Kovács, G., & Kot, S. (2017). Economic and social effects of novel supply chain concepts and virtual enterprises. *Journal of International Studies, 10*(1), 237-254. doi:10.14254/2071-8330.2017/10-1/17

Journal of International Studies





# Economic and social effects of novel supply chain concepts and virtual enterprises

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**Abstract**. Growing market globalization, increasing global competition, more complex products results in application of new technologies, methods and business processes – due to the abovementioned tendencies novel supply chain strategies (Lean, Agile and Leagile Supply Chains) are established. In this study these supply chain concepts are being described and compared. Virtual enterprise is a temporary alliance of enterprises that come together to share their skills, core competencies, costs and resources in order to better respond to rapidly changing market environment and dynamic customer demands. Economic and social benefits and effects of virtual enterprises for customers and production companies and service providers are also described. Optimization software has been developed for optimal formation of virtual enterprise networks and is also introduced in this study. The aim of this software application is to define virtual enterprise as the optimal combination of supply chain members.

**Received:** November, 2016
**1st Revision:** March, 2017
**Accepted:** April, 2017

DOI: 10.14254/2071-8330.2017/10-1/17

**Keywords:** supply chain, virtual enterprise, economic, social, optimization.

**JEL Classification:** C61

## INTRODUCTION

Rapidly changing market environment and global competition as well as fluctuating customer demands resulted in the emergence of new technologies, business processes and application of more complex

networks of supply chains. Novel supply chain concepts are formed besides traditional ones in order to retain competitiveness of supply chains and chain members.

Value chains today are getting globalized, cooperation between their members becomes more dynamic, size of these networks is getting larger, virtual enterprises are established. The key to success for these chains is to understand customer needs, and fulfill them with the highest quality, adapting at the same time to the expected changes in market demand. Reduction of total costs and lead time in chains, and higher customer service level becomes the most commonly used objectives for operation of supply chain networks.

To achieve the abovementioned goals novel supply chain strategies (Schönsleben, 2000) are established (Lean Supply Chains, Agile and Leagile Supply Chains) and more and more frequently also virtual enterprises (VE) are formed (Camarinha, 2001).

Virtual enterprise is a temporary alliance of enterprises that come together to share their skills, core competencies, costs and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks.

In our study these three novel supply chain concepts (Lean Supply, Agile and Leagile Supply Chains) are described and compared.

Economic and social benefits and effects of virtual enterprises for customers, production companies and service providers are also described. The available today literature often discusses the key features of virtual organizations, however, there is gap in literature concerning the optimization of virtual enterprises. This is the reason why this research is original and unique, especially since optimization software has been for that matter developed and is further introduced in this paper. The aim of this software application is to define Virtual enterprise as the optimal combination of supply chain members.

## 1. RESEARCH GOALS AND METHODOLOGY

The goal of this research is not only the introduction and comparison of three novel supply chain concepts (Lean Supply Chains, Agile Supply Chains and Leagile Supply Chains) but the introduction of economic and social reasons of these tendencies. Furthermore, the economic and social benefits and effects of established virtual enterprises are also discussed from the perspective of the customers and production/service enterprises.

Supply chain management and supply chain optimization appear frequently in the literature (Stevens, 1989). Although the existing literature often discusses the characteristics and analysis of virtual organizations (Camarinha-Matos, 2001; Gunasekaran et al., 2008; Esposito and Evangelista, 2014), there is a gap in the literature in the field of optimizing virtual enterprises. Thus, this research topic is absolutely original and unique. Optimization software was developed for the optimal formation of virtual enterprise networks which will also be introduced in this study. The aim of the software application is to define the optimal formation of a virtual enterprise (VE), which is the optimal combination of supply chain members.

The main characteristics of the virtual enterprises are the following (Gunasekaran et al., 2008): the main aim of VE is to exploit fast-changing market opportunities; sharing of risks, costs and competencies is the main partnership objective (Camarinha-Matos, 2001); the virtual enterprise is characterized by a dynamic and flexible network; the organization is typified by relationships involving independent companies; the partnership is typically temporary and based on a collaborative approach; coordination and communication tools that are used are based on ICT (Esposito and Evangelista, 2014).

There are lot of relevant publications (some of them listed in the reference list) in this topic that were evaluated to provide the theoretical background of our research. In the past decade we have completed

several R&D projects for production companies and service providers, so we have experience in the field of the cooperation of enterprises and cooperation between university and enterprises. In this study, we introduced some general statistics but statistical data relating to virtual enterprises are not available, because there is not enough experience in how VEs operate. Only tendencies can be defined which are shown in the recent study. The research topic is not only theoretical; optimization software for virtual networks was also developed which can be applied very efficiently in practice. This software application is also described in our study.

## 2. ECONOMIC AND SOCIAL REASONS OF FORMING NOVEL SUPPLY CHAIN CONCEPTS

Reasons for new supply chain concepts are global tendencies of the 21st century focusing on changes in the main production and service processes and activities.

The analysis is executed by the following aspects that influence the production, service and logistics processes.

### 2.1. Change in customer demands and product characteristics

Due to individual customer demands the manufacturing companies have to offer wider, more custom-designed product portfolios for the customers. As a result, a huge variety of finished products is manufactured. In order to meet and identify these customer needs, companies must be able to identify and recognize customer demands.

These unique and fluctuating customer demands (variety and volume of final products) require absolutely new production and stocking strategies in many industrial sectors, as the traditional mass production is replaced by the production of unique products (Kovács & Kot, 2016).

The required final products are becoming more and more complex, which requires new, more flexible production technologies and logistics processes.

The main aim of production, service and logistics sectors is the maximal customer satisfaction.

### 2.2. Economic and social tendencies that influence the production, service and logistics sectors

According to a study of the Fraunhofer Institute (2015), 10 main economic and social reasons were defined that have an effect on the manufacturing, service and logistics sectors.

Reasons that are difficult for enterprises to affect are:

| | |
|---|---|
| 1. Globalization,<br>2. Demographic development,<br>3. Sustainability, | 4. State intervention,<br>5. Rising risk. |

Reasons which can be adopted for successful business options are:

| | |
|---|---|
| 6. Professionalization – efficiency,<br>7. Focusing on core competencies – effectiveness,<br>8. Service oriented operation, | 9. Application of innovative technologies,<br>10. Faster-ticking clocks. |

### 2.3. Changes in production philosophy and production processes

The traditional mass production is replaced by unique production (or smaller batches), or from the philosophical point of view, the 'Push' approach (make to stock) is replaced by the 'Pull' approach (make to order).

In Push production, planning is based on forecast data (not actual customer demand); thus the result is a high amount of products, including unsalable stocks. On the contrary, the uniqueness of production with the Pull philosophy lies in the fact that production starts only when an actual customer demand appears (with detailed specifications), which starts procurement and manufacturing processes. Based on the fundamental differences between the two approaches it is clear that, unlike the Push approach, the Pull approach results in the realization of logistical goals, which are the following: 1. shorter lead time; 2. production is scheduled based on the customer's demands; 3. only a small amount of stock is realized before (raw materials), during (semi-finished products) and after (finished product stock) the production process; 4. flexible reaction to changing customer demands; 5. dedication to continuous improvement; 6. smaller area needed for production; 7. higher utilization of human resources and equipment; 8. higher productivity, etc.

The Lean production philosophy utilizes the advantages of the Pull philosophy, and it is spreading throughout many sectors, in both production and service companies in the automotive industry, the electronic industry, offices and the health industry as well. (Lean philosophy will be discussed in Section 4)

### 2.4. Changing the types of supply chains, forming new supply chain concepts

The supply chains are becoming more complex and huge networks due to growing market globalization, global competition and the complexity of products. The key of success for chains is maximal customer satisfaction, which can be achieved by fast reaction and adaptation to the changes in rapidly fluctuating customer demands and market environments. The supply chains (and the final products of the supply chains) are competing for customers. The most important influencing factors of customer buying decisions are cost, lead time, quality and customizability.

To retain the competitiveness of the supply chains and the members of the chains, novel supply chain concepts are formed besides the traditional ones.

## 3. NOVEL SUPPLY CHAIN CONCEPTS

Stevens (1989) defined the supply chain as a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via a feed forward flow of materials and feedback flow of information.

Figure 1 shows supply chain networks that include a large number of customers, production companies and service providers. Customers can be consumers, end-users, etc. Production companies are the final assemblers, primary or secondary suppliers or raw material suppliers. Possible service providers in the supply chains can be logistics service providers, information service providers, Research & Development service providers, financial service providers, etc.

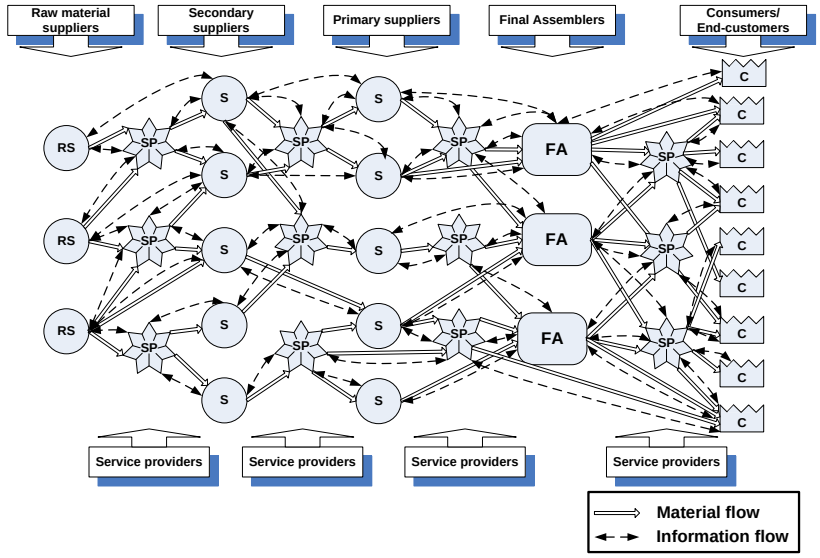


**Figure 1. Supply chain networks**

Source: Authors' elaboration

According to an international survey executed by Jones Lang LaSalle (2012), companies working in the logistics sector defined their main challenges for the next five years (2012-2017) with 13 points (Table 1).

Table 1

Main challenges of logistics sector (2012-2017)

| |
|---|
| 1. Reduction of supply chain costs (reported by about ~75% of the responding companies); |
| 2. changing customer demands (~65%); |
| 3. increasing volume of e-commerce (~40%); |
| 4. improvement of relations between supply chains (~40%); |
| 5. reduction of stock level (~35%); |
| 6. sensitivity and flexibility of supply chains (~34%); |
| 7. sustainability (~33%); |
| 8. application of new technologies (~30%); |
| 9. intermodality (~25%), |
| 10. cooperation in transport activities (~25%); |
| 11. reverse logistics (~23%); |
| 12. new transport corridors (~18%); |
| 13. increasing of global purchase (~15%). |

Source: (Jones Lang LaSalle, 2012)

It can be seen based on the statistical data that the cooperation of enterprises and optimal operation of supply chains have high priority.

**Three novel supply chain strategies are established:**

1. Lean Supply Chains,
2. Agile Supply Chains and
3. Leagile Supply Chains.

### 3.1. Lean Supply Chains

The main goal of the application of "Lean Supply Chains" is to minimize losses in the whole supply chain, by eliminating non-value-adding activities, and to improve the processes continuously (Womack et al., 1990). These goals are supported by several Lean strategies, such as shortening waiting times and set-up times (Liker & Lamb, 2000). This results in the realization of production smaller in volume, but more economical and flexible.

This strategy can be applied mostly in case of products with a relatively long lifetime (more than 1-2 years), and the members of the chain work in a traditional networked organizational form.

In today's increasingly global marketplace, many manufacturers are adopting Lean manufacturing practices (see Section 4) in order to optimize quality and costs, thereby gaining a competitive advantage.

### 3.2. Agile Supply Chain

Agile Supply Chain is another new supply chain concept. Agile refers to the ability of the supply chain to react and adapt to the changes in market environment and fluctuating customer demands. These chains need to be flexible and can respond to rapidly changing customer needs (in the variety and the volume of final products). This paradigm is applied for innovative and new products with relatively short lifetimes (maximum 1 year). The final products are more custom designed and are manufactured in smaller batches.

The members of an Agile supply chain work in the framework of a virtual enterprise. (The characteristics of the virtual enterprise will be discussed in Section 5)

### 3.3. Leagile (Hybrid) Supply Chain

A Leagile Supply Chain is a combination of Lean and Agile supply chains. The Leagile Supply Chain utilizes the advantages of the Lean and Agile paradigms. This concept is applied in the case of innovative and unique final products which are more custom designed. Most chain members apply the Lean manufacturing philosophy and form virtual strategic cooperation to improve the flexibility of the chain.

## 4. LEAN PHILOSOPHY APPLIED IN LEAN SUPPLY CHAINS

The Lean supply chain is the most common organizational form in many sectors. This is the reason why we introduce it in detail.

The focus of Lean philosophy is to decrease the cost of production and to cut activities which do not add value to the product from the customer's point of view. The main perspective of the Lean production system is to improve quality, decrease wastes and optimize the cost of production processes in order to increase competitiveness (Womack & Jones, 1996; Holweg, 2007). The focus of the Lean methodology is to create value-adding processes, and to realize only value-adding processes throughout the whole production system.

Lean philosophy is a performance-based process used in manufacturing and service organizations to increase competitive advantage in an increasingly global market (Fawaz & Jayant, 2007). Nowadays this philosophy is applied in many sectors including automotive and electronics production, white goods, and consumer product manufacturing, administration, hospitals, education, etc.

Originating from the Toyota Production System, many of the tools and techniques of Lean manufacturing (e.g., just-in-time (JIT), Value Stream Mapping, One-piece flow, Takt time analysis, Heijunka, Single Minute Exchange of Dies (SMED), Jidoka, Pull system, Kanban, Kaizen, 5S, Total Productive

Maintenance (TPM), 6σ, etc.) have been widely used in the manufacturing and service sector (Holweg, 2007; Womack et al., 1990; Womack & Jones, 1996).

**Advantages of Lean manufacturing** can be described (Kovács, 2012) by the following key performance indicators (KPI)**:**

- higher productivity,
- higher utilization of resources (labour and equipment),
- shorter lead times,
- smaller inventories,
- increased quality of products, etc.

### 4.1. Lean principles and wastes

There is a great deal of literature in the topic of Lean production principles and their application (e.g., Fawaz & Jayant, 2007; Fullerton et al., 2003; Dekier, 2012).

Lean manufacturing techniques are based on the application of five principles to guide the management's actions toward success

1. Value: The foundation for the value stream that defines what the customer is willing to pay for.

2. Value Stream: Mapping and identifying all the specific actions required to eliminate the non-value added activities from design concept to customer usage.

3. Flow: The elimination of all process stoppages to make the value stream "flow" without interruptions.

4. Pull: The ability to streamline products and processes from concept through customer usage.

5. Perfection: The ability to advocate doing things right the first time through the application of continuous improvement efforts.

All of the processes can be categorized into three groups (Liker & Lamb, 2000):

- value-adding activities (e.g. manufacturing, assembly),
- required but non-value-adding activities (e.g. exchange of die),
- waste is "any element that does not add value, or that the customer is not prepared to pay for" (over-production, transportation, etc.).

Seven types of waste can be identified in processes (McLachlin, 1997): 1. Over-Production; 2. Waiting; 3. Motion; 4. Transportation; 5. Inventories; 6. Over-processing; 7. Defects; 8. Other (under-utilized worker creativity and resource, application of non-adequate equipment and systems, wasted energy and water, and damage of environment).

These wastes are readily apparent in every manufacturing and service sector in the business world. Companies that identify, manage, and minimize these wastes are able be most successful in the very competitive marketplace.

## 5. VIRTUAL ENTERPRISE (VE) APPLIED IN AGILE SUPPLY CHAINS

The partners of an Agile supply chain usually form a dynamic cooperation in the framework of virtual corporate networks, which supports the fast fulfillment of the dynamically changing customers' demands (Ślusarczyk et al., 2016; Liberko et al., 2015).

There are several definitions for virtual organizations. A *virtual organization* (Schönsleben, 2000) is a short-term form of cooperation among legally independent co-producers in a logistics network of long-term

duration of potential business partners for the development and manufacturing of a product. The strength of virtual organizations is their ability to form quickly and gain competitive advantages.

Camarinha-Matos (2001) interpreted the *virtual enterprise* as a temporary alliance of enterprises that come together to share their skills, core competencies, costs and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks.

Esposito and Evangelista (2014) prepared a very detailed and systematic analysis of the most frequently cited characteristics of the virtual enterprises. They summarized the following aspects:

- the main aim of VE is to exploit fast-changing market opportunities,
- sharing of risks, costs and competencies is the main partnership objective,
- the virtual enterprise is characterized by a dynamic and flexible network,
- the organization is typified by relationships involving independent companies,
- the partnership is typically temporary and based on a collaborative approach,
- coordination and communication tools used are based on information communication technologies (ICT).

Gunasekaran et al. (2008) defined virtual enterprises as being characterized by several strategic objectives:

- maximizing flexibility and adaptability to environmental changes,
- developing a pool of competencies and resources,
- reaching a critical size to be in accordance with market constraints, and
- optimizing the global supply chain.

Virtual organizations are used in an increasing number of industries, e.g. the fashion industry, food industry, automotive industry, etc.

Figure 2 shows supply chain networks and a virtual enterprise as a temporary alliance of enterprises.

Supply chain networks include a large number of customers, final assemblers, supplier companies and service providers. Customers can be consumers, end-users, etc. Production companies are the final assemblers, primary or secondary suppliers, or raw material suppliers.

Possible service providers in the supply chains can be the following:

- logistics service providers (forwarding comp., warehousing comp., SC managing comp., etc.),
- information service providers (IT companies, telecommunication companies, etc.),
- Research & Development service providers (research institutes, universities, consulting enterprises, etc.),
- financial service providers (banks, lease brokers, consulting enterprises, etc.).

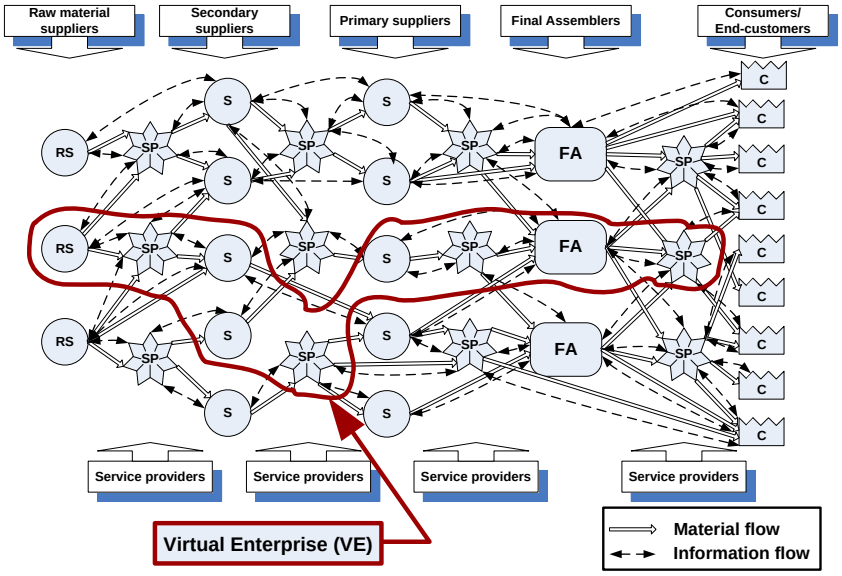


**Figure 2. Supply chain networks and a virtual enterprise**

Source: Authors' elaboration.

Flexibility is a key characteristic; the organizational structures need to be more flexible, allowing swift adaptation to change (Pollalis & Dimitriou, 2008). The other important property is the intensive use of information communication technologies (ICT) and knowledge management (KM). Enterprises need to adopt ICT tools for managing information (Jin and Robey, 2008) and knowledge in order to exploit innovation and collaborative relationships in a more efficient and effective way (Iandoli et al., 2012).

The VE concept can be applied if the following requirements are fulfilled (Culley, 2001):

- high level of personal and system trust,
- collaboration experience of all partners,
- commitment of all partners,
- knowledge of the skills and capacities of the partners involved,
- participation in bearing the loss and sharing the reward,
- transparent and fair processes.

**6. Network optimization in case of a virtual enterprise**

The goal of the research is the optimization of virtual enterprises, which means the optimal combination of supply chain members. The objective in the optimization of a supply chain network is to produce and deliver finished products to end consumers in the most cost-effective and timely manner and to achieve higher customer satisfaction.

This section shows the optimization method for the operation of a virtual network. Objective function and constraints will be elaborated. Total cost should be minimized, taking into consideration constraints relating to production and service capacities, inventories and flexibility in the chain. The theory of the optimization is introduced only briefly due to lack of space.

A theoretical problem is described by the following (input data): product types and quantities ordered by customers, possible suppliers of components, possible final assemblers, possible service providers, list of required services leading to customer satisfaction, manufacturing capacities of production plants, capacities at service providers, distances between the possible members of the network, cost and time of

activities required for manufacturing components and final products to fill customer orders. The optimal formation of a virtual enterprise (optimal combination of members of the supply chain) is sought.

Indices used in mathematical formulation are the following: *i*- products; *j*- possible suppliers (including raw material suppliers, primary, secondary, or other suppliers); *k*- final assembly companies; *l*- customers; *m*- possible service providers; *t*- time periods.

### 6.1. Objective function and constraints used for optimization

**Cost objective function**

Total cost includes raw material and component cost ($C_{mat}$), production cost ($C_{prod}$), transportation cost ($C_{tran}$), inventory cost ($C_{inv}$), cost of activities of service providers ($C_{serv}$), and operation cost of the virtual enterprise ($C_{oper}$) (Kovács et al., 2016).

$$C_{total} = C_{mat} + C_{prod} + C_{tran} + C_{inv} + C_{serv} + C_{oper} \quad (1)$$

**Constraints**

Possible constraints taken into consideration are the following: production ($V_{ijt}$ , $V_{ikt}$) and service capacities ($V_{imt}$), volume of inventories ($I_{ijt}$ , $I_{ikt}$ , $I_{imt}$) and flexibility in the chain.

The virtual enterprise is characterized by a dynamic and flexible network, so the following flexibility constraints are defined for the chain members in the software:

- flexibility of the manufacturing system at the manufacturing companies,
- flexibility of the IT infrastructure at the companies,
- liquidity of the chain members,
- flexibility due to the organizational structure of the chain members.

These types of constraints are not easy to define, but these can be given by a value in a given interval (1-5).

### 6.2. Software application for optimal design of supply chain networks

Based on the above-mentioned optimization concept, a software application was developed for the optimization of a virtual enterprise network. The software is written in Java programming language, and Eclipse software framework was used to develop the application (Kovács et al., 2016).

The software provides the possibility of determining:

- data for the products to be produced,
- data for potential members of the supply chain and,
- data for relations of the supply chain members (Figure 3).


**Figure 3. Main menu of the program**

In the menu "Data for the products to be produced" we can define the parameters of the product to be manufactured, while in the menu "Data for potential members of the supply chain" we can define the most important parameters relating to the final assembler, suppliers and forwarding service providers (Figure 4).

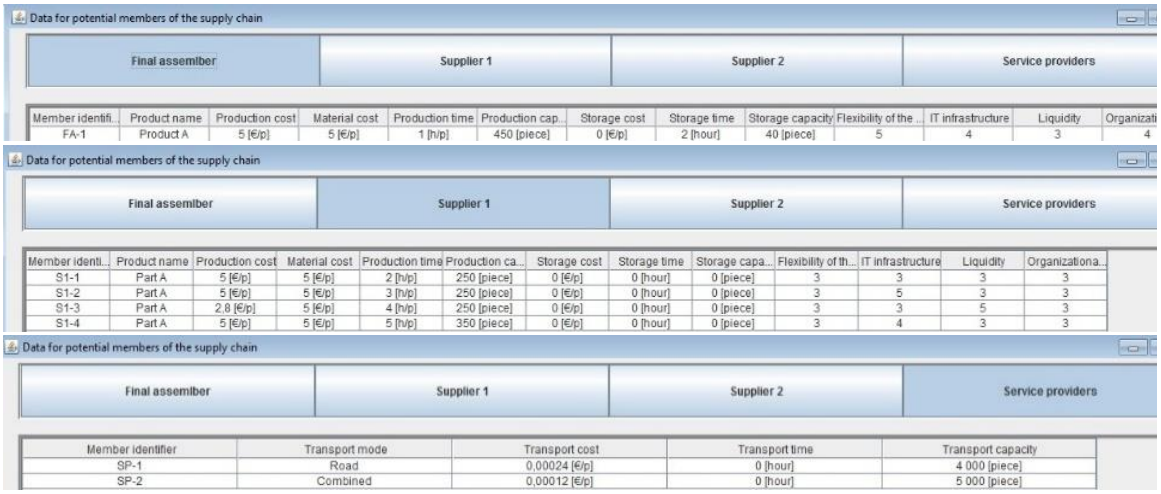


**Figure 4. Screens for parameter setting of supply chain members**

In the menu "Relations for potential members of the supply chain" the relation matrix, distance matrix and transport modes can be defined (Figure 5).

In the menu "Results of the optimization" we can select the objective function of the optimization (Figure 6). In this study, the cost optimization procedure is shown, (time optimization and multi-objective optimization are under development).

Flexibility constraints relating to the chain members can also be set (Figure 6). Recently the optimization in case of single objective optimization has been performed by systematic search. This method is absolutely good in the case of a small network, but for a huge network we will apply more a robust optimization algorithm. The multi-objective optimization algorithm is also under development.

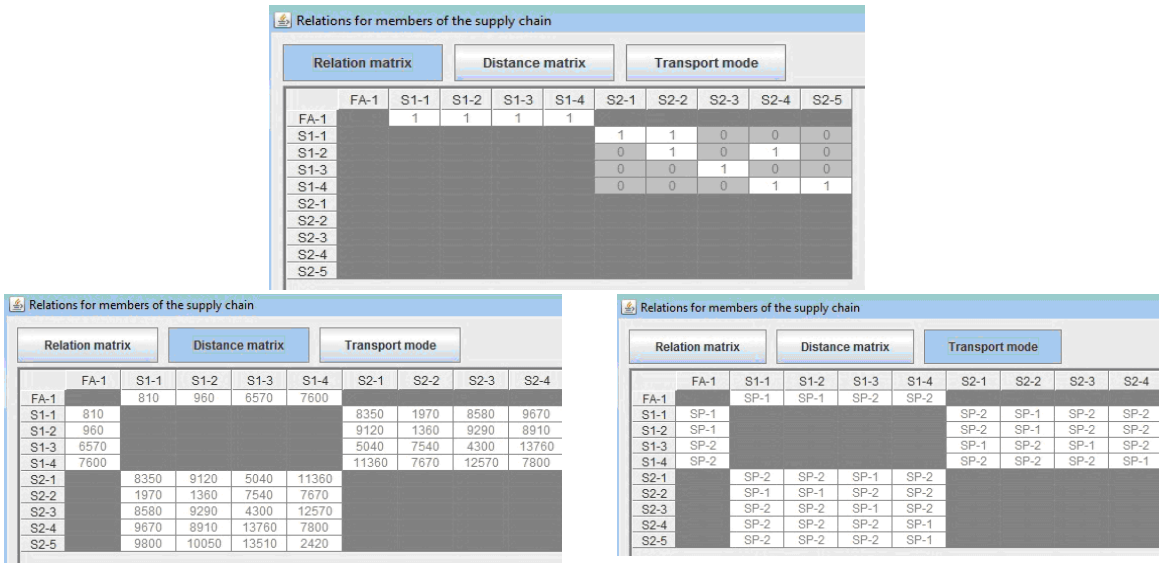


**Figure 5. Screens for parameter setting of relation matrix, distance matrix and transport modes**

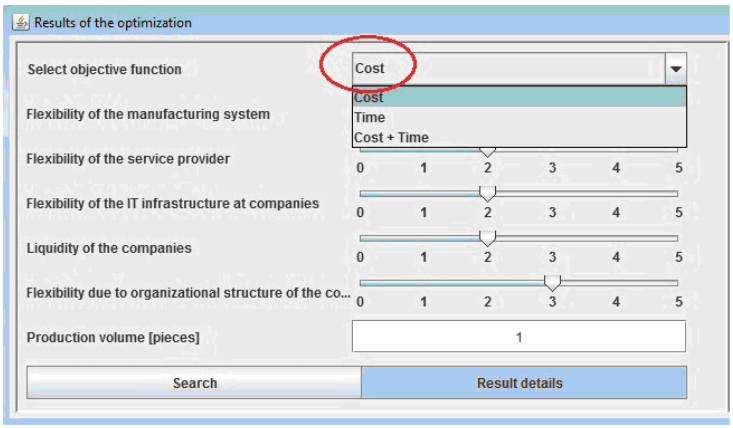


**Figure 6. Screen for selecting the objective function, parameter setting of flexibility constraints**

### 6.3. Case study for the optimization of a virtual enterprise

In our example (Figure 7) the supply chain includes one final assembler (FA), four primary suppliers ($S_{11}$, $S_{12}$, $S_{13}$, $S_{14}$) and five possible secondary suppliers ($S_{21}$, $S_{22}$, $S_{23}$, $S_{24}$, $S_{25}$).

The input data (relating to the final assembler (FA), primary suppliers ($S_{1i}$) and secondary suppliers ($S_{2i}$) and to their relations) is not detailed here due to lack of space. The objective function in the optimization is the total cost (Eq. (1)); the applied constraints are detailed earlier.

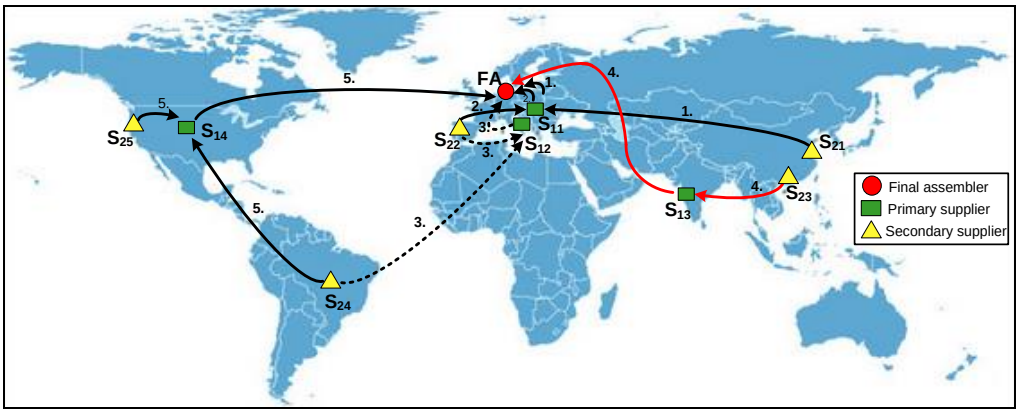


**Figure 7. Possible supply chain combinations (optimal chain is highlighted in red)**

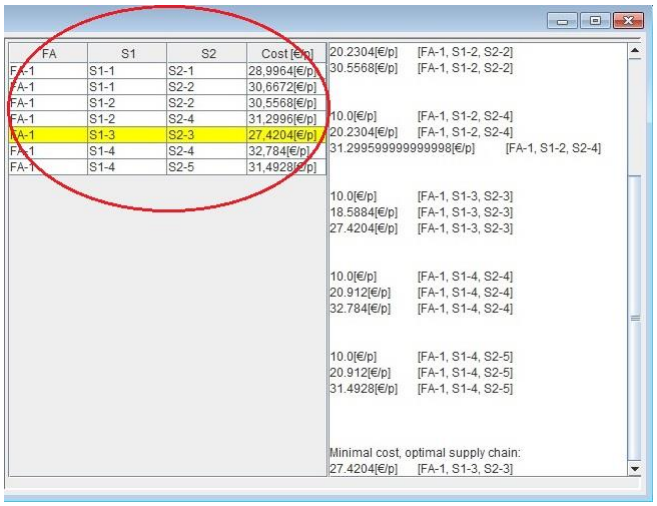


**Figure 8. Screen for the results of the optimization**

The result of the cost optimization (specific total cost of one piece of final product) can also be seen in the menu "Results of the optimization". The possible chain combinations that fulfill the constraints can be listed in the screen (see Figure 8). As can be seen in Figure 8, the optimal formation of the supply chain in our example is **FA – $S_{13}$ – $S_{23}$**, when the total specific cost of the supply chain will be minimal and all of the constraints will be fulfilled.

## 7. ECONOMIC AND SOCIAL BENEFITS OF VIRTUAL ENTERPRISES

### 7.1. General benefits of virtual enterprises for customers

The most important aim of the VE is the maximal customer satisfaction:

- maximal satisfaction of more unique and rapidly changing customer demands,
- unique products/services in case of several industries, the variation of finished products/services that can be chosen by the consumers is almost infinite, and the customer can freely determine the composition of the ordered finished products,

- shorter lead time: the customer receives the ordered product in the shortest time possible,
- meeting customer demand for increased quality.

### 7.2. General benefits of virtual enterprises for production companies and service providers

Cost and risk reduction in enterprises is due to the share of their skills, core competencies, costs, risks and resources. To make this happen, enterprises have to understand the customers' needs and have to fulfill these with the highest quality, and at the same time adapt to the expected changes in market demands. VE offers the following benefits:

- maximal utilization of production (or service) and logistics capacities,
- optimal utilization of human resources and equipment,
- flexible production (or service) and logistics processes needed to answer the demands of the rapidly changing economics and dynamic customer demands,
- fostering high transparency and continuous monitoring of the efficiency of the systems essential to the development of business processes
- ensuring and enhancing the quality of the processes,
- in terms of cost reduction, the main goal is to operate production and service processes efficiently,
- the optimal realization of transport chains in global or intercontinental supply chains.

### 7.3. Special benefits of virtual enterprises for the production sector

The traditional mass production is replaced by unique production, or from the philosophical point of view the 'Push' approach (make to stock) is replaced by the 'Pull' approach (make to order). On the contrary, the uniqueness of production with Pull philosophy lies in the fact, that production starts only when an actual customer demand appears, which starts procurement and manufacturing processes.

Based on the fundamental differences between the two approaches it is clear the unlike the Push approach, the Pull approach results in the realization of logistics goals, which are the following:

1. shorter lead time; 2. production is scheduled based on the customer's demands; 3. only small amount of stock is realized before, during and after the production process; 4. flexible reaction to the changing customer demands; 5. higher utilization of human resources and equipment; 6. higher productivity, etc.

### 7.4. Special benefits of virtual enterprises for main logistics service providers

***Benefits in the warehousing sector***

- In the perspective of cost reduction, the main goal of logistics is to decrease stocks,
- The spatial concentration of stocking: application of fewer stocking units results in significant savings,
- The establishment and operation of centralized inventory bases,
- Stocking time decreases because the speed of transportation increases,
- Just in Time supply and inventory strategy is widely used,
- Stock reduction and continuous flow of goods are also supported by Cross Docking and Vendor Managed Inventory (VMI) strategies.

***Benefits in the shipping sector***

Shipping accounts for 30% of the whole supply chain costs; therefore, every production company puts large emphasis on the optimization of transportation and reduction of transport costs.

- Cooperation between the transport modes (road, rail, water and air) is intensified to form more economic and fast transport chains.
- Volume of international shipping rises and shipping distances become longer due to the formation of transcontinental global supply chains.
- Quality of transport activities is increased,
- The shipping time defined by the customer is shortened,
- Optimization of transport coordination and utilization of resources take place,
- Specific transport costs of transport chains are reduced,
- The technology in the transport sector is developed,
- Application of informatics tools in logistics improves the efficiency of transport activities. (Kovács & Kot, 2016)

***Benefits in the logistics service sector***

There is a general tendency for production companies to put more emphasis on the core activities and main tasks, and the ratio of outsourced logistics activities is continually growing.

- 3700 companies were asked in a survey (EY, 2013) in 8 countries (Denmark, Finland, Germany, the Netherlands, Norway, Spain, Sweden, and the United Kingdom) about the willingness for outsourcing. Most frequently outsourced activities are in Table 2.

Table 2

Most frequently outsourced activities

| |
|---|
| 1. legal services (19% of the companies outsourced);<br>2. facilities management (19%);<br>3. logistics (16%); call center and customer support (15%); design and engineering (13%); marketing (9%); production and development (9%); procurement (7%); HR services (7%); finance and accounting (7%); sales (7%). |

Source: (EY, 2013)

- The role of integrated logistics service providers with diverse activities is ever increasing (3PLP - 3rd Party Logistics Provider, 4PLP – 4th Party Logistics Provider).
- Due to the logistics trends, promoting integrated solutions increases the role of cooperation between service providers. This tendency is also supported by several fusions (merging or buying-in companies and strategic partnerships) observed in the logistics service provider market (Bokor, 2005).
- The growth of the production sector and the resources of the European Union support the creation of more industrial parks and logistics centers, which provide more complex and high quality services so that they catalyze the improvement of other industrial sectors in the region as well.

## 8. ECONOMIC, SOCIAL AND SOCIOLOGICAL EFFECTS OF VIRTUAL ENTERPRISES

The most important goal of establishing a virtual enterprise is to share the skills, core competencies, costs, risks and resources of enterprises in order to better and more quickly respond to business opportunities and improve economic performance.

Due to this cooperation, companies do not have to invest in new technologies, equipment or workforce, so the operation cost can be reduced at the individual companies. The companies can get new business opportunities that would be unreachable without this form of collaboration. Table 3 summarizes the economic, social and sociological effects of virtual enterprises.

Table 3

Economic, social and sociological effects of VEs

| virtual Enterprise: improve economic performance<br>**POSITIVE EFFECTS**<br>⇓ | |
|---|---|
| **FOR CUSTOMERS** | **FOR PRODUCTION COMPANIES OR SERVICE PROVIDERS** |
| 1. reduction of specific cost of goods and services<br>⇓<br>2. cheaper goods and services<br>⇓ | 1. reduction of operation costs, more and prospering business opportunities<br>⇓<br>2. reduced cost of manufacturing and services<br>⇓ |
| 3. higher quality goods and services<br>⇓ | 3. higher income, higher profit<br>⇓ |
| 4. realization of a wide, custom-designed product/service portfolio<br>⇓ | 4. possibility of applying new technologies, business processes<br>⇓ |
| 5. products/services available for all social strata<br>⇓ | 5. increasing flexibility of production/services activities<br>⇓ |
| 6. increasing consumption<br>⇓ | 6. maintaining jobs and creating new jobs<br>⇓ |
| 7. increasing excise duty for the government<br>⇓ | 7. reduction in unemployment<br>⇓ |
| 8. possibility for more state interventions/rules and regulations for social and welfare actions<br>⇓ | 8. increasing tax revenue for the government<br>⇓ |
| 9. reducing social inequality (in the field of financial conditions, education, public health, culture, etc.) | 9. More state interventions/rules and regulations for: sustainability and the use of environmental-friendly materials and technologies also defined as goals, as well as green waste management and recycling |
| ⇓<br>**POSSIBILITY FOR WELFARE SOCIETY** | |

Source: own

## CONCLUSIONS

Due to globalization, changing economic environment and customer demands and the ever-increasing competition in the market, the need for new manufacturing technologies and business processes has emerged. Novel supply chain concepts are being formed besides the traditional ones in order to retain the competitiveness of the supply chains and supply chain members. In this study these supply chain concepts were introduced and compared.

Virtual enterprises are special organizational forms of Agile supply chains: temporary alliances of enterprises that come together to share their skills, core competencies, costs and resources in order to better respond to global competition and fluctuating customer demands. The literature often discusses the characteristics and analysis of virtual organizations, but there is a gap in the literature in the field of analysis of economic, social and sociological benefits and effects of VEs. These effects and benefits of established virtual enterprises were discussed from the perspective of customers and production/service enterprises.

As was mentioned earlier, the existing literature often discusses the characteristics and analysis of Virtual organizations, but researchers had not deal with the optimization of virtual enterprises. This is the main reason that this research is absolutely original and unique. The optimization software was developed and introduced in this paper. First the optimization method (objective function and constraints) was elaborated for the optimization of virtual enterprise networks. Total cost should be minimized, taking into consideration constraints relating to production and service capacities, inventories and flexibility in the chain. Based on the elaborated theory the optimization software was developed. The aim of the software application was to define the optimal formation of a virtual enterprise, which is the optimal combination of supply chain members.

Recently the optimization in case of a single objective optimization has been performed by systematic search, a method that is absolutely adequate in case of a small network, but for a huge network we need to apply a more robust optimization algorithm. Thus, a multi-objective optimization algorithm is under development.

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