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EXAMINING THE EFFICIENCY OF SUPPLY CHAINS

GÁBOR NAGY[1]–ÁGOTA BÁNYAI TÓTH[2]–BÉLA ILLÉS[3]

Abstract: By increasing international competition, manufacturing companies are looking for suppliers who can deliver high-quality raw materials at low cost. The increasingly intense competition, companies are able to maintain their market position in the long term, which recognize the importance of cooperation between members of the supply chain. The paper examines how to increase the competitiveness of automotive manufacturing companies through network-based operation.
Keywords: supply chain, logistics, Industry 4.0

1. INTRODUCTION

Nowadays, the intensification of international competition and the shortening of the life cycle of products have a significant impact on the operation of automotive companies, during which the basic goal is to satisfy customer needs at a higher quality level and at a lower price. Companies that recognize the interdependence between their customers and their suppliers and that can work with their suppliers and customers to meet consumer needs can emerge victorious from the increasing competition in the market [1].

In the last few years, due to the complexity of the supply chain, the term supply network has been used by professionals, as members of the chain have to build a complex network of activities to produce a product. Accordingly, the supply chain is the process chain along which the product travels from the supplier to the final consumer. Processes transcend company boundaries with the goal of enhancing the performance of the entire chain [2]. Supply chain design is becoming increasingly important in the operation of production and service processes, as logistics costs account for a significant portion of the price of products and services, and one of the most important means of increasing cost efficiency is to design an optimally functioning supply chain.

2. INCREASE EFFICIENCY THROUGH COLLABORATION BETWEEN CHAIN MEMBERS

The need to organize supply chains is justified by the growing economic role of stocks. In recent years, there has been an increasing trend in the automotive industry to shorten the life cycle of products and develop technical inventories, but inventory is a significant expense for the company. The benefits of inventory can be reaped while minimizing the disadvantages that companies face in maintaining optimal inventory levels. A supply chain approach has a number of benefits through cross-company partnerships: inventory

[1] research assistant, Institute of Logistics, University of Miskolc, Hungary
altnagy@uni-miskolc.hu
[2] PhD., University of Miskolc, Hungary
altagota@uni-miskolc.hu
[3] univ. professor, University of Miskolc, Hungary
altilles@uni-miskolc.hu

reduction along the entire supply chain; higher standard of customer service; better quality and common goals between chain members.

Based on the above, it can be concluded that if all chain members have the same goals, the supply chain operates cost-effectively. There have been a number of changes in the economy in recent decades that have enhanced the role of collaborations. The competitiveness of the supply chain depends on how members of the chain are able to resolve their conflicts of interest. If partners can work together successfully in the long run, chain members can reap significant economic benefits that can result in lower inventory levels, shorter lead times, lower procurement costs, and faster customer satisfaction. Through these benefits, supply chain members can secure a long-term competitive advantage in the automotive industry.

Effective supply chains can only be imagined in a strategic alliance. We distinguish three types of strategic corporate collaborations [3]: horizontal alliance, vertical alliance, and diagonal alliance. A horizontal alliance is a strategic collaboration between competitors in the same sector of activity. Such an agreement most often concerns pre-production research and development or the placing on the market of the finished product. The significance of a vertical alliance is that non-competing companies enter into a long-term alliance with a supplier-buyer relationship.

Among the motivating factors for forming an alliance is that cooperation can reduce the problems caused by a lack of information. A characteristic of a diagonal alliance is that companies belonging to different sectors of activity form such a strategic alliance between which there is no supplier-buyer relationship. The strategic alliance between customers and suppliers is an increasingly observable trend. The advantage of a supplier-customer partnership is information sharing, which helps the supplier plan efficiently. Creating a strategic alliance also has common benefits, as unnecessary order items can be avoided, manual tasks can be automated, and unnecessary control steps can be eliminated from the process.

3. SUPPLY CHAIN DESIGN

In the following, the supply chain design concept is described through an example. In the course of the analysis, in this example, the process stages spanning two companies are the subject of our study. During the planning process, the task is to create an optimal supply system between the two members of the supply chain, the production company producing the finished product and the direct supplier. In this task, we present the design of the supply chain of a production company performing a manufacturing activity that can be traced back to a mixing problem. The mixing task encompasses a range of operations research tasks in which the task is to produce an appropriate mixing ratio for the components of products to be produced with mixing technology to meet a predefined customer demand while respecting the quality limits of the finished products. Many variants of mixing tasks are known, the typical areas of application are: development of production technology in chemical and petrochemical plants using single and multi-level mixing technologies [4]; determining the optimal food composition taking into account different dietary considerations; optimal design of fertilizers and dried fodder to achieve optimal composition; determining the optimal proportion of raw materials for products made from recyclable materials.

Mixing tasks can also be classified according to how complex the formulation of the task is. In the case of a simple mixing task, we consider the quality limits for each parameter of the finished product to be given and the quality parameters for each component as well as the purchase price of the components and the selling price of the finished product. The goal is to determine the optimal product composition while maximizing profits [5]. In the case of a complex mixing task, in addition to the parameters formulated in the simple mixing task, there is a restriction on the availability of components (quantitative limit), the demand for the finished product, the processing capacity of each component, and there are models in the literature that require the finished product. Depend on the success of their marketing activities [6]. There are a small number of complex mixing tasks in the literature that take into account, in addition to the technological parameters, other costs related to the operation of the supply chain related to the technology. Such costs may include the costs of logistics operations related to the procurement of components and the production of the finished product (loading, transport, storage and packaging).

In the following, we present a model in which we provide an approach to solving the mixing problem that goes beyond the technological problem and takes into account the logistics costs.

The production company produces several finished products (T_i). The finished products can be prepared by arbitrarily mixing different raw materials (A_j). The parameters describing the quality of the raw materials (P_k) are considered to be known, and the quality parameter limits (lower and upper parameter values) are given for each finished product. The task is to determine the optimal mixing ratio, i.e. the procurement portfolio that ensures the maximum return. The automotive supply chain model describing the design task is illustrated in Figure 1.

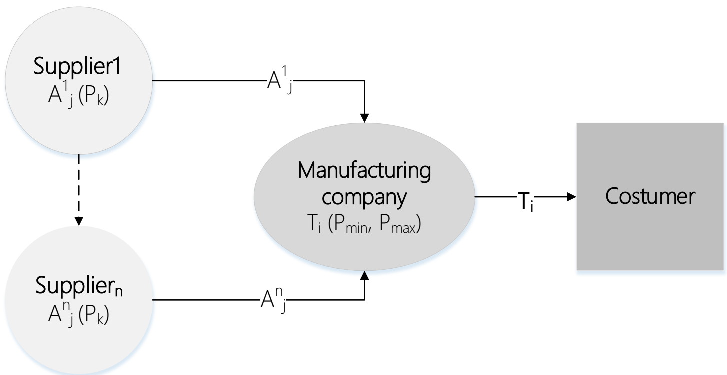

Figure1. Supply chain of a company based on blending technology (own editing)

In the planning of the supply chain, it is our duty to determine the quantity of raw material to be produced by the producing company for the finished product. So, the goal is to specify x_{ij}, which the producing company uses the quantity of j-th raw material for the i-th finished product:

- v_i – the daily quantity in units of mass to be produced from the i-th finished product,
- a_i – the specific sales price of the i-th finished product,
- b_j – the specific purchase cost of the j-th raw material,

$\propto_{ip}^{min}$ – the minimum value of i-th finished product for p-th specific parameter,
$\propto_{ip}^{max}$ – the maximum value of i-finished product for p-th specific parameter,
$\propto_{jp}$ – the value of the j-th raw material for p-th specific parameter

The specific purchase cost of the raw material includes not only the purchase price of the raw material, but also the logistics costs incurred in the delivery, which includes loading, storage and transport costs.

When solving this problem, we must consider that the producing company must produce the finished products in quantity and quality ordered by the buyer. The quantitative requirement criterion:

$$\sum_j x_{ij} = v_i \tag{1}$$

$$x_{ij} \geq 0 \quad and \quad v_i \geq 0 \tag{2}$$

Condition for the qualification of finished products:

$$\propto_{ip}^{min} \leq \frac{\sum_j x_{ij} \cdot \alpha_{jp}}{\sum_j x_{ij}} \leq \alpha_{ip}^{max} \tag{3}$$

During the design, we must consider the supplier's limitation that the supplier may produce a limited quantity of the individual raw materials under the conditions prescribed by the buyer. The restriction can be described as follows:

$$0 \leq \sum_i x_{ij} \leq x_j^{max} \tag{4}$$

In designing the supply chain, we aim to minimize purchasing costs and thus maximize profits. The supply chain approach described in the study naturally requires that the supplier has accurate sales data for the finished product so that the stocks can be kept at minimum levels on the chain members. This means that the supplier only implements the raw material required by the producing company and does not stock an excess amount. Based on these, the target function can be written as follows:

$$\sum_i \left(v_i \cdot a_i - \sum_j x_{ij} \cdot b_j \right) \to max. \tag{5}$$

Considering the stated conditions and limitations, the task can be solved and determined by the objective function, and the optimal order quantity per raw material can be determined.

4. DIGITAL SUPPLY NETWORK

The example described above showed only a small slice of the actual operation of the system, in reality these processes are much more detailed and go hand in hand on several levels. The technological tools provided by the 4th Industrial Revolution provide an opportunity to ensure the efficiency and adaptability of global supply chains to customer needs. The diversity of customer needs, changing demand, encourages global networks to try to improve their position with the capabilities of technology to avoid high inventory. The emerging new concept is called Digital Supply Network (DNS), a customer-centric model capable of collecting, processing, and evaluating large amounts of real-time data from a variety of sources [7]. Transforming a traditional supply chain model into a digital supply network is a very complex and lengthy task in which an accurate understanding of partners ’processes and data exchange is essential. It is important to mention that the basic condition of the new concept is that production will not be driven by production efficiency, but by the expectations and needs of customers. Today, the Industry 4.0 concept is being built, developed or even used in many segments of the industry. It is safe to say that Industry 4.0 cannot exist without Supply Chain 4.0, and companies need to rethink the way they transform their supply chains as soon as possible. The three main criteria for the supply chain of the future are speed, flexibility and the existence of communication technologies. Speed as a criterion for creating digitized processes will take place at ever-increasing speeds due to which delivery times will also be reduced. It also speeds up decision-making processes by evaluating the large amount of real-time data available to make increasingly accurate predictions [8]. Approached from a flexibility perspective, Supply Chain 4.0 allows companies to use the supply chain as a service, freeing up significant resources. With the help of the possibilities provided by communication technologies, a platform can be created where everything is available to the partners involved in processes, and even the same information can be found in an authenticated form for all participants [9].

Digitization in the logistics segment will only intensify in the coming years, exacerbated by the pandemic. During a pandemic, the importance of this technology transformation in terms of material and information flow is confirmed.

Characteristics of DSN network capabilities (Figure 2, 3) [7]:

- Digital Development: This capability uses technology to conceptualize, design, and integrate products into production, ensuring multifunctional collaboration throughout the product lifecycle and improving design efficiency to develop high-quality products that meet unique customer needs.
- Synchronized Planning: This capability aligns strategic business goals with financial goals and operational plans for various business functions. This layout helps to efficiently calculate customer needs and optimize inventory across the entire DSN.
- Intelligent Supply: This capability helps companies work more effectively with their strategic partners and improve customer and supplier satisfaction by using advanced electronic platforms for ordering and invoicing.
- Factory of the future: This capability uses a calculated balance of human and machine intelligence to improve business performance and employee safety based on production and demand data.
- Dynamic Fulfillement: This combined, multi-company capability delivers the right product to the right customer at the right time, enhancing the overall customer experience. It uses technologies such as Internet of Things and robotics to provide real-time visibility and flexibility throughout the supply chain, facilitating multifunctional collaboration and improving responsiveness.
- Connected Customer and Aftermarket: This capability allows companies to move from a traditional transaction-based relationship to seamless customer engagement throughout the customer lifecycle.

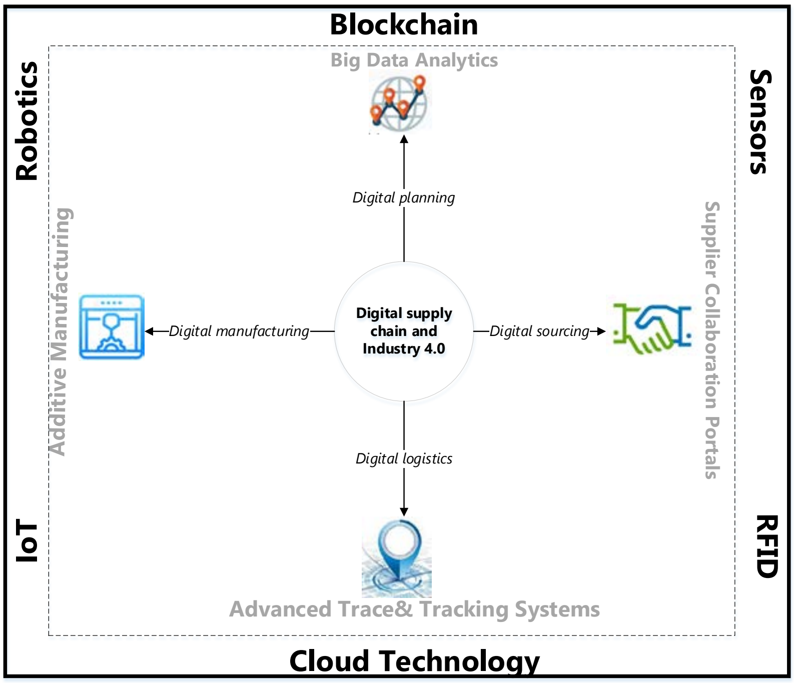

Figure 2. Digital supply chain model structure (own editing based on [10])

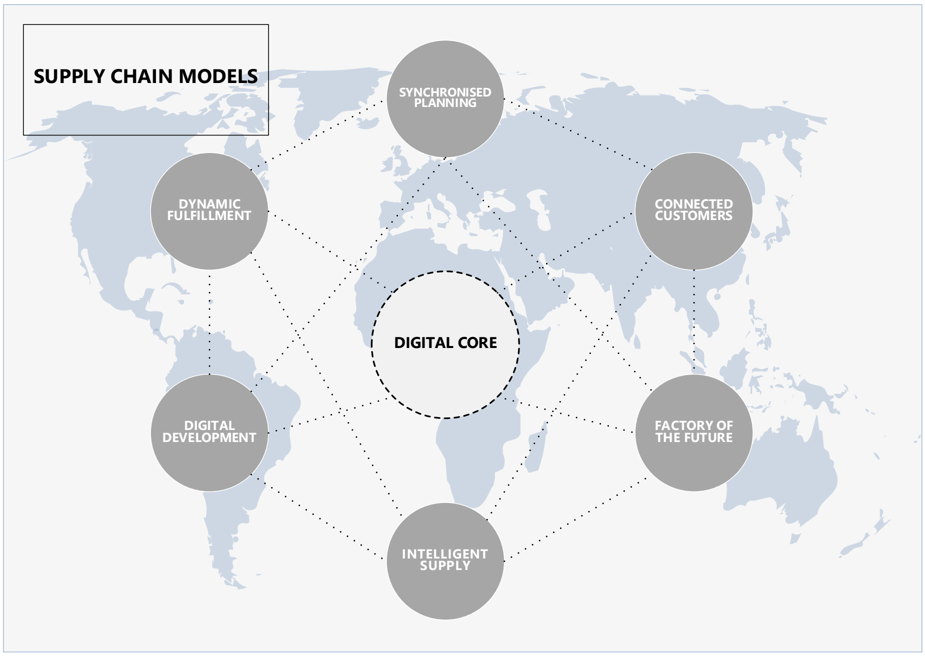

Figure 3. Building blocks of digital supply chains (own editing based on [7])

5. SUMMARY

The role of procurement logistics has undergone significant changes in recent decades, mainly affecting the automotive industry. Procurement plays a strategic role in advanced corporate practice. Through the development of information processes, it is possible to create optimal supplier networks, through which procurement costs can be reduced, thereby increasing the efficiency of the procurement logistics process.

Based on the supply chain planning task examined in the paper, it can be stated that logistics costs must be taken into account when determining the procurement cost during the design of the supply chain. Based on the examined model, we can state that the optimal parameters of the mixing technology change when the supply chain costs are taken into account. From this it is important to conclude that in the case of manufacturing processes based on mixing technology, the optimal mixing ratio should not be determined solely by considering the quality parameters of the finished product, as component costs and input parameter constraints can significantly affect optimal system parameters.

REFERENCES

[1] Lummus, R. R. & Vokurka, R. J. (1999). Defining supply chain management: a historical perspective guidelines. *Industrial Management & Data Systems,* **99**(1), 11-17, https://doi.org/10.1108/02635579910243851

[2] Szegedi, Z. (2012). *Supply Chain Management (in Hungarian).* Kossuth Kiadó, Budapest

[3] Christensen, P. R. (2000). Challenges for Small Sub-Contractors in an Era of Global Supply Chain Restructuring. *In Vatne, E. & Taylor, M. (ed): The Networked Firm in a G W.*, Ashgate, Burlington, 67-92.

[4] Kolodziej, S. P., Grossmann, I. E., Furman, K. C. & Sawaya, N. W. (2013). A discretization-based approach for the optimization of the multiperiod blend scheduling problem, *Comput. Chem. Eng.* **53**, 122-142, https://doi.org/10.1016/j.compchemeng.2013.01.016

[5] Cignitti, S., Zhang, L. & Gani, R. (2015). Computer-aided framework for design of pure, mixed and blended products, *Comput. Aided Chem. Eng.*, **37**, 2093-2098, https://doi.org/10.1016/B978-0-444-63576-1.50043-1

[6] Anosov, A. A., Efitov, G. L. & Zusman, S. D. (2017). N-line gasoline blending optimization with in-flow blend quality analysis. *Automat. Rem. Contr.*, **78**(3), 515-524, https://doi.org/10.1134/S0005117917030110

[7] Bernardes, E., Sinha, A., Calderon, R. & Wuest, T. (2020). Digital Supply Networks transform the Future. *ISE Magazine,* **52**(5), 28-33.

[8] Sinha, A., Bernardes, E., Calderon, R. & Wuest, T. (2020). *Digital Supply Networks: Transform Your Supply Chain and Gain Competitive Advantage with Disruptive Technology and Reimagined Processes*, McGraw Hill, New York

[9] Nagy, G., Bányai, Á. & Illés, B. (2016). The improvement of the efficiency of purchasing by networking operation. *Advanced Logistic Systems: Theory and practice,* **10**(2), 79-90.

[10] Ivanov, D., Tsipoulanidis, A. & Schönberger, J. (2019). Digital Supply Chain, Smart Operations and Industry 4.0. *In Global Supply Chain and Operations Management*, 481-526, Springer, https://doi.org/10.1007/978-3-319-94313-8_16