

Decision-Making of Supply Chain Finance, based on Inventory Financing Procedure under Default Risk and Market Risk

Shiying Chen, Tomohiro Murata

Abstract—Limited working capital is a frequent constraint in corporate procurement decision. However, small size and start-up firms often have difficulty accessing financing from banks directly, due to their lack of guarantees. In this case, Supply Chain Finance (SCF) is undoubtedly a good choice as a means of substituting for lower credit availability. For the purpose of reducing loan risk and increasing expected return of bank when implementing SCF, this article studies inventory finance model and build an optimization mathematical model. Furthermore, this article does series sensitivity analysis on key parameters such as default probability and the market price of collateral by simulating. The result shows that inventory finance can extend credit to downstream enterprise and benefits all members of the chain.

Index Terms—Inventory Finance, Expected return maximization, Default risk, Market risk

I. INTRODUCTION

In Supply Chain Finance, Inventory finance is a creative service integrating logistics and finance through the downstream enterprise pledges collateral to logistic company assigned by bank when financing. It is a classical application of prepaid accounts financing that bank cooperates with core enterprise, and extends credit to downstream enterprises. The concept of collateral includes liquid assets such as raw material and products, not just fixed assets in the traditional sense. In the same time, the loan risk can be reduced by introduce a guarantee measure of core enterprise repurchase. For inventory finance is carried out based on collateral and installment loan on margin, the assessment to the security capacity and repayment ability is necessary. So the key point of reducing loan risk and expanding business scope is setting reasonable pledge ratio and initial margin ratio.

Theoretically, some scholars have done research on these aspects in different perspectives. (1) The structure model with assuming the endogenous of default. The default of the finance enterprise relates to the fluctuation of the value of debt and pledge only, so that the pledge ratio can be determined by the structure method. And some scholars compared the decision of pledge ratio when bank pursue different goals with the application of Stackelberg Game theory and VaR method. Actually, enterprises can default

even go bankrupt when capital is lack of liquidity. So the endogenous of default is not reasonable. (2) Assuming the exogenous of default based on the idea of simplify. The default probability of finance enterprise is given exogenously under analysis rating or the valuation of historical data. Also obtain a coherent pledge ratio with risk bearing capacity of bank by building model. However, research above focus on financial products mainly, not suitable fits at the general merchandise as collateral being in circulation in supply chain for value fluctuation. Some literatures consider exogenous default probability of enterprise comprehensively, and research on the standard inventory pledge rate with the same risk bearing capacity of bank. But the collateral of inventory finance model is dynamic pledge with batch delivery, not be pledged until the end of loan period. Some of them mentioned about dynamic pledge only involved qualitative research rather than quantitative research. Besides, pledge ratio become different according to different risk preference, for example, literature (3) and (4) did research on it in the perspective of mean-variance and loss aversion.

In practice, banks often carry out the valuation of collateral rely on experience, such as 70% for real estate mortgage and 50% for production equipment mortgage. The way of valuation only rely on experience is unable to predict the risk influence from pledge rate on loan business accurately. So that the quantitative research on pledge ratio can greatly help in reducing loan risk and provide the basis for the decision-making of bank.

This article research on a pledge ratio model with the target of maximizing the expected return of bank based on the whole inventory finance business process of Supply Chain Finance. Further more, analysis the influence of different parameters on pledge ratio considering factors such as default probability, repurchase price, margin ratio and market price of collateral. The overall structure of this article as follows: introduce the research background and related literatures in part 1. Establish model according to the finance procedure of inventory finance in part 2. Numerical simulation and analysis of the relevant parameters are carried out in part 3. Draw the relevant conclusion in part 4.

II. MODEL CONSTRUCTION

A. Procedure Introduction of Inventory Finance

In the procurement phase, downstream small and medium-sized enterprises often need to payment to the core enterprise in advance to obtain the required raw materials and products. For enterprises those are difficult in short-term funds transfer, they can obtain the short-term credit aid from

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bank by implementing inventory finance. The whole financing procedure is shown in figure 1.

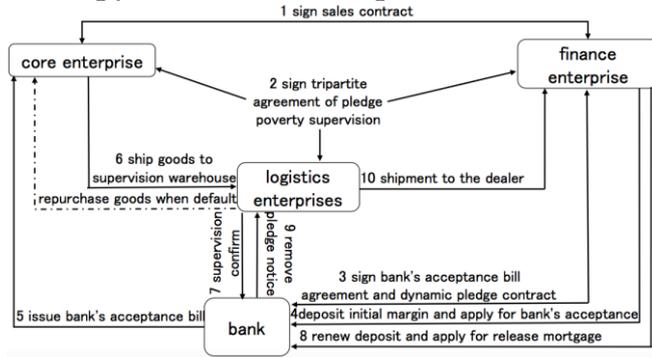


Figure 1. Inventory financing procedure

Firstly, supplier signed sales contracts with its dealer, and applied for commercial bank to carry out inventory finance. Bank signed loan and repurchase agreement with both sides, and designated a warehouse logistics enterprise to deal with intermediate business after confirming the authenticity of the transaction information, the repayment ability of financing enterprise, the credit and repurchase capacity of the core enterprise.

The next, financing enterprise deposit initial margin-an established ratio (ζ) of total loan amount-into bank, and could not get back when default happen. Then bank valued the collateral of quantity (q) according to the market price (P_0), and provide the credit extension ($V = \omega q P_0$) to financing enterprise according to pledge ratio (ω). The core enterprise should ship goods to the warehouse logistics enterprise as collateral when receiving money, on the other hand, it also should repurchase remaining collateral with an agreed price (P_c) in the situation that financing enterprise defaulted.

Among the loan period of T months, the bank's profit and cost calculated with the monthly loan rate (R) and monthly deposit rate (r), thus, the debts serviced by financing enterprise should be $V e^{RT}$, and the cost of bank should be $V e^{rT}$. The financing enterprise can hand in cash deposits to bank as a kind of repayment form in "n" times with fixed time interval after gaining loan, and the quantity of goods released to financing enterprise is according to the proportion of replenished margin amount among the total loan amount. Then, financing enterprise should continue to replenish margin until deposits equal to the principal and interest of the loan.

B. Formula Derivation

During "i" months, the remaining quantity of collateral in warehouse logistics enterprise is " q_i ", and the j'th replenished margin amount is " M_j ". So the quantity of deliver goods in "i" months is $q - q_i = \frac{\sum_j \frac{M_j}{RjT}}{V} \times q$, in which $\sum_j \frac{M_j}{RjT}$ is the sum of replenished margin discounted to the base period in "i" months.

Meanwhile, the market price of collateral in month "i" is P_i with the distribution function $F(x) = P(P_i < x)$, $x \in (0, +\infty)$ and density function $f(x)$, which obey logarithmic normal distribution of (μ, σ^2) .

The article makes the following assumptions according to introduction of background and symbol.

(1) The loss of financing enterprise is more than its profit when default happen:

$$P_i \times q_i \geq \left(V - V \times \zeta - \sum_j \frac{M_j}{e^{\frac{RjT}{n}}} \right) \times e^{ri}, \quad (0 \leq i \leq T), \text{ i.e.}$$

$$P_i \geq A, \text{ in which } A = \left(V - V \times \zeta - \sum_j \frac{M_j}{e^{\frac{RjT}{n}}} \right) \times \frac{e^{ri}}{q_i}.$$

Obviously, financing enterprise won't default under this situation, and the return of bank $\pi = \frac{V(e^{RT} - e^{rT})}{e^{r(T-i)}}$.

(2) The loss of financing enterprise is less than its profit when default happen:

$$0 < P_i < A. \text{ The financing enterprise will default with default probability "Q" under this situation.}$$

So the return of bank is: $\pi = \frac{V(e^{RT} - e^{rT})}{e^{r(T-i)}} \times (1 - Q) +$

$$\left[P_c \times q_i + (V \times \zeta - \sum_j \frac{M_j}{e^{\frac{RjT}{n}}} - V) \times e^{ri} \right] \times Q.$$

With the above situation considered, the expected return of bank $E(\pi)$ is:

$$E(\pi) = \frac{V(e^{RT} - e^{rT})}{e^{r(T-i)}} \times [1 - F(A)] + \frac{V(e^{RT} - e^{rT})}{e^{r(T-i)}} \times (1 - Q) \times F(A) + \left[P_c \times q_i + (V \times \zeta - \sum_j \frac{M_j}{e^{\frac{RjT}{n}}} - V) \times e^{ri} \right] \times Q \times F(A).$$

Then, consider the constraints involve in the model. Firstly, bank's profit when finance enterprise default should not less than its loan profit in normal situation, otherwise, the bank will unwilling to participate this financing activity. Secondly, Bank's loan profit should not less than the profit under market average ROI with the monthly market average ROI- ξ . Thirdly, finance enterprise's profit should not less than its operation expenses with the monthly average operation cost of finance enterprise-C. So these constraints can be present to:

$$(1) V \times \zeta + \sum_j \frac{M_j}{e^{\frac{RjT}{n}}} + \frac{P_c \times q_i}{e^{ri}} \geq \frac{V e^{RT}}{e^{rT}}$$

$$(2) E(\pi) \geq V(1 + \xi)$$

$$(3) \sum_j \frac{f \left[\frac{P_i \left(\frac{T}{n} \right)}{e^{\frac{RjT}{n}}} \right] \times q_j}{e^{\frac{rjT}{n}}} - \left[V \times \zeta + \sum_j \frac{M_j}{e^{\frac{RjT}{n}}} \right] \geq C \times \sum_j \left[\frac{1}{(1+r)^j} \right]$$

According to assumptions above, the optimization model is:

$$\begin{cases} \max E(\pi) \\ \text{s.t. } V \times \zeta + \sum_j \frac{M_j}{e^{\frac{RjT}{n}}} + \frac{P_c \times q_i}{e^{ri}} \geq \frac{V e^{RT}}{e^{rT}} \\ E(\pi) \geq V(1 + \xi) \\ \sum_j \frac{f \left[\frac{P_i \left(\frac{T}{n} \right)}{e^{\frac{RjT}{n}}} \right] \times q_j}{e^{\frac{rjT}{n}}} - \left[V \times \zeta + \sum_j \frac{M_j}{e^{\frac{RjT}{n}}} \right] \geq C \times \sum_j \left[\frac{1}{(1+r)^j} \right] \end{cases}$$

C. Solving Method

The objective function and constraints involve non-linear expression, multi-objective, and uncertainty, therefore it is hard to be solved by using mathematical programming optimization method. So, the solving method for this optimization model is hybrid GA and simulation. Add BFGS into GA as a parallel factor as selection, crossover and mutation to solving optimization problems. This Hybrid Genetic Algorithm can overcome the defect of local

search on BFGS, and the convergence problem of GA.

III. NUMERICAL SIMULATION

Basic data in this section can be set as follows: the total quantity of collateral $q=10000$ with the market price $P_0=150$, the repurchase price $P_C = 160$, initial margin ratio $\zeta = 0.3$, loan period is 12 months $T=12$, and monthly loan rate $R=0.009$ and monthly deposit rate $r=0.0035$. Assumes that the finance enterprise replenishing the margin each half a month with its sales revenue.

A. The Influence from Default Probability Q on The Pledge Ratio ω

To research conventionally, the assignment to other key parameters are: $\mu = 120, \sigma = 8$.

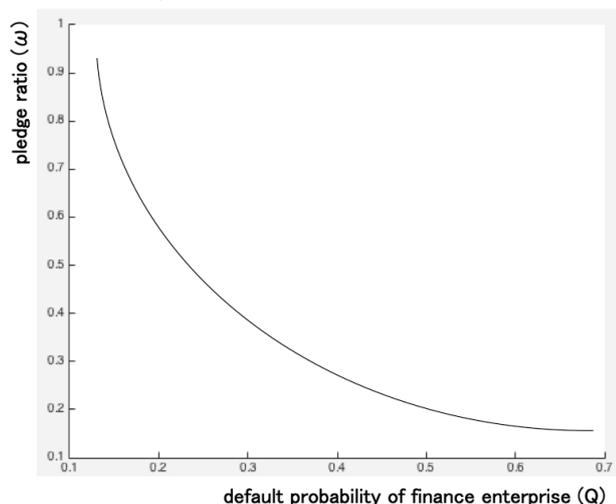


Figure 2. The influence from default probability Q on the pledge ratio ω

As shown in figure 2, it is a curve with diminishing marginal effect. Pledge ratio “ ω ” decreased when the default probability of finance enterprise increased. When $Q < 0.3$, a little change of default probability can make a great influence on pledge ratio, on the contrary, pledge ratio stay a low level and didn’t change a lot when $Q \geq 0.3$. Specially, the pledge ratio became less than 0.2 when Q close to 0.5. Bank will seldom consider the loan business under this situation.

On one hand, bank pay a lot attention to the default probability of finance enterprise, and regard it as a main standard when evaluating. So, assessment the default level of finance enterprise comprehensively and assignment the default probability reasonably should be the key point of setting pledge ratio for bank. On the other hand, the pledge ratio increased rapidly when Q less than 0.2. In order to gain higher pledge ratio, finance enterprise should keep more eyes on its credit level.

B. The Influence from The Market Price P_i on The Pledge Ratio ω

The influence of market price can be converted to the research of its logarithmic mean- $\ln(\mu)$ and standard deviation- σ . And the default probability valued 0.25.

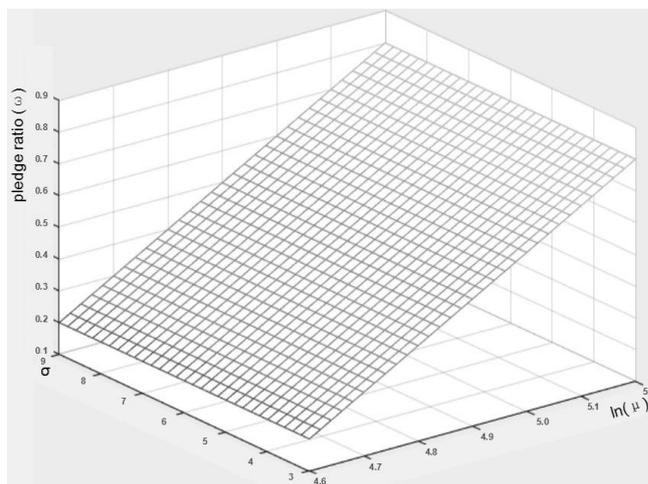


Figure 3. The influence from the market price of collateral P_i on the pledge ratio ω

As shown in figure 3, pledge ratio “ ω ” increased when $\ln(\mu)$ increased and σ decreased. Compare with $\ln(\mu)$, the change of standard deviation can make greater influence on pledge ratio. Obviously, the market price of collateral and its fluctuation affect the pledge ratio significantly. Especially, the collateral with high price and small fluctuations can gain higher pledge ratio.

On one hand, the market price can be affected easily when the economic and political environment is not stable, and will increase the risk of bank loan to a great extent. So the bank prefer the collateral with high and relatively stable market price to be pledge to decrease the credit risk of finance enterprise and the liquidity risk. On the other hand, for finance enterprise, the collateral with high price and small fluctuations can gain higher pledge ratio, means that the goal of obtaining financing can be achieved easily.

IV. CONCLUSION

Probability of default of financing enterprise is important to Loan-to-value ratio. To bank, Probability of default of financing enterprise has direct effect on risk of Confirming warehouse financing and set of Loan-to-value ratio. Therefore, how to evaluate default level by credit of financing enterprise becomes the key of Loan-to-value ratio. Under considering the whole environment of financing market, the bank should strengthen the static credit evaluation for financial indicators of financing enterprise. It should also quantitative evaluation criteria. By using evaluation method “The main + Debts”, comprehensive dynamically inspect the credit of financing enterprises, the core enterprise, the whole supply chain. For financing enterprise, if they want to get high loan-to-value ratio, the critical point is how to improve the credibility and reduce the probability of default. Financing enterprise should set up the enterprise values of honest and trustworthy, pay attention to their credits and perfect the enterprise financial system.

The change of market price of collateral has direct effect on the loan-to-value ratio. For bank, the change of market price of collateral has direct effect on loan risk and affects the set of loan-to-value ratio. Bank should consider the stability of the whole financing market environment and prevent choosing the collaterals which cannot guarantee the

value to handle the profit and risk under recession caused by sudden case. Under this occasion, banks should track and control the change of the collateral marketing price by information from storage and regulation. Therefore, banks prefer the collaterals with high and stable price.

For financing enterprises, they should pay attention to the marketing price and the fluctuation of it. The collateral with high price and low volatility ratio is the best choice for confirming warehouse financing. With this, financing enterprise can get higher Loan-to-value ratio and more short-term financing to relieve the strain on money.

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