Decision Analysis of Conditional Risk Method Based on Accounts Receivable Financing Mode

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Abstract. In order to study how factoring mode is involved in easing the flow of funds in the supply chain, such as upstream and downstream enterprises, etc. On the basis of accounts receivable financing mode, we use the measurement criteria of conditional risk method to formulate decision criteria. Then, it is assumed that the market demand will fluctuate randomly and consider the default risk of the downstream enterprises, and establish a conditional risk model consisting of three parties of a single factoring, a single retailer and a single product supplier. After balancing the pros and cons, we get the optimal rate of factoring, the optimal ordering quantity of retailers and the optimal wholesale price of product suppliers. The results show that under certain conditions, the use of factoring model can make the three parties optimize the operation of funds under the premise of effectively avoiding the risk, and all achieve the best goal.

Introduction
As we all know, if a supply chain wants to gain advantages in the market competition, the running of capital flow in the supply chain must be safe and smooth, otherwise, the supply chain is broken, which endangers the operation of the whole supply chain. In our country, the demand of small and medium-sized enterprises can not be satisfied because of their lack of funds and the inability to increase production.

Establishment and Analysis of CVaR Model Based on Accounts Receivable Factoring Mode

Symbolic Definition

The symbol hypothesis and the name of the variable are as follows:

- Q: Retailer's order quantity;
- W: Wholesale price of products;
- P: Market price of products;
- C: Production cost of unit product, \( C < W < P \);
- x: Market demand, X is a random variable with a random distribution, which satisfies the distribution function \( F(x) \) and probability density function \( f(x) \);
- B: Unit repurchase price;
- a: Unit guarantee amount;
- y: Treatment of surplus value of factoring merchants, if \( y + a < W(1 + r) \);
- \( \alpha_1 \): Risk aversion coefficient of retailer;
- \( \alpha_2 \): Risk aversion coefficient of supplier;
- \( \alpha_3 \): Risk aversion coefficient of factoring;
- \( \beta \): Return threshold;
- \( c_1 \): Production cost of supplier unit;
- \( c_2 \): Factoring rate; agent to the retailer;
- \( m_1 \): Intermediary fees charged by a factoring provider;
- \( m_2 \): Intermediary fees charged by a factoring agent;
- \( \phi \): Probability of breach of contract

Premise Hypothesis and Problem Analysis

Hypothesis 1: The supplier only produces one product. In the early stage of production, if the supplier is short of funds, it can be produced from outside financing through factoring mode. Suppose that the total amount of financing from suppliers to factoring is \( R = QW \), and there is no Retention Fund. All the money for financing is used to produce products.

Hypothesis 2: Suppliers, retailers and factoring companies all have risk aversion characteristics. Accounts receivable financing mode is the core of the following travel enterprises. In the production
process, small and medium-sized suppliers often have sufficient orders and insufficient production funds and need to finance outside. At this point, retailers need to guarantee because of insufficient credit loans. The retailer will bear a penalty amount of $Z$ for breach of contract, and the factoring provider will provide the guarantee amount for the manufacturer to reduce the risk, that is, the factoring ratio should be adjusted. In order to avoid risks, suppliers sign an optimal order contract with retailers. Finally, after factoring determines the financing rate, the supplier and the retailer determine the wholesale price and the order quantity respectively. In this paper, the risk aversion level of three parties in the supply chain is considered, and the CVaR model of the supplier, retailer and factoring provider is established respectively, and the optimal solution of the supply chain scheme will be solved.

**Revenue Function Analysis of Retailers, Suppliers and Factoring Firms**

When $Q > x$, the order quantity of retailers exceeded the market demand, resulting in a large number of surplus, which caused retailers to be unable to repay. Retailers tend to default and pay penalty costs at this time.

Retailer’s profit function: $\omega_1 = P - QW(l + r) - B(Q - x)$; $\omega_2 = -ka(Q - x) + (P - W(l + r))$

Supplier’s profit function: $\omega_0 = (W - c)Q - B(Q - x)$; $\omega_2 = -a(l - k)(Q - x) + Q(W - c)$

Factoring agency’s profit function:

$$\omega_0 = m_1 + m_2 - Qc_2 + QW$$

When $Q < x$, the supply of goods was in short supply and retailers were unlikely to default.

Retailer’s profit function: $\omega_3 = -W(l + r) + PQ$

Supplier’s profit function: $\omega_3 = Q(W - c)$

Factoring agency’s profit function: $\omega_3 = m_1 + m_2 - Qc_2 + QrW$

**The CVaR Model of Retailers, Suppliers and Factmakers**

First, the auxiliary function is introduced: $F(\beta) = \beta - \frac{1}{1 - \alpha} \left[ \int_0^\infty (\beta - \omega) + f(x)dx \right]$, This article takes into account the benefits of different situations.

When $Q > x$, The case of breach of contract appears, we bring in $\omega_2$, $\omega_3$:

Retailer’s CVaR model:

$$F_1(Q, \beta) = \beta - \frac{1}{1 - \alpha} \left[ \int_0^\infty (\beta - (P - WQ(l + r)) + a(Q - x)(1 - k) + f(x)dx + \int_{Q}^{\infty} (\beta - (P - WQ(l + r)) + f(x)dx) \right]$$

Supplier’s CVaR model:

$$F_2(W, \beta) = \beta - \frac{1}{1 - \alpha} \left[ \int_0^\infty (\beta - Q(W - c)) + (P - QW(l + r)) + f(x)dx + \int_0^\infty (\beta - Q(W - c)) + f(x)dx \right]$$

Factoring agency’s CVaR model:

$$F_3(r, \beta) = \beta - \frac{1}{1 - \alpha} \left[ \int_0^\infty (\beta - rQW) + c_2Q - m_1 - m_2) + f(x)dx \right]$$

When $Q < x$, The case of breach of contract appears, we bring in $\omega_1$, $\omega_3$:

Retailer’s CVaR model:

$$F_1(Q, \beta) = \beta - \frac{1}{1 - \alpha} \left[ \int_0^\infty (\beta - QW(l + r) - P - B(Q - x)) + f(x)dx + \int_{Q}^{\infty} (\beta - (P - WQ(l + r)) + f(x)dx) \right]$$

Supplier’s CVaR model:

$$F_2(W, \beta) = \beta - \frac{1}{1 - \alpha} \left[ \int_0^\infty (\beta - Q(W - c)) + (P - WQ(l + r)) + f(x)dx + \int_0^\infty (\beta - Q(W - c)) + f(x)dx \right]$$

Factoring agency’s CVaR model:

$$F_3(r, \beta) = \beta - \frac{1}{1 - \alpha} \left[ \int_0^\infty (\beta - rQW + c_2Q - m_1 - m_2) + f(x)dx \right]$$

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Decision Optimization of Retailers, Suppliers and Factoring Based on CVaR

**Retailer's Optimal Order Quantity.** Theorem 1: Supplier wholesale prices and factoring interest rates are known, when \( Q < \alpha \), which means the retailer will not default. Retailers seek maximum profits while considering risk aversion. Because of \( \beta = \lambda W(1+r) + P \), Retailers have an optimal order: \( Q_{r1} = \frac{(1-\alpha_z)(P - W(1+r))}{Z(P - B)} \), when \( 1 - F(Q) > P + c_1(1+r) + ka \) and \( \beta \) is monotonically decreasing, there is no optimal solution. Therefore, the result of solving equation is:

\[
Q_{r1} = \frac{(1-\alpha_z)(P - W(1+r))}{Z(P - B)}
\]

Theorem 2: Supplier wholesale prices and factoring interest rates are known, when \( Q > \alpha \), which means the retailer will not default. Retailers seek maximum profits while considering risk aversion. The result of solving equation is:

\[
Q_{r1} = \frac{(1-\alpha_z)(P - W(1+r))}{Z[P - W(1+r) + ka]}
\]

**Supplier's Optimal Wholesale Price.** Theorem 3: If optimal order of retailer is \( Q'_{r2} = \frac{(1-\alpha_z)(P - W(1+r))}{Z(P - B)} \), when \( 1 - F(Q) > P + c_1(1+r) + ka \), suppliers seek maximum profits while considering risk aversion. The result of solving equation is that supplier's optimal wholesale price is:

\[
W_{s2} = \frac{B P(1-\alpha_z) + c_1(P - B)(1-\alpha_z)}{(P - B)(1-\alpha_z) + B(1-\alpha_z)(1+r)}
\]

Theorem 4 can be obtained by the same way.

**Factoring Agency’s Optimal Interest Rate.** Theorem 5: If the optimal order of retailer is \( Q'_{r2} = \frac{(1-\alpha_z)(P - W(1+r))}{Z(P - B)} \), after the calculation, I get that:

\[
W_{s2} = \frac{B P(1-\alpha_z) + c_1(P - B)(1-\alpha_z)}{(P - B)(1-\alpha_z) + B(1-\alpha_z)(1+r)}
\]

After the calculation, I get that:

\[
Q(W_{s2}^* + \frac{\partial W_{s2}^*}{\partial r} r + \frac{\partial Q_{s2}^*}{\partial r} (W_{s2}^* r - c_z) = 0 \text{ and } 2Bf(Q) + f'(Q)(P + Br)(-c_z + rW) < 0)
\]

Theorem 6: If the optimal order of retailer is \( Q'_{r2} = \frac{(1-\alpha_z)(P - W(1+r))}{Z[P - W(1+r) + ka]} \), supplier's optimal wholesale price is:

\[
W_{s2} = \frac{a(1-k)(1-\alpha_z) + (1-\alpha_z)(P + c_1(1+r) + ka)}{(2(1+r)(1-\alpha_z)}
\]

**Literature References**

Furthermore, because the small and medium-sized enterprises are not enough to get enough loans,
the problem of low supply chain efficiency can not be effectively solved\textsuperscript{[1]}. It is this big environment that has spawned supply chain finance.

Supply chain finance is not something new. As early as 2003, James B.Rice\textsuperscript{[2]}, a foreign scholar, defined the concept of early supply chain finance. He proposed that we could try to apply traditional financial instruments to the operation of supply chain, and effectively enhance the efficiency of production and operation of enterprises in the supply chain. Hoffman. E\textsuperscript{[3]} put forward a similar view. He believes that supply chain finance can improve the management efficiency of the whole supply chain and the net income of the whole society by regulating the flow of funds between upstream and downstream enterprises through commercial banks. Yue-fei Hu\textsuperscript{[4]}, a domestic scholar, further points out that The supply chain finance, that is, the financial institution represented by the bank, provides a better fund operation scheme to the upstream and downstream enterprises of the supply chain to achieve the purpose of integrating all the resources in the supply chain. He puts forward a new concept of the evolution from the "financial supply chain" to the supply chain finance.

As one of the supply chain financial products, the account receivable factoring model is widely used internationally because of its advantages of convenient operation mode, low cost of financing and so on. This paper mainly studies the application of factoring mode in the supply chain, drawing on the experience of many domestic and foreign scholars. Sopranzetti\textsuperscript{[5]} set up a supplier profit model to study the supplier's factoring strategy. It believes that both the bankruptcy risk and the credit level will affect the willingness of the enterprise to take the right of recourse. Leora Klapper\textsuperscript{[6]} analyzed the advantages and challenges of accounts receivable factoring financing, and put forward the concept of reverse factoring. Hui yu\textsuperscript{[7]} have studied the influence of the operation process and financing mode on the performance of supply chain.

In addition, CVaR has been widely applied to supply chain research in recent years because of its unique advantages in the field of financial risk control. For example, Yan-Ju Zhou\textsuperscript{[8]} constructed a multi product ordering risk decision model through CVaR method. C B Zhu\textsuperscript{[9]} has studied how to use the CVaR rule to optimize the coordination mechanism and supply chain decision-making under the condition of the supply chain terminal. C B Zhong\textsuperscript{[10]} used CVaR rule to coordinate the revenue sharing model of the supply chain.

It is undeniable that the research results have played a great role in promoting the development of supply chain management and risk control, but the lack of the United States and China are not fully considered when most scholars have studied the related issues. For example, the distinction between financing methods is not prominent, the risk attitude is not fully considered and the participants in the supply chain are not fully considered. Therefore, this article only analyses the mode of accounts receivable factoring, and establishes a conditional risk decision model considering the retailer's default risk. This paper studies how retailers and suppliers maximize their own interests by setting up order and pricing decisions, and draws the best factoring interest rate that the factoring firms should make.

**Summary**

By Theorem 1, theorem 3 and Theorem 5, it is known that when the retailer does not exist default, considering the risk aversion, the enterprise seeks the maximum profit, the bank has the optimal interest rate to satisfy the sufficient and necessary conditions. According to the optimal interest rate, the supplier can make the optimal wholesale price, and the retailer will get the optimal order quantity.

From theorem 2, theorem 4, theorem 6, we know that when a retailer breaks a contract, the bank has an optimal interest rate that satisfies certain conditions. At this point, the supplier can formulate the optimal wholesale price for the profit maximization, and the retailer can make the optimal order quantity.
Under the condition of certain conditions, the optimal solution of the article model shows that the cooperation mode is feasible, and the three party can get the best goal. How to reduce the conditions to achieve this goal still needs a certain access mechanism, the prevention and control mechanism, and the need for legal protection. This paper only considers the CVaR model of supply chain finance under the account receivable factoring model, and the other two kinds of financing have not been taken into consideration, and therefore need further study.

Reference:


