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COLLABORATIVE PLANNING IN THE SYSTEM OF SUPPLY CHAIN MANAGEMENT BASED ON THE CPFR METHOD

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Abstract: The current dynamics of the market environment intensifies efforts to create value networks intended to enable collaboration among partners in meeting the requirements of the end customer. An important area of the cooperation in the value chain is the collaboration to synchronize the material flow through the chain in accordance with the requirements of end customers based on methods such as Quick Response or CPFR. These methods are focused on integration of processes of forecasting and planning as well as replenishment of stocks to individual links of the chain. Their application, however, requires adjusting in principle general recommendations to the specifics of a particular chain. These specifics are determined especially by the types of production systems that are part of the chain. The article describes a specific method of coherent planning in a chosen type of the value chain operating on the basis of the above-mentioned methods.

1 INTRODUCTION

Already Porter [1] stated that obtaining and maintaining the company's competitive advantage increasingly depends on knowledge, understanding and creating a functional and efficient system of delivering value to end customers. This system consists of the company's value chains, its suppliers, distributors, immediate customers and downstream clients of these customers, because they all contribute to delivering value to end customers. Value chains of individual subjects represent different transaction cycles, among which the change of values takes place. The differences between the value chains of the organizations are a key source of competitive advantage.

These principles of Porter were gradually developed, until recently the prevailing view is that an increasingly important role in creating competitive advantage for any company is its ability to link the value chains of all its direct and indirect partners, participating in varying degrees and in different ways in detecting, creating, delivering and improving value for not only the immediate customers, but also for clients of these customers to the final consumers or users [2]. It requires the enterprise to create and constantly improve the functioning of the so called value network. This value network includes not only relationships with entities traditionally included in the supply chain, but also the relationships with entities such as university researchers or, for example, the government's control authorities, which means with all partners who can contribute in any way to increase value for end clients and consumers and to increase the efficiency and effectiveness of its provision. It brought a more complex concept of the value management where the traditional supply chain management is developed into a comprehensively conceived value chain management or even value network management [2,3].

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2 OPPORTUNITIES OF COOPERATION IN VALUE CHAINS

The concept of value chain management or, in the past two years, the value network management stresses the need to focus not only on coordination and synchronization of the material flow, but also coordination and synchronization of the strategic marketing analysis, product and technology research and development, communication and provision of various services to end customers across the value network. This requires a parallel involvement of a range of partners, who are involved in all these other activities that contribute to increasing value for customers. It means the interconnection and cooperation of all those entities participating in creating, delivering and improving value for customers. In this value network, there are both entities directly connected in the logistics chain, but also other entities parallelly connected to them to facilitate strategic marketing analysis, communication and provision of various services to customers and even to other partners in the value network. Importantly, the sense of connection and cooperation between all these entities of the value network should be as-perfect-as-possible and, at the same time, effective satisfying of the needs and requirements of end customers. A great benefit of their interconnection and cooperation is the integration of activities and the possibility to use synergy effects, which leads to increasing the effectiveness of processes taking place in the network. These tendencies can be compared to an enterprise involving all stakeholders in value-making activities and bringing them into accord in "an orchestra" that will subsequently deliver to a higher value to the target market than any competitive value network is able to offer [4].

Kannegiesser [2] emphasizes the need for integration of value, demand and offer decisions in the value network from strategic marketing analysis, actual product and technology research and development, proposals for setting up a production and distribution system, pre-sales consulting to sales and after-sales customer service. In doing so, the point is to introduce and develop cooperation among entities, value networks using optimization and simulation methods. The key point is to integrate decision making at all levels of the company's value network with a clear definition of the bounds and limits of the suppliers, customers and other partners. That is the only way to establish an efficient and effective value management within the network. In doing so, it is necessary to solve two questions:

- How can volumes and values within the value network be managed in the integrated way?
- Specifically, how can a global commodity value chain within the special product category be planned by values an volumes?

3 COOPERATION IN MANAGING THE MATERIAL FLOW

One of the most important areas of cooperation in the value network is common or at least mutually coordinated management of the material flow throughout the value network. Individual activities related to the providing of value for end users must continuously follow up on each other. This implies in particular linking of business logistics systems into the supply chain. The material flow management by this supply-chain then has to be not only with the maximum focus on the needs and requirements of the end users, but it is also influenced in particular by the form of production systems of individual companies that make up the chain. Managing the material flow through the chain is not only about whether the individual processes are of chemical-technological or mechanical-technological nature, but also about whether these are discontinuous processes (and batch production) or continuous (and mass). In both cases, the material flow must be synchronized, but the ways to do this will vary. The question is therefore how to conduct collaborative planning in different types of production systems as individual components of the chain, or more precisely the network since "despite many pilot scheme, the wide scale implementation of collaborative planning has not happened" [5]. When designing the method of coherent planning in the chain (network) with continuous production systems (i.e. systems of continuous production, which typically produce only one product, bought by one or more customers) one should come from general principles of collaborative planning in the chain, or more precisely the network.

3.1 The principles and basis for collaborative planning in the chain

Since the early 1990s, there has been a growing understanding that supply chain (resp. network) management should be built around the integration of trading partners [6]. There is a need to collaborate between supply chain members and share accurate and timely information with both upstream and downstream supply chain partners. This, in turn, creates visibility and offers possibilities to synchronize supply chain planning activities, which will reduce uncertainty, bullwhip effects, inventory, etc. [6]. Number of authors suggests that in order to achieve “a synchronized more responsive supply chain “organization must collaborate on “planning and execution” [7]. Collaborative planning is a concept that seek for the first time to balance supply with demand through demand driven process [8].

According to Rudberg [6] five collaborative processes have been identified:

1. demand planning;
2. supply planning;
3. promotion planning;
4. transportation planning; and
5. product development.

Demand planning represents a set of procedures and information technologies for exploitation of demand forecasting in planning process [9]. Both demand planning and demand forecasting aim to predict demand patterns for goods and services. The activities from these processes have been merged into one, collaborative demand planning [6].

Collaborative supply planning is the process that has to ensure that the demand plan can be fulfilled. The purpose of supply planning is thus to determine the production and purchasing requirements in order to meet the demand plan [6,10]. The enterprise to create adaptability and agility in collaboration in material and capacity planning in order to give availability to promise to customers [11].

Most likely the collaborative demand and supply planning processes will be iterative, due to constraints and changing demand patterns within the supply chain [6]. According to Rudberg [6] supply chain planning is possible to divide into two parts:

1. supply chain planning (SCP); and
2. supply chain execution (SCE).

The major distinction between the two areas is the planning horizon, the former being more strategic and tactical, whereas the latter being more tactical and operational. Furthermore, SCP focuses on getting ready for a job, while SCE focus on getting a job done [6] .

Collaborative planning is important at a tactical level between retailers, manufacturers and their suppliers, however, it must also be integrated with both firm’s operational and strategic activities in order to be truly effective in term of fulfilling demand and maintaining senior management support [7].

The forecasting and planning process in supply chain is often called sales and operations planning. There are two kinds of collaborative activities:

1. sharing resources; and
2. collaborative process operation.

Sharing resources is to share standardized information (e.g., forecast, shipment, inventory, production, and purchasing data) and customized information (e.g., factors of demand fluctuation, and operational resources and constraints). Collaborative process operation is to connect forecast and plan based on a schedule established in advance and to reexamine activities to adjust deviations from forecast and plan when contingencies arise [12].

For full benefits of collaborative planning and integration of the supply chain to be realized, organizations must ensure that internal integration, i.e. with marketing and production function is in place [7]. If a manufacturer shares resources among departments and operates the forecasting and planning process collaboratively, the manufacturer can provide accurate forecasts and plans to suppliers and channel partners, and jointly operate the forecasting and planning processes with them [12].

Similarly, through a high degree of external resources sharing and operational coordination, the manufacturer can operate the forecasting and planning process using accurate forecasts and plans [12]. Manufacturers need to improve internal and external forecasting and planning process simultaneously. Thus, we can expect that there will be a positive relationship between internal collaboration and external collaboration in the forecasting and planning process [12]. The integration both internally and externally with supply chain partners is heavily dependent on extensive information sharing and process alignment [7].

The collaborative supply planning structure shows great similarities with the collaborative demand planning structure. The same parties are likely to take part in the collaboration, e.g. a manufacturer performs demand planning with its retailer or distributor as well as the retailer or distributor performs supply planning with the manufacturer [6]. Planning on an inter-enterprise basis, rather than just intra-enterprise, requires the planning to be done jointly among many of the chain's trading partners, where suppliers' and customers' constraints are incorporated within the planning process.

In term of organization of whole planning 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 [13].

In the first model, each planning entity is responsible for developing plans for its own operations, but each plan incorporates relevant information, such as resource constraints, from other organizations. Thus, no single organization needs to have the authority to develop plans for the whole supply chain, but a harmonized set of synchronized and relatively consistent plans can be developed through collaboration [6] .

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 [13]. 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.

Two-stage planning process recommends Entrup [14] in process organization with many different machines of similar functions, multi-stage production processes and many lot sizes within the planning interval. A decomposition of the overall decision problem into two planning level is required to reduce the computational burden.

The two-stage planning process would therefore be suitable for discontinuous production processes where products are made in individual series. In planning these production systems, of the ultimate importance are both customer requirements for technical quality and volume of the product, as well as requirements for delivery time. When planning these production systems is important to adapt to individual customer requirements and implement their satisfaction with diversity of products delivered at the right time. In the two-stage planning process, plans will be synchronized in the first step throughout the chain, thereby creating challenges for individual production systems. In the second step then, in-house production plans are drawn up, respecting the specified production targets.

By contrast, when managing the supply chain, or the network, containing continuous, mass production processes it is necessary to focus in particular on securing the smoothness of the material through the company and the chain. According to Entrup [14] with regard to the smaller number of products in this type of production system, one single planning step is preferable.

The collaborative planning process (as one of the business processes) can involve various stakeholders. These collaboration partners inside the organizational boundaries include top management, middle management and employees, technical specialists. External partners in the process are lawmakers, customers, professional organizations, suppliers, distributers, software consultants and business process management consultants [15].

Collaboratively assembled or at least shared plans, reflecting the anticipated customer requirements, predetermine the material flow throughout the entire chain. This collaborative planning must then be followed up with agreements on a mechanism to supply individual customers in the chain. Thus the planning phase is completed and there follows the realization of the material flow, i.e. continuous (for instance, even automatic) replenishment. In essence, it is about implementing the individual steps recommended by the CPFR method (Collaborative Planning, Forecasting and Replenishment).

Finally it is necessary to add that not only sharing resources and collaborative process operation but also collaborative process improvement play a crucial role in gaining sustainable competitive advantage in logistics and production [12].

Based on these theoretical foundations, a collective procedure (single-stage) of the tactical and operational planning was designed for chains with continuous production systems. To illustrate, the procedure is demonstrated on the example of a selected supply chain, or precisely speaking a network.

3.2 Specification of a supply chain for demonstration of single-stage collaborative planning in the chain (or network)

To demonstrate the way of collaborative, one single step planning in chain (precisely speaking a network) let us consider a simplified example of supply chain composed of logistics chains of individual companies. The material flow in this chain can be indicated through Figure 1.

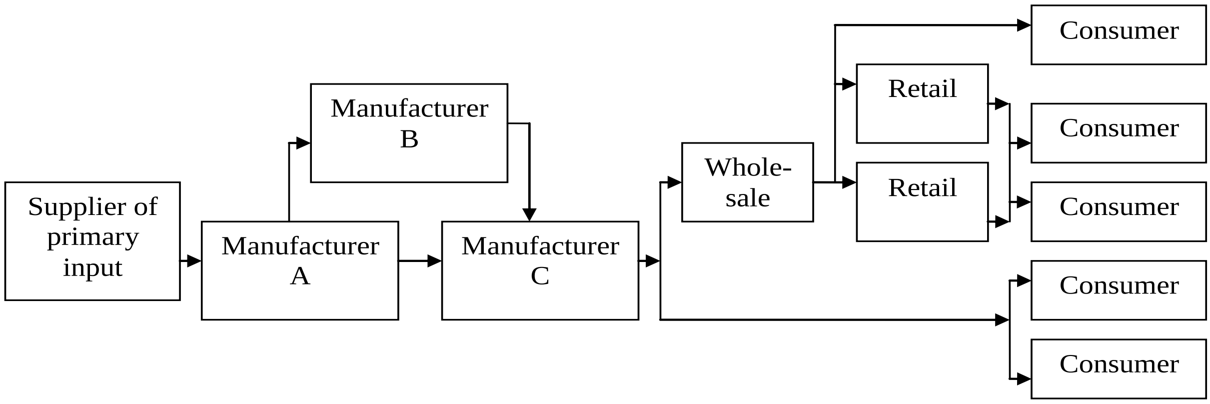

Figure 1: Example supply chain [16]

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 collaborative production planning, we consider a supply chain (network) 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 Manufacturers B and C. This product is a strategic material input for both customers. Manufacturer A's product is not delivered to other manufacturers. Manufacturer A processes the primary input into the chain [16].

3.3 Linked planning in the supply network based on application of the CPFR method

The first step should be to forecast demand and sales to the end users of the chain (network). 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 and to link forecasting the same way as planning process.

When planning the material flow, the first step needs to be choosing a time horizon for planning, which must be consistent with the time horizon for forecasting. The planning horizon differs between weeks and months with time buckets of days or weeks [14,17]. 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 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.

The forecast of the demand and sales is an important information input in the process of material flow planning, including production planning in the enterprises involved in the chain. 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. At the chain indicated, the actual product is not differentiated; the individual items differ in the size of packages (fertilizers, detergents). Suppose that the forecast sales for the next week is 1000 bags of nitrogenous fertilizer of the size of 5 kg (retail sales) and also 1000 bags of the size of 5 kg for sale at wholesale.

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 (to supply to retail outlets 1000 bags of the size of 5 kg), and supply itself for the given period (to keep 1000 bags of the size of 5 kg for sale at wholesale). 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 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 (200 bags of the size of 5 kg). This information determines the manufacturer C's way of production planning. 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 (10 000kg, i.e. 10 t), 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. For simplicity suppose, that maintenance of production equipment is not scheduled in this week. For production is available 168 hours in the week ((T^{plan}).

Based on the formula for calculating the production capacity in a continuous production, the required hourly output of the production facility is calculated:

$$Q^{plan} = T^{plan} * q_t^{plan} \,\big|/ year\big| \rightarrow q_t = \frac{Q}{T} = \frac{10000}{168} = 60 kg / hr. \qquad (1)$$

where

Q^{plan} is the planned capacity of the production facility (kg / week);

T^{plan} the number of hours planned for production in a given week (hours / week);

q_t^{plan} is the production facility output per hour (kg / hr.).

The production facility output in the given week will be 60 kg/hr. In the event that a stop for repairs was planned for the week, the calculation would be modified. This would reduce the available number of hours and the planned output per hour would have to be increased.

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).

Supplier A and B must supply raw material for the planned production facility output (i.e. for the output of 60 kg/hr.), and that is prior to commencement of production in the given week, i.e. no later than on Saturday at 12 pm. When calculating the required quantity of the supplied inputs, it is necessary to use information about the size of the raw material consumption S (kg) per unit of the manufactured product Q (kg). If the planned size of the consumption of the raw material supplied by the manufacturer B (HNO_3) for the product (nitrogenous fertilizer):

$$s_q^{plan} = \frac{S}{Q} \left[kg/kg \right] = 0{,}15 \qquad (2)$$

then the hourly need of the nitric acid in the production of the nitrogenous fertilizer is 9 kg. The planned weekly production of the nitrogenous fertilizer therefore requires 1,512 kg of HNO_3.

If the planned size of the consumption of the raw material (ammonia) supplied by the manufacturer A for the product (nitrogenous fertilizer),

$$s_q^{plan} = \frac{S}{Q} \left[kg/kg \right] = 0{,}10 \qquad (3)$$

then the hourly need of ammonia in the manufacture of nitrogenous fertilizer is 6 kg. The planned weekly production of nitrogenous fertilizer requires 1,008 kg of ammonia.

The moment of the expedition of these volumes of raw material from the manufacturer B's and A's company is determined by the time needed for transport. We assume that transportation of the raw material (nitric acid) from the manufacturer B takes 4 hours while transportation from the manufacturer A (ammonia) takes 6 hours. The desired number of necessary inputs for the production of the nitrogenous fertilizer must be shipped from the manufacturer B's company on Saturday at 8 pm, the expedition from the manufacturer A's company must take place on Saturday at 6 pm.

Both the productions (nitric acid and ammonia) are also planned for each week.

- Production at the supplier B (HNO_3) is planned from Saturday 8 pm to the following Saturday 8 pm (e.g. from Saturday January 30 at 8 pm till Saturday February 6 at 8 pm). During the week, for which the planning is performed, 1,512 kg of HNO_3 must be produced for the producer of the nitrogenous fertilizer and assume 5,000 kg of HNO_3 for other customers. The production is also continuous, no stops are planned. The planned number of hours for the production in the given week is 168 hours. The required output per hour of the production facility for the production of HNO_3:

$$q_t = \frac{Q}{T} = \frac{1512 + 5000}{168} = 38{,}8 kg/hr \qquad (4)$$

- Supplier A supplies both Supplier B (and thus indirectly Manufacturer C) and directly Supplier C. In this case, the volume of the Manufacturer A's production is determined concurrently by the performance of the two downstream manufacturing facilities in the following week (and by Manufacturer C's production performance in the following week). Therefore, when planning the production of ammonia for the week preceding the production of the nitrogenous fertilizer (i.e. from Saturday January 30 at 6 pm till Saturday February 6 at 6 pm) it should be considered that the weekly production of ammonia has to cover the production of the nitrogenous fertilizer and nitric acid in the following week (the HNO_3 production reflects the requirements of other customers and the assumption of production of the nitrogenous fertilizer in the following week, i.e. from February 14, 0 am till February 20, 12 pm).

To maintain the smooth flow of the material throughout the whole network we need to have fully synchronized deliveries of the primary input with the planned production volume of the manufacturer A. Therefore, once the production is scheduled with the manufacturer A (the producer of ammonia) in the week preceding the production of the nitrogenous fertilizer, the need can be calculated for the primary input (natural gas). That could be supplied to the supplier A's company through a pipeline. Thus the time needed for transport would drop out. It would only reconcile the amount in the pipeline with its need in the production of ammonia.

The described system of the collaborative planning is simplified. The planning was done only for the package of the size of 5 kg, sales through direct distribution channels from the company C are not included in the planning and no change in inventory was considered at the input and output of individual enterprises. However, sales of the product in different packaging can be simply added, and it is also possible to take into account the demand for a change in inventories (add or subtract the desired change in inventories). The change in inventories is then essentially a requirement by the actual company to manufacture the product. To better illustrate it, the process of the collaborative planning is captured in the following table (Table 1).

Table 1: Collaborative planning of material flows for the outlined supply network [18]

Date and Time	Planned Activities	Planned Quantity
14 February *8 am*	Expedition of products from the wholesale store to retailers	1,000 bags of 5 kg
14 February *0-8 am*	Transporting products from the nitrogenous fertilizer manufacturer's company to the wholesale store	2,000 bags of 5 kg
7 February *(0 am)* – 13 February *(12 pm)*	Production of the nitrogenous fertilizer	10,000 kg, i.e. 10 t
6 February *12 pm*	Delivery of material inputs into the production of nitrogenous fertilizer	1,008 kg ammonia 1,512 kg HNO_3
6 February *8-12* pm	Transportation of HNO_3 into the nitrogenous fertilizer manufacturer's company	1,512 kg HNO_3
6 February *6-12* pm	Transport of ammonia into the nitrogenous fertilizer manufacturer's company	1,008 kg ammonia
30 January *(8 pm)*- 6 February *(8 pm)*	Production of HNO_3 for the production of nitrogenous fertilizer and other company's customers	5,000+1,512 kg = 6,512 kg
30 January *(6 pm)* – 6 February *(6 pm)*	Production of ammonia for the production of the nitrogenous fertilizer in the following week and production of ammonia for the production of HNO_3 in the following week (the need of which is determined from the nitrogenous fertilizer production in the week from 14 February to 20 February and from requirements of other customers)	1,008 kg + quantity for the production of HNO_3 according to the predicted nitrogenous fertilizer sales in the week from 14 February to 20 February and the requirements of other customers
6 February *6-8 pm*	Transport of ammonia into the HNO_3 manufacturer's company	quantity for the production of HNO_3 according to the predicted nitrogenous fertilizer sales in the week from 14 February to 20 February and the requirements of other customers
30 January *6 pm*	Commencement of natural gas consumption from the pipeline as an input to the production facility for the production of ammonia	in the amount equivalent to the production of ammonia

By determinating the collaborative planning in the material flow area, the companies acquire information inputs into other business plans (which may also be collectively developed and coordinated with the plans of suppliers and customers). Following the material flow plan, more tactical operational plans are drawn up, for example by individual functional areas. The resulting tactical operational plan allows preparing the entire chain and its individual members for the anticipated requirements of customers. These plans must, however, be flexibly adjusted and concretized according to the evolving current requirements of the chain customers. This allows the supply of individual enterprises in accordance with current requirements of customers.

4 CONCLUSIONS

One way to gain a competitive advantage for any company is its ability to connect all the value chains of its partners and create the value to the customers through the value network created. This implies a parallel connection of a number of partners involved in increasing the value for the customers. The application of this idea to the area of the material flow management through the chain resp. netrwork requires interrelated manufacturing, or rather logistics plans (plans for sales, production and purchasing), which are the basis for the smooth movement of raw materials and products throughout the chain (or network). The method of preparation of these linked plans depends on the form of the production systems that are part of the chain (or network). If the chain contains continuous production systems, it is necessary to apply the one-stage planning process. The planning must be carried back against the flow of material. Using:

- capacity standards (defining the required output of individual production facilities) and
- consumption standards of materials and raw materials (determining the desired level of consumption of particular raw materials per unit of the product produced)

it is necessary to plan progressively the output of the preceding production levels.

In the event that there are production systems of batch (and discontinuous) nature in the chain (network), the method of the collaborative planning of the material flow is different. How this planning should be executed is the subject of further research. However, it is obvious that a collaborative planning in such a chain (or network) will be much more difficult and a two-stage planning process must be applied. However, if the businesses manage to apply the integrated planning of the material flow, they can take advantage of the synergistic effects, resulting in increasing the efficiency of the processes taking place in the chain or the network, as the case may be.

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