Research on the Enterprise Raw Material Ordering and Transshipment Problems based on the Dual-objective Planning Model: Taking a Building Materials Enterprise as an Example

Linfei Zhang[1][a], Yuan Gao[2][b] and Mingxuan Zhou[1][c]
[1]*School of Economics, Henan University, Kaifeng, China*
[2]*School of Eurasia International, Henan University, Kaifeng, China*

Keywords: Enterprise Cost Reduction Plan; Comprehensive Evaluation System Construction; Dual-Objective Planning Model; Price Correction Factor.

Abstract: Based on hierarchical clustering, technique for order preference by similarity to an ideal solution and dual-objective planning models, we give manufacturers a raw material ordering and transshipment solution involving multiple supply chain participants, including supplier evaluation, cost control and loss control. Compared with the traditional increase of constraint conditions to optimize the model, we introduced the price correction factor containing multiple components from the perspective of system analysis to simulate the dynamic characteristics of the supply chain system. By constructing the "relative ordering price", the form of the objective function is affected in real time, thereby increasing the understanding space, so that the objective function in the process of solving can be more close to the global optimal solution in a limited number of iterations .The empirical results pointed out that after the introduction of the price correction factor, the ordering plan formulated has obvious selectivity to the production materials, which significantly improves the production enterprises' anti-risk ability and capacity improvement potential, thereby promoting the transformation and upgrading of the enterprises and also improving its operational management capabilities and supply chain management capabilities.

1 INTRODUCTION

1.1 Research Background

In recent years, as the global value chain layout has been further adjusted due to the impact of the covid-19, the degree of uncertainty in the economic market has deepened and the government's macro-control role in the "horizontal integrated" supply chain management model has become extremely important.

From China's 2017 "Guiding Opinions of the General Office of the State Council on Actively Promoting Supply Chain Innovation and Application", which promoting innovation of industrial organization and government governance methods, to promote management modernization and upgrading of industrial structure in the "14th Five-Year Plan and 2035 Vision Goals Outline" ,from the second plenary session to the sixth plenary session of the 19th Central Committee, in the spirit of dealing with excess capacity and promoting the optimization and upgrading of the supply chain and industry chain, enterprises are not only the main body pursuing individual economic interests, but also need to perform corresponding social responsibility. Enterprises need the assistance of government governance to maximize their profits, which in turn promotes social and economic development. The production and operation transactions between the upstream and downstream of the supply chain are continuously optimized and upgraded under the guidance of policies.

Under the influence of the pandemic, China's building materials industry has been greatly affected but still maintains a steady upward development

[a] https://orcid.org/0000-0003-3746-408X
[b] https://orcid.org/0000-0003-4379-1060
[c] https://orcid.org/0000-0002-6071-4334

Zhang, L., Gao, Y. and Zhou, M.
Research on the Enterprise Raw Material Ordering and Transshipment Problems based on the Dual-objective Planning Model Taking a Building Materials Enterprise as an Example.
DOI: 10.5220/0011150200003437
In *Proceedings of the 1st International Conference on Public Management and Big Data Analysis (PMBDA 2021)*, pages 22-31
ISBN: 978-989-758-589-0

trend. According to the "Building Materials Industry and Economic Operation in 2020", China's building materials industry has grown by 2.8% year-on-year with generally stable prices and rising profits. We take a small and medium-sized building materials enterprise as our research object and analyze its order volume, supply volume and transshipment data of various participants in the past ten years to formulated the optimal raw material ordering plan and transshipment plan. Based on this, production enterprises can adjust their development strategy and accelerate the process of transforming and upgrading.

1.2 Research Purpose and Significance

China's "14th Five-Year Plan" outline a procedure to transform and upgrade traditional industries, especially promoting the layout optimization and structural adjustment of the raw material industries such as petrochemicals, steel, nonferrous metals and building materials to promote green building materials. The development of the building materials industry will shift from "incremental expansion" to "improving quality and efficiency". We take a certain building materials enterprise as the research object and introduce the price correction factor to simulate the dynamic characteristics of the supply chain. Our primary method is to build a dual-objective planning model to analyze the enterprise's optimal ordering plan and transshipment plan for raw materials from the perspective of supply chain management.

China's supply chain industry has developed rapidly in recent years. Existing researches often focus on a single manufacturing enterprise as research object and generally do not consider the dynamic characteristics of the supply chain system in the modeling process. With the idea of system analysis, we creatively introduce the price correction factor, which can simulate the dynamic characteristics of the supply chain system to a certain extent. Our planning model under this correction can not only reduce the cost of the production enterprise, but also significantly improve the enterprise's ability to resist risks and increase the potential for productivity. Further we take the price correction factor as the coefficient of the decision variable to affect the form of the objective function. As a result, in the process of optimizing the solution result of the model, there are only a few and concise constraints, which simplifies the complex processing methods of the traditional model.

While promoting enterprises to reduce costs, improve their ability to resist risks and increase production potential, our results also have certain reference significance for the transformation and upgrading of China's material industry, operation management and supply chain management in the future development and contribute to social and economic construction and development.

1.3 Existing Research

With regard to the research on supply chain ordering and transshipment, relevant conclusions have been discussed since the 1970s. A.A. (Gaballa 1974) first used the mathematical programming model to study the problem of supplier selection. K. and S. (Skouri and Papachristos 2002) proposed damage cost, holding cost and so on. C.O. (Brien 2006) adopted the ownership goal method to evolve the single-objective cost planning model into a multi-objective cost planning model, marking the formal formation of the supply chain logistics integration mode. Michael (Stuart 2010) starts from the three aspects of order acquisition, transportation, and inventory to minimize the sum of order processing costs, transportation costs, and inventory costs. Some scholars (Liu et al. 2017) used AHP and TOPSIS evaluation models to reconstruct a scientific and effective supplier evaluation system. Some also (Zhang et al. 2010) mentioned the importance of realizing the mutual sharing of information between enterprises at various nodes during cost control based on the perspective of supply chain . Other schoalrs (Liu 2019) think that enterprises should not only regard the supply chain as a product supply ,transshipment and storage, but should recognize the relationship between supply chain changes and product development and marketing.

In summary, we can find that there are many research results on supply chain research methods and supplier selection at home and abroad, but most of them stay on the level of cost control and do not consider the dynamic characteristics of the supply chain system, thus the solution results are limited to the improvement of supply chain stability and capacity potential. Therefore, with the rapid development of information economy and support of government policies, it is imperative to formulate effective methods on the optimal ordering plan and transshipment plan from the perspective of system analysis.

1.4 Research Content and Methods

For production enterprises, ensuring their normal production, operation and maintenance is the most basic and important thing. Some enterprises may have seasonal changes in supply, they will get a very low score in the comprehensive evaluation, or even be directly excluded. This is obviously unreasonable. Therefore, prior to the comprehensive evaluation, first perform hierarchical clustering based on the supply capacity of the manufacturer and rank the suppliers with reference to the clustering results and actual conditions. Next, we carry out the “protection” operation for the higher-rated suppliers.

Based on that, we conduct a comprehensive evaluation of suppliers based on TOPSIS and quantitatively analyze their value to the production enterprise through the index system of “supply capacity, supply stability, supply satisfaction rate, average response time”. In the formulation of ordering and transshipment plans for production enterprises, we take the most economical ordering and the smallest transshipment loss as the objective function, set the constraint conditions with the lowest storage threshold and other actual conditions and creatively introduce the “price correction factor”.

The price correction factor comprehensively considers the characteristics of the production materials, the comprehensive ratings of suppliers and the supply and demand status of the production materials, which includes “linear components”, “composite components” and “time-varying components”, which are combined based on the coefficient of variation method. Similar to the adjustment of prices by macro market conditions, the price correction factor also simulates the characteristics of the supply chain system to a certain extent. “Relative order price” also has dynamic characteristics.

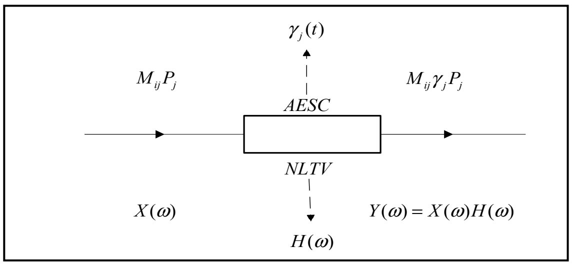

Figure 1: Analogy diagram of price correction factors.

Analog communication system may be easier to understand the role of price correction factor (see figure 1): if the order price before correction is analogous to the input signal, then the price correction factor can be compared to a system function of this nonlinear time-varying system, and the price correction factor can be used to represent an approximately equivalent supply chain (AESC) system, and the revised “relative price” also has the characteristics of this system.

We conducted an empirical analysis based on the ordering and transshipment data of a building materials enterprise with various suppliers and the transshipment data of various forwarders in the past ten years (Data from the second author’s family business which is authorized to use).The analysis results pointed out that after the introduction of price correction ,the subsequent model solution results shows a clear preference towards the raw materials, and even some ordering nodes completely abandon certain types of raw materials. In fact, C raw material is a kind of high pollution and low pollution that have been gradually eliminated in recent years. But in the absence of price correction factors, this tendency is not reflected in the solution results of the model. From the perspective of the storage change curve before and after the price correction factor is introduced, the solution result before the introduction of this factor makes the production enterprise often in the two extreme situations of raw material backlog and raw material shortage. And according to the quantitative analysis of the three parameters "average replenishment response cycle", "storage vigilance level" and "peak storage volume", the solution result after introducing the price correction factor enables the production enterprise to have stronger capacity improvement potential and anti-risk ability.

2 SYMBOL DESCRIPTION

Table 1: Symbol Description.

Symbol	Description	Unit
S_{it}	Supply volume of the i-th supplier in week t	m^3
O_{it}	Order amount of the i-th supplier in week t	m^3
M_j	J-th raw material	/
P_j	J-th raw material price	RMB
η_j	The number of j-th raw materials consumed per cubic meter of product	m^3
T_m	M-th forwarder	/
σ_m	Loss rate of the m-th forwarder	/
$\gamma_j(t)$	The price correction factor for the j-th raw material in week t	/

3 ASSUMPTIONS

- The enterprise has continuous production for 48 weeks a year.It has a weekly production capacity of H million cubic meters and raw material inventory should meet the production capacity requirements for the next two weeks;
- The production enterprise has 2H million storage capacity in initial week ;
- There are n suppliers, and one supplier only produces one kind of raw material;
- The supplier only corresponds to the order quantity sent once each time, and the supplier responds to the order each time;
- All transshipment enterprises' maximum weekly transshipment capacity is 60 million cubic meters;
- The weekly supply of a supplier is transshipped by a forwarder.
- There are s kinds of raw materials, the price of each raw material remains constant at every week.

4 MODEL

4.1 Supplier Evaluation

4.1.1 Supplier Rating System based on Hierarchical Clustering Algorithm

Based on the total supply volume of each supplier in the past Y years, we use a systematic clustering method based on supply capacity and the elbow rule to comprehensively classify suppliers with actual situation considered. Specific classification methods are as follows.

First priority supplier: They can stably provide a large amount of production materials in actual situation and often has a strategic cooperative relationship with the manufacturer.

Second-priority suppliers: Their supply characteristics are also stable, medium-range or have periodic large-scale supply.

The third priority supplier: They are used as an alternative to the production enterprise

Fourth priority supplier: They are generally excluded and does not participate in the comprehensive evaluation.

4.1.2 Supplier Selection Evaluation Index System

In order to select a certain number of qualified suppliers from n suppliers, we establish an index system to evaluate the supplier's supply characteristics. The evaluation system is as follows.

Table 2: Evaluation System of Suppliers.

Symbol	Description	Unit
f_i^1	The supply capacity of the i-th supplier	m^3
f_i^2	Supply stability of the i-th supplier	/
f_i^3	Supply satisfaction rate of the i-th supplier	/
f_i^4	The average response time of the i-th supplier	week

Here are the definitions of four evaluation indicators.

a)Supply capacity

$$f_i^1 = \sum_t S_{it} \tag{1}$$

b)Supply stability

$$f_i^2 = \sigma_i \tag{2}$$

This indicator is an extremely small type indicator, i.e. the smaller the value, the more stable of the supply.

c)Supply satisfaction

$$f_i^3 = \frac{\sum_t O_{it}}{\sum_t S_{it}} \times 100\% \tag{3}$$

Define this indicator to measure the matching degree of supply and demand.

d)Average response time

Considering that there may be many unordered or unshipped situations in the actual ordering and shipping data, here is the definition of the annual effective order quantity and the annual effective shipment quantity.

The effective ordering quantity of the manufacturing enterprise to the i-th supplier at the n-th effective ordering node in a certain year can be defined as

$$O_{iE}(n_{io}) = O_i(t-kT), k=1,2,3...48 \tag{4}$$

Among them, the effective ordering node of the i-th supplier in the k-th sampling $n_{io}(k)$ can be defined as

$$n_{io}(k)=\begin{cases} n_{io}+1, O_i(t-kT)\neq 0 \\ 0, O_i(t-kT)=0 \end{cases}, \quad (5)$$

$$n_{io}=1,2,3...\max(n_{io})$$

Similarly, the effective supply volume of the n-th effective supplying node of the i-th supplier in a certain year can be defined as

$$S_{iE}(n_{is})=S_i(t-kT), k=1,2,3...48 \quad (6)$$

Among them, the effective supplying node of the i-th supplier in the k-th sampling can be defined as

$$n_{is}(k)=\begin{cases} n_{is}+1, S_i(t-kT)\neq 0 \\ 0, S_i(t-kT)=0 \end{cases}, \quad (7)$$

$$n_{is}=1,2,3......\max(n_{is})$$

According to the supplier only corresponds to the order quantity sent once each time, and the supplier responds to the order each time, there is

$$n_{io}=n_{is}=n_i \quad (8)$$

According to the above definition, the average response time of the i-th enterprise in the past Y years can be defined as

$$f_i^4=\frac{\dfrac{\sum_{y=1}^{Y}\sum_{n_i=1}^{\max(n_i)}(k_{yisE}(n_i)-k_{yioE}(n_i))}{\max(n_i)}}{Y} \quad (9)$$

The effective ordering sampling sequence of the i-th supplier k_{ioE} can be expressed by the inverse function of the effective shipping node $n_{io}(k)$ as

$$k_{ioE}(n_i)=n_{io}^{-1}(k), n_{io}(k)\neq 0 \quad (10)$$

Similarly, the effective supplying sampling sequence of the i-th supplier can be expressed as

$$k_{isE}(n_i)=n_{is}^{-1}(k), n_{is}(k)\neq 0 \quad (11)$$

Obviously, this indicator should be regarded as an extremely small type indicator, that is, the smaller its value, the quicker the supplier can supply the manufacturer.

4.1.3 Quantitative Evaluation of Suppliers based on TOPSIS

Use TOPSIS to normalize and standardize the four indicators of all suppliers, and calculate the scores of n suppliers and sort the suppliers accordingly.

4.2 The Establishment of Dual-objective Planning Model

In order to formulate the most economical ordering plan and transshipment plan with the least loss rate in the next t weeks, the enterprise needs to evaluate and select four parts of raw materials, suppliers, ordering quantities, and forwarders so as to construct two optimal solutions.

4.2.1 The Introduction of Price Correction Factors

We comprehensively consider multiple participants in the supply chain and introduce the price correction factors, which will affect the ordering and transshipment strategies of manufacturers by modifying the unit price of raw materials.

Therefore, the price correction factor $\gamma_j(t)$ for the $j-th$ raw material in the $t-th$ week can be decomposed into linear components γ_{lj}, complex component γ_{cj} and time-varying component $\gamma_{vj}(t)$.

Linear components can be defined as

$$\gamma_{lj}=\frac{\eta_j-\eta_{\min}}{\eta_{\max}-\eta_{\min}} \quad (12)$$

η_j is the input-output ratio of the j-th raw material.

Composite components can be defined as

$$\gamma_{cj}=\frac{Mark_j-Mark_{\min}}{Mark_{\max}-Mark_{\min}} \quad (13)$$

$Mark_j$ is the average score of the supplier that produces the j-th raw material.

Time-varying components can be defined as

$$\gamma_{vj}(t)=\frac{\dfrac{1}{W_j(t-1)}-\min\left(\dfrac{1}{W(t-1)}\right)}{\max\left(\dfrac{1}{W(t-1)}\right)-\min\left(\dfrac{1}{W(t-1)}\right)} \quad (14)$$

$W_j(t)$ is the storage volume of the j-th raw material in the t-th week.

Since some suppliers may have seasonal and periodic supply characteristics, considering that the entropy method is susceptible to the impact of the jump value, and the coefficient of variation can well explain the value of the jump value. In this case, the coefficient of variation method is used to synthesize the above three components.

Let $\alpha_i = [V_1, V_2, V_3]^T$, V_1, V_2, V_3 are coefficients of variation of the above three components.

It should be noted that α_3 is also a function of time, so $\gamma_{vj}(t)$ is called a time-varying component.

In summary, the price correction factor $\gamma_j(t)$ can be expressed as

$$\gamma_j(t) = \alpha_1 \gamma_{lj} + \alpha_2 \gamma_{cj} + \alpha_3 \gamma_{vj}(t) \tag{15}$$

In addition, different from the impact of macro objectively factors such as the market supply and demand relationship on the actual order price of raw materials, the "correction" here is partial, which is a relative correction to ensure the maximum benefit of the production enterprise. The revised order prices are references only for formulating the ordering plan and the transshipment plan.

4.2.2 Formulation of the Most Economical Ordering Plan

Aiming at n suppliers for s kinds of raw materials, we try to formulate the most economical raw material ordering plan for the enterprise in the next t weeks. The economic expenditure includes ordering cost, transshipment cost and storage cost. the objective function is that these three types of expenditure are the smallest.

First, the ordering cost can be defined as

$$C_1 = \sum_{i=1}^{n} \sum_{j=1}^{s} \sum_{t} M_{ij} \gamma_j P_j O_{it} \tag{16}$$

M_j is a logical variable which takes value one if i-th supplier produces j-th raw material, otherwise is zero.

Second, for z forwarders, the transshipment cost can be defined as

$$C_2 = TF(\sum_{m=1}^{a} \sum_{i=1}^{n} \sum_{t} T_{mi} S_{it}) \tag{17}$$

T_m is a logical variable which takes value one if m-th forwarder transship the raw material of the i-th supplier, otherwise is zero.

Third, for the raw materials transferred by z forwarders, the storage cost can be defined as

$$C_3 = TR(\sum_{m=1}^{a} \sum_{i=1}^{n} \sum_{t} (1 - \sigma_{mt}) S_{it}) \tag{18}$$

σ_{jt} Take the historical average of the same period in the past Y years

$$\sigma_{mt} = \sum_{t} \left(\frac{\sum_{y=1}^{Y} (\sigma_{mt}(t + 48y))}{Y} \right) \tag{19}$$

Considering that the decision variable of the objective function is O_{it} , we give a formula to describe the relationship between O_{it} and S_{it} .

$$S_{it} = f_i^2(n_i) O_{it} \tag{20}$$

Here, we use the historical average of f_i^2 over the same period as a measure of the supply satisfaction rate of the i-th supplier in the next t weeks

$$f_i^2(n_i) = \sum_{n_i=1}^{\max(n_i)} \left(\frac{\sum_{y=1}^{Y} \frac{S_{yiE}(n_i + \max(n_i) y)}{O_{yiE}(n_i + \max(n_i) y)}}{Y} \right) \tag{21}$$

In summary, the objective function with the lowest total cost is

$$\min f_1(O_{it}) = C_1 + C_2 + C_3 \tag{22}$$

4.2.3 The Formulation of the Least Loss Plan

According to the above definition, the objective function of the lowest loss rate is

$$\min f_2(O_{it}) = \sum_{m=1}^{a} \sum_{i=1}^{n} \sum_{t} T_{mi} \sigma_{mt} S_{it} \tag{23}$$

4.2.4 Constrains

In order to ensure the normal operation and maintenance of production enterprises, combined with the actual conditions of each link of the supply chain, constraints are as follows.

According to assumption A and B, the weekly storage volume needs to be able to maintain the enterprise's production capacity for two weeks, namely

$$\sum_{m=1}^{a}\sum_{j=1}^{s}\sum_{i=1}^{n}\sum_{t}\sigma_{mt}\eta_j S_{it}-10^4 P\sum_{t=2}^{t}(t-1)\geq 2P\times 10^4 \tag{24}$$

According to assumption C, a supplier only produces one kind of raw material, so the rank of M_{ij} is 1 all the time.

$$R(M_{ij})=1 \tag{25}$$

According to assumption E, the weekly transshipment capacity of each forwarder is 6000 cubic meters at most, that is

$$\sum_{m=1}^{a}\sum_{i=1}^{n}\sum_{t}T_{mi}S_{it}\leq 6000t \tag{26}$$

According to each supplier's raw materials have and only one forwarder is responsible for the transshipment every week, so

$$\sum_{m=1}^{a}\sum_{i=1}^{n}T_{mi}=1 \tag{27}$$

In summary, the dual-objective programming model can be described as

$$o.f.\begin{cases}\min f_1(O_{it})=(\sum_{i=1}^{n}\sum_{j=1}^{s}\sum_{t}M_{ij}\gamma_j P_j O_{it}+TF(\sum_{m=1}^{a}\sum_{i=1}^{n}\sum_{t}T_{mi}S_{it})\\ +TR(\sum_{m=1}^{a}\sum_{i=1}^{n}\sum_{t}(1-\sigma_{mt})S_{it}))\\ \min f_2(O_{it})=\sum_{m=1}^{a}\sum_{i=1}^{n}\sum_{t}T_{mi}\sigma_{mt}S_{it}\end{cases} \tag{28}$$

5 EMPIRICAL RESULTS

5.1 Problem Introduction

Combined with the above, we are now studying the ordering and transshipment plan of a building materials enterprise in the next 24 weeks.

In this example, in addition to satisfying the above assumptions, a total of 369 suppliers, 8 forwarders, 4 types of raw materials, the prices of them are $P_j=[1.0,1.2,1.5,1.3]$ and weekly production capacity of the manufacturer are $H=3.12\times 10^4 m^3$. The quantity of four kinds of raw materials required to produce building material per cubic meter is $0.68m^3$, $0.70m^3$, $0.77m^3$, $0.73m^3$,which means $\eta_j=[0.68,0.70,0.77,0.73]$ .Besides, we still have the supply condition of these 369 suppliers and weekly transshipment loss rate of forwarders in the past ten years. According to the above discussion, we follow the steps below to study the ordering and transshipment plan of the manufacturer

5.2 Simulation Solution

5.2.1 Hierarchical Clustering Analysis based on Supplier's Supply Capacity

Combined with the pedigree chart and the elbow rule, we divide 396 suppliers into 4 categories, and carry out the "protection" operation for the first and second types of suppliers, which means even if they fail to enter the top 80 in the comprehensive evaluation in the next step, we will replace the original supplier from back to front.

5.2.2 Comprehensive Evaluation based on TOPSIS

Based on the evaluation system and protection operations constructed above, a comprehensive evaluation of these 396 suppliers was made and the top 80 were evaluated.

Table 3: Top Eighty Suppliers.

Rank	Supplier	Materials	Score
1	S229	A	0.067374975
2	S361	D	0.062735875
3	S140	B	0.05772693
4	S108	A	0.04809566
5	S151	C	0.040590773
......	......	......	......
77	S223	C	0.001923605
78	S237	A	0.001915819
79	S324	C	0.001904659
80	S092	D	0.001896674

Among the top 80 suppliers, the scores of the suppliers who supply the four raw materials are as follows.

Table 4: Scores of The Suppliers Who Supply Four Materials.

Materials	Number of suppliers	Average Score	Highest Score
A	26	0.013341073	0.067374975
B	19	0.014170486	0.05772693
C	14	0.005367099	0.040590773
D	21	0.008707384	0.062735875

5.3 Analysis

5.3.1 The Influence of Linear Component and Composite Component on Raw Material Ordering Preference

Since materials A and C are the most popular and the least popular materials respectively, their order ratio is used as the basis for analysis.

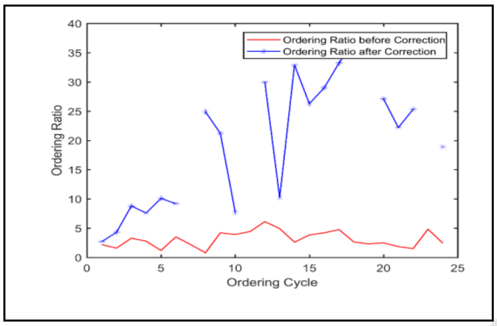

Figure 2: Ordering ratio of A and C raw materials.

It can be concluded that before the introduction of the price correction factor and the nature of the raw material C itself, starting from the goal of the least loss and the lowest cost, there has been

$$\frac{M_1O_i(t)}{M_3O_i(t)} \ge 1, \; always\ hold\ for\ any\ t \in [1,24]$$

From figure 2, after the introduction of the price correction factor, the manufacturer's preference for raw material A has increased significantly, and even the situation of $\frac{M_1O_i(t)}{M_3O_i(t)} \to \infty$ has occurred. This is caused by the fact that the manufacturer did not order raw material C at some nodes. This shows that the price correction factor has been strengthened the profit gap between different raw materials.

From the analysis of the composition of price correction factors, there are linear components directly related to the input-output ratio of raw materials and composite components directly related to the supplier's score. Therefore, differences in these factors are no longer only reflected as constraints, but directly modifies the weekly ordering prices of different raw materials, and their values directly affect the coefficient of the decision variable, which is quantified in the objective function.

5.3.2 The Influence of Time-varying Components on the Storage Volume of Raw Materials

We calculate the weekly storage volume before and after the price correction factors are introduced.

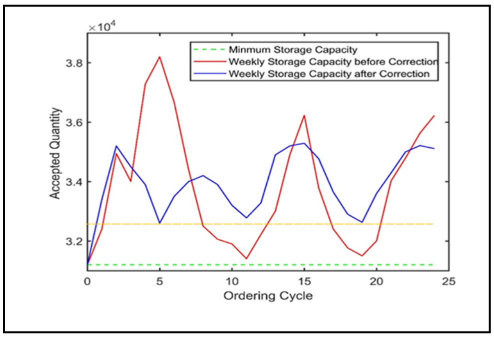

Figure 3: Storage volume of change curve.

From figure 3, we know that before the introduction of the price correction factor, the overall storage volume change curve shows the following characteristics:

- The peak storage volume is too high, and excessive storage of raw materials is prone to occur.
- Low sensitivity of the enterprise to decreasing in storage volume.
- The average replenishment response cycle is longer, that is, the storage volume is at a low level for a longer time.
- Lower storage vigilance level, that is, the timing of replenishment is often selected when the storage volume is very close to the minimum level.

In contrast, after introducing the price correction factor, the overall storage volume change curve shows the following characteristics:

- Peak reserves are relatively moderate, and the backlog of raw materials is not easy to appear.
- The enterprise is more sensitive to the decline in storage volume.
- The average replenishment response cycle is shorter, the time when the storage volume is at a lower level is shorter.
- Higher storage vigilance level , that is, when the storage volume reaches a moderate value, the restocking starts.

The main characteristic value of the storage volume change curve mentioned above are as follows.

Table 5: Characteristic Parameters of Storage Volume. **Change Curve**

	Average Response cycle	Peak Reserves	Restocking Vigilance Level
Before Correction	4.625	38200	31430
After Correction	2.783	35290	32680

From a global perspective, before and after the price correction factor is introduced, the solved total storage cost can be maintained at a low value. For the former, this is due to its lower storage vigilance level, higher replenishment response time and higher storage peaks. It should be noted that, for a manufacturing enterprise, having these characteristics at the same time means that the enterprise is often in a bad closed loop of production raw material backlog-rapid consumption of production raw materials-urgent production of raw materials-large purchase of production raw materials. According to the actual situation, combined with the storage volume change curve of the production enterprise in such a bad closed loop, the following conclusions can be obtained:

Affected by the low storage vigilance level, enterprise in the replenishment period often need to purchase a large amount of raw materials for production, and at this time they have just gone through a period of raw material backlog, so the expenditure during this period is higher than average. Under the combined influence of these two factors, production enterprises are prone to accidents such as the break of the capital chain.

When the production enterprise needs to increase production capacity to a certain extent, its long replenishment response time and poor sensitivity to the decline in storage volume determine that this goal is difficult to achieve.

After the introduction of price correction factors, the above problems have been effectively alleviated, and the value of each characteristic of the storage volume change curve is in a relatively reasonable range, which can effectively improve the risk resistance of manufacturers and can accept a certain degree of increase in production capacity. This can be explained by the composition of the price correction factor, where there is a time-varying component directly related to the storage volume, and its value is inversely proportional to the weekly storage volume of each raw material. After the price correction factor is introduced, the weekly storage volume will no longer only be reflected as a constraint, but as a time-varying component to directly modify the weekly order prices of different raw materials. Its value directly affects the coefficient of the decision variable and is reflected in the objective function quantitatively.

5.3.3 Analysis of the Influence of Price Correction Factors on the Dual-objective Programming Model

The price correction factor comprehensively considers the influence of multiple participants in the supply chain, contains multiple components, and its value can be used as a coefficient of a decision variable to affect the form of the objective function in real time. This directly increases the solution space of the objective function, making it closer to the global optimal solution in a limited number of iterations. Compared with the traditional method of adding more constraints, it is highly subjective, static, and significantly increases the complexity of the model. It is a means of improving the enterprise's anti-risk ability and profitability based on the internal factors of the production enterprise and price modification. The factor has the characteristics of non-linear and time-varying, which can simulate the dynamic characteristics of the supply system, and the consideration factors are more systematic, more objective, more flexible and the calculation cost is also smaller.

6 CONCLUSIONS

After the above discussion, we gave a raw material ordering and transshipment formulation strategy and evaluation index based on common mathematical modeling methods for manufacturers, and introduced the concept of the price correction factor, and gave the calculation of each component formula, practical meaning and synthesis method. It should be noted that considering the efficiency of model solving, we made tougher assumptions and constraints. One is that we assume the order price of raw materials is constant, and completely ignores the influence of external factors on the price of raw materials., which has a certain degree of time-varying characteristics. When considering the influence of these factors, it is necessary to define another influence factor, and take a part of this factor and the time-varying component of the price correction factor, which will increase the complexity of the model. Due to the limitation of data, this article did not do any spatial domain analysis of the entire model and did not consider the delay of a series of actions among suppliers, forwarders and manufacturing enterprise. To a certain extent, this also weakens the rigor of a series of parameters such as average response time, replenishment response cycle and time-varying components. Empirical analysis points out that the model solution results can meet actual operating needs of the production enterprise.

With the development of social economy and the change of social thinking, the roles between enterprises and governments are constantly changing. Enterprises must have sufficient time and space to reduce costs, improve their own risk resistance and capacity improvement potential, so as to achieve transformation and upgrading and improve their own operational capabilities. In this process, the government must provide a policy environment that is in line with enterprise development so as to consolidate the results of enterprise development. Enterprises play a good role in fulfilling individual economic responsibilities in their development. The two-way interaction between the government governance and enterprises forms a social environment of good governance.

REFERENCES

A.A.Gaballa (1974). Minimum cost allocation of tender. J. Operational Research Quarterly.3, 389-398.

C.O.Brien(2006). The total cost of logistics in supply selection under conditions of multiple sourcing and criteria. J.Production Economic.5,15-17.

K.Skouri and S.Papachristos(2002). A continuous review inventory model with deteriorating items. J. Applied Mathematical Modelling.26,603-617.

Liu Sen, Zhang Yingying, Zhang Yan, Yang Junai(2017). Research on green supplier selection integrating AHP and TOPSIS evaluation model. J.Logistics Engineering and Management. 39,1-4+11.

Liu Zelin(2019). Sustainable development of supply chain management: creating new core competitiveness. J. China Industry and Information Technology. 7,30-39.

Michael Stuart(2010). Benefits and Drawbacks of Technology in Supply Chain Management. J.Practical Application of Science.5,99-201.

Zhang Shan, Zhang Wenfang, Lu Zhou(2011). Analysis of logistics cost management based on supply chain. J. Finance and Accounting Newsletter. 2,136-137.