International Order Negotiation in Two Tier Supply Chain of Manufactures

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Abstract. The order negotiation are regular activities for a synergic operations planning between supply chains partners. As operations planning can usually be realized only for isolated parts of an overall supply chain, the question arises whether there are alternative negotiation ways of synergic operations planning. In this paper we propose a recursion-based order negotiation model which can be used to modify orders in the cooperation of the buyer and supplier according to their external orders, available resources and inventory, and for generating optimal results as obtained by supply chain system coordination. Three scenarios emerge in the application of the model: the solution is in the solution set (orders can be accepted by the other party); the solution is in the solution set, but cannot be further optimized; the solution is completely out of the solution set (called order conflicts). And under the three scenarios, we provide the corresponding solutions, especially for the order-conflict scenario. First, find an initial relaxation solution that minimizes overall cost of the supply chain as the reference solution. Second, maximize the utilization of production with a simulation optimization method to increase the purchase order. Then find an optimal solution which balance the supply and demand of both sides. Finally, the validity of the order negotiation model is verified in various situations by computational tests.

Introduction

A cooperative relationship is decided by independent choices of the supply chain upstream and downstream. And the sound cooperative relations of supply chain partners enhances the core competitiveness in market competition. For manufactures this relationship is usually a long-term relationship, partners not only need to optimize their production and business plans based on limited information[1], but also tend to accept central coordination for reducing exposure to supply outages, increasing competitiveness, and develop more coordinated relationships[2-3].

Purchasing decisions of manufactures are importance of achieving collaborative production. The classic order negotiation model in 2005 and 2007, Jerzy Dudek [4-6] proposed that there are spaces for modifying the order plan, correcting each period of the plan period based on external orders, available resources and inventory, and implementing interactions (order information) through the iterative algorithm of the negotiation model. For uncertain external orders, the order negotiation between supply chain partners is a dynamic process. It is hard for negotiating parties to ensure whether the feasible regions of solutions have intersections at each round of iteration. In this paper, it is defined as the order conflict.

When there is no intersections [7-10]. For solving this, a recursion-based order negotiation model under three scenarios is proposed in this paper, which greatly contributes to expansion of model coverage.

Model Framework

The order negotiation system based on production and inventory information consists of seller's and buyer's models. The model framework and running process are shown in Figure 1.
The specific steps are as follows:

1) The buyer calculates an initial order plan based on his own external requirements, as well as production data and inventory information, and delivers it to the seller in accordance with his one-party cost optimal model.

2) The seller uses its own program evaluation model 1 to evaluate the impact of the program on its production and operation plans. When the order interaction times, when I = 1, judge whether there is a solution in model 1, and no solution is the order conflict scenario. In this scenario, model 4 is used to solve the order conflict solution. If there is a solution, continue the following steps. When I > 1, skip this judgment, because the resulting scheme in the subsequent loop is a non-degenerate revision of the model with a solution.

3) Explore the possibility of further optimization and adjustment. Based on the Suggestions of the other party, the local optimal cost scheme is solved by using the model, 2. If there is no solution, or if there is no solution but no order adjustment, the other party's Suggestions shall be adopted. If there are solutions and order adjustments, continue the following steps.

4) Adjustment plan. Model 3 is used to solve the order adjustment scheme with the aim of minimizing local cost and order adjustment. If no new order plan is generated, both parties reach an agreement, otherwise this adjustment proposal will be sent to the other party.

5) The buyer need to repeat the above three steps (from step 2 to step 4), iterates repeatedly, obtains the corresponding order solution under the following different scenarios, and stops the iteration. Each iteration has two suggested order interactions, each of which is irreversible.

**Model Analysis**

Through the program evaluation model, the buyer and the seller evaluate the order plan of the other party, and measure the impact of accepting the program on the local production operation and cost consumption. The symbolic interpretation of variables in the model is shown in Table 1:
Table 1. Model notations.

<table>
<thead>
<tr>
<th>Index sets</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>$T$</td>
<td>Set of planning periods</td>
</tr>
<tr>
<td>$K$</td>
<td>Set of buyer’s products</td>
</tr>
<tr>
<td>$J$</td>
<td>Set of supplier’s materials</td>
</tr>
<tr>
<td>$S_k$</td>
<td>Set of direct successor products of $k (S_k \subseteq K)$</td>
</tr>
<tr>
<td>$S_j$</td>
<td>Set of direct successor products of $j (S_j \subseteq J)$</td>
</tr>
<tr>
<td>$M$</td>
<td>Set of resources</td>
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</tbody>
</table>

Indices

<table>
<thead>
<tr>
<th>Meaning</th>
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<tbody>
<tr>
<td>$t$</td>
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The objective function is to minimize the total cost of the supply chain while minimizing the amount of order adjustment:

$$\min\left(c_b + c_s + \varepsilon d_b\right)$$  \hspace{1cm} (1)

In this objective function, $c_b$ is the cost of the buyer, $c_s$ is the cost of the seller, is the order adjustments of buyer, and $\varepsilon$ is a sufficiently small parameter. These formulas are as follows:

$$c_b = \sum_{t \in T} \left(d(t_{k,t} + c(t_{j,t} + \sum_{m \in M} \omega_{m} \rho_{m} \right) + \sum_{j \in J} \delta_{j_{S_j}}$$ \hspace{1cm} (2)

$$c_s = \sum_{t \in T} \sum_{k \in K} \left(ch_{j,t} + c(t_{j,t} + \sum_{m \in M} \omega_{m} \rho_{m} \right)$$ \hspace{1cm} (3)

$$d_b = \sum_{t \in T} \left(d_{j,t}^{+} + d_{j,t}^{-}\right)$$ \hspace{1cm} (4)

As the target of minimum total cost of Model 4 often leads to loss of unilateral benefits, such as the wasting of production resources for sellers or unmet demand of the buyers. Therefore, it is necessary to further improve on the basis of the initial relaxation solution. Set $\mu_j = \left|\sum_{t \in T} x_{j,t}^{s_{j,t}} - \sum_{t \in T} x_{j,t}^{s_{j,t}}\right|$ as the total deviation of product $j$ in the proposed plan and the buyer's initial plan and use $\min\left(\max_{j} \mu_j\right)$ to minimize the maximum deviation product orders - demand as the goal, the initial relaxation solution to the model 2, adjust the deviation, the product quantity of biggest proposal until resource consumption to reach the seller production resources limit. Thus, an adjustment proposal is proposed to maximize the use of available resources to meet buyer's needs.
**Model Application**

**Case Background and Data Design**

An automobile parts assembly plant (the buyer) and supporting parts supplier (the seller) negotiate the order quantity of the three products in three ordering sub-periods respectively. Both the production and assembly take two types of resources, the unit of each product for a certain resource demand does not vary with the times, the two types of resources in the three periods established to order. Resource 1 and resource 2 have the same utilization rate during the three ordering periods, all of which are 90%, 80% and 60%.

**Scenario Analysis**

In the context of the above case, there are three negotiation scenarios, and the model verification results of the three scenarios are shown by Figure 2:

First of all, from above four solutions of each product order amount, as shown in Figure 2 (a), the buyer and the seller is product 3 quantity deviation is more obvious, that both sides of the controversy focuses on product 3 order. Moreover, the largest deviation between the total amount of products ordered in plan a and S1 is product 3, while the deviation between the total amount of products ordered in plan b and S1 and S2 is 23.63% and 51.11%, respectively, compared with plan A.

Secondly, the resource utilization of programmes a and b in three sub-periods was compared through Figures 2 (c), (d) and (e). In Figures 2 (d), although the use of resource 2 in the second sub-period of plan a reaches the upper limit, the use of resource 1 is zero, while that of resource 1 in plan b increases substantially and is close to the resource limitation. As shown in Figures 2 (e), in the third phase of plan b, both resource usage amount is close to resource limitation, and resource utilization rate is close to 100%. As shown in Figures 2 (c), plan b is necessary spare resources in the first phase 1, because the scheme 2 is close to the limit of resources, to adjust the product 3 & 2 excess production will lead to resources at any time. By comparing the solutions a and b respectively with S1 and S2 products quantity deviation, and plan a and plan B periods of resource usage, reflects the advantage of simulation optimization for plan B, show the effectiveness of this method in order conflict situations and practical value.

**Summary**

Based on the changes of production, inventory and external demand information of both parties in order negotiation in each supply sub-period, this paper analyzes the optimization scheme of order negotiation dynamically. The total project period under the allocation of resources constraints purchases unchanged, adjust the house during the period of purchasing, production, inventory to optimize the production operation cost of the enterprise, at the same time in order information interaction in the process of seeking cooperation order scheme. Through the model application, the
order negotiation between manufacturing enterprises can be supported, which can be carried out more effectively when analyzing the internal production, inventory and external demand information of both parties. In the regular supply relationship, the order negotiation model based on production and inventory information is modeled to provide the intelligence analysis and method basis for the order negotiation of manufacturing enterprises.

The essence of this contribution is on the basis of the classical supply chain collaboration order negotiation model, puts forward several possible scenario is a complete scenario model framework, analysis of possible collaboration in order negotiation, collaboration is not convergence, convergence and the conflict three orders, and corresponding solutions are given respectively and extend the applicability of the model.

It is worth emphasizing that, negotiation model is not necessary to replace the real negotiation for the purpose, but provides the intelligence analysis for negotiations, the repetitive, the intrinsic relationship between mechanism, programming, intelligent, collaborative decision-making between the effective support to enterprises.

References


