Design of Supply Chain Resource Distribution Allocation Model Based on Deep Learning

Yuanyuan Guan(✉) and Li Yu

College of Finance and Economics, Chongqing Chemical Industry Vocational College, Chongqing 400000, China

Abstract. With the continuous deepening of economic upgrading and transformation, the scope of the supply chain of SMEs has gradually expanded. At present, in the process of supply chain resource allocation, the supply chain resource distribution allocation model is often used to study it. But the cost control ability of this model is poor. For this reason, this research designs a supply chain resource distribution allocation model based on deep learning. Select the indicators of the supply chain resource distribution allocation model to determine the principle of resource input, risk compensation, maximum utility and comprehensive optimization. Then construct the objective function of supply chain distribution configuration according to the cost and benefit requirements, and then use deep learning technology to obtain the optimal solution of the objective function scheme. By comparing the model in this paper with the traditional model, we can see that the model in this paper has better cost control ability.

Keywords: Deep learning · Resource allocation · Supply chain · Cost control

1 Introduction

With the continuous maturity of macro level supply chain collaboration research, such as collaborative mechanism and collaborative technology, how to guide and manage resource allocation among enterprises from the micro level (i.e. supply chain resource perspective) will become a breakthrough in the bottleneck of supply chain resource allocation [1, 2]. The key to achieve effective resource integration among supply chain members can create greater synergy effect. On the one hand, through the cooperation in material supply, production, distribution, distribution and other links, each member can form the complementary advantages of resources, give full play to their own advantages, enable partners to focus on their areas of expertise, avoid low efficiency and waste caused by decentralized utilization of resources, and realize the efficient utilization of resources of enterprises; On the other hand, by sharing information, both upstream suppliers and downstream distributors can timely and accurately adjust their own resource allocation according to the market information provided by their partners, so as to respond to the market demand and avoid the loss to enterprises caused by information asymmetry in the traditional market. Therefore, the realization of resource collaboration among supply

W. Fu et al. (Eds.): ICMTEL 2021, LNICST 387, pp. 321–332, 2021.
https://doi.org/10.1007/978-3-030-82562-1_30

chain enterprises is of great significance to promote the successful application of supply chain collaboration.

At present, the concept of supply chain competition has been widely circulated in the industry and academia. Scholars at home and abroad have conducted in-depth discussions on the supply chain competition and have achieved certain research results [3]. However, through in-depth analysis of existing research results, this article finds that there are still many issues that need to be further explored in the supply chain resource allocation. In addition, the competition between supply chains will further aggravate the uncertainty in the supply chain system, which makes the supply chain system management more difficult. On the one hand, the dynamics and complexity of the supply chain system often frustrate the efforts of enterprises, and the stable system behavior will reduce the cost of the system. On the other hand, as a complex game problem, supply chain competition often has multiple equilibrium solutions. Therefore, how to refine multiple equilibrium solutions and select stable equilibrium strategies for decision makers is also an important research problem. One of the effective ways to solve this problem is to design an effective distribution allocation model of supply chain resources.

In view of the above background, this study designs a supply chain resource distribution allocation model based on deep learning. By selecting the indicators of the supply chain resource distribution allocation model, the principles of resource input, risk compensation, maximum utility and comprehensive optimization are determined. Then, the objective function of supply chain distribution allocation is constructed according to the requirements of cost and benefit, and the deep learning technology is used The optimal solution of the objective function scheme is obtained to realize the optimal distribution allocation of supply chain resources.

2 Design of Resource Distribution Allocation Model in Supply Chain

In view of the limitations of the current research on supply chain resource allocation, this paper constructs a supply chain resource allocation model with resource allocation and asymmetric supply chain structure, and studies the stability of the game, cooperation strategies between supply chains and effective strategies to deal with interference events. The design process of supply chain resource distribution configuration model is shown in Fig. 1.

This paper studies the problem of income distribution among supply chain partners. First, it analyzes the composition of cooperative benefits in the supply chain and the characteristics and principles of the distribution of benefits; secondly, it focuses on the three main risks that affect the distribution of cooperative benefits in the supply chain: market risk, technology risk, and cooperation risk. A more in-depth analysis was carried out from four perspectives of risk control and distribution, which provided a basis for the realization of risk sharing and avoidance in the income distribution model. Then, it analyzes and compares the income distribution models from the three aspects of the selection of the optimal plan by these models, the comparison between the models and the application of the models.

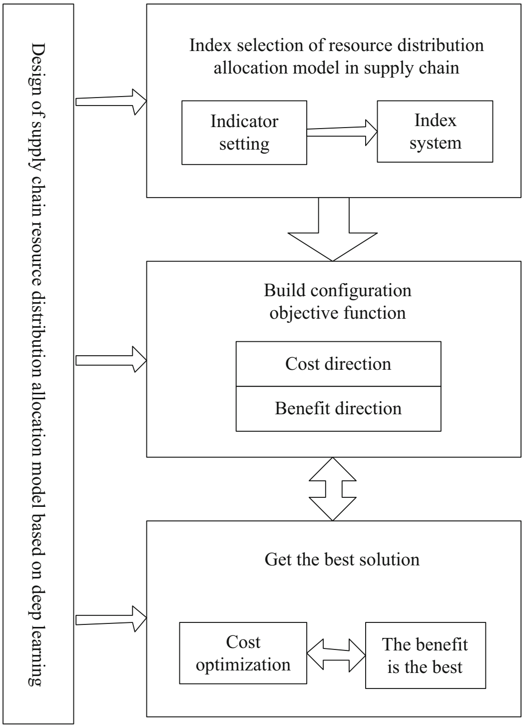


Fig. 1. Design process of supply chain resource distribution configuration model

2.1 Index Selection of Resource Distribution Allocation Model in Supply Chain

There are many principles for resource allocation in the supply chain, but they can be classified into four categories: the principle of resource input, the principle of risk compensation, the principle of maximum utility, and the principle of comprehensive optimization.

Resource allocation based on the principle of performance income: in order to maximize the contribution of enterprises, it is very important to pay and gain in direct proportion - distribution according to work. The input here is not only the input resources mentioned above, but also a lot of investment, such as the completion of multiple tasks in production, design, scientific research and training, and the unknown responsibilities in the supply chain (such as the responsible person of the core enterprise). These data are collectively referred to as contribution $E_i(i = 1, 2, ..., n)$.

$$\frac{v_1}{E_1} = \frac{v_2}{E_2} = ... = \frac{v_n}{E_n} \tag{1}$$

$$v_i = \frac{C_i I_i}{\sum_{i=1}^{n} C_i I_i} V \tag{2}$$

Income distribution based on the principle of risk compensation: First, the determination of risk. Risk refers to an event that is not expected to occur. Therefore, risk U is not only a function of the probability P of the occurrence of a risk event, but also a function of the loss w caused by the risk event, namely:

$$U = f(p, w) = pc \tag{3}$$

As the partner can bear the loss caused by the risk event with all the resources invested, $w = \beta I$,Where β is the risk loss rate. Then according to formula (4), it can be obtained that:

$$U = p\beta I \tag{4}$$

Let $\lambda = pa$, from the above formula, we can get:

$$U = \lambda I \tag{5}$$

Among them, λ is a parameter related to the probability of a risk event and the risk loss rate. It can be obtained by analyzing historical data. Under normal circumstances, the value of λ is between 0.1 and 0.8. Then, the income distribution plan is determined. The income b_i allocated to partner i should be proportional to the risk it bears. Then:

$$\frac{v_1}{U_1} = \frac{v_2}{U_2} = \ldots = \frac{v_n}{U_n} \tag{6}$$

From Formula (5) and (6), it is concluded that:

$$v_i = \frac{\lambda_i I_i}{\sum_{i=1}^{n} \lambda_i I_i} V \tag{7}$$

Income distribution based on the principle of resource input: the income V_i allocated by partner i should be in direct proportion to its input resource I_i. If the total revenue of the supply chain is V, then:

$$\frac{v_1}{I_1} = \frac{v_2}{I_2} = \ldots = \frac{v_n}{I_n} \tag{8}$$

However, the role played by each resource in the supply chain is different, so we also have to introduce cost value weight L_i for modification:

$$\frac{v_1}{L_1 I_1} = \frac{v_2}{L_2 I_2} = \ldots = \frac{v_n}{L_n I_n} \tag{9}$$

Through the above analysis, it can be concluded that:

$$v_i = \frac{L_i I_i}{\sum_{i=1}^{n} L_i I_i} V \tag{10}$$

Income distribution based on the principle of comprehensive optimization. The principle of comprehensive optimization can be said to be a combination of the above three principles. The formulation of the income distribution plan is to scientifically make the partners' income reflect their investment and risks, while maximizing the overall utility and ensuring the stability of the entire supply chain cooperation [4, 5]. Then, based on the principle of comprehensive optimization, the proportions of benefits distributed according to the three single factors are Q_i, T_i, and K_i. When considering the impact of the three factors comprehensively, because the three factors of performance level, risk level and invested resources have different degrees of impact on income distribution, the group center of gravity model is used to determine the total income distribution of the supply chain cooperation. The weights of the three are respectively set as R_q, R_t, R_k, which are obtained through a series of comprehensive evaluation methods, such as expert method, analytic hierarchy process, network analysis method, fuzzy comprehensive evaluation method, gray correlation method, TOPSIS [6], etc.

$$V_i = (R_q Q_i + R_t T_i + R_k K_i) \tag{11}$$

Through the above formula to determine the supply chain resource distribution allocation model indicators, and build the basis of its model.

2.2 Constructing the Objective Function of Deep Learning

On the basis of selecting the indicators of the distribution allocation model of supply chain resources, the deep learning objective function is constructed to lay the foundation for obtaining the optimal distribution model.

Suppose that the whole supply chain is divided into i link. In stage $k - 1$, after a sub supply chain is completed, there are j resources released, waiting for the reallocation of application environment. In order to evaluate the advantages and disadvantages of each resource allocation scheme, the deep learning criterion is to maximize the organizational interests of the whole supply chain. Therefore, the benefit function E_{ij} of the model represents the benefit of allocating j resources to the i sub supply chain; the subject of the benefit function is the measurable organizational value R_i of the project, and the cost P_{ij} of resource allocation is used as the measurement coefficient. In order to simplify the problem and facilitate interpretation, the benefit function $(1 - P_{ij})$ multiplied by R_i is expressed in the formula.

$$R_i = E_{ij} \times (1 - p_{ij}) \tag{12}$$

Assuming that the effective investment ability of worker j in sub-supply chain position i is Y_{ij}, and H is the number of q supply cycles that can be completed when the degree of experience is 1, then the experience distribution value of resource j in supply chain i For $R_i \times E_{ij} \times p_{ij}$, the distribution cost can be expressed as:

$$R_i \times E_{ij} \times p_{ij} \times k = w \tag{13}$$

Where k is the adjustment coefficient, g_{ij} is 0–1 variable, which represents the matching between i supply chain and j resource; $g_{ij} = 0$ is that j resource is not allocated to i

supply chain link; $g_{ij} = 1$ is to allocate j resource to i link. Multiply the benefit function S_{ij} of each allocation scheme by the sum of state variables g_{ij}, the objective function of deep learning can be obtained as follows:

$$\max = \sum_{i} \sum_{j} g_{ij} \times S_{ij} \tag{14}$$

The above formula is the objective function formula in this research process, and the corresponding distribution model can be obtained by using this formula.

2.3 Obtain the Optimal Distribution Model

According to the set objective function, more configuration schemes can be obtained. In this design, in order to obtain the optimal result, the selection principle of the optimal scheme is set as follows:

(1) The overall planning level. The standard requires that the order of distribution of sub-supply chains should be consistent with the overall goals of the supply chain, while considering the internal logical relationship of each supply chain [7], mainly including three aspects: the priority of the supply chain should follow the order of supply chain construction; the sub-supply chain The priority should support the priority proposed by the superior supply chain; the priority of the sub-supply chain should conform to the supply chain rules and regulations.

(2) Positive benefit level. The criteria require that projects be prioritized according to the evaluation of supply chain benefits. It mainly includes: the potential benefits of the supply chain should be higher than the cost; the availability of the management information accumulated by the supply chain to the project; and the benefits brought by the supply chain to the people's livelihood and economic operation.

(3) Negative benefit level. The standard requires consideration of the risk of supply chain implementation. In this level, we mainly consider the following factors: the operability of the core technology of the supply chain, the difficulty of the implementation of the supply chain, and the on-time completion rate of the supply chain. According to the above configuration principle, the selection of configuration scheme is set as a multi-objective optimization problem, and its processing flow is shown in Fig. 2.

The project priority is set as multi-attribute problem D, the alternative scheme set is $M = \{m_1, m_2, ..., m_i\}$, $N_{i1} = \{n_{i1}, n_{i2}, ..., n_{ii}\}$ is the attribute set of scheme i, where n_{ii} is the G attribute value of the i scheme and $n_{ij} = n_{ii} \times m_i$ is the i attribute value. The decision matrix of the problem is represented by matrix $V_{m\times n}(m_i)$ [8–10]. The optimal model can be expressed as follows:

$$n'_{ij} = \frac{n_{ii} - n_j^{min}}{n_i^{\max} - n_j^{min}} \tag{15}$$

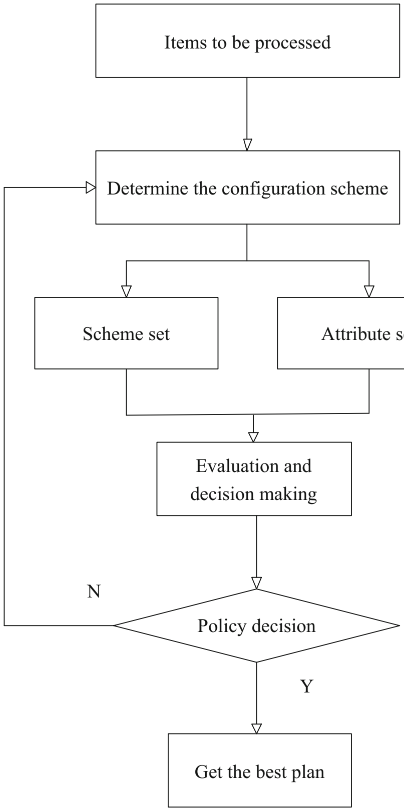


Fig. 2. Scheme selection process

When paying attention to cost in the distribution process, the optimal model can be expressed as:

$$n'_{ij} = \frac{n_j^{\max} - n_{ii}}{n_i^{\max} - n_j^{min}} \tag{16}$$

Using the above formula, determine the best resource distribution allocation scheme. So far, we have completed the design of the distribution allocation model of supply chain resources based on deep learning.

3 Experimental Demonstration Analysis

3.1 Experimental Environment Setting

In order to verify the practical application effect of the supply chain resource distribution allocation model based on deep learning (the model in this paper) designed above, it is compared with the methods currently in use. The experimental platform parameters are shown in Table 1.

Table 1. Experimental platform parameters

Test environment	Test environment composition	Specific parameters
Experimental server hardware	CPU	Intel
	RAM	8G
	Hard disk	96G
Experimental server software	Operating system	CentOS 6.5 (Linux)
	Development language	Python 2.7
	Web frame	Flask 0.12
	Python analysis environment	Gunicorn + Gevent
	Web performance optimization	Nginx
Database server hardware	RAM	8G
	Hard disk	96G
	CPU	Intel
Database server software	Database	SQL
	Operating system	CentOS 6.5 (Linux)

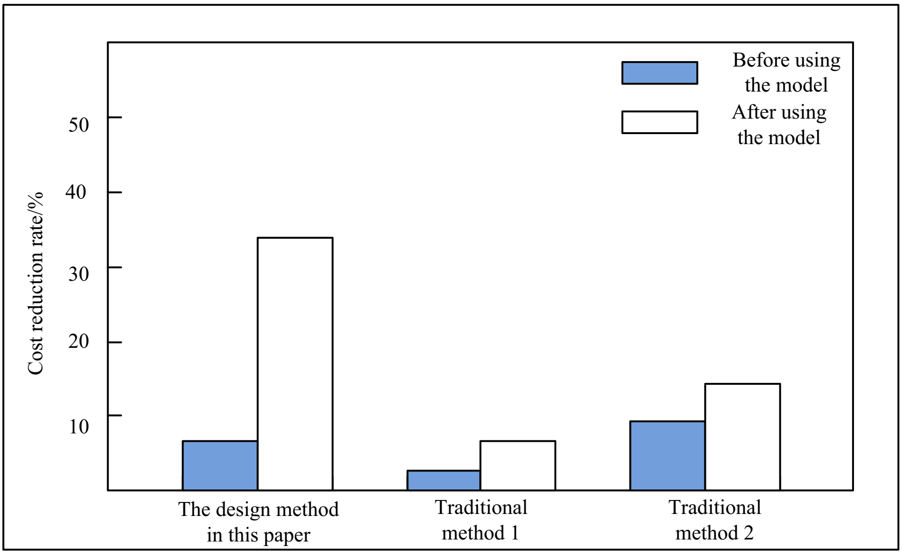
The above parameters are used to complete the performance comparison between the proposed method and the traditional method. In the process of the experiment, the comparison object is set as two parts: the decline degree of distribution cost and the response time of distribution configuration scheme selection. Through the combination of the two parts, the comprehensive analysis of the use effect of this method is realized. In order to improve the reliability of the experimental results, the experimental environment is set to focus on cost and benefit.

3.2 Preparation of Experimental Data

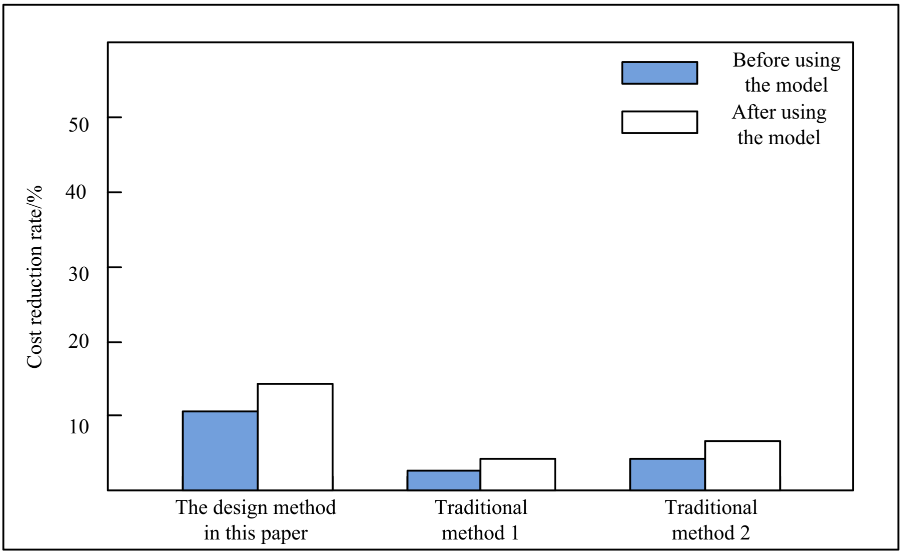
In this study, a resource distribution allocation model is proposed, and the specific calculations of some empirical examples are supplemented for the theory, which is used to practice the theory and methods. Choose a manufacturing supply chain as a sample of model application. A YD Manufacturing Co., Ltd. is a private enterprise, and it has been showing a good development trend since its establishment. Especially since the company implemented the shareholding system reform, informatization transformation and high-level talent introduction strategy in 2001, the company has transitioned from a family system to a modern management model, and the company has achieved rapid development. Take this enterprise as the experimental object to study the distribution configuration of its supply chain.

3.3 Analysis of Experimental Results

The experimental results of cost reduction effect are shown in Fig. 3.



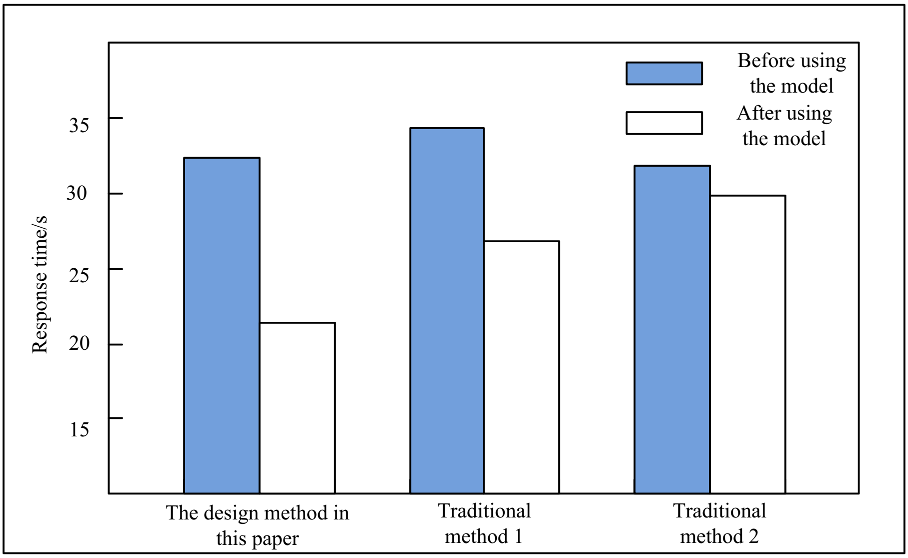
(a) Pay attention to the results of cost experiment



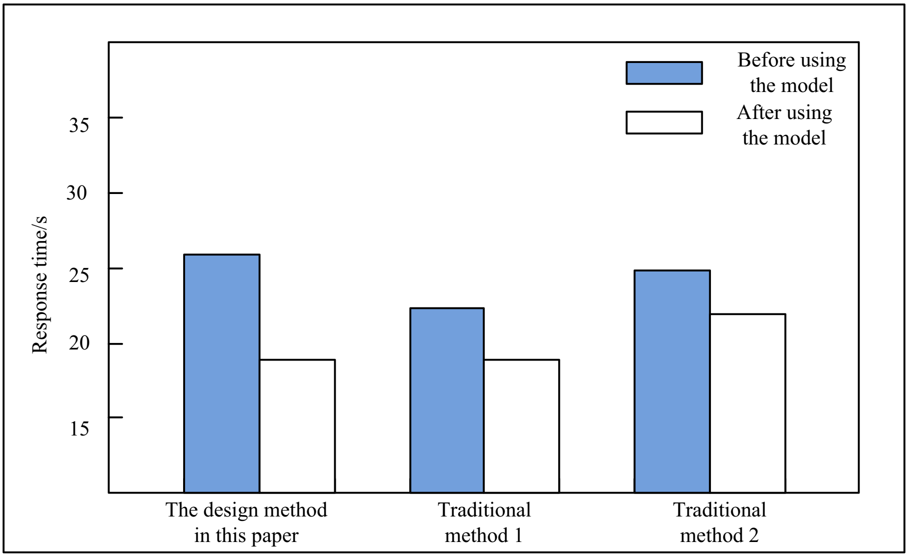
(b) Pay attention to the results of benefit experiment

Fig. 3. Experimental results of cost reduction effects

According to the analysis of Fig. 3, the cost control ability of traditional model 1 and traditional model 2 is low, and the effect of cost reduction is not good. In the process of massive data processing, this situation will have a negative impact on the supply chain



(a) Pay attention to the results of cost experiment



(b) Focus on the results of the benefit experiment

Fig. 4. Response time experiment results

and reduce customer satisfaction. Compared with the two traditional models, the cost control ability of this model is better and will not affect the subsequent calculation.

Under the premise of using the actual problems, the design model can be used to process a variety of supply chains and improve the accuracy of data.

The experimental results of response time are shown in Fig. 4.

It can be seen from Fig. 4 that the use effect of this model is significantly better than that of the traditional model. In the two different environments, the operating state of the model in this paper is obviously relatively stable, and there is no significant fluctuation in the background processing time caused by the change of focus. The traditional model used in this part has the problem of large fluctuation energy. In actual use, fluctuations in response time will have a serious impact on the choice of distribution configuration options. Therefore, it can be determined that the performance of the model in this part of the experiment is better than the traditional model.

4 Conclusion

Based on the self-organization theory and enterprise resource theory, using the methods of synergetics, system dynamics and economic mathematics, this paper focuses on the conceptual framework, mechanism and model of distribution allocation of supply chain resources. According to the requirements of cost and benefit, it constructs the objective function of distribution allocation of supply chain resources, and then uses the deep learning Learning technology obtains the optimal solution of the objective function scheme, so as to realize the optimal distribution allocation of supply chain resources. Through the research on the complex adaptability, dissipative structure, structural model, operation mechanism, evolution process and measurement method of supply chain model, the main conclusions and innovations are as follows: supply chain resource allocation needs reasonable research on risk. In the process of using supply chain model in the future, this part of the content will be mainly studied in order to improve the use effect of the model.

References

1. Jizi, L., Nian, Z., Chunling, L.: Optimization of order-driven production decision making in crowdsourcing supply chain with omnichannel design. Comput. Integr. Manuf. Syst. **25**(05), 1248–1258 (2019)
2. Xuelong, Z., Doudou, W.: An Optimal Design Model of Multi-stage Supply Chain Network With Interval Grey Features. Stat. Dec. **36**(01), 167–171 (2020)
3. Pin, Z., He, X., Fen, L.: The optimal ordering decision under the bargaining power of supply chain partners. J. Ind. Eng. Eng. Manage. **33**(04), 130–135 (2019)
4. Pei, L., Gengjun, G.: P-DEA and Shapley value models based on green supply chain profit distribution. J. Railway Sci. Eng. **15**(09), 2448–2454 (2018)
5. Jiannan, S., Xiaofeng, S.: Operational decision and optimal choice of payment to a supply chain based on wholesale price incentive. Chin. J. Manage. **15**(01), 103–110 (2018)
6. Xiaomei, L., Yangang, F., Jiaxin, S.: Coordination model of telecom supply chain based on network externality. J. Qiqihar Univ. (Nat. Sci. Edn.) **36**(01), 45–50+67 (2020)
7. Nannan, Y., Bogen, D.: Bi-level programming model of port supply chain coordination under revenue sharing contract. J. Shanghai Marit. Univ. **40**(03), 80–86 (2019)

8. Shuai, L., Zhaojun, L., Yudong, Z., et al.: Introduction of key problems in long-distance learning and training. Mob. Netw. Appl. **24**(1), 1–4 (2019)
9. Shuai, L., Mengye, L., Hanshuang, L., et al.: Prediction of gene expression patterns with generalized linear regression model. Front. Genet. (10), 120 (2019)
10. Weina, F., Shuai, L., Gautam, S.: Optimization of big data scheduling in social networks. Entropy **21**(9), 902–918 (2019)