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Research on Optimization Model of Online Shopping Supply Chain

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Abstract. How to improve vendor management inventory levels, and how online retailer optimize inventory costs and transportation costs, to obtain greater profit margins, has become the supply chain cannot be ignored. In this paper, revenue sharing contract under the conditions set forth the number of multi-stage inventory optimization strategies vendor products, revenue sharing contract parameters according to the supplier and retailer network share a common transportation costs, so that based on revenue sharing contract under the conditions of the two sides are greater than profits online shopping in the traditional supply chain profits and examples show the feasibility of this model to the economic benefits of cooperation, in order to better promote the cooperation provides an effective path.

Keywords: Revenue sharing contract; Stock transport; Dynamic optimization; Inventory decisions.

1. Introduction

With the development of e-commerce, online shopping has gradually become a new growth point of modern economy, the number of online retailer also showed a rapid upward trend. To improve service levels and competitiveness, online retailer and supplier need to maintain a good relationship between the two sides how to optimize revenue and inventory and transport costs, or inventory and transport costs must be the biggest gains, become the online shopping supply chain hot spots and key issues.

Scholars have done some research on revenue sharing contract .For example, Gerchak and Khmelnitsky [1] studied the VMI model where a single supplier is in the leading position of Stackelberg. The retailer provides a certain percentage of the distribution profit generated by revenue sharing to the supplier. Shauhan et al. [2] analyzed the benefits of different members of the supply chain on the basis of the profit sharing two-level supply chain model. Shukla et al. [3] and Ozener [4] studied the inventory transport model of individual retailers and individual suppliers under stochastic demand. But these studies fail to combine the revenue-sharing contract with online shopping supply chain inventory and transportation, and study the cooperative promotion effect of revenue-sharing contract. In this paper, the profit-sharing contract is introduced into online stock supply chain inventory and transportation joint optimization study, to improve system performance and the benefits of the participants, and to promote better cooperation between supplier and online retailer.

2. Problem Description

In this paper, a clothing supplier and online retailer in a city as the object of study, we consider the relationship between demand and time, and divide the development process into several stages according to the chronological order. We use the dynamic programming model to calculate the transportation cost of each retailer in a city. Phase optimal decision-making, in order to obtain the maximum benefit (as shown in figure 1 and figure 2).

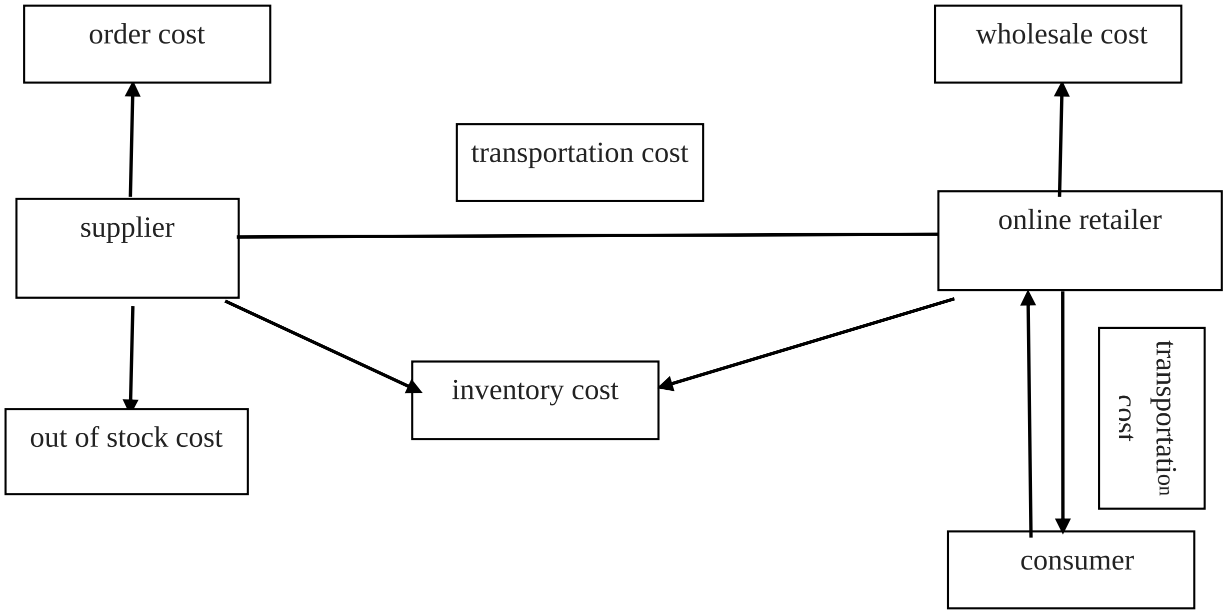

Fig. 1 Costs in the traditional supply chain

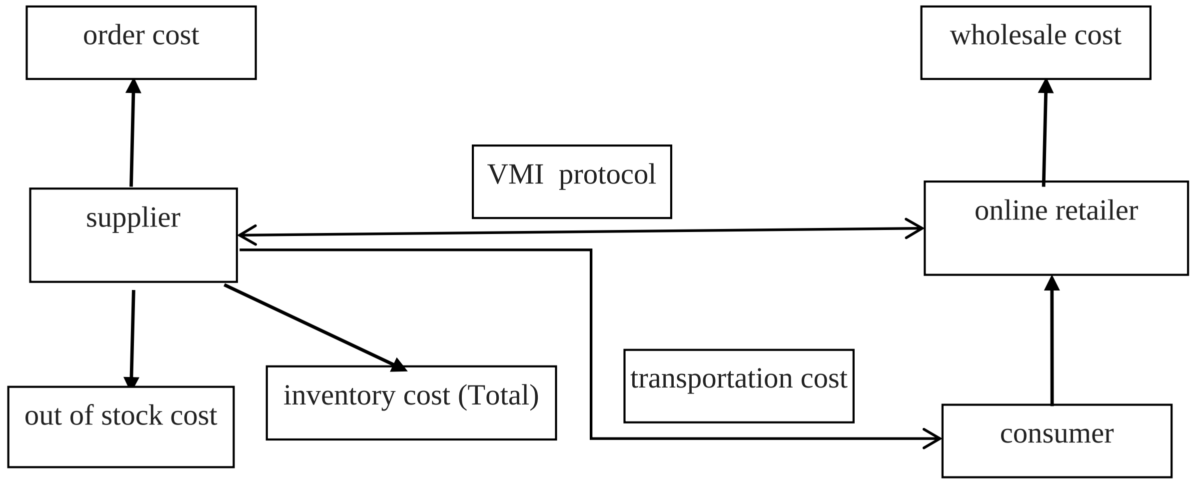

Fig. 2. Based on VMI protocol optimization framework

A clothing supplier to the cities online of retailer to provide certain types of clothing, supplier and online retailer for long-term cooperation, the following assumptions are:

(1)Suppliers to supply a month for a cycle, each cycle is divided into early, mid, late three stages;

(2)The market demand at each stage of the planning period is known;

(3)Where a certain period of time arrival, and in the same period of time spent depletion of materials are not period inventory management fee;

(4)Purchase price has nothing to do with the order quantity.

A period of the upper, middle and late stages of the three types of clothing on the market demand as shown in Table 1.

Table 1 The Demand for Each Type of Clothing (Units: sets)

Time	Early	Mid	Late
Online retailer demand	q_1	q_2	q_3

For the supplier: hypothesis S is the total order cost in the traditional supply chain; S* is the total order cost of the optimized supplier; h_1 is the stock cost per unit product; k_1 is the inventory cost per unit product; y_1 is the transportation cost per unit product. For the online retailer: p is the selling price per unit product; p_1 is the wholesale price per unit product; k_2 is the unit product inventory cost; y_2 is the transportation cost per unit product. The market demand for each stage is q_i , and the cost of the inventory increase of the garment factory is directly proportional to the square of the product quantity, the proportion factor is θ, then the ordering cost of the supplier is :.$S_i = \theta q_i^2$, where $i = 1,2,3$.

3. A Joint Optimization Model for Inventory and Transportation in Online Shopping and Supply Chain Based on Revenue Sharing Contract

3.1 The Decision - maker's Income Model of Supply Chain in Traditional Supply Chain

If the demand to organize the order, the supplier inventory is zero, the supplier order cost is: $S = \theta q_1^2 + \theta q_2^2 + \theta q_3^2 = \theta \sum_{i=1}^{3} q_i^2$; Online retailer hold inventory, the demand for each stage of the stage of inventory, of course, can also be stored in the beginning of the beginning of the amount of the month, which will lead to increased inventory costs, is clearly unreasonable. Retailer stock charge: $K_2 = k_2 \sum_{i=1}^{3} q_i$. Supplier's shipping cost: $Y_1 = y_1 \sum_{i=1}^{3} q_i$ Shipping cost for online retailer: $Y_2 = y_2 \sum_{i=1}^{3} q_i$ Supply chain total shipping cost: $Y_1 + Y_2 = (y_1 + y_2) \sum_{i=1}^{3} q_i$. Supplier profit: $\pi_1 = (p_1 - h_1 - y_1 - k_1) \sum_{i=1}^{n} q_i - \theta \sum_{i=1}^{n} q_i^2$. Online retailer profit: $\pi_2 = (p - p_1 - y_2 - k_2) \sum_{i=1}^{n} q_i$. Total profit: $\pi = \pi_1 + \pi_2$.

3.2 Profit Model of Multi - stage Decision Dynamic Programming Based on Revenue - sharing Contract

Assume that in the online shopping supply chain, the supplier holds the inventory. Through the reasonable design of the revenue-sharing contract, the cost of the supplier: $T_1 = S^* + (k_1 + h_1 + \mu y_1) \sum_{i=1}^{3} q_i$; The cost of the online retailer: $T_2 = [p_1 + (1 - \mu) y_1] \sum_{i=1}^{3} q_i$. Where μ is the proportionality factor for the supplier to apportion the transportation cost, when $\mu < 0$, it indicates that the online retailer provides the freight subsidy to the supplier; when$0 \le \mu \le 1$, it indicates that the transportation expenses are distributed proportionally; when $\mu \ge 1$, the supplier online retailer offer shipping subsidies.

Through the introduction of multi-stage dynamic programming analysis framework, the dynamic joint optimization of inventory and transportation is analyzed. The dynamic joint optimization model of supply chain inventory and transportation is constructed as follows: $f_i(x_i) = \min\{d_i(x_i, v_i) + f_{i+1}(x_{i+1})\}$. Where $f_4(x_4) = 0, i = 3,2,1$. x_i is the inventory of product in phase i, v_i is the number of inventory items that need to be added in state x_i of phase i ; In the *i* phase of the increase in inventory inventories arising from the subscription costs and initial inventory costs is: $d_i(x_i, v_i) = k_1 x_i + \theta v_i^2$; Increased inventory from status x_i up to the end of the collaboration The total cost of the order and initial stock required is: $f_i(x_i) = \min_{v_i \ge q_i - x_i}\{k_1 x_i + \theta v_i^2 + f_{i+1}(x_{i+1})\}$ for $f_4(x_4) = 0, i = 3,2,1$. By state x_k take v_k after the state transition equation is: $x_{i+1} = x_i + v_i - q_i$ .Use the Backstepping algorithm to solve the above model:

(1) When $i = 3$,

$f_3(x_3) = k_1 x_3 + \theta (q_3 - x_3)^2 = \theta q_3^2 + (k_1 - 2\theta q_3) x_3 + \theta x_3^2$ where $v_3 = q_3 - x_3$.

(2) When $i = 2$,

$$f_2(x_2) = \frac{(q_2^2 + 2q_2q_3 - q_3^2)\theta + (q_3 - q_2)k_1}{2} - \frac{k_1^2}{8\theta} + \left(\frac{3}{2}k_1 - \theta q_2 - \theta q_3\right) x_2 + \frac{\theta}{2} x_2^2.$$

(3) When $i = 1$, find the limit there

$$f_1(x_1) = \min_{v_1 \ge q_1 - x_1} \left\{ k_1 x_1 + \theta v_1^2 + \frac{(q_2^2 + 2q_2q_3 - q_3^2)\theta + (q_3 - q_2)k_1}{2} - \frac{k_1^2}{8\theta} + \left(\frac{3}{2}k_1 - \theta q_2 - \theta q_3\right) x_2 + \frac{\theta}{2} x_2^2 \right\}$$

When $x_1 = q_1 - \frac{q_2 + q_3}{2} + \frac{3k_1}{4\theta}$, The cost $f_1(x_1)$ is minimum. So one month cycle, the upper, middle and late stages of the three types of the initial inventory and the stage of the increase in inventory were as follows: $x_1 = q_1 - \frac{q_2 + q_3}{2} + \frac{3k_1}{4\theta}, x_2 = 0, x_3 = \frac{q_2 + q_3}{2} - \frac{k_1}{4\theta} - q_2$;

$$v_1 = \frac{q_2 + q_3}{2} - \frac{3k_1}{4\theta}, v_2 = \frac{q_2 + q_3}{2} - \frac{k_1}{4\theta}, v_3 = \frac{q_2 + q_3}{2} + \frac{k_1}{4\theta}.$$

To facilitate cooperation, the supplier and the online retailer share the transportation cost according to a certain proportion, the proportion coefficient isμ, the total transportation cost is $Y_3 = y_1 \sum_{i=1}^{3} q_i$, the freight cost borne by the supplier is μY_3, and the freight rate borne by the network retailer is $(1-\mu)Y_3$.

Using the multi-stage dynamic model of inventory and transport joint optimization strategy was changed to: $\Delta\pi_1 = (1-\mu)y_1 \sum_{i=1}^{3} q_i + \theta(\sum_{i=1}^{3} q_i^2 - \sum_{i=1}^{3} v_i^2)$; The change in profit for online retailer is: $\Delta\pi_2 = [y_2 + k_2 - (1-\mu)y_1]\sum_{i=1}^{3} q_i$. If the two sides take the initiative to take joint optimization and optimization strategy, you need to meet the conditions$\Delta\pi_1 > 0$, $\Delta\pi_2 > 0$. Therefore, $1 - \frac{y_2+k_2}{y_1} < \mu < 1 + \frac{\theta(\sum_{i=1}^{3} q_i^2 - \sum_{i=1}^{3} v_i^2)}{y_1 \sum_{i=1}^{3} q_i}$.

When the value of μ in the above range, through the online shopping supply chain inventory and transport optimization, supplier and network retailer profit than traditional supply chain profits have increased, both ITIO cooperation can be reached; when the μ is not within the above range, it means that at least one party's profit will be impaired, that is, it is difficult for both parties to cooperate.

4. Case Study

In order to verify the research conclusion, this paper gives a concrete example for numerical calculation. Let p=200, $p_1 = 100$, $y_1 = 20$, $y_2 = 10$, $k_1 = 10$, $k_2 = 5$, $h_1 = 5$, $\theta = 0.05$. $q_1 = 400$, $q_2 = 300$, $q_3 = 500$. It is possible to obtain: $x_1 = 150$, $x_2 = 0$, $x_3 = 50$; $v_1 = 250$, $v_2 = 350$, $v_3 = 450$. $0.25 < \mu < 1.2344$.

When $0.25 < \mu < 1$, the transportation costs are shared by supplier and retailer according to μ: $(1-\mu)$; when$\mu = 1$, transportation costs are all borne by the supplier; when $1 < \mu < 1.2344$, the supplier will subsidize the part of online retailer. The relationship between supplier and online retailer's profit and contract parameters is shown in Fig.3 and Fig.4.

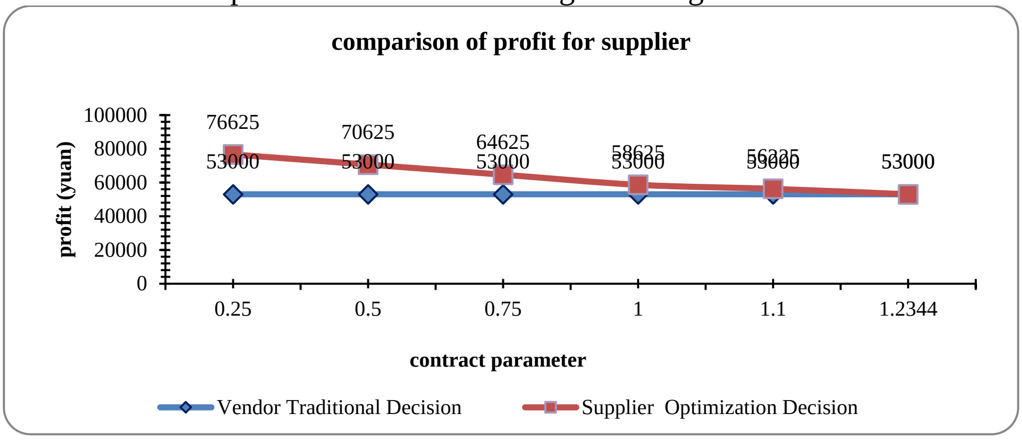

Fig. 3 Comparison of profit for supplier

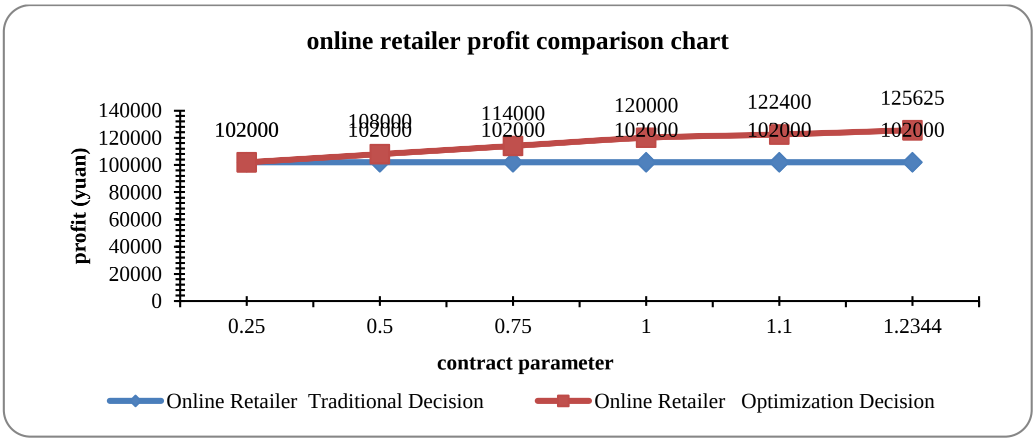

Fig. 4 Online retailer profit comparison chart

5. Conclusion

In this paper, we first construct the profit distribution model of the supplier and the retailer in the traditional supply chain, and find out the cost and profit of the supplier and the online retailer in the traditional supply chain. Secondly, by using the VMI idea, a multi-stage dynamic model is constructed to study the ITIO dynamic optimization of supplier and online retailer under the revenue sharing contract. It is found that the profit of the two parties is more than that of the traditional supply chain; finally, an example is given to verify the relationship between the change of profit before and after the optimization of the retailer and the online retailer, and to test the effectiveness of the model.

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