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Retraction

Retracted: Simulation Research on Information-Sharing Value of Two-Level Supply Chain

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] X. Zhang, Z. Lin, and L. Xiao, "Simulation Research on Information-Sharing Value of Two-Level Supply Chain," *Security and Communication Networks*, vol. 2021, Article ID 5361887, 8 pages, 2021.

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Research Article

Simulation Research on Information-Sharing Value of Two-Level Supply Chain

Xiaheng Zhang,[1,2] Zekai Lin,[3] and Lin Xiao[2]

[1]*College of Business and Trade, Nanchang Institute of Science and Technology, Nanchang 330108, China*
[2]*School of Management, Northwest University of Political Science and Law, Xi'an 710122, China*
[3]*School of Geography and Tourism, Hanshan Normal University, Chaozhou 521041, China*

Correspondence should be addressed to Zekai Lin; lzk@hstc.edu.cn

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In the two-stage supply chain model, the incentive effect to the supplier's sharing of demand information and performance evaluation and the effect of various parameters on the incentive effect of the supply chain are studied through a multiagent simulation model constructed for the purpose. It is found that the incentive coefficient of demand information-sharing degree, the number of selected suppliers, the order allocation coefficient, and the order proportion are positively related to the incentive effect of demand information sharing. So, the greater the demand information sharing is, the greater the impact of these parameters on the incentive effect is. Based on the demand information sharing, the supplier performance evaluation rules are shared, and when the actual evaluation rules are inconsistent with the supplier's expectations, the incentive effect is further enhanced. Other parameters do not affect the incentive effect of demand information sharing and performance evaluation rule sharing.

1. Introduction

With the market becoming more and more mature, the market competitions are becoming more and more intense. The market environment is more complex and changeable, and enterprise competition has evolved into competition among the supply chains. Lee et al. in 2000 [1] said that the supply chain is a very complex network chain model, covering the whole process from suppliers at all levels, manufacturers at all levels, distributors at all levels, and retailers to the end users. Zhang in 2007 [2] studied a two-level make-to-order supply chain composed of one manufacturer and one supplier and found that information sharing can reduce system cost, and the main benefit comes from coordination. A two-level supply chain is the basic unit of the whole complex network chain model. The research on the operation mode of a two-echelon supply chain system is helpful to understanding the influencing factors of supply chain operation. It is the basis for understanding and analyzing the operation mode of the complex supply chain. Supply chain management is on the whole supply chain of each node in the enterprise, between the departments of logistics, information flow, and cash flow planning, organization, coordination, and control, mainly through strengthening cooperation to achieve the effective use of resources. Xiao et al. in 2014 [3] and Zhou and Ran in 2019 [4] thought that information, as the communication carrier of each link in the supply chain, plays an important role in the cooperation among enterprises and the effective utilization of resources. In the supply chain, each node enterprise may serve as the supplier of information and at the same time as the demand side of information. The smooth information communication between upstream enterprises and downstream enterprises can provide work efficiency and reduce costs. Information sharing among supply chain enterprises is the key to improve the performance of supply chain.

The sharing of knowledge and information between enterprises is not only conducive to the efficient use of existing knowledge and information but also to strengthen the coordination among enterprises and provide the coordination of enterprises at the information level. Information

sharing among enterprises has become a hot topic in the enterprise and academic circles [5, 6]. Demand information sharing can effectively reduce the uncertainty of the supply chain [7], reduce the total inventory and total cost of the supply chain, and improve the efficiency of the supply chain [8]. Some scholars have found that supply chain performance improvement brought about by demand information sharing benefits the upstream members of the supply chain [9, 10]. Some scholars pay attention to how to motivate the downstream members of the supply chain to share the demand information [11, 12]. The existing research results show that the supply chain model involved in the supply chain information sharing is composed of a supply chain upstream enterprise and a downstream enterprise or a supply chain upstream enterprise and a number of downstream enterprises [13, 14]. This is a kind of supply chain information-sharing model under ideal conditions, but in the actual operation of enterprises, except in special circumstances, such as in monopoly or oligopoly industry, most of the actual needs of the enterprise are based on business, such as the control of procurement risk, reduction of procurement costs, and often the selection of suppliers.

Chen in 2003 [15] analyzed supply chain cost pricing mechanism based on three different situations, that is, complete information, incomplete information, and limited information. This study will introduce the idea of multi-suppliers in the supply chain, and demand information sharing can be divided into three types. First, the limited demand information sharing, supplier orders only know their own, does not know the total amount of orders to other suppliers and downstream enterprises; second, incomplete demand information-sharing, except that their supplier orders, orders also know downstream enterprises on the part of other suppliers; third, total demand information-sharing, sharing the total demand information for all suppliers and downstream enterprises, suppliers not only know their orders but also know their order proportion. In the case of demand information sharing, the suppliers will have a strong incentive effect because of their low-order proportion and are willing to pay more effort or lower prices or increase the service level. In order to get more orders in proportion, the results will lead to lower corporate profits.

In the multisupplier supply chain model, the downstream enterprises adopt limited demand information sharing, incomplete demand information sharing, or complete demand information sharing, which is related to the realization mode of information sharing. Based on the development and wide application of information technology, network technology, and communication technology, it is possible to complete information sharing. The supply chain information-sharing model has three types, namely, information transfer model, third party model, and information center model [16]. The supply chain demand information-sharing model based on the information transfer model attracts more and more attention, and the latter two models are often ignored, which also affects the complete demand information sharing in the supply chain management research that is often ignored. Although the technology development makes the total demand information sharing possible, demand information sharing will aggravate the competition of supply chain and the profit of downstream enterprise, but the incentive effect of size of the total demand information sharing is influenced by other factors, such as supplier cost, service level, supplier number, the selected number of suppliers, distribution rules and orders of supplier evaluation, and supplier pricing rules. This paper constructs a simulation model of two-level supply chain information sharing and studies the information sharing, incentive effect, and supply chain parameters of a manufacturer and multiple parts suppliers, in order to analyze the impact of information sharing demand on incentive effect.

2. Two-Level Supply Chain Model with Multiple Suppliers

2.1. Research Premises. In order to better realize the research topic of this study, the following research premises are proposed.

(1) Supply chain consists of 1 manufacturer and n suppliers. All suppliers are the alternative suppliers of the manufacturer, and they only supply the manufacturer. There are no other manufacturers in the market.

(2) Manufacturers evaluate supplier performance from two aspects of price and service level, in which service level is composed of nonprice factors, such as product quality, speed of supply, and after-sale service. According to supplier performance sequencing, the manufacturer selects m suppliers from alternative suppliers to distribute their purchased orders.

(3) All suppliers will face three kinds of information disclosure. Firstly, when the producers of limited demand information sharing, supplier only knows the received orders. Secondly, when producers do not completely demand information sharing, except that their supplier orders, they can know other producers' supplier orders. Lastly, when the demand information sharing occurs, the suppliers know producers' total orders and suppliers' order proportion.

(4) Total order quantity of the manufacturer remains unchanged, and the order quantity of each supplier may change.

(5) Supplier will dynamically adjust the current product price and service level according to the proportion of the changes in profits and orders during the previous period. The suppliers use the same policy.

(6) All suppliers have unlimited capacity, which can completely meet the orders of the manufacturer.

2.2. Manufacturer Selection. Manufacturers comprehensively weighted the price and service level, which are used as the supplier's performance to make the decision on each supplier and its order quantity. Supplier performance = V.

$$V_i = (1 - \alpha)S_i - \alpha P_i. \quad (1)$$

Among them, V_i is the total performance of the i supplier. S_i and P_i, respectively, represent the service level and price of the supplier, and the α represents the weight of the price. The manufacturer, according to the V_i ranking of the n suppliers, selects the supplier in accordance with the order from large to small ($m \le n$) suppliers.

At the same time, the manufacturer uses the geometric model to allocate orders among suppliers, which is K.

$$\kappa = \frac{Q_{i+1}}{Q_i}. \quad (2)$$

Among them, $i = 1, 2, \ldots, m-1$, Q_i represents the order quantity assigned by the i supplier from the manufacturer, and $k \in (0, 1]$.

The quantity of orders is obtained by each supplier, which is Q_i.

$$Q_i = \frac{\kappa^{i-1}}{\sum_{j=1}^{m} \kappa^{j-1}} Q. \quad (3)$$

Among them, Q represents the total demand of the manufacturer.

2.3. Suppliers Decision. The decision of suppliers has the initial price and service level and the dynamic adjustment state of the price and service level of each period. It is assumed that the service level of the i supplier is S_i, $S_i \le \text{Max}(S_1, S_2, \ldots, S_n)$, MaxS represents the highest level of service that a supplier can achieve, and it is subject to Uniform$(100 - \beta,\ 100 + \beta)$ distribution. Among them, β represents the maximum fluctuation of the service level of suppliers. When $S_i = 0$, it means that the service level on behalf of suppliers reaches the minimum level required by the manufacturer. Initial S_i obeys uniform (0.9 Max S_i, Max S_i) distribution. The level of service affects the cost of manufacturers. It is assumed that the marginal cost of service increases, which is $\partial C/\partial S = \rho S$, where ρ is the marginal cost coefficient. The cost of the i supplier is C_i.

$$C_i = C_{0i} + \frac{1}{2\rho S_i^2}. \quad (4)$$

Among them, C_{oi} is the fixed cost and obeys the Uniform $(100 - \lambda, 100 + \lambda)$. λ is the fixed cost variation range on behalf of suppliers.

Assuming that the base rate of return is 0.05, the supplier's lowest offer is Min $P_i = 1.05C_i$. $P_{\text{i}} \ge \text{Min}(P_1, P_2, \ldots, P_n)$, and the initial quotation follows the Uniform (Min P_i, $1.1C_i$) distribution. Supplier dynamically adjusts the price and service level at each period. This study analyzes the impact of supplier complete demand information sharing and performance evaluation rule sharing on supplier price and service level selection. On the basis of the DF algorithm, a common dynamic pricing algorithm for agents, combined with the improved form of the DF algorithm [17], it is used as the basis of the supplier price adjustment model. The dynamic selection rules are as follows:

(1) If the current income of the supplier is greater than or equal to the previous income, the price and service level remain unchanged. Otherwise, the next stage will adjust the price and service level. The adjustment of price follows the Triangular (0, 0, $0.1P_i$) distribution, and the adjustment of service level obeys the Triangular (0, 0, $0.1S_i$) distribution.

(2) If the manufacturer shares limited demand information, the probability distribution of supplier performance is 1; when the manufacturer share incomplete demand information, the probability distribution of the supplier's performance is 0.5;

When manufacturers share full demand information, the probability of supplier performance is $1 - R_i^{\mu}$. The probability of decreasing performance is R_i^{μ}. R_i is the order proportion of suppliers, and μ is the incentive coefficient of order proportion.

(3) When $P_i > \text{Min}(P_1, P_2, \ldots, P_n)$, suppliers can improve their performance by lowering prices or improving service levels. If the supplier does not know the manufacturer's evaluation rule, the probability of lowering the price and raising the service level is 0.5. If the supplier knows the manufacturer's evaluation rules, the probability of decreasing the price is α, and the probability of raising the service level is $1 - \alpha$.

(4) When Pi = Min ($P1$, $P2$, $\ldots$,P_n), suppliers can improve their performance by simultaneously reducing price and service levels, or at the same raising, and services. At this point, supplier performance is Vi.

$$V_i = S_i(1 - \alpha) - 1.05\alpha\left(C_{0i} + \frac{1}{2\rho S_i^2}\right). \quad (5)$$

If the manufacturer does not share the evaluation rules, then the $\alpha = 0.5$. When $\partial I_i/\partial S_i > 0$, and $1 - \alpha/\alpha > 1.05\,\rho\, S$, suppliers will increase prices and service levels at the same time. Otherwise, the supplier will lower the price and service level at the same time.

3. Model Building

To build a multiagent simulation model using Anylogic 7.0 software in a two-level supply chain, we define 6 kinds of agents, namely, manufacturer agent, supplier agent, limited demand information-sharing agent, incomplete demand information-sharing agent, complete demand information-sharing agent, demand information-sharing agent, and evaluation rules.

3.1. Manufacturer Agent. A manufacturer agent simulates a producer. This model defines the following parameters: namely, supplier number (n), the number of selected suppliers (m), supplier performance adjustment period (T), each purchase total demand (Q), the supplier order distribution coefficient (k), provider of fixed cost fluctuation (λ), the maximum change amplitude of service provider (β),

the marginal cost of service level (P), supplier performance evaluation price weight (a), and the incentive coefficient of order ratio (U). The definition of variables in the model are as follows: the average performance of limited demand information sharing with selected suppliers (LV), the average performance is not only demand information sharing with selected suppliers (NCV), the average performance of total demand information sharing with selected suppliers (CV), total demand information and performance evaluation rule sharing with selected supplier performance (CWV), the average difference between NCV and LV (NCV_LV), the difference between CV and LV (CV_LV), the difference between CWV and LV (CWV_LV), the difference between CWV and NCV (CWV_NCV), and the difference between CWV and CV (CWV_CV).

3.2. Supplier Agent. Supplier agent simulates a supplier. The model defines the following parameters, namely, the supplier fixed cost (C_0). The following variables are defined: supplier service level (S), the total cost of the supplier (C), the supplier (Min P), the lowest price quotation from suppliers (P), the supply of small performance (V), supplier orders received by the supplier (Q), the proportion of orders (R), and the supplier of current earnings (E).

3.3. Information-Sharing Agent. This study considers limited demand information sharing, incomplete demand information sharing, complete demand information sharing, and demand information and evaluation rule sharing of 4 kinds of agents, simulates the decision-making behavior and transaction process of producers and suppliers in the different information-sharing models in 4 types of agents that include a producer agent and n supplier agents, and defines a price-service level adjustment and order allocation event. The incident occurred in the interval of the T cycle, followed by the completion of the supplier's price and service level adjustment, manufacturers' supplier selection, supplier selection, supplier selection order distribution average performance statistics, and other activities.

4. Simulation Result Analysis

With the constructed model, the average performances of selected suppliers with different information-sharing models are compared through simulation experiments, the incentive effect of fully verified demand information sharing and performance evaluation rules of sharing, and the sensitivity experiment of the relevant parameters, to study the influence of these parameters on the incentive effect. The simulation period of the model is ST = 500, and the initial parameters are shown in Table 1. The number of repetitions per experiment is greater than 50, and the confidence level is 99.9%.

4.1. Incentive Effects of Information and Evaluation Rules. Under the condition of the initial parameters of the model, the dynamic change in the average performance of selected supplier in the 4 information-sharing models with simulation time is obtained, as shown in Figure 1. Among them, the abscissa of Figure 1 is the simulation period, and the ordinate is the supplier evaluation performance obtained by the manufacturer.

Table 1: Initial parameters of the simulation model.

Parameter	N	m	Q	k	T	λ	β	ρ	α	μ
Value	10	4	100	0.5	5	20	20	0.05	0.4	1

From Figure 1, we find that that the average performance of suppliers is significantly improved and more stable than that of limited demand information sharing, incomplete demand information sharing, and full demand information sharing. Compared with the incomplete demand information sharing, the average performance of suppliers is higher under the condition of complete information sharing. On the basis of complete demand information sharing, if we share performance evaluation rules at the same time, we can further improve the performance of selected suppliers. This shows that the higher the demand information sharing is, the higher the incentive effect for suppliers is. Shared performance evaluation rules also have the function of motivating suppliers.

4.2. The Influence of the Quantity of the Selected Suppliers on the Incentive Effect of Information Sharing. It changes the number of selected suppliers (m) in the interval (2, n). The average performance difference of the selected suppliers between 4 different sharing modes is shown in Figure 2. Among them, the abscissa is the number of selected suppliers, and the ordinate is the average performance difference of the selected suppliers. With the increase in the number of selected suppliers, CWV_LV, NCV_LV, and CV_LV showed an increasing trend, and the benefit value of CWV_LV was the largest, while CWV, _NCV, and CWV_CV were relatively stable and fluctuated little. This shows that with the increase in the number of selected suppliers, the incentive effect increases with the degree of information sharing, but the incentive efficiency of supplier evaluation rules is basically unchanged. When the number of selected suppliers increases, the average proportion of each supplier's order will be reduced, and then, the power of suppliers to enhance performance will become stronger. Therefore, under the condition of a given number of alternative suppliers and the selection of all alternative suppliers, the complete demand information sharing has the biggest supplier performance results.

4.3. The Influence of the Number of Alternative Suppliers on the Incentive Effect of Information Sharing. It changes the number of alternate suppliers (n) in the interval (2, 15), and $m = n$. The average performance difference of the selected suppliers in 4 different sharing modes is shown in Figure 3. Among them, the abscissa is the number of alternate suppliers, and the ordinate is the average performance difference of selected suppliers. With the increase in the number of alternative suppliers, CWV_LV, NCV_LV, and CV_LV

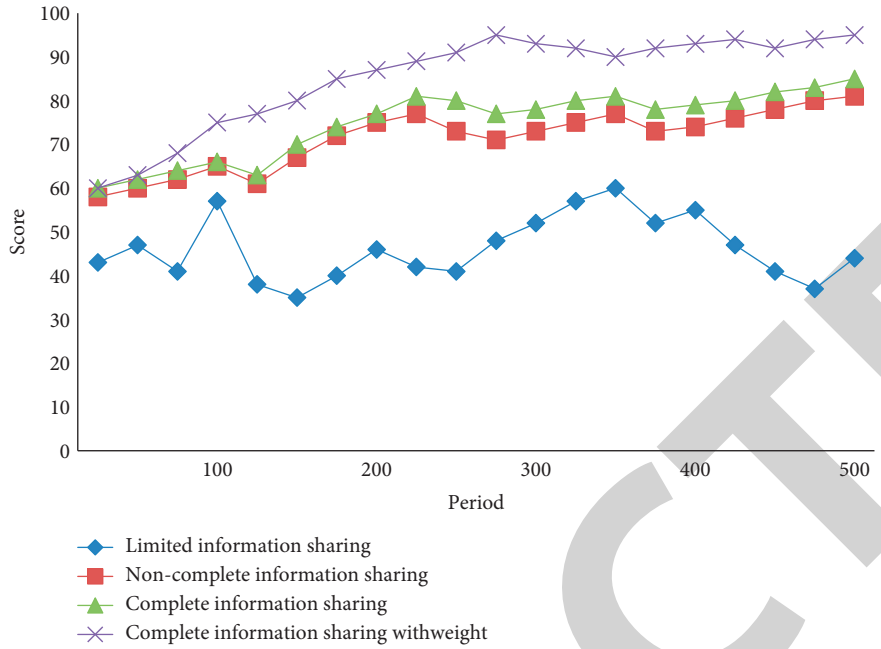

Figure 1: The average performance of selected suppliers under different information-sharing models.

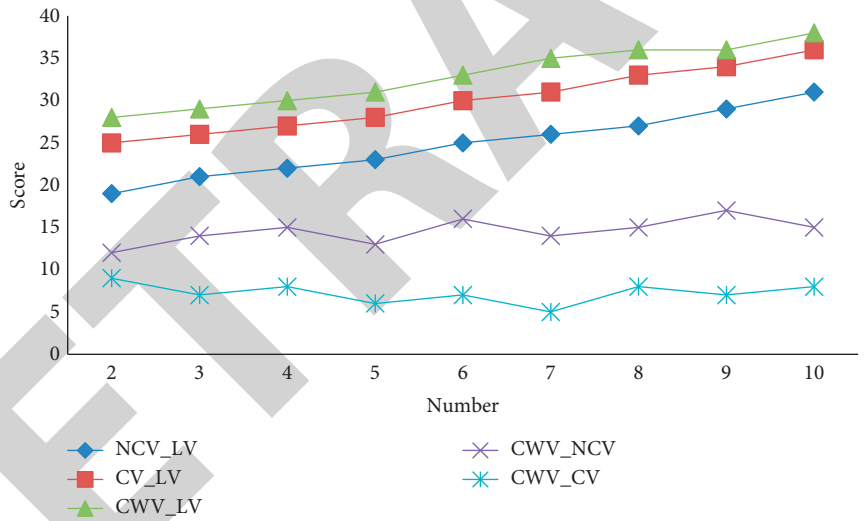

Figure 2: The influence of the number of selected suppliers on the incentive effect of information sharing.

showed the trend of increasing first and then decreasing. The maximum value appears near 3, while CWV_NCV and CWV_CV are relatively stable. This shows that when the supplier and the number of selected suppliers are in the same number, there is a demand for an information-sharing degree of the state of the incentive effect, there is an optimal number of candidate supplier, but the number of alternative suppliers for sharing performance evaluation rules of the incentive effect basically has no influence.

4.4. Order Allocation Coefficient of Incentive Effect of Information Sharing. It changes the order of the distribution coefficient (k) in the range of (0.1, 1.0). Four different average sharing performances of supplier selection in the pattern of difference are shown in Figure 4. The abscissa is the order distribution coefficient, and the vertical axis is the average difference between the performances of supplier selection. With the increase in the order allocation coefficient, CWV_LV, NCV_LV, and CV_LV show an increasing trend, while CWV_NCV and CWV_CV are relatively stable. This shows that the incentive effect of the order distribution coefficient and information sharing is positively correlated. With the increase in order sharing coefficient, the greater the degree of information sharing is, the stronger the incentive effect of the state is, but the incentive effect of supplier evaluation rules is almost unchanged. When $k = 1$, the order is distributed among the selected suppliers, and the full demand information sharing has the biggest supplier incentive effect.

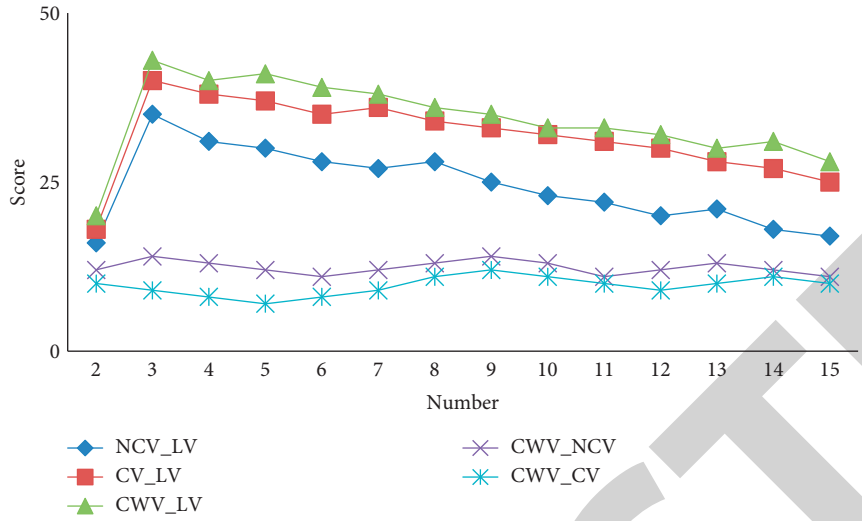

Figure 3: The influence of the number of alternative suppliers on the incentive effect of information sharing.

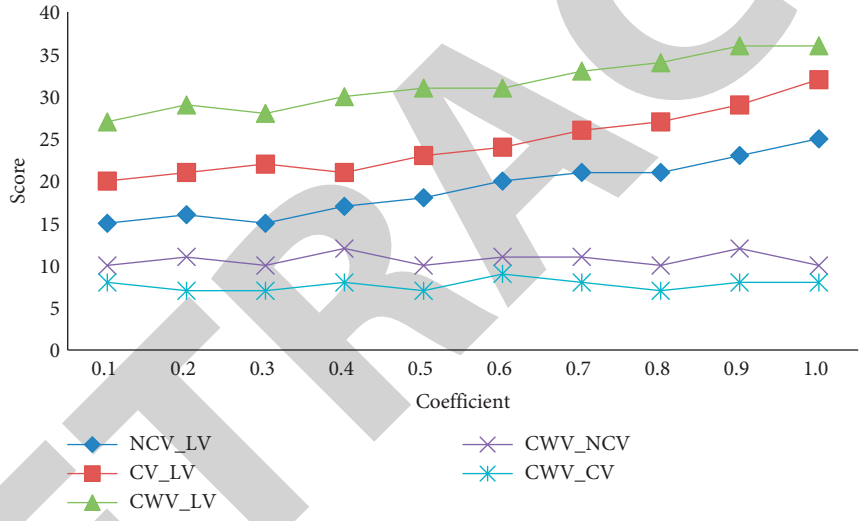

Figure 4: The influence of order allocation coefficient on the incentive effect of information sharing.

4.5. The Proportion of Incentive Coefficient of Orders and Incentive Effect of Information Sharing. It changes the incentive coefficient (μ) of order sharing in the interval (0.1, 1.0). Four different average sharing performances of supplier selection in the pattern of difference are shown in Figure 5. Among them, the abscissa is the incentive coefficient of order ratio, and the ordinate is the average performance difference of selected suppliers. With the increase in the proportion of incentive coefficient of order, CWV_LV, NCV_LV, and CV_LV show an increasing trend, while CWV_NCV and CWV_CV are relatively stable. This shows that the inventive effect of the proportion of incentive coefficient of orders and information sharing is positively related to the proportion of orders, the incentive coefficient increases, and the incentive effect of incomplete demand information sharing and information sharing needs to be completely strengthened, but the incentive effect of the supplier evaluation rules has no effect. We assume that all suppliers are of infinite capacity and the proportion of orders is the incentive coefficient of the same parameters, but in the actual operation, the capacity of all suppliers is not unlimited, and the proportion of incentive coefficient of orders reflects the willingness of suppliers to obtain higher-order intensity ratio but no orders with suppliers to meet the production capacity and influencing factors.

4.6. The Influence of Price Weight on Incentive Effect of Performance Evaluation Rule Sharing. It changes the weight of the price (α) in the price range (0.2, 0.9). Different price weights of the CWV_NVC and CWV_CV are shown in Figure 6. The abscissa is the price weight, and the ordinate is the supplier average performance difference. When $\alpha = 0.5$, CWV_NCV = 0, and CWV_CV = 0, it means that it is shared in the incomplete demand information sharing and total demand information, and sharing of supplier performance evaluation rules will not increase the incentive effect of suppliers, because the condition of supplier expected price

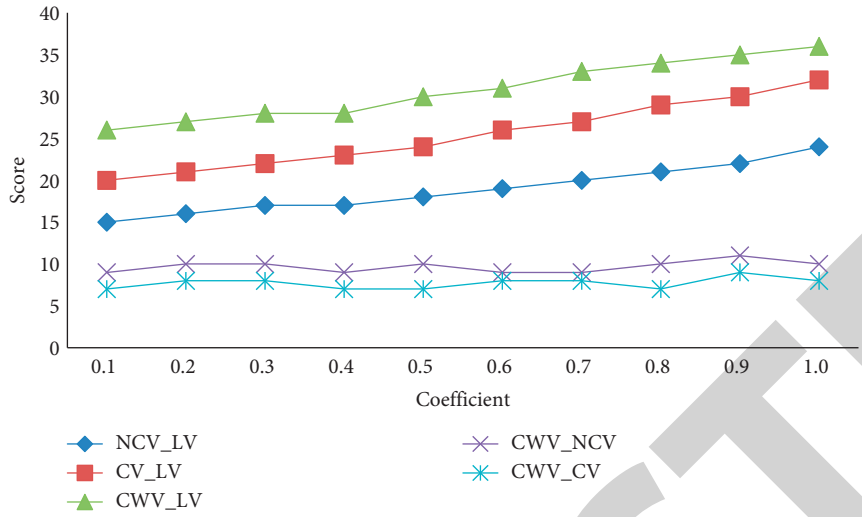

Figure 5: The influence of the incentive coefficient of order sharing on the incentive effect of information sharing.

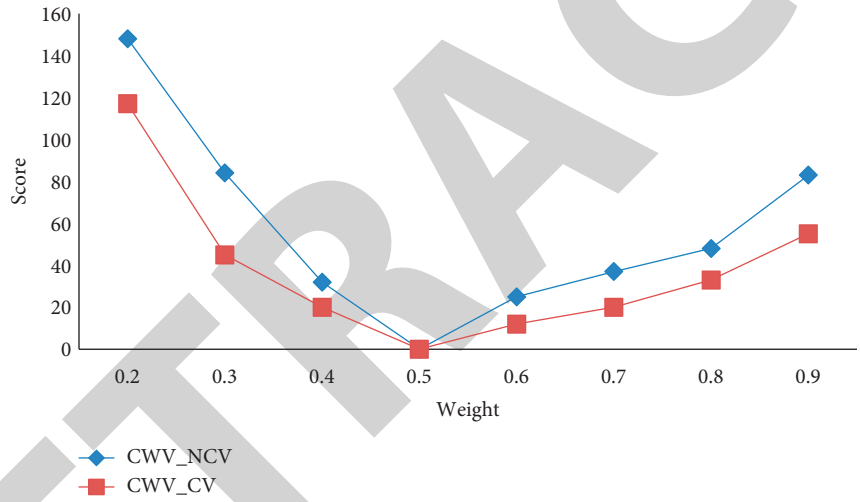

Figure 6: The influence of price weighting on the incentive effect of performance evaluation rule sharing.

weights is consistent with the actual weight of price. When $\alpha \neq 0.5$, CWV_NCV > CWV_CV > 0, and the actual weight of price deviated from the price weight of the suppliers expected, this state of sharing performance evaluation rules can complete demand information sharing on the basis of a further increase in the incentive effect of the supplier, and the incentive effect is enhanced with the increase in information sharing.

4.7. The Influence of Other Parameters on the Incentive Effect of Information Sharing. The supplier performance adjustment period (T), the rate of change in the cost of fixed suppliers (λ), the maximum level of service supplier changes (β), and the marginal cost of service level (P) for the sensitivity analysis of parameters found the incentive effect of these parameters on the incomplete demand information sharing, and information sharing and performance evaluation of total demand rules are not sensitive to share.

5. Conclusions

The multiagent simulation model to build a multisupply chain supplier analyzes the incomplete demand information sharing, information sharing, and the incentive effect of total demand evaluation rule sharing to the supplier, through sensitivity analysis to investigate the effect of the incentive effects of parameters on the supply chain. Research findings are as follows.

First, compared with the limited demand information sharing, the demand information-sharing degree is positively related to the supplier's incentive effect, and the greater the sharing degree is, the stronger the incentive effect is. On the basis of demand information sharing, the supplier performance evaluation rules are further shared. If the actual evaluation rules are inconsistent with the supplier's expected evaluation rules, the incentive effect will be further enhanced. With many enterprises in the supply chain system, the manufacturer can demand by increasing the degree of information sharing, especially the demand information

sharing helps supplier performance evaluation rules to get more revenue sharing.

Second, the quantity of the selected suppliers is positively related to the incentive effect of the demand information sharing, and the incentive effect of the demand information sharing increases more, while the alternative supplier quantity has the optimal value. In the multisupplier supply chain, in order to give full play to the incentive effect of full demand information sharing, manufacturers can appropriately optimize the number of alternative suppliers and select as many suppliers to purchase.

Third, the larger the order allocation coefficient is, the more average the order is between the alternative suppliers, and the greater the incentive effect of the complete demand information sharing. The greater the incentive coefficient of order proportion is, the greater the incentive effect of information sharing is. Under this condition, the incentive effect is positively related to the degree of demand information sharing.

Fourth, other parameters are supplier performance adjustment cycle, fixed cost change in incentive effect range, the maximum service level, and service level changes in the magnitude of the marginal cost for the demand of information sharing, and performance evaluation rules of sharing.

Lastly, the sensitivity analysis on the parameters of the supply chain, sharing incentive effect from the perspective of information only, but in actual work, supplier selection and order allocation will consider supplier product quality, delivery safety, payment terms, and some other factors. The supplier will also exist capacity constraints and multicustomer supply situations, the total demand of the manufacturers is not fixed and will be dynamically adjusted with the market and their own needs, and these problems will be further studied in-depth.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest with any financial organizations regarding the material reported in this manuscript.

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