Advanced Logistic Systems – Theory and Practice, Vol. 16, No. 2 (2022), pp. 24-36.
https://doi.org/10.32971/als.2022.010

THE ROLE OF DIGITALIZATION IN THE QUALITY ASSURANCE OF LOGISTICS NETWORKS

GÁBOR NAGY[1], ÁGOTA BÁNYAI[2], BÉLA ILLÉS[3], AKYLBEK UMETALIEV[4]

Abstract: Logistics, as one of the most integrated sciences, plays a key role in many segments of company operations. Nowadays, efficient, fast and reliable customer service is important, and to achieve this, companies have begun to operate in a networked manner. In addition to customer satisfaction, an important aspect in today's economic environment is finding the optimal point for each process, thus achieving a cost-effective operation strategy. With regard to the forms of operation, the network structure appeared, which changed the production structure taking place at one location to the multi-location operation. This form of operation has proven to be effective in serving the globalized system approach, but the system alone cannot be effective. It is very important to regulate, maintain, supervise and improve the processes for which quality assurance is responsible. The thesis presents the versions of the logistics network models, their characteristics and the technological solutions present today that can increase the level of quality. Furthermore, using a known method, we present a possible performance measurement procedure for logistics processes.

Keywords: logistics network, quality assurance, digitization, performance measurement

1. INTRODUCTION

Logistics networks, or supply chains as they are also called, is a dynamically developing, rapidly changing field, in the shaping of which, in addition to the events and economic processes taking place in our world, a large number of practical specialists and theoretical researchers take part. With the growth of civilization and the development of the technological environment, supply chains will become longer and more complicated, these conditions make it more difficult to monitor, measure and control the processes taking place in them. These extended-scale so-called global supply chains as a whole have significant committed capital and high inventory levels, thereby making the management, measurement and optimization of the system important at the global economic level as well. In order to be able to operate these chains effectively from the perspective of all interested parties, the issue of quality assurance plays a key role. Nowadays, the ongoing industrial revolution provides solutions that can support quality assurance to a large extent and raise it to an increasingly reliable level from both the service provider and the user side.

2. ESTABLISHING OF LOGISTICS NETWORKS

Before these possible solutions are explained and presented in the thesis, it is important to discuss the beginnings, that is, the initial phases of the formation of these networks. We can

[1] research assistant, Institute of Logistics, University of Miskolc, Hungary
altnagy@uni-miskolc.hu
[2] associate professor, University of Miskolc, Hungary
altagota@uni-miskolc.hu
[3] univ. professor, University of Miskolc, Hungary
altilles@uni-miskolc.hu
[4] univ. professor, Kyrgyz State Technical University, Kyrgyz Republic
akylbek.umetaliev@gmail.com

try to approach and define the supply chain as a concept from two directions, on the one hand, it means the exact description of the relationships, their appearance, the structure of the system, but on the other hand, it also means a kind of approach, and because of this, the evolution of the development process takes place on two separate planes. Parallel to the emergence of globalization, the geographical extent is also increasing, and as a result, company management is developing new tools and introducing new principles. The supply network management concept was mainly used in order to realize the benefits that can be achieved by combining the company's internal business processes, such as procurement, production, sales, and distribution [1, 2].

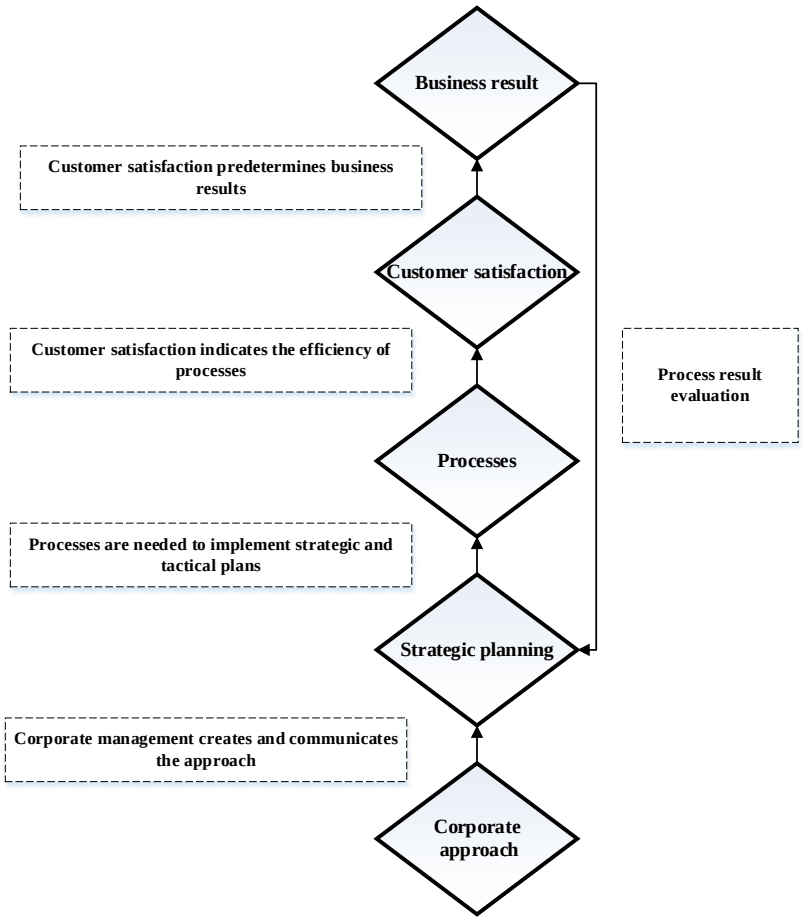

Figure 1. Strategic approach to a supply network (based on my own editing [4])

Initially, supply chains focused on processes within the organization, so primarily on the company's internal supply chain, and on how different functions can be integrated in order for the material flow to function smoothly. This approach to the supply chain is closely related to what [2] the company calls the value chain. The powers of this network organization were later expanded, extending beyond the organization itself, so that in

addition to the production company, the supplier and sales chain was also involved. This extension provided the philosophy of supply chain management with an inter-organizational rather than an intra-organizational focus [3]. As a result of globalization, today's supply tasks can only be handled in a network structure, because the level of service required by the consumer requires a high degree of quality assurance in the completion of each process. Logistics plays a strategic role in both corporate operations and supply chain management, and serious attention must be paid to it already at the planning stage. Figure 1 shows the strategic approach of the supply chain approach.

It can be seen from the figure that up to now the strategic approach has primarily determined the foundations of planning, and according to the principle, a good strategy is also a guarantee for a satisfied customer. However, based on the productive principle as "doing effective things, in an efficient way", it seems necessary to investigate at the tactical and operational levels as well, since problems and obstacles appearing at this level of supply chains can even frustrate the strategy. In the event that technologically it is not possible to solve the correct objectives "effectively", then the system is doomed to failure. That is why it is also important to quantitatively measure logistics performance in an operative, technological sense. This can even be called the quality assurance of logistics processes. The figure also shows a feedback branch, which is used to check the operational feasibility of the strategy.

3. FORMS OF APPEARANCE AND OPERATION METHODS OF LOGISTICS NETWORKS

In this chapter, the appearance and operation alternatives of logistics networks are described. The driving force behind network collaborations is the realization of the benefits that can be realized through cooperation. In order to achieve these opportunities, different organizational forms have emerged. There are many different forms of network cooperation, but the two most significant in the operation of small and medium-sized enterprises are vertical and horizontal networks. The difference between vertical and horizontal networks can be seen not only in their structure, but also in their operational characteristics. The purpose of creating vertical networks is joint collaborations, where cooperations are organized along the value chain. Among the cooperating members, only cooperative behavior can be observed, that is, there is no competitive behavior. In contrast to this, in the case of horizontal networks, competition appears between network members, and in other cases, cooperation in achieving a common goal. Therefore, these networks are more often referred to as "competition through cooperation", and it may often happen that the interests of the members do not coincide. The two different approaches determine the behavioral characteristics of network forms.

3.1. Vertical networks

Examining the structure of the vertical network, it can be stated that it consists of one or more large companies or organizations performing the integrator function, around which small and medium-sized enterprises are organized [5] (Figure 2). The most important task of this type of network is to unify the operation of independent small and medium-sized enterprises, which in many cases is realized on the occasion of some kind of market cooperation. The relationships are usually established, all actors are aware of the tasks they

have to perform, and mutual expectations are typically recorded in writing. In relation to vertical networks, the key to the success of cooperation depends mostly on the activities of the integrator. It is a general finding that with this form of cooperation, lasting mutual cooperation can only be imagined if each partner benefits during the process. Precisely for this reason, vertical networks are usually based on mature relationships; the partners often conclude network framework agreements for several years.

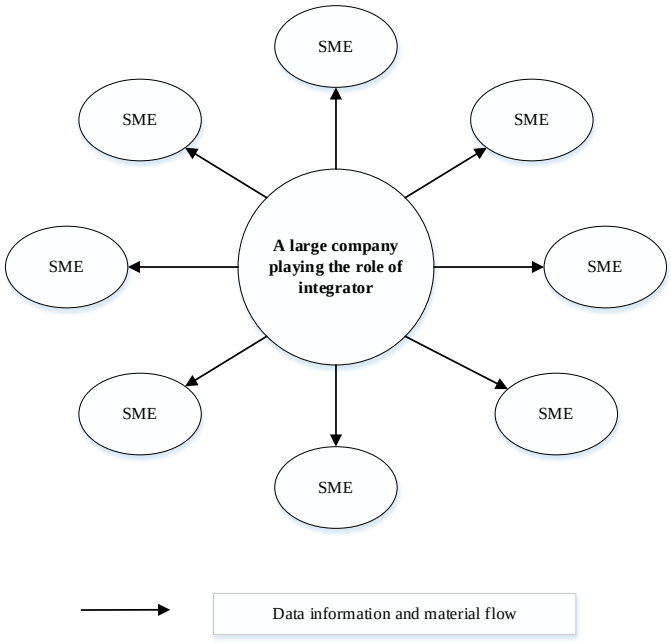

Figure 2. Structure of vertical networks (my own editing)

Its most typical appearance is the supplier network, in which the main focus is on the product flow, but in some cases, other side processes can also be observed. Small and medium-sized enterprises participating in this type of network can realize the following benefits from membership [6]:

- Networking offers the opportunity to enter the international market.
- Small and medium-sized enterprises come into contact with partners who encourage their development.
- A benchmarking learning process is provided.
- The success of businesses that already have supplier status encourages small and medium-sized businesses to develop and become suppliers.
- Financial intermediaries prefer to finance SMEs connected to larger enterprises
- In the relationship of vertical networks, several separable types of supplier relationships have emerged [7]. These are the following [7] (Figure 3):
  - In the case of "standardized" deliveries, suppliers only offer standardized products, individual needs are not taken into account, and if business relations are interrupted, there are no particularly significant consequences.

- In the case of "traditional" deliveries, the cooperation between the partners is already closer, and the relationships and tasks are more complex. The suppliers want to target the free capacities of potential customers with their flexibly changing offer. Exit costs are also low in this case.
- "Strategic" supplier relationships, on the other hand, show a strong interdependence, it is very common that the supplier has only one serious customer, which even transfers technology, or they carry out joint developments. As a result of the close ties, the exit costs are usually significant.

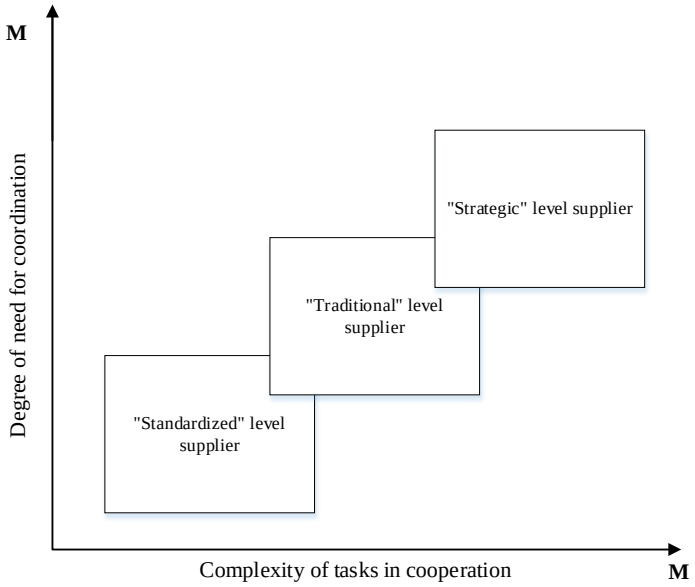

Figure 3. Levels of supplier networks

3.2. Horizontal networks

Another characteristic form of network cooperation is the horizontal network [5] (Figure 4). In this case, there is no integrator company, but small and medium-sized enterprises cooperate for some predefined common goal.

The most important characteristics of such networks are the following [5]:

- Small and medium-sized enterprises of approximately the same size cooperate.
- Common forms of cooperation are joint cooperation in the fields of marketing, product development, or procurement.
- One of the main goals is to overcome the disadvantages resulting from economies of scale.
- Growing opportunity for innovation and learning.

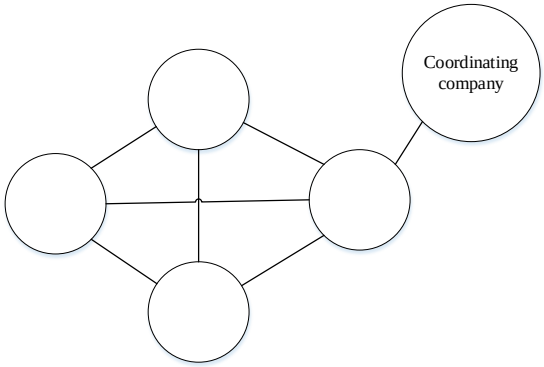

Figure 4. Structure of horizontal networks (my own editing)

The role of coordinators is also prominent in the case of horizontal network collaborations. The role of the coordinator is assigned to the enterprises, and his main task is to unify the activities and unite the network despite the different processes. Without such a coordinating organization, it is impossible to achieve long-term cooperation between the parties despite extremely different and diverse corporate interests.

4. LOGISTICS NETWORK MODEL VERSIONS

The literature [8] most often classifies supply chain models into four groups:

- deterministic models;
- stochastic models;
- hybrid models;
- IT-based models.

In the case of deterministic models, the parameters of the bounded model are known and fixed, while in stochastic models, uncertain and random parameters also appear. Deterministic models can be divided into two main subgroups: single-criteria and multi-criteria models [9, 10].

Hybrid models contain both deterministic and stochastic components. Its two main groups are inventory optimization and simulation models. Its great advantage is that it can work efficiently with predictable and non-predictable parameters at the same time [11, 12].

The use of the following model type has become highly valued these days. We can experience how the events taking place in our world today affect the supply networks, the weak points of which are brought to the surface as a result of such events. The purpose of IT-based models is to improve the transparency of the chain with the help of real-time information during supply chain planning.

Such model variants are WMS (Warehouse Management System) [13], TMS (Transportation Management System) [14], and production management systems (MRP II. Manufacturing Resource Planning), distribution network planning (DRP - Distribution Resource Planning) [15].

The grouping of supply chain models is illustrated in Figure 5 [8]. In essence, this grouping combines several aspects that are not closely related to each other. In sectioning, it is very important to include external environmental effects, since we can only talk about

stochastic or deterministic models for the individual processes in terms of external effects. At the same time, there are differentiations, the handling of which is a matter of technical detail, since it is determined by the circumstances given by computer technology that a given task is solved with simulation methods, or in a closed form, analytically, or with a recursive algorithm.

IT-based models are closest to the operational level, but here the connection between the functions of the supply chain is not close enough, since optimizations at the strategic level are not shown. The choice between the individual strategies is determined to a large extent by the level of efficiency achieved with regard to the individual functions at the operative level.

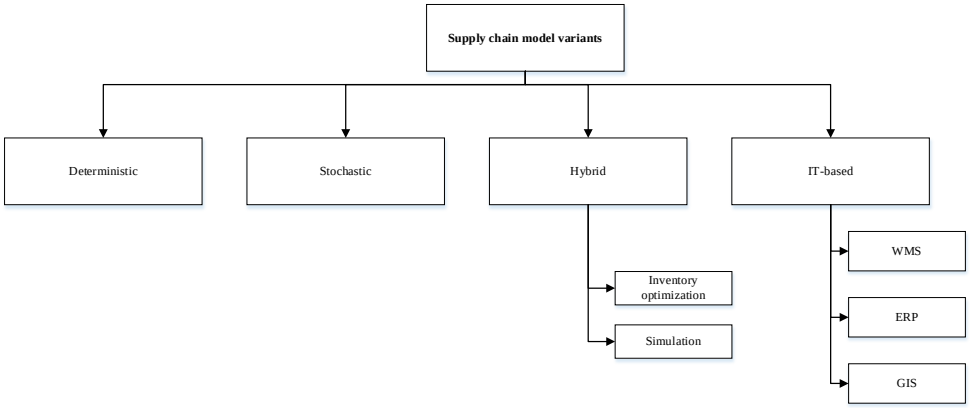

Figure 5. Grouping of supply chain model variants (my own editing)

5. THE OPPORTUNITIES OFFERED BY DIGITALIZATION FOR LOGISTICS

Digitalization as a term is regularly heard these days, especially since the epidemic. It can be defined most simply as the process of making a physical quantity process by a computer in some way. Digitization does not simply mean that we use digital tools. This is much more complex, and there is also a change in the way of thinking behind it. We achieve new results with new tools and new procedures. The technological tools and solutions provided by digitalization also had an impact on the operation of supply chains, including the support of logistics processes. It can be stated that digitization now dominates almost the entire logistics sector. It is very often experienced and observed that vertical and horizontal organizational levels appear within a global supply network, which make the visibility of the system even more complicated. A cross-border supply chain can operate in a system consisting of several levels, where versions of network cooperation alternate at each level. Events taking place today have shown which factors result in the vulnerability of these supply chains. One factor is visibility and the other is responsiveness. Visibility means the traceability of a product or process and knowledge of its current state. Despite its simple definition, it is not something that is easily achieved. A "high visibility" supply chain is characterized by the ability to determine the overall status of all elements of the supply chain at a glance, as well as the ability to search for additional details on the current status. Supply chain complexity is a major issue for supply chain visibility. Only a very small

percentage of today's global supply chains have full visibility, which was demonstrated in the crisis situation caused by the pandemic. However, achieving increased visibility is essential for achieving efficiency and agility. Another factor is reactivity. In unpredictable times, such as the one that surrounds us today, responsiveness is a key driving force in the life of companies, which enables them to provide quick and cost-effective responses to deal with emerging disturbances.

Industry 4.0, as the epitome of digitization, enables the digital transformation of supply chains by leveraging advanced technologies such as the Internet of Things, artificial intelligence, robotics and 5G technologies. The digital transformation of supply networks can solve the problem of visibility and responsiveness. Whether it's a "black swan" event like COVID-19, a trade war, an act of war or terrorism, a regulatory change, a work dispute, a sudden spike in demand, or a supplier failure, organizations that adopt a digital supply chain concept will be prepared to deal with the unexpected [16].

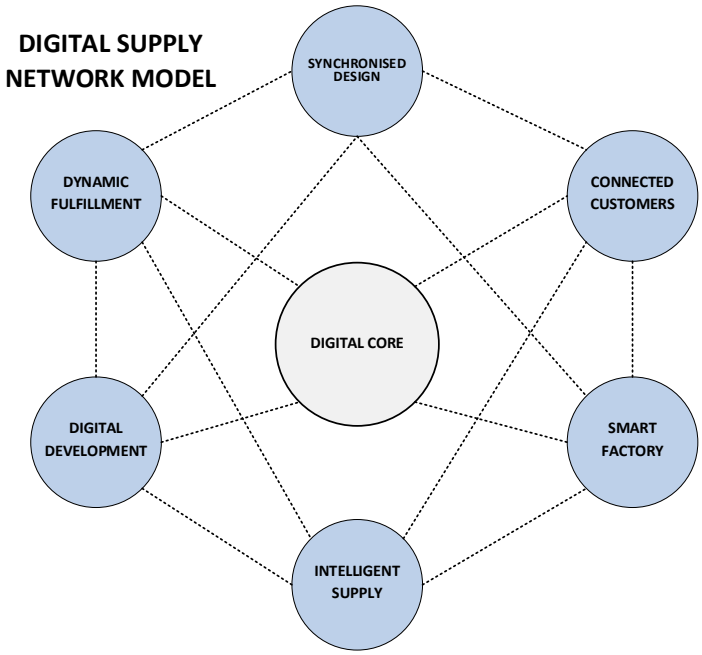

Figure 6. Transformation of supply chains by the technological environment (based on my own editing [16, 17])

Characteristics of DSN model capabilities (Figure 6) [16, 17]:

- Digital Development This capability uses technology to conceptualize, design, and integrate products into production, ensuring cross-functional collaboration across 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 of different business functions. This layout helps to efficiently calculate customer demand and optimize inventory across the entire DSN.

- Smart 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.
- Smart Factory: This capability uses a calculated balance of human and machine intelligence to improve business performance and worker safety based on production and demand data.
- Dynamic fulfilment: This connected, cross-company capability delivers the right product to the right customer at the right time, enhancing the overall customer experience. It uses technologies such as IoT and robotics to provide real-time visibility and flexibility across the supply chain, facilitating cross-functional collaboration and improving responsiveness.
- Connected Customer: This capability enables companies to move from a traditional transaction-based relationship to seamless customer engagement throughout the customer lifecycle.

The application of the opportunities provided by digitization and automation together changes the operating method of the logistics industry, and the companies that apply it gain a serious competitive advantage.

Below are some of the technologies that support the processes of the logistics sector:

- Thanks to the Application Programming Interfaces (API) interfaces - which enable smooth and automatic data exchange - the systems can be directly integrated into each other.
- With Big Data analyses, we turn unstructured information into valuable knowledge that helps us make more informed decisions. This is especially important for predictive analytics and risk mitigation.
- We use machine learning and artificial intelligence for special trend recognition, which helps in quality management and preventive maintenance.
- Using the Internet of Things (IoT), our monitoring sensors monitor in real time during transport and simultaneously transmit temperature, local and other data, thereby ensuring high quality, efficiency and traceability of processes and deliveries.
- Blockchain technology supports secure data exchange between partners and eliminates the need for additional communication channels that raise trust and data security issues.

6. QUALITY ASSURANCE PERFORMANCE MEASUREMENT OF LOGISTICS PROCESSES

In the following, a well-applied performance measurement procedure is described, which has been known and used for a long time in the corporate environment. It provides measurable feedback for controlling, so that the fulfilment of quality parameters can also be demonstrated with its help. These performance measures are simple and easy to apply. Due to the shortcomings of the logistics indicators for the operation, the need arises to create a complex set of indicators that, on the one hand, includes the indicators in a logical framework, and, on the other hand, contributes to the implementation of the logistics strategy and its regulation. The logistical adaptation of the Balanced Scorecard BSC, the method developed for this purpose in international practice, may be the solution. The

Balanced Scorecard (BSC) methodology has been widely used since its publication in 1992, and it is regarded as a tool that can be used for performance measurement and strategy management purposes in the business sphere, and which takes into account even small details. The BSC model was developed in order to have a method that deals with the process of strategic development, monitoring of strategic results and performance measurement. The BSC organizes and then transforms the organization's strategic goals into a finite set of performance indicators, the elements of which are divided between four perspectives (Figure 7). The division used in the BSC model is made according to four coherent aspects (Figure 7).

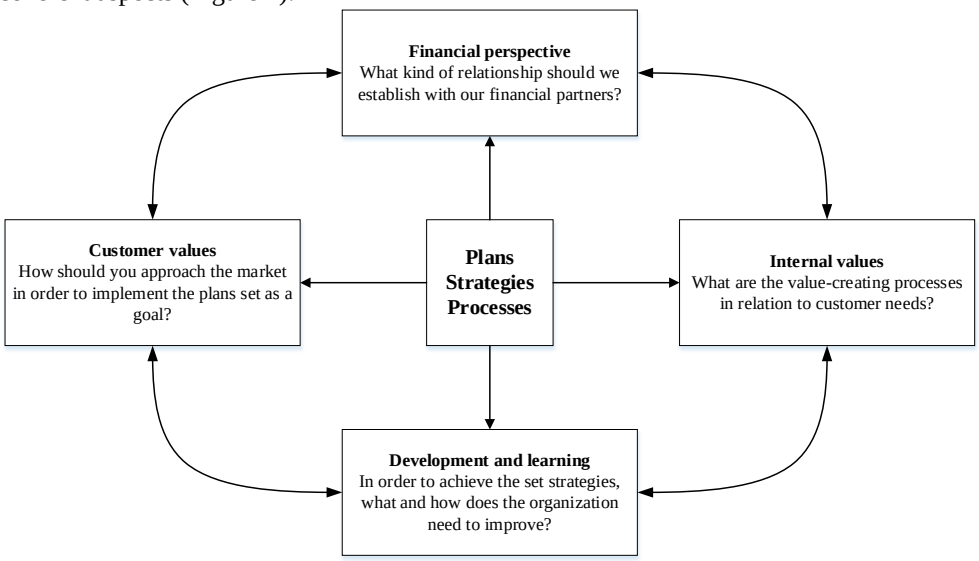

Figure 7. Strategic aspects of BSC (based on my own editing [14])

1. The question of the financial aspect is "How should we relate to the owners and investors?" A question of growth, profitability and risk from the perspective of the owners.
2. Examining customer aspects, we can ask the question, "How do our partners view us?" The strategy of value creation and the development process from the customers' point of view.
3. Approached from the point of view of the internal processes of the business, "What should we do to stand out in the sector and be better than our competitors?" Which strategic priorities of the different business processes lead to satisfying the needs of customers and owners?
4. Cornerstones of the innovation and learning phase "Are we able to develop even further and create continuous value?" What are the priorities and guidelines that promote organizational changes, innovation, and growth [18, 19].

Once the goals have been developed, it is necessary to determine how they can be measured and what target values the company wishes to achieve. For this, the actions that serve the implementation must be selected. Similar to the designation of target values, this is a general management task for which the literature is detailed, so in this study I will not deal

with this topic in more detail. In the case of a large auto parts supplier company, which is present in 30 countries on several continents, for example, the company group has a concern-level BSC, and the individual member companies derive their own BSC system from this, and in addition, some of the most important functions of the company (production, controlling , logistics, etc.) also has its own BSC system for the entire concern. These BSC systems form a logical network where the BSC of the higher level determines the BSCs of the lower levels and designates the frames. In this way, the corporate group is able to ensure strategic coherence in addition to its geographically and product-wide diversified operations.

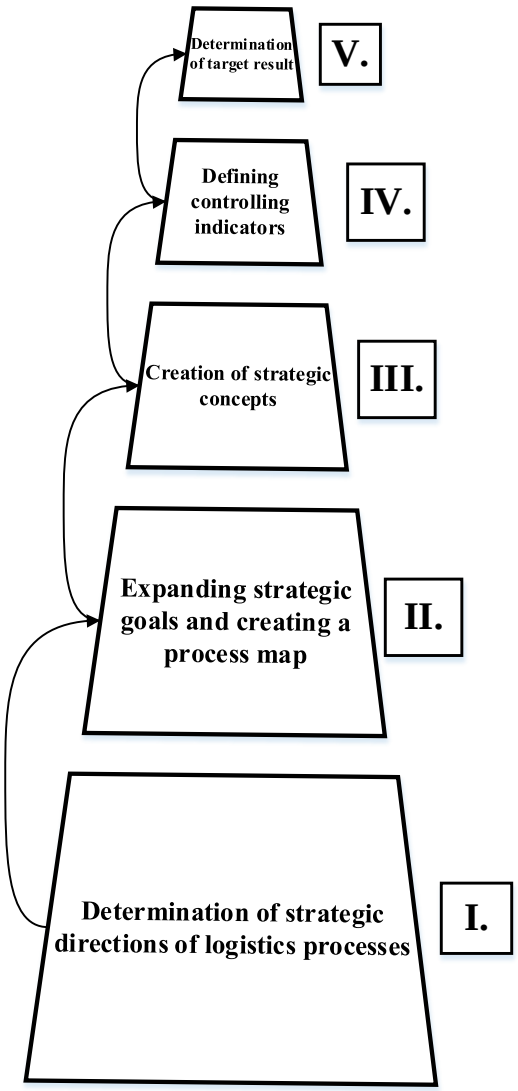

Figure 8. The process of creating a BSC delineated to logistics services (my own editing)

The management of the company often sets personal goals for the logistics area. These include, among other things, what dimensions the company's management intends to follow in order to carry out improvements in its logistics area in the next period. Based on these, the expert team determined the strategic goals. Figure 8 shows the steps of this process.

7. SUMMARY

It can be said that supply chains are present in so many forms of appearance and operation in the world economy, where a high level of service is essential these days. The importance of the delimited topic area is confirmed by the world economic processes taking place today, such as the "black swan" event, which includes the Covid-19 pandemic and the Russian-Ukrainian war. As a result of these events, it can be clearly stated that supply networks on a global scale ensure the maintenance of the economic cycle. We could see how the disruptions caused by the above-mentioned events affected the operation of the chains and thus the consumers located at the end of the chains. As an integral part of network operation, logistics also faced many challenges. Nowadays, quality assurance does not only focus on the consumer, but also ensures the stable operation of the companies present during the product's life cycle. This means providing the necessary information, which allows you to organise the flow of materials well. Nowadays, information manifests itself in a multitude of data, which ensures even faster passage between individual organisational levels. It can therefore be concluded that problems arising in the quality of logistics services do not only affect the logistics service centers that offer and provide logistics services, but - to a certain extent - all players in the market. The fourth industrial revolution has created the necessary framework for efficient process organisation, and we can say that it is expecting a tangible result in the operation. There are many possibilities to prove its existence with exact indicators. In the study, I described a long-standing and used method. In the future, I will also examine other performance measurement methods and compare their effectiveness.

REFERENCES

[1] Glover, F., Jones, G., Karney, D., Klingman, D. & Mote, J. (1979). An integrated production, distribution, and inventory planning system. *Interfaces* 9(5), 21–35. https://doi.org/10.1287/inte.9.5.21

[2] Dubois et al. (2004). Supply chains and interdependence: a theoretical analysis. *Journal of Purchasing and Supply Management* 10(1), 3-9. https://doi.org/10.1016/j.pursup.2003.11.003

[3] Németh et al. (2008). Measures and Actions for Coordinated Regional Logistics Policies. In *Proceedings of the 6th International Conference on Management, Enterprise and Benchmarking* (MEB 2008), 311-321. Budapest, Hungary,

[4] Tan, K. C. (2001). A framework of supply chain management literature. *European Journal of Purchasing & Supply Management* 7(1), 39-48. https://doi.org/10.1016/S0969-7012(00)00020-4

[5] Sprenger, R. U. (2001). *Inter-firm Networks and Regional Networks*. ADAPT, Bonn.

[6] UNIDO 2000: *Promoting enterprise through networked regional development.* UNIDO, Vienna.

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

[8] Min et al. (2002). Supply chain modeling: past, present and future. *Computers & Industrial Engineering* 43(1-2), 231-249. https://doi.org/10.1016/S0360-8352(02)00066-9
[9] Lee, H. L. & Billington, C. (1993). Material management in decentralized supply chains. *Operations Research* 41(5), 835–847. https://doi.org/10.1287/opre.41.5.835
[10] Swaminathan, J. M. & Tayur, S. R. (1999). Stochastic programming models for managing product variety. In: S. Tayur, R. Ganeshan and M. Magazine (eds.): *Quantitative models for supply chain management*, 585–622. Kluwer Academic Publishers, Boston, MA https://doi.org/10.1007/978-1-4615-4949-9_19
[11] Lee et al. (1997). Information distortion in a supply chain: The bullwhip effect. *Management Science* 43(4), 546–558. https://doi.org/10.1287/mnsc.43.4.546
[12] Cachon, G. P. (1999). Competitive Supply Chain Inventory Management. In: Tayur, S., Ganeshan, R. & Magazine, M. (eds) Quantitative Models for Supply Chain Management. *International Series in Operations Research & Management Science* 17, 111–146. Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-4949-9_5
[13] Petrovic et al. (1998). Modeling and simulation of a supply chain in an uncertain environment. *European Journal of Operational Research* 109, 299–309. https://doi.org/10.1016/S0377-2217(98)00058-7
[14] Camm et al. (1997). Blending OR/MS judgment, and GIS: Restructuring P&G's supply chain. *Interfaces* 27(1), 128–142. https://doi.org/10.1287/inte.27.1.128
[15] Johnston et al. (1999). Highly constrained multi-facility warehouse management system using a GIS system. *Integrated Manufacturing Systems* 10(4) 221–232. https://doi.org/10.1108/09576069910280567
[16] Bernardes, E., Sinha, A., Calderon, R. & Wuest, T. (2020). Digital Supply Networks transform the Future. *ISE Magazine* 52(5), 28-33.
[17] 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
[18] Kaplan, R. S. & Norton, D. P. (1992). The balanced scorecard – measures that drive performance, *Harvard Business Review*, January-February, 71-9.
[19] Fentahun, M. (2007). *Multi-criteria Performance Measurement Model Development for Ethiopian Manufacturing Enterprises*, MSc. thesis at the Addis Ababa University, School of Graduate Studies, Mechanical Engineering Department

ACKNOWLEDGEMENTS
Project no. 2019-2.1.11-TÉT-2020-00198 has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary from the National Research, Development and Innovation Fund, financed under the 2019-2.1.11-TÉT funding scheme.