

RESEARCH ON PARTIALLY GUARANTEED INVENTORY PLEDGE FINANCING STRATEGIES OF CROSS-BORDER SUPPLY CHAIN UNDER EXCHANGE RATE FLUCTUATIONS

Xingxing Hai¹, Ming Jian² and Shinichi MUTO³

¹Non-Member of JSCE, Integrated Graduate School of Medicine, Engineering and Agriculture Sciences, University of Yamanashi
(3-11, Takeda 4, Kofu, Yamanashi 400-8511, Japan)
E-mail: g19tca03@yamanashi.ac.jp

²Non-Member of JSCE, Professor, School of Transportation and Logistics, Southwest Jiaotong University
(high-tech Zone Western, Xipu, Chengdu, China)
E-mail: jianming@swjtu.edu.cn

³Member of JSCE, Associate Professor, Graduate Faculty of Interdisciplinary Research, University of Yamanashi
(3-11, Takeda 4, Kofu, Yamanashi 400-8511, Japan)
E-mail: smutoh@yamanashi.ac.jp

Abstract: In a capital-constrained cross-border supply chain, the trade decisions and the financing decisions will be affected by exchange rate fluctuations. In the cross-border supply chain inventory pledge financing, partial guarantees from the supplier will reduce bank's financing risks. This article is based on a cross-border supply chain composed of a foreign supplier and a domestic retailer. In this cross-border inventory pledge financing model, the exchange rate fluctuation coefficient and the cross-border supplier's partial guarantee ratio are introduced to establish the model of inventory pledge financing that with the help of the cross-border supplier's partial guarantee under exchange rate fluctuation to explore the optimal decisions of various entities in the cross-border supply chain and analyze the impact of exchange rate fluctuations on various entities in cross-border financing. This article will provide a reference for inventory pledge financing decisions of cross-border supply chain parties under exchange rate fluctuations.

Key Words: *cross-border supply chain, exchange rate fluctuations, partial guarantees, inventory pledge financing*

1. INTRODUCTION

Exchange rate fluctuations make cross-border trade often face capital constraints¹). How to effectively deal with the funding constraints of cross-border supply chains under exchange rate fluctuations and reduce the risk of cross-border financing, has very important commercial value and

practical significance for the companies in the cross-border supply chain²).

Few authors have paid attention to the issue of exchange rate fluctuations in funding-constrained cross-border supply chain³). Yang Honglin, Wang Yaoyu and Gao Mingyun considered the impact of exchange rate fluctuations on financing ordering decisions in the capital-constrained cross-border

supply chain, discussed the loss probability of each party in the cross-border supply chain under exchange rate fluctuations, and finally gave the cross-border supply chain Relevant measures taken by various entities to respond to exchange rate fluctuations⁴). And the research on inventory pledge financing mostly considers the issue of inventory pledge financing strategy under a single influence factor. Yuan Wenyan, Han He, Wu Jun, etc. considered the issue of inventory pledge financing decision under the influence of supplier partial guarantee, established a model of inventory pledge financing under supplier partial guarantee contract, and analyzed the optimal decision of each subject in the supply chain⁵).

This article is based on a two-tiered cross-border supply chain consisting of a domestic import retailer and a foreign export supplier. And based on the wholesale price contract and revenue sharing contract, to build a model of inventory pledge financing that partially guaranteed by the cross-border supplier under exchange rate fluctuations. Through the Stackelberg game, the financing decisions of every entities in the cross-border supply chain are analyzed, and the impact of exchange rate fluctuations on cross-border supplier, retailer, and bank decisions is examined.

The main innovations of this paper are as follows: First, the effects of exchange rate fluctuations and supplier's partial guarantees on cross-border financing are considered at the same time. The second is based on the supply chain contract combination of wholesale price contract and revenue sharing contract, combining trade practices in cross-border inventory pledge financing to discuss the issue of cross-border financing.

2. MODEL DESCRIPTION

(1) Model framework

Based on a two-tier cross-border supply chain consisting of a domestic retailer and a foreign supplier, this article builds a partially secured inventory pledge financing framework for cross-border suppliers against the background of exchange rate fluctuations, as shown in Figure.1.

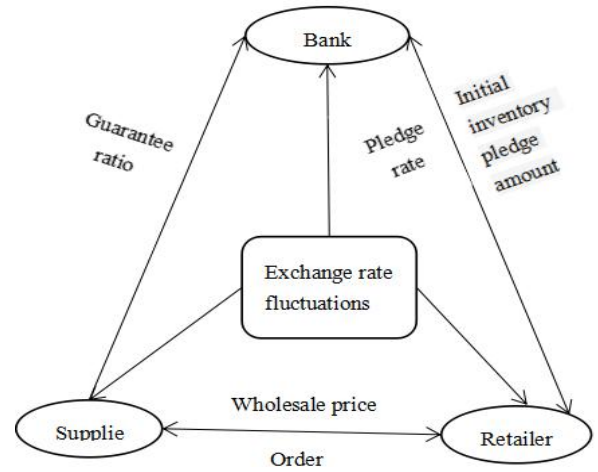


Fig.1 Model framework.

The cross-border inventory pledge financing process is as follows:

Firstly, under the wholesale price contract, the retailer uses its own funds to make the first order, and then uses part of the order as inventory to be pledged to the bank for trade financing; at the same time, in order to reduce financing risks, the bank signs a financing guarantee contract with the supplier to determine the guarantee ratio; and the supplier signs a revenue-sharing contract with the retailer to partially guarantee its financing³). So, the retailer makes a second order under the revenue-sharing contract after receiving the financing loan. After the sales period ends: the retailer keeps the contract and repays or the retailer defaults, the supplier fulfills some of its guarantee obligations, and the financing process ends⁶).

(2) Parameter symbol

The parameter variables and symbols required in the model are as follows:

x_i —The product market demand at time

$y = \sum_{i=1}^n x_i$ is the sales volume of the product unit

price p_i under the background of exchange rate fluctuations, $f(y)$ is the probability density function of market demand, and $F(y)$ is a cumulative distribution function that is differentiable, monotonically increasing and continuous;

L_i —The exchange rate of local currency to foreign currency under the direct quotation method when retailer financing loans, $i = 1, 2, \dots, n$;

θ_i —Exchange rate fluctuations coefficient;

p_i —Product sales unit price, $i = 2, \dots, n$; p_1 is the market price of the product at the retailer's loan moment, p_1 is a fixed value and

$$p_i = p_{i-1} \frac{L_i}{L_{i-1}} = p_{i-1} \theta_i;$$

w_j —Wholesale unit price of the product at j th order, $j = 1, 2$;

c —Unit production cost;

v —Unit residual value of the product;

q —Product order quantity;

B —The retailer's own funds;

β —Supplier guarantee ratio;

φ —Proportion of sales revenue received by retailers under revenue sharing contracts;

q_m —The amount of initial inventory pledge;

λ —Pledge rate;

r_i —Lending rates under exchange rate

fluctuations, $r_i = r_{i-1} \frac{L_i}{L_{i-1}} = r_{i-1} \theta_i, i=2, \dots, n$;

r_c —Repayment rate when the retailer defaults;

r_{f1} —Risk-free interest rate in local currency;

r_{f2} —Risk-free interest rate in foreign currency.

(3) Basic assumptions

Assumption 1: The retailer has two order activities: under the wholesale price contract, the

first order under its own funds, $q_1 = \frac{B}{w_1}$; under the

revenue sharing contract, the second order under the

loan funds, $q_2 = \frac{\lambda p_1 q_m}{w_2}$; the total order quantity is

$q = \frac{B w_2 + \lambda p_1 q_m w_1}{w_1 w_2}$. And before the second order,

the retailer mortgages part of the first order amount to the bank to make a financing loan. The initial inventory pledge amount is $q_m \leq q_1$.

Assumption 2: The bank pledges the inventory in accordance with the product price p_i at the time of the loan, and the bank determines the inventory

pledge rate λ and the financing interest rate r_i . The pledged inventory is given priority to sales, and the payment is directly credited to the bank account.

Assumption 3: The repayment rate when the retailer defaults is $r_c, r_c > r_i$.

Assumption 4: There are two types of opportunity costs for the bank: risk-free returns $r_{f1} \lambda p_1 q_m$ on investment in the domestic currency market; and risk-free returns $r_{f2} \lambda p_1 q_m$ on investment in the currency market of the country where the foreign supplier is located.

Assumption 5: The product has only one sales opportunity in the market.

Assumption 6: When the sales income and residual value income of the pledged inventory can repay the principal and interest of the bank loan, the retailer keeps the contract, and the supplier's partial guarantee contract is immediately canceled; if the principal and interest of the loan are defaulted by the retailer, the retailer needs to liquidate all the proceeds of the pledged inventory to the bank. The supplier's partial guarantee contract will take effect immediately, and the supplier will fulfill its partial guarantee contract obligations. That is, when

$$\sum_{i=1}^n p_i x_i + v(q_m - \sum_{i=1}^n x_i)^+ > \lambda p_1 q_m (1 + r_i) \rightarrow \sum_{i=1}^n x_i > \frac{\lambda p_1 q_m (1 + r_i) - v q_m}{p_i - v},$$

the retailer can repay the principal and interest of

$$h = \frac{\lambda p_1 q_m (1 + r_i) - v q_m}{p_i - v}$$

bank loans by itself. Let

h be the minimum market demand for the retailer to repay the principal and interest of a bank loan by itself⁽⁷⁾.

3. ANALYSIS AND SOLUTION

(1) The retailer's optimal decision

The retailer has two sources of profit:

When the market demand for the product is greater than the minimum demand, the retailer keeps the contract⁽⁴⁾: the retailer can pay off the principal and interest of the bank loan by itself;

When the market demand of the product is less than or equal to the minimum demand: the retailer will clear all the income of the inventory pledge to the bank, and only obtain the residual value income of the product⁸⁾.

Retailer profit function:

When $y = \sum_{i=1}^n x_i > h$:

$$\Pi_{R_1} = (1-\varphi) \left[\sum_{i=1}^n p_i x_i + v(q - \sum_{i=1}^n x_i) \right] - B - \lambda p_1 q_m (1+r_i)$$

When $y = \sum_{i=1}^n x_i \leq h$:

$$\Pi_{R_2} = (1-\varphi)v(q - q_m) - B$$

After analysis, we get:

Conclusion 1: In the process of inventory pledge financing, if there is a foreign export supplier who provides partial guarantee for it, at the same time, when the wholesale price of the second order and the bank pledge rate are determined, the retailer has the only optimal order quantity:

$$q^* = F^{-1} \left(\frac{w_2(1+r_i)[1-(1-\varphi)F(h)]}{(1-\varphi)v} \right) \quad (1)$$

And there is an optimal initial inventory pledge amount:

$$q_m = \min \left(F^{-1} \left(\frac{w_2(1+r_i)[1-(1-\varphi)F(h)]}{(1-\varphi)v} \right), \frac{\lambda p_1 B}{w_1 w_2}, \frac{B}{w_1} \right) \quad (2)$$

Next, we analyze the impact of exchange rate fluctuations on the retailer and finally get:

Conclusion 2: The impact of exchange rate fluctuations on the profits of the domestic imported retailer: When the retailer keeps its promise, the profits are affected by exchange rate fluctuations, and the greater the exchange rate fluctuations, the greater the retailer's profits; when retailers default, the profits are not affected by exchange rate fluctuation influences.

(2) The supplier's optimal decision

The cross-border supplier has two types of trade activities: one is wholesale sales under different

supply chain contracts, and the other is partial guarantees under partial guarantee contracts. Among them, the wholesale sales of goods are carried out under the wholesale price contract and the revenue sharing contract, and the wholesale price for two orders is w_1 and w_2 respectively. Partial guarantee is the performance of part of the credit guarantee contract obligations with the bank, when the retailer defaults, the supplier will perform part of its guarantee responsibility, and the credit guarantee ratio is β .

Supplier profit function:

When $y = \sum_{i=1}^n x_i > h$:

$$\Pi_{S_1} = (w_1 - c) \frac{B}{w_1} + (w_2 - c) \frac{\lambda p_1 q_m}{w_2} + \varphi \left[\sum_{i=1}^n p_i x_i + v(q - \sum_{i=1}^n x_i) \right]$$

When $y = \sum_{i=1}^n x_i \leq h$:

When

$$\begin{aligned} \Pi_{S_2} = & (w_1 - c) \frac{B}{w_1} + (w_2 - c) \frac{\lambda p_1 q_m}{w_2} + \varphi(q - q_m) \\ & - \beta[\lambda p_1 q_m (1+r_c) - \sum_{i=1}^n p_i x_i - v(q_m - \sum_{i=1}^n x_i)] \end{aligned}$$

After analysis, we get:

Conclusion 3: When the optimal secondary order quantity, bank pledge rate, revenue sharing ratio and supplier guarantee ratio are given by the retailer, there is an optimal secondary wholesale price:

$$w_2^* = \frac{(\beta + \varphi)\varepsilon}{\frac{dq_2}{dw_2}} + c - \varphi v \quad (3)$$

to optimize the supplier's profits, where

$$\varepsilon = F(h) \left(\frac{v}{\lambda p_1} - (1+r_i) \right).$$

Next, we analyze the impact of exchange rate fluctuations on the supplier and finally get:

Conclusion 4: The impact of exchange rate fluctuations on the profits of the foreign export supplier: When the supplier partially guarantees, the greater the exchange rate fluctuation, the smaller the supplier's profit; when the supplier does not need a

partial guarantee, the greater the exchange rate fluctuation, the greater the supplier's profit.

(3) The bank's optimal decision

Bank financing profits come from two situations: one is to obtain the entire loan principal and interest when the retailer keeps the contract; the other is that when the retailer defaults, the bank can only obtain the liquidation of the retailer's inventory and the supplier's partial guarantee fee. And there are two types of opportunity costs for the bank in this financing service: risk-free returns from investing in the domestic currency market; and risk-free returns from investing in the currency market of the country where the foreign supplier is located.

Bank profit function:

$$\text{When } y = \sum_{i=1}^n x_i > h:$$

$$\Pi_{B_1} = \lambda p_1 q_m r_i - \max\{r_{f1} \lambda p_1 q_m, r_{f2} \lambda p_1 q_m\}$$

$$\text{When } y = \sum_{i=1}^n x_i \leq h:$$

$$\Pi_{B_2} = \lambda p_1 q_m [\beta(1+r_c) - 1] + (1-\beta) \left[\sum_{i=1}^n p_i x_i + v(q_m - \sum_{i=1}^n x_i) - \max\{r_{f1} \lambda p_1 q_m, r_{f2} \lambda p_1 q_m\} \right]$$

After analysis, we get:

Conclusion 5: When the retailer's initial inventory pledge amount and the supplier's guarantee ratio are given, the bank has the optimal inventory pledge rate:

$$\lambda^* = \frac{(p_i - v) F^{-1} \left(\frac{\max(r_{f1} p_1 q_m, r_{f2} p_1 q_m) - p_1 q_m r_i}{p_1 q_m (1-\beta)(1+r_i)} \right)}{p_1 q_m (1+r_i)} + \frac{v}{p_1 (1+r_i)} \quad (4)$$

Next, we analyze the impact of exchange rate fluctuations on the bank and finally get:

Conclusion 6: The impact of exchange rate fluctuations on bank profits: The greater the exchange rate fluctuations, the greater the bank profits.

4. CONCLUSION

This paper introduces the exchange rate

fluctuation coefficient and the supplier guarantee ratio to establish a partially pledged inventory pledge financing model under the exchange rate fluctuations. By analyzing the model, we get that the inventory pledge financing strategies of cross-border supply chain under exchange rate fluctuations. It innovatively explores the optimal decisions of cross-border supply chain entities under the combined effects of exchange rate fluctuations and supplier partial guarantees.

However, this article only considers the impact of exchange rate fluctuations on the profits of various entities in the cross-border supply chain, and does not examine the impact of exchange rate fluctuations on the optimal decisions of each entity. In future research, we will continue to study the impact of exchange rate fluctuations on the decision-making of various entities in cross-border inventory pledge financing, and make recommendations for cross-border financing entities that are closer to the business practice of cross-border financing under exchange rate fluctuations.

ACKNOWLEDGMENT: First of all, I want to thank my teacher, Professor Muto, for his careful guidance and patient supervision, which enabled me to complete this article.

Secondly, thanks to my classmate Li Ying, with his help, I learned the basic methods and steps of thesis writing, and also learned the method of model solving. Finally, thank my family for their support that made it possible for me to finish this article.

REFERENCES

- 1) 1)Chen, X. F. : Supply chain financial services innovation, Fudan university press, pp. 6-43, 2008.
- 2) 2)Qu, H. L. : On Design and Optimization of Financial Products in Supply Chain, China Internet Finance and Investment, No. 2, pp. 53-61, 2017.
- 3) 3)Tan, Y. Y., Yang, Z. : 'Research on Optimal Equilibrium Strategy of Online Supply Chain Finance Based on Revenue Sharing Mechanism, Management Review, No. 9, pp. 242-254, 2019.
- 4) 4)Yang, H. L., Wang, Y. Y. and Gao, M. Y. : Capital Constrained Cross-border Supply Chain Financing Ordering Decision Considering Exchange Rate Fluctuations, Systems Engineering, No. 8, pp. 97-105, 2018.
- 5) 5)Yuan, W. Y. , Han, H. and Wu, J. : Financing Decision of Inventory Pledge under Partial Supplier Guarantee,

Journal of Beijing University of Chemical Technology
(Natural Science Edition), No. 1, pp. 117-123, 2019.

- 6) 6)Xiong, X., Ma, J., Zhao, W.J. : Credit Risk Evaluation under Supply Chain Finance Model, Nankai Management Review, No. 4, pp. 92-98, 2009.
- 7) 7)Wang, W. L., Wang, Y. P. : Supply chain financing strategies for capital-constrained retailers, Economic Issues, No. 9, pp. 47-52, 2018.
- 8) 8)Sun, X. M. , Zhao, G. K. : Research on inventory pledge rate considering credit level of supply chain, China management science, No. 7, pp. 77-84, 2015.