for completion. FPLs first bargain with banks, after the price is determined, FPLs bargain with TPLs. During the course of the game, FPLs do not know its own cost function in advance, under the situation, what the equilibrium result is in the game between FPLs and banks. According to the analysis process in the 3.1.1 section, we directly give the game equilibrium results.

(1) FPLs' offer is $P_{f1} = \left[2\tau C_{e0} + \lambda_b m + \left(2 - \lambda_b\right) n\right] / 4$ in the first stage of the game

(2) When $C_b \ge \left[2\tau C_{e0} - \lambda_b m + \left(2 - \lambda_b\right) n\right] / 2\left(2 - \lambda_b\right)$, banks will accept FPLs' offer P_{f1},

and the game ends, otherwise banks refuse, and the game enter the second stage.

(3) In the second stage, banks will choose the offer given by $P_{b2} = \left(C_b + m\right) / 2$.

(4) When $P_{b2} = \left(C_b + m\right) / 2 \ge C_e$, FPLs accept banks' offer P_{b2}, otherwise refuse.

3.2.2 FPLs Bargain with TPLs

In this subsection, we focus on the bargaining game between FPLs and TPLs. If $C_b \ge \left[2\tau C_{e0} - \lambda_b m + \left(2 - \lambda_b\right) n\right] / 2\left(2 - \lambda_b\right)$, FPLs will make an agreement with banks in the first stage of the game. Because of the analysis process similar to 3.1.1 section, we directly give the game equilibrium results.

(1) In the first stage of the game, FPLs' offer is $P_{e1} = \left[\left(2 - \lambda_b\right) n + \left(2 + \lambda_b\right) m + \lambda_t\left(n - m\right)\right] / 4$

(2) When $P_{t2} \le \left[\left(2-\lambda_b\right)n+\left(2+\lambda_b\right)m-\lambda_t\left(n+m\right)\right]/2\left(2-\lambda_t\right)$, TPLs accept FPLs' offer P_{e1}, the game ends, otherwise, the game enter the second stage.

(3) In the second stage of the game, TPLs will provide the offer $P_{t2}=\left(C_t+n\right)/2$

(4) If $P_{t2}=\left(C_t+n\right)/2 \le \left[\lambda_b m+\left(2-\lambda_b\right)n\right]/2$, FPLs will accept the offer P_{t2}, otherwise, FPLs will refuse.

4. Result Analysis

Proposition 1 Compared with the general inventory financing, FPLs give the higher prices of logistics tasks in agricultural products financing. Because of characteristics of agricultural products, such as difficulty for transportation, difficulty for storage, volatile etc., FPLs ask banks to afford a higher price when undertaking logistics tasks, such as supervision, value assessment, transportation, storage, disposal etc.. At the same time, when bargaining with TPLs, FPLs also give a higher offer, because they know weakness of agricultural products. Therefore, in the first quotation, FPLs will give a higher price in order to avoid TPLs direct refusal.

proposition 2 During the course of the game between FPLs, TPLs and banks, the price offered by FPLs is not influenced by their own bargaining ability, only by banks' and TPLs' bargaining abilities; FPLs will offer different price under two situations, FPLs will provide a higher prices when banks' bargaining ability is weak or TPLs' bargaining ability is strong.

Proposition 3 In the second stage of the game, FPLs' bargaining order does not affect banks' and TPLs' offer under two kinds of situations, In other words, under two kinds of situations, banks or TPLs offer the same quotation. When offering a price, they will take full account of their operating costs, if the tasks cost is high, they will offer a higher price.

Proposition 4 For any given numbers of these variables λ_b, λ_t, m and n, and as long as the cost of banks completing logistics tasks meet $C_b \ge \omega$, the cost of TPLs completing logistics tasks meet $C_t \le \nu$, FPLs will deal with banks in the first stage of the game, at the same time, FPLs can subsequently deal with TPLs in the first stage of the game, and FPLs obtain positive returns in the transaction. Where,

$$\omega=\frac{\left(2-\lambda_b\right)\left(m+n\right)+\lambda_t\left(n-m\right)}{2\left(2-\lambda_b\right)}, \nu=\frac{\left(2-\lambda_t\right)\left(n+3m\right)-\lambda_b\left(n-m\right)}{4\left(2-\lambda_t\right)}$$

Proposition 5 When the cost of banks completing logistics tasks meet $\kappa < C_b < \upsilon$, the cost of TPLs completing logistics tasks meet $C_t \le \xi$, and $\frac{\lambda_t\left(3-2\lambda_b\right)}{\left(2-\lambda_b\right)}<1$, FPLs and banks can strike a bargain in a second stage of the game. At the same time, FPLs and TPLs will subsequently strike a bargain in the first stage of the game, and FPLs will get a positive return. Where,

$$\kappa=\max\left[m+\lambda_t\left(n-m\right), \frac{\lambda_t\left(m+n\right)-3m}{2\lambda_t-3}\right], \upsilon=\frac{\lambda_t\left(n-m\right)}{4-2\lambda_b}+\frac{m+n}{2}, \xi=\frac{C_b-\lambda_t\left(n+m\right)+3m}{4-2\lambda_t}$$

5. Conclusions

Agricultural product financing broaden the application scope of inventory financing, but the particularity of agricultural products need higher levels logistics service, FPLs' participation effectively make up TPLs' limitation in scheme optimization, resources integration, scale, information technology and other aspects, which will further enhance banks' enthusiasm to participate in the business, and effectively promote further development of agricultural product financing. However, to ensure healthy operation and sustainable development of agricultural product financing, the price determination of logistics tasks is an urgent issue to resolve. To solve this problem, this paper constructs bilateral bargaining game model under information asymmetry using Rubens turns bargaining game theory. Through game analysis, we get some findings: FPLs' offer is unrelated to their patience, banks' and TPLs' offer is affected by their own cost of completing logistics tasks. Compared with the case of knowing cost, FPLs will provide a higher offer in the case of unknown cost.

Although we get some new findings through our research on the issue, there are still many problems which need to be further explored about agricultural product financing, such as operational selection, risks control, the

determination of value ratio, risks evaluation, and so on.

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