CPFR METHOD APPLICATION IN SUPPLY CHAIN INVOLVING CONTINUOUS PRODUCTIONS

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Abstract

The growing dynamics of changes in the market environment creates pressure to increase speed and flexibility of enterprises at acceptable costs to meet the quickly and sometimes unexpectedly changing requirements of immediate customers but also customers of these customers in the value chain. A tool for achieving this goal can be the integration of the business logistics system with logistics systems of suppliers and customers on the basis of CPFR methods (Collaborative Planning, Forecasting and Replenishment). Implementation of CPFR requires adapting to the specifics of each supplier-customer value chain. The method of supply chain management and mechanism of replenishment by suppliers to their customers is dependent on the type of production process in the given supply chain. A different way of supply chain management on both the company and inter-company level must be applied in the case that it is a continuous production, another one in the case of batch production. The paper specifies how to use the CPFR method in chains with continuous productions, which are located in chemical-technological and metallurgy industry. Using a concrete example of supply chain with these production systems, the article outlines the principle of managing the material flow based on the CPFR method. It specifies how to implement collaborative sales forecasting and logistics planning, how to set up a mechanism of stock replenishment and also provides a flexible way of replenishment on the basis of current requirements of end customers, including operational management of the continuous productions in this system of supply chain management.

Keywords: Value Chain, Supply Chain Management (SCM), Collaborative Planning, Forecasting and Replenishment (CPFR), continuous production.

1. INTRODUCTION

The growing dynamics of changes in the market environment creates pressure to increase speed and flexibility of enterprises at acceptable costs to meet the quickly and sometimes unexpectedly changing requirements of immediate customers but also customers of these customers in the value chain. A tool for achieving this goal can be the integration of the business logistics system with logistics systems of suppliers and customers on the basis of CPFR methods (Collaborative Planning, Forecasting and Replenishment). CPFR was developed to minimize out-of stocks by synchronizing forecasting and planning between retailers and manufacturers [1,2]. The focus of CPFR lies in vertical channel integration to achieve some of the efficiencies of coordinated systems without ownership [3] Skjoett-Larsen et al. define CPFR as “Collaboration where two or more parties in the supply chain jointly plan a number of promotional activities and work out synchronised forecasts, on the basis of which the production and replenishment processes are determined” [4]. CPFR is a set of business processes that are established and empowered by a formal agreement to cooperate on strategy, tactics and execution by resolution of exceptions [5]. According to Danese [6] companies implement CPFR for two main reasons. In some cases central companies aim to reduce costs (e.g. investments in stocks) without penalising service levels (strategy of efficiency); in others the main purpose is to make the supply network more reactive to demand changes (strategy of responsiveness). CPFR method is generally applicable in all chains, where there is sufficient willingness of
individual members to this type of collaboration. Implementation of CPFR requires adapting to the specifics of each supplier-customer value chain. The method of supply chain management and mechanism of replenishment by suppliers to their customers is dependent on the type of production process in the given supply chain. A different way of supply chain management on both the company and inter-company level must be applied in the case that it is a continuous production, another one in the case of batch production. However, the professional literature has so far addressed the CPFR method only in general terms. For now, one can not find more coherent instructions on management of logistics processes based on this method, taking into account the specifics of individual chains. It is therefore not yet recommended to use the management method in the supply chain based on this method, involving various types of production systems. The paper specifies how to use the CPFR method in chains with continuous productions, which are located in chemical-technological and metallurgy industry.

2. CPFR METHOD APPLICATION IN SUPPLY CHAIN INVOLVING CONTINUOUS PRODUCTIONS

In managing chains with discontinuous production processes in which products are made in different series (such as organic pigments and dyes, pharmaceutical substances), customer requirements for technical quality and volume of the product are of utmost importance and so are requirements for delivery time. In managing these chains, it is important to adapt to individual customer requirements and make them satisfied with diversity of products delivered in due time. The moment of delivery should be as synchronized as possible with the time the product is needed in the manufacturing process of the customer. It is necessary to deliver on due date, or even better in due hour. By contrast, in managing a logistics chain including continuous, mass production processes (by which basic inorganic chemicals are produced, for example), CPFR-based methods, it is necessary to focus mainly on continuity of the flow through the company and chain. Crucial is to tune individual production stages so that there was a continuous and economical material flow. Logistical systems (of particular members) of the whole chain have to be closely linked and various activities related to providing value to end users must follow each other smoothly. The material flow through the entire chain must be predicated by jointly drawn or at least shared plans and must comply with current requirements of end users. Information sharing is probably the most pertinent one because it affects performance of the whole supply chain significantly [7]. To demonstrate the management of material flow in the chain, let us consider a simplified example of supply chain composed of logistics chains of individual companies. Corporate logistics systems contain mass continuous manufacturing processes. The material flow in this chain can be indicated through Figure 1.

![Figure 1 Example of supply chain](image-url)

Let us assume that individual buyers in the chain are key customers of their suppliers. The product of the entire chain is sold through wholesale, wholesale and retail, or through direct sales (e.g. sale of fertilizers). To demonstrate application of the method, we consider a supply chain whose last members (wholesale and retail) are separate business entities. All production systems in the chain are mass, continuous productions. Manufacturer C purchases major material inputs from Suppliers A and B. Supplier B delivers his/her product not only to Manufacturer C but also to many other manufacturers. Supplier A supplies his/her products to
2.1 Collaborative Demand and Sales Forecasting

The first step should be to forecast demand and sales to the end users of the chain on the basis of which plans are then drawn up to manage material flow through the chain. Actual deliveries are, however, governed by the actual demands by the end customers of the chain. As for demand forecasting methods, this work is not intended to address these in detail. However, it is appropriate to emphasize the need to choose the right method. The various methods of forecasting sales are not interchangeable, and each of them is suitable for a different event. The claim that the more a method is complicated, the more accurate the forecasts are is not generally valid. The selection of the method should be governed by a rule that for most users the most suitable is the method that gives the best results [8]. Very important is to identify the period for which both forecasting and planning are intended. Due to the type of production processes in a particular chain, one week would appear to be a suitable period. One day interval for planning and stock replenishment to individual customers is just too short with regard to the fact that the production processes are continuous in the particular chain. In these types of productions, tactical and operational plans are usually elaborated for each month. Even one-week interval might be too short with regard to the quantity to be transported between particular enterprises. For this interval, a prediction is therefore made according to individual items and individual retailers. Subsequently, the predictions of individual retail sales are summarized at the wholesale level, and the projected wholesale sales are added. In term of organization of whole process it is possible to differentiate two models: the first model assumes that each member updates future demand forecasts periodically and is able to integrate the adjusted forecasts into the replenishment process; in the second model, called the collaborative forecasting model, the supplier and the retailer jointly determine the forecast in the system, and forecasting information becomes public information to them [7].

Using the second model requires, however, that the shared demand and sales forecast be subject to comment by all the partners, within which objections may arise. The point is that the amount of sales and demand, for example, may be affected by the planned marketing activities in individual companies. Particularly important is, for example, information on the planned application of sales promotions. The final demand and sales are of course affected most by the tactical and operational marketing management of the retail as the last link in the chain, but the purchasing may be affected also be another link in the chain. A set and agreed sales forecast by individual items is the basis for planning the material flow through the chain.

2.2 Collaborative Planning in the Supply Chain

Suppose that the sales forecast for the end product is determined according to individual retailers, by individual items and by individual weeks. At the chain indicated, the actual product is not differentiated; the individual items differ in the size of packages (fertilizers, detergents). The wholesale should therefore in accordance with the sales forecasts just before the start of a particular week supply individual retails with a sufficient quantity by individual items, and supply itself for the given period. To do this, it needs well in advance (which will allow distribution to retail stores) to receive from the manufacturer the demanded volumes of the product according to individual items. The moment of delivery of products to retail outlets is the deadline on which the manufacturer must deliver products in a desired range and quantity. If one subtracts the time to transport the product to the wholesaler, the manufacturer of the end product gets an indication of the necessary time of shipment. This is the last possible moment when the correct amount of products should be in the manufacturer's shipping warehouse by individual items. The time of shipment is critical for planning the production volume of Supplier C. The volume of production must be ensured by a smooth flow of material production and shipping. It is actually about planning the overall use of the production equipment (capacity utilization) in a given period (week). The production volume of Manufacturer C determines the material flow from the supplying companies. If one could realize deliveries from Supplier B
and A by pipeline, one would need only to align the volume of material passing through the pipeline with the necessary input size (spraying) of the raw materials to the manufacturing equipment with Supplier C. If productions are not interconnected by the pipeline, it is necessary supply Manufacturer C with the raw material in certain quanta so that the raw material enters its production facilities continuously in accordance with the planned performance of the production facility (which reflects the demand and sales forecast for the period). In the case indicated, the situation is slightly more complicated in that Supplier A supplies both Supplier B (and thus indirectly Manufacturer C) and directly Supplier C. This situation occurs, for example, in the production of fertilizers (ammonium saltpetre). The input into production is then both nitric acid and ammonia, while nitric acid is also produced from ammonia. In this case, the volume of the Manufacturer A production is determined concurrently by the performance of the two downstream manufacturing facilities in the following week (and by Manufacturer C production performance in the following week). To maintain a smooth flow of material throughout the whole chain, it is important that deliveries of the primary input are fully synchronized with the planned volume of Manufacturer A [9].

If demand and sales are forecasted and planned according to particular weeks, so must the tactical and operational plans in the production chain be developed according to particular weeks. The process of planning the production in a given period (week) is influenced by when you need to ship the first consignment to the dealer (wholesale). If a wholesale replenishes retailers just before the start of the given week, e.g. Sunday 8 am, the manufacturer of the end product (Supplier C) must deliver products by this time at latest to the wholesale according to individual items. In planning production, one must first subtract the time needed to transport the product from one's own business to the wholesale and gain the time of the expedition. Suppose that transport will always require 8 hours. Dispatch from Manufacturer C's company must take place on Saturday at 12 pm. To produce the required amount of the product, the manufacturer has the time until the last shipment, i.e. from the previous Saturday at 12 pm. Thus is determined the potential number of hours for production while time lags need to be simultaneously considered due to scheduled maintenance of the production equipment. Based on the findings of the planned number of hours for production, the required hourly production performance is set for the manufacturing facility. Subsequently, Manufacturer C's requirement arises to supply the material inputs from Suppliers B and A. The requirement is based on the standard raw material consumption per unit of production and planned production volume. If the production facilities in the chain are not interconnected by the pipeline, it is again necessary to determine the time required to transport and use it as a basis for the planned number of hours for production and hence the required size of the hourly output of the manufacturing equipment of both the Manufacturer B and C. In the joint planning in the indicated chain, it must be considered that Manufacturer A must meet the immediate demands of the two customers, with the requirement of Manufacturer B being influenced by the need of Manufacturer C in the week that follows after the one being considered.

In the described system of joint planning, simplification is made consisting in the fact that a change in inventory was not considered when entering and exiting the individual companies. However, it would not be a big problem to adjust the calculation by adding (or subtracting) the necessary changes in inventories. This correction in the calculation could be made even if the individual companies supplied other customers as well. In this case, the change in inventories would reflect the demands of other consumers who are not part of the chain.

2.3 Setting the Replenishment Mechanism

To secure smooth material flow throughout the chain, it is not enough merely to conduct a joint forecasting and planning, but the companies in the chain must work together to prepare a mechanism by which the individual items of inventory to customers are replenished according to the current requirements of customers. Concluded among the links of the chain, general (preliminary) agreements may be used for an agreement on the mechanism of replenishment. Therein, issues are to be arranged such as the appearance
of the product, the price (or method to determine it in the future), payment terms, etc. and also everything necessary for replenishment. It is necessary to set [9]:

- Mechanism for sharing information on current customer requirements and at least also on those of a direct costumer (in particular the way and the interval of information transmission).
- The mechanism for the replenishment management and control variables determining the time and/or size of the delivery. Deliveries can be either periodic (fixed-time-period with variable sizes of the delivery) or continuous (fixed-order-quantity in irregular periods). The first option offers the advantage that one can be better prepared both for the expedition (at the supplier side) and for receiving the delivery and stocking in the customer enterprise. Nevertheless, it brings a higher risk out of stock. The advantage of the other variant is a lower risk, but it requires greater flexibility in organizing expeditions and reception of deliveries. In some cases, it might be necessary to dispatch a delivery and/or to accept in a most inopportune moment (e.g. Sunday at 3 am).
- Division of activities and mutual responsibility at replenishment. It must be quite clear who is to set the reference variables and how, how the ordering process is carried out and how the other partner will participate in the decision-making on the delivery or check supplies which are within the responsibility of the other partner.
- Other matters arising from applying the CPFR method, such as a treatment of security of transferring and sharing of information and the penalties for errors that lead to economic losses.

The system of joint forecasting and planning as well as setting of the mechanism for the replenishment is the preparation of individual links in the chain to meet current needs of end customers. The material flow throughout the chain must, however, be in close accordance with actual requirements of customers. Suppose that automatic replenishment will be implemented in our chain by the suppliers to the customers. The suppliers therefore need to systematically gather information about current requirements of end customers as well as plans for demands (or production plans) of their customers, as well as information about the current stock of items for the replenishment of which they are responsible. They also need information about the set maximum and/or minimum stock levels, unless they bear responsibility for this activity. In such case, they set these limits and inform the business partner about them (he/she may cooperate with them in this activity or confirm the proposed limits).

2.4 Method of Flexible Streamlining of the Material Flow throughout the Chain in accordance with Current Requirements of End Customers

Real market information shared among all partners in the chain help to update jointly developed operational plans. Let us consider a situation that the current requirements of the customers of the chain are higher than expected. Quick response is needed not only by the wholesale, but also by the whole chain. If a system is applied in the chain for the periodic replenishment in regular delivery dates (fixed-time-period system), a higher demand arises in the next term for product delivery. The manufacturer of the end product, however, monitors developments in the wholesale sales (where they collect also data from retailers, assort and assemble them for future use) while being informed about increased demands of the end customers. He/she expects higher demand for supplies from the wholesaler (who subsequently satisfies the requirements of individual retailers). Therefore, he/she immediately adjusts the production schedule and increase production capacities in order to satisfy the current wholesale demand at the time of distribution. A response by Manufacturer C and the subsequent increase in his/her production would be possible only while safety stock lasts, if not directly supported by his/her suppliers. It is therefore necessary for his/her suppliers to respond to the higher sales as well as. That is possible due to information received about the (increased) requirements of end users and information about modification of the operational production plan of the Manufacturer C.

Manufacturer B may also increase production output, if he/she expects no changes in purchases from other customers, or choose not to increase it and operatively resolve meeting the increased demand by Manufacturer C at the expense of other customers (if they have less value for him/her). Anyway, it is
necessary for Manufacturer A to immediately obtain information on how the situation is solved by Manufacturer B as well as Manufacturer C. He/she obtains it the modified production plans provided. Immediately he/she adjusts his/her production plans, so he/she should also be capable of flexible response in meeting the needs of his/her customers. Of course, he/she should immediately report the changes also to his/her supplier (who expects it as a result of sharing market information). The given system should not get into any significant trouble, not even at a higher deviation of actual requirements from those planned, i.e. not even if the increase in end-customers\’demands is so large that it is not possible to wait with replenishing for the scheduled delivery time. As the following productions are immediately informed of the need for higher production volume, the delivery could be carried out in an earlier date. The replenishment system will work with both the variable term of replenishment and variable size of the supply. However, this requires establishing both upper and lower order levels. Of course, we suppose that the necessary increase will be allowed by production capacities of individual suppliers. If an opposite measure was necessary, i.e. reduction in deliveries to outlets and, as a result, in the production performance of the chain, it would mean reducing the performance of individual production facilities, again in a synchronized manner. In this case, it is necessary to determine the percentage of utilization of the performance of each production facility in the chain for the given period. Theoretically, it is possible to respond to the change by stopping the production process. However, this does not seem very realistic, taking into account the type of the production system. Renewal of continuous production processes requires investment of high costs and a considerable amount of the time required. Since the commissioning of a continuous production process may take several days, flexibility of individual links and the chain would be greatly compromised.

3. SUMMARY AND CONCLUSION

In the system of supply chain management based on the CPFR method, the stock is replaced with information. The faster and more accurate the information is, the easier it is to balance the material flow throughout the chain with the consumption by end customers. Nevertheless, the information must also be directly or indirectly shared with other processes that support the main material flow throughout the chain (especially securing the production with energy, maintenance, packaging, transport, etc.) to constitute its effective support. If one succeeds to build such a system of cooperation based on principles of the CPFR method, it could lead to gaining a significant competitive advantage and improvement in the performance of enterprises of the chain and the supply chain as a whole.

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