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Enterprise benefit game model of collaborative supply chain in logistics industry park

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ABSTRACT

Multi-objective harmony optimization algorithm dominated by α in negotiation supply chain of self-adaptive weighted constraint penalty is proposed for high dimension of objective optimization and low algorithm accuracy and computational efficiency in the collaborative supply chain between enterprises in Logistics Industry Park. Firstly, the collaborative scheduling model of supply chain is researched, the collaborative scheduling multi-objective optimization model is constructed, the single collaborative scheduling optimization model is established with the method of self-adaptive weight, and the collaborative scheduling multi-objective compensation model is set up by means of integrated constraint; secondly, the multi-objective evolutionary algorithm is improved, elite gradient selection strategy dominated by α is constructed for the problem of missing guidance in Pareto solution, and multi-objective harmony search optimization algorithm dominated by α is established by combining with harmony search algorithm; finally, scheduling effect of distributors is improved and good results of α dominating set is obtained under the premise that the manufacturers scheduling is ensured.

1. Introduction

The main role of distributors in Logistics Industry Park is to help manufacturers distribute goods. Several distributors can form a supply chain network together with manufacturers. In general, distributors and manufacturers belong to separate entities, but they share the downstream benefits of the supply chain. The day-to-day decisions of distributors and manufacturers are presented in the form of job scheduling and play the role of coordinating two entities [1,2]. In the actual supply chain, the manufacturer is often the system center, of which influence is stronger than that of the distributor. The distributor's decision usually depends on the manufacturer's decision and scheduling data. This scheduling mode is beneficial to manufacturers but not conducive to distributors' profitability, and also affects the overall performance of the supply chain. In this regard, the literatures, from the perspective of coordination mechanism, schedule [3] the coordination between the upstream and downstream entities of the supply chain.

Literature [4] studies assembly and scheduling negotiation of supply chain and proposed the supply chain planning algorithm of collaborative compensation mechanism dominated by the supplier and coordinated by the manufacturer. The experimental data shows that the scheduling coordination process can reduce the scheduling cost of supply chain by 81.19%; Literature [5] is also based on the similar negotiation compensation algorithm; Literature [6] studies the scheduling coordination of newspaper manufacturers in the distributing process and the distribution and scheduling coordination problems of the similar newspaper manufacturers. In this paper, the problems in separation scheduling are studied, and the mechanism of link scheduling between manufacture and distribution is considered, and the corresponding dynamic planning optimization process is proposed. Simulation results show that the coordination mechanism can improve the distribution efficiency of distributors and reduce the distribution cost of manufacturer in supply chain by 35% on average. Then, this paper, from the perspective of integrated negotiation scheduling and for the purpose of improving the cooperation and scheduling benefit between manufacturer and distributor, establishes the algorithm optimization process, the integrated transportation and production scheduling process [7] and the integrated production and distribution negotiation process [8]. Literature [9] puts forward the consideration in constraints of multi-stage supply chain scheduling of window due date, molecular problem, sequencing scheduling and batch scheduling [9]; Literature [10] uses the ant colony optimization process for dynamic scheduling in customization of environmental supply chain customization.

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Although there are many research achievements in scheduling problem of supply chain of Logistics Industry Park at present, application of the multiple distributors supply chain system results in the poor scheduling effect since the distributor can only independently communication and consult with corresponding manufacturer, or communication and consult with manufacturer combining with the distributor's returns to share coordinated return results. However, in the practical application of supply chain, distributors are independent and the distributors' objectives are to maximize their returns, without mutual trust and keeping the secret in operation time and cost. While in the ideal condition, distributors' returns are combined and the negotiation is based on it to maximize the distribution benefits. Focusing on maximizing the returns of distributors, multi-objective scheduling problem in distribution and manufacture is taken into account in this paper.

2. Problem description of negotiation supply chain

The negotiation supply chain is composed of m independent distributors and 1 commodity manufacturers. The distributor $i(i = 1, \cdots, m)$ needs to schedule the n_i operation processes to realize the commodity distribution. The manufacturer produces operation products and distributes them through distributors. The time of the operation $J_{i,j}$ of the distributor i is $p_{i,j,u}$ (at the manufacturer) and $p_{i,j,d}$ (at distributor), where $p_{i,j,u}$ is the operation time of generalized concept and the window due date of operation $J_{i,j}$ is $d_{i,j}$.

The distributors and manufacturers in Logistics Industry Park are important components in the distribution process of supply chain. When the operation time is not shared, that is to say, the time $p_{i,j,d}$ of operation $J_{i,j}$ of manufacturer to distributor and the operation time $p_{i,j,u}$ of distributor to manufacturer are unknown. Nevertheless, cooperative scheduling is allowed among enterprises in supply chain. In the supply chain, the manufacturers are dominating and all the distributors are independent in the same grade. The manufacturers own scheduling process is dominant, which is followed by that of distributor. The manufacturers take the advantages of scheduling which is usually beneficial to their returns but not conducive to the distributor's returns, which is harmful to the overall distribution performance of the supply chain, relative speaking. Thus, research on negotiation scheduling between multiple distributors is advantageous to maximize the supply chain returns and reduce the distribution cost.

It is assumed that each operation process is started at zero time which is generally in the initial stage of distribution cycle of supply chain), the scheduling optimization objective of manufacturer is to minimize the total time length of operation and of distributors is to minimize the total weighted delay of operation, and then $a/b/c$ scheduling rule is used: a as the machine environment, b as operation characteristics, c as scheduling objective, then the scheduling optimization process of manufacturer is $1\|\sum_{i=1}^{m}\sum_{j=1}^{n_i} C_{i,j}$ while that of distributor is $1|r_{i,j}|\sum \omega_{i,j}T_{i,j}$. In the formula, time $r_{i,j}$ of operation $J_{i,j}$ is related to the execution time of manufacturer and $\omega_{i,j}$ is the weighted delay penalty factor of $J_{i,j}$. $s_{i,j,u}$ and $e_{i,j,u}$ are respectively the starting time and ending time in the operation $J_{i,j}$ of manufacturer, $s_{i,j,d}$ and $e_{i,j,d}$ are respectively the starting time and ending time in the operation $J_{i,j}$ of distributor, α and β_i are respectively the manufacturing scheduling process and i distribution scheduling process, and α_i is the operation of relevant distributor i in the manufacturers. α_i must be connected to β_i reasonably, namely $s_{i,j,d} \geq e_{i,j,u}$. $O(\alpha_i)$ and $O(\beta_i)$ are respectively the scheduling objective of α_i and β_i, μ_i is the unit operation cost of$O(\alpha_i)$, and v_i is the unit operation cost of $O(\beta_i)$.

3. Multi-objective scheduling negotiation model

3.1. Multi-objective negotiation scheduling model for distribution supply chain

In Logistics Industry Park, the order is needed to be processed in the processes of manufacture and distribution, the manufacturer exerts the influence on the distributor through the operation time, and the specific constraint connection form is $s_{i,j,d} \geq e_{i,j,u}$, that is to say, starting time of operation $J_{i,j}$ of distributor i is required to be later than the ending time of manufacturer operation. $e_{i,j,u}$ is the operation time $r_{i,j}$ of $J_{i,j}$ in the distribution scheduling, and if the distributor i improves the scheduling operation under the premise that $r_{i,j}$ is optimized, the above is equivalent to the negotiation mechanism of distribution and manufacture. The ending time of $J_{i,j}$ in the process of manufacturing scheduling is $e_{i,j,u}$, which is the improved value useful for itself. Improvement of $e_{i,j,u}$ is equivalent to improvement of manufacturing scheduling process. The distribution compensation process is required for providing incentive mechanism of new scheduling mode. Without loss of generality, the distributor compensates for the manufacturing operation and the effect better than that of original scheduling mode shall be obtained. Otherwise, negotiation operation is not necessary, and the specific process is shown as follows:

$$\sigma = \sum_{k=1}^{m} u_k(O(\alpha'_k) - O(\alpha_k)) \tag{1}$$

$$v_i O(\beta'_i) + \sigma_i > v_i O(\beta_i) \tag{2}$$

The distributor i shall provide a manufacturing compensation parameter σ_i not less than the benefit damage value of new scheduling manufacturing plan. After deducting compensation σ_i, the distributor i will select the most favorable scheduling operation process for itself. Since m distributors are in the same grade and all the distributors need to coordinate with the manufacturer in scheduling, the manufacturer is required to deal with the m scheduling processes at the same time, but these schedules will conflict. In order to deal with the loss of distributors' customers properly, the corresponding compensation is needed for fair distribution in the process of manufacturer scheduling. If the new distribution scheduling plan can increase returns of some distributors but reduce returns of other distributors, this distribution scheduling process will be given up. The manufacturers only select the scheduling plan optimizing the returns of all distributors. Thus, this operation is a process of collaborative scheduling multi-objective optimization, and the purpose of manufacturer to select the new scheduling plan is to maximize the scheduling improvement.

The compensation σ_i provided by the distributor i depends on the returns obtained from new scheduling plan, that is to say, more return, and more compensation. If the total compensation of distributors is σ, δ_i is the cost difference between the new and original scheduling plans, β'_i is the operation of distributor i in new scheduling plan, δ_i is defined as in formula (3) and σ_i is defined as in formula (4):

$$\delta_i = v_i \max(0, (O(\beta_i) - O(\beta'_i))) \tag{3}$$

$$\sigma_i = \frac{\delta_i}{\sum_{i=1}^{m} \delta_i}\sigma \tag{4}$$

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