Production Network Planning Based on Constraint Relaxation and Discount Approach

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***Abstract*—In the real world, one of the major factor that contributes to the complexity of supply chains is the structure of supply chain. Compared with a supply chain with two members, operations planning in a manufacturing network where members are independent entities require a special attention to the details. This paper will focus on the specific case of manufacturing network planning. Our objective is to propose a new planning methodology between independent production companies to achieve an agreed plan.**

***Index Terms*—supply chain, manufacturing network, independent company, planning strategy, operations planning, negotiation.**

I. Introduction

The simplest form of a manufacturing supply chain is a two party supply chain including a supplier and a manufacturer (Fig. 1). In the real world the management of this simplest form of supply chain could be difficult, especially when the partners are independent organizations. In this context, the complexity is related to the difficulty of the coordination management of these two members.

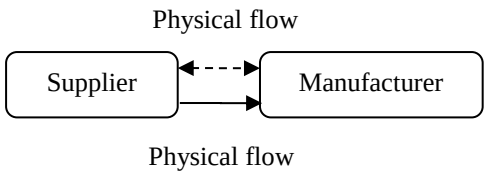

Figure 1. Two parties supply chain.

Now, imagine a network of manufacturing where the members are independent with their own objectives (Fig. 2). The organizations want to coordinate their plan with other members of network by minimum level of information. In this case, the complexity increases with the number of partners in the network. The question is to how to achieve a plan, which is accepted by all members of network, considering the independency of partners. This paper tries to answer this question by proposing a planning methodology which can be used by the members of a manufacturing network to generate an agreed plan after some iterative negotiations between members of this manufacturing network.

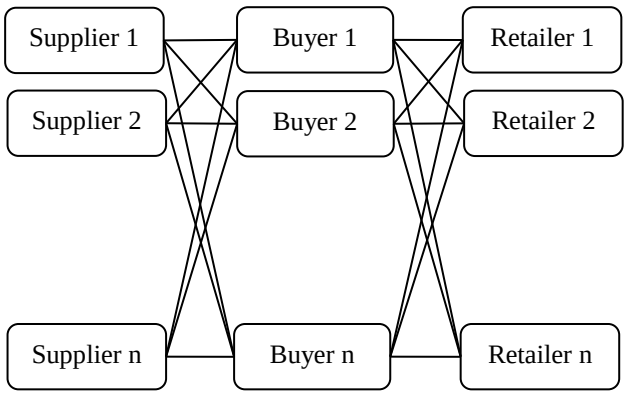

Figure 2. Supply network.

The reminder of this paper is organized as follow. A literature review is presented in the next section. Then, we introduce our planning methodology. During the section three to four we detail the mathematical aspect of our approach with an example. Finally, Section five concludes and presents directions for future research.

II. Literature Review

Management of supply chains is the coordination of operations planning in the value chains. In this context decentralized approaches in which partners are totally independent need essential attention. In these approaches, it is essential to propose an incentive system to encourage the partners modify their initial plan to achieve an agreement. Considering the independency of organizations, companies need some incentive mechanisms to encourage the independent partners to participate in coordination process. In this section, we decided to review the literature of supply chain management from the viewpoint of incentive systems because the core of our approach is also based on the incentive systems.

In general the incentive approaches could be categorized into two main approaches. Following we will explain these two categories.

First group are flexible contract-based approaches. In this group, in order to achieve an agreement, partners have the flexibility to make some adjustments in their order. Usually the manufacturer makes a commitment

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and subject to the information received from the supplier, he will adjust the order quantity later [1]. The flexibility sometimes could be awarded by sharing the revenue, defined in the contract [2].

Second category is monetary-based approaches. In this category, which can be considered the main incentive system, there is not any contract. So, in order to encourage other partners to participate in coordination action, the members of manufacturing network can propose the monetary incentive. For example, in discount policy, a manufacturer may be able to increase its ordering quantity by receiving an incentive in the form of rebate from supplier [3]. As another example of the main category of the monetary-based approaches, in buyback policy supplier accepts the return of product for the credit given to the manufacturer. This policy could encourage a manufacturer to order more which could be concluded to the coordination of members of a supply chain [4].

III. Planning Methodology

If we want to categorize our approach in the literature presented above, we can include our approach in the main category of monetary-based approaches. Our objective is to propose a planning methodology for decentralized manufacturing network. The specific case of a divergent network is considered including one supplier who produces the products for a group of three manufacturers (Fig. 3).

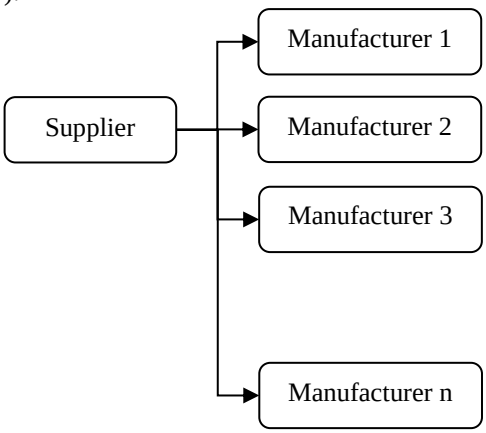

Figure 3. Divergent manufacturing network.

As our planning methodology is to coordinate a decentralized network, minimum level of information sharing is considered. The incentive system is used to encourage the partners of network to modify their plans. Following we explain our proposed planning methodology, which is a developed version of our previous work used to coordinate just two partners of supply chain [5].

In this developed method, the manufactures imitate by proposing their order quantity to the supplier. The supplier first evaluates the received order plans. To evaluate, supplier first identifies its optimal plan, which is in the neighborhood of the plan derived from the manufacturers' original plans. The supplier also determines its upstream plan determined by respecting the exact number of products ordered by group of manufacturers. The positive difference between these two plans is referred to as the Additional Supply Plan (ASP) matrix, which represents the matrix of quantities for specific products at specific time periods that the supplier's desire to increase the original order. Next, the supplier calculates the Maximum Discount (MD) that can be offered to the manufacturers if they accept in totality to coordinate their order plans in accordance with the Additional Supply Plan (ASP) of supplier. The Maximum Discount is defined as the gap between the objectives functions of two plans presented above. It means the difference between the profit generated from delivering the local optimal plan and the profit generated from delivering the manufacturer's original Order Plans. Finally, using the ASP and the MD, the supplier defines and offers a Discount Plan (DP) to the manufacturer, which consists in offering part of the MD for an adjustment of the original OP equal to part of the ASP. In other words, if the manufacturers accept to increase their original order plan for specific products at specific time periods up to at least the specified portion of the ASP, then a fixed discount is offered to the manufacturer. The aim of this Maximum Discount Plan is to generate a base in order to propose different Discount Plans (DP) to encourage manufacturer deviate from their original order plans (Fig. 4).

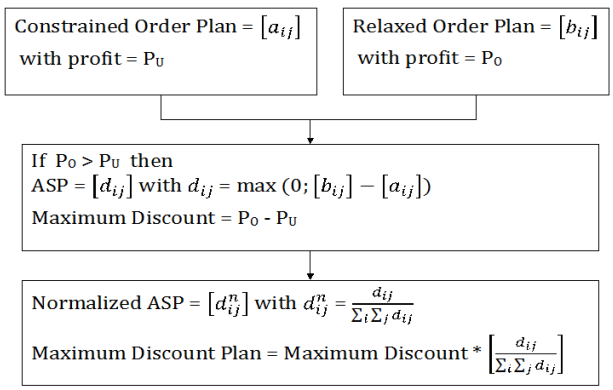

Figure 4. Maximum discount plan [5].

At every round of the mutual adjustment, α percent of Maximum Discount Plan, known as Discount Plan (DP) (DP= α * MD, 0≤α≤1) can be proposed to the manufacturers, if they accept to coordinate their plan, up to β percent of Additional Supply Plan (ASP) (β * ASP, 0≤β≤1). If the manufacturers refuse a given discount plan, the supplier simply could reduce the deviation asked to receive the discount (i.e., β) until the manufacturers accept the discount plan.

In this approach, the supplier validates any adjustments made to the order plan by the manufacturers upon the receipt of this discount plan. If the supplier does not improve its initial profit with this new order plan, it decreases the discount (i.e., α) offered to the manufacturers without adjusting the deviation asked (i.e., β).

IV. Example

As an example, we consider a divergent supply chain including one supplier and four manufacturers (Fig. 5). The objective is to plan the production of a specific product over two planning periods. In this example, the upstream planning approach produces a total supply chain profit of 3500 monetary units. However, supplier, after using a relaxed lot-size plan, prefers to switch the production of 30 units of this product from period one to period two, with a local potential profit increase of 2500 - 500 = 2000.

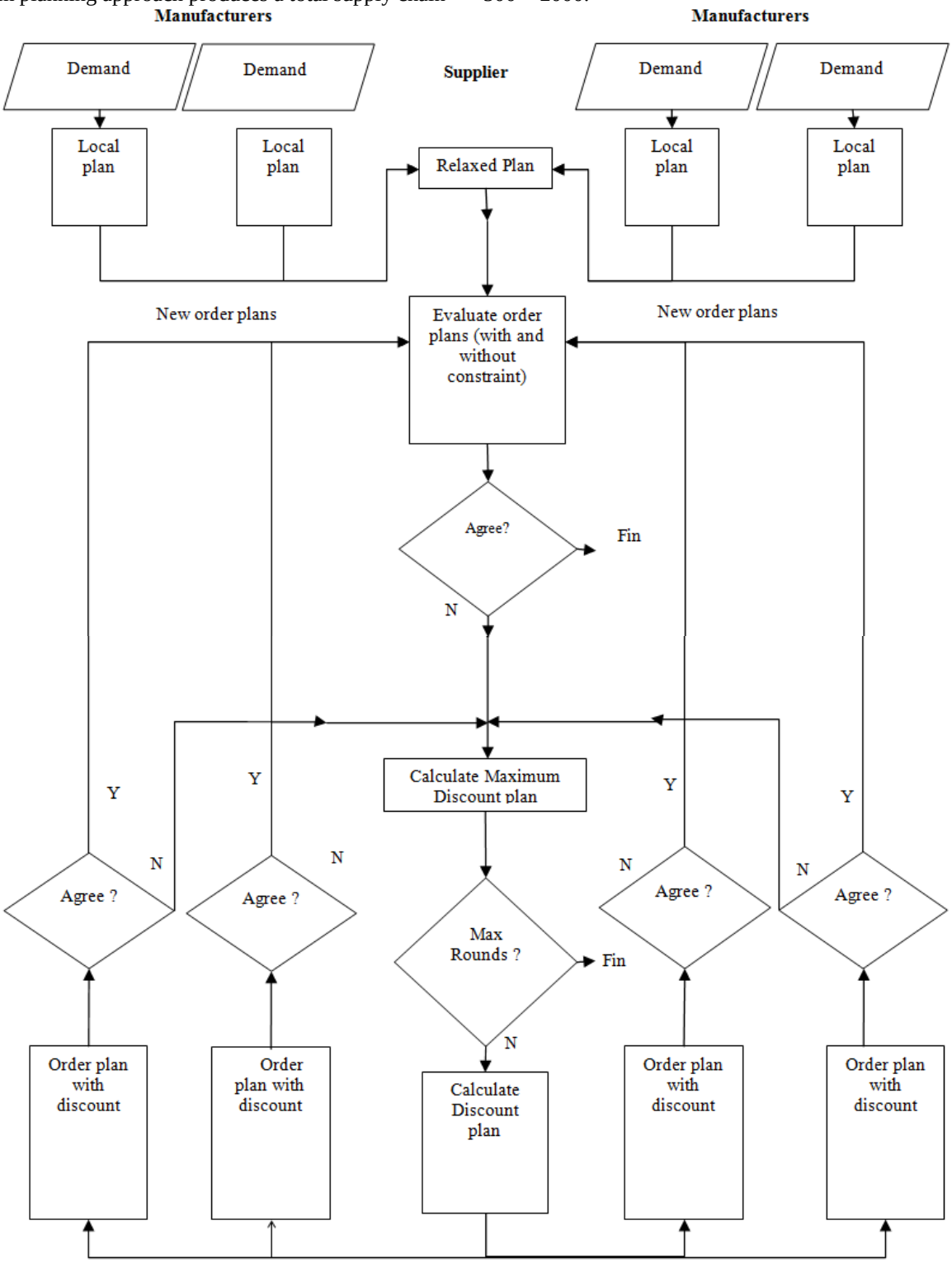

Figure 5. Planning methodology.

To encourage the partners to participate in the coordination action, suppliers could offers a discount plan based on the maximum discount plan. So, the supplier computes the Additional Supply Plan and Maximum Discount Plan. These two matrixes will be used to create incentive proposals to the each of the three manufactures.

In the next stage, the supplier proposes in a first round of negotiation, 30% of this maximum discount plan

($\alpha 1 = 0.075,\ \alpha 2 = 0.075,\ \alpha 3 = 0.075,\ \alpha 4 = 0.075$) to the three manufacturers. Each manufacturer can benefit from 7.5% of maximum discount plan, if he increases his order plan for product 1, period 2, at least from zero to two units ($\beta = 0.1$).

In this example because the incentive is not sufficient to change the manufacturers' order plans, the supplier increases the offered discount to 60% of the Maximum Discount Plan ($\alpha 1 = 0.15,\ \alpha 2 = 0.15,\ \alpha 3 = 0.15, \alpha 3 = 0.15$), for a similar increase of its order plan for product 1, period 2, from zero to, at least, two units (10% of the ASP,$\beta = 0.1$), which results in three partners benefiting from improved profit compared to the original solution.

V. Conclusion

This paper presents a planning methodology to coordinate the operations planning in a decentralized supply chain network. In this planning methodology, one member uses an incentive mechanism to encourage the manufacturers to participate in coordination process and to plan simultaneously the operations in a production network. This approach is based on an iterative non-collaborative based negotiation between five partners. The partners have the same decision authority and it is not necessary to exchange of strategic information like the inventory level or the cost structures of partners [6] A particular relation between one supplier and four manufacturers is studied. The computational results are necessary to show promising results.

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