CHALLENGES OF LOGISTICS IN THE CONCEPT OF INDUSTRY 4.0

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Abstract

Concerns about the marginalization of Europe in world production prompted the development of the concept of Industry 4.0, which will allow highly developed countries to regain the status of leaders in industrialization. As part of the proposed concept, which is to form the basis of the fourth industrial revolution, it is planned to closely connect physical objects with the information network. The application of new production strategies, such as Agile Manufacturing and Mass Customization, are causing manufacturing companies to be transformed into integrated networks in which they combine their core competencies. The idea of Industry 4.0 is to create sophisticated business networks, connected by intelligent resources communicating via the internet, using well-known and already used technologies, including the Internet of Things (IoT), big data, cloud computing, etc. As a result of applying these solutions, autonomous systems exchange data between themselves and the boundaries between enterprises are disappearing more and more. Therefore, the aim of the article is to identify key challenges of today's logistics (called Logistics 4.0) in the perspective of the development of the industry concept 4.0.

Keywords: Industry 4.0, Logistics 4.0, production networks management, Internet of Things (IoT)

1. INTRODUCTION

Development of the concept of Industry 4.0, dictated by the need to reverse the trend of decline in industrial production of European enterprises, is forcing modern enterprises to adapt quickly and flexibly to changing demand conditions, reduce labour costs and search for new strategies of the business. Due to novel manufacturing strategies such as Agile Manufacturing and Mass Customization, manufacturing enterprises are transformed into integrated networks, in which they join their core competencies. Consequently, industrial production is moving towards globalization, open supply chain network, short-term business connections and cooperation between the stakeholders [1,2]. As part of the proposed concept, which is to form the basis of the fourth industrial revolution, it is planned to closely connect physical objects with the information network. The idea of Industry 4.0 is to create sophisticated business networks, connected by intelligent resources communicating via the internet, using well-known and already used technologies, including the Internet of Things (IoT), big data, cloud computing, etc. This means that today's enterprises, especially small and medium-sized ones, which want to stay on the market must cooperate within cyber-physical systems.

In order to gain a competitive advantage in the market, a completely new, incomparably more modern and innovative approach to manufacturing and management of a company is needed which dramatically increases productivity and also helps to build very fast, efficiently managed supply chains [3].

One of the key problems of implementing the Industry 4.0 concept is the efficient implementation of logistics processes both in terms of physical and information flows in the entire logistics chain [4]. Therefore, the aim of the article is to identify the key challenges of modern logistics (called Logistics 4.0) in the perspective of the development of the industry 4.0 concept.

2. ASSUMPTIONS OF THE INDUSTRY 4.0 CONCEPT

Since 2011, Industry 4.0 has been a subject of discussion regarding the new direction of economic development worldwide. The process of moving enterprises outside Europe increases the danger of deepening the decline in the industrialization of countries such as Germany, France, Italy or Switzerland. Maintaining the potential of the industry in Western Europe is now becoming an important goal of the strategic development of these economies. Concerns about the marginalization of Europe in world production have prompted German experts to develop the concept of Industry 4.0, which will allow them to regain the status of the industrialization leader of highly developed countries [5]. The most intensive discussions are in the process of development and are taking place in the German industry because German managers are fighting to improve the competitive advantages of their automotive industry with the aim of maintaining leadership in the world market [6]. Furthermore, strong competition and growing customer expectations in today's markets mean that along with an increase in production efficiency, product customization is also taking place [7]. There is now a product manufacturing model in which the customer decides about the product configuration. At the same time, the price of the product should be close to the price of products manufactured in mass production. This is exactly what the Industry 4.0 concept provides, on the assumption of the creation of a fully integrated system of suppliers, producers and clients creating so-called the Cyber-Physical Systems (CPS), which are open socio-technical systems, capable of implementing a number of functions and actions imposed by production, logistics or management [8].

These systems must be flexible and self-controlling. The concept of a smart factory should be oriented towards high profitability of production plants and value added to industries. Companies have to change from existing forms of business activity to the new platform. This task requires a total transformation of organizations and their processes. The process should be managed in a new way where a significant element of a success is digital thinking and collecting and analysing data. All production areas should be fully integrated and controlled using advanced IT technologies. Production organization is aiming for much greater efficiency, flexibility and speed. The main elements of Industry 4.0 development are shown in **Figure 1**. Bauer et al. identified five technology fields, which are considered in the Industry 4.0 concept. For them, smart objects embedded in CPS, the concept of a Smart Factory, robust networks, cloud computing, and IT-security constitute the technological cornerstones for future production and success [9].

Figure 1 Elements of Industry 4.0 development [17]

Kagermann et al. [10] and Hermann et al. [11] identified three components of Industry 4.0. These are CPS, IoT and smart factory. CPS is understood as integrations of computation and physical processes, with embedded computers and networks monitoring and controlling physical processes. CPS comprises smart machines and production facilities that are capable of autonomously exchanging information, triggering actions and controlling each other independently. They most often occur in the form of built-in systems and monitoring and physical processes controlling networks operating in feedback loops. In CPS systems, physical processes are the source of data for calculating a signal controlling object [12]. The use of CPS may support both horizontal as well as a vertical integration of IT systems integrating the entire supply chain or other areas (objects) of a particular industry. Slack et al. [13] described IoT as a combination of RFID chips, sensors and Internet protocols that allowed networking of the location and state of physical objects. A result of the development of the Industry 4.0 concept is the creation of fully automated and Internet-based smart factories. This means progress in three significant areas [14,15,16]:

- digitalization of production (information systems for production planning and management);
- automation (systems for data acquisition from machines and production lines);
- Automatic Data Interchange (linking manufacturing sites in a comprehensive supply chain).

In smart factories, the priority is a mass customization (MC). In mass customization, the customer determines the characteristics of the product that he wants to purchase and automatically, such a personalized product is manufactured very quickly. This solution is very attractive to the customer, but it is a real challenge for the manufacturer, who must prepare the procurement system and production system to automatically and quickly produce customized products. The expectations and needs of every client are fulfilment, however this is connected with an increase of design and manufacturing costs. Products meet customer's needs the best with almost mass production efficiency. Mass customization is possible when an enterprise has a flexible manufacturing system and can also quickly design and implement new products and processes. The design process must be accelerated by the use of simulation and analytics in such a way that the first sample produced is efficient and fulfils customer expectations. Using simulation and 3D printing will enable rapid prototyping, which will greatly increase the cost savings of materials and energy [18].

Mass customization brings many benefits such as: increased customer satisfaction, reduced cost of capital, reduced cash flow variability, increased brand equity, reduced price sensitivity, increased chances to cross-sell and up-sell, increased customer loyalty, increased share of wallet, increased purchases, reduced promotion costs, ease of launching new products [5].

Implementation of the of industry 4.0 concept means not only the introduction of digitization and robotics, but also decision processes based on virtual simulations and processing enormous amounts of data in real time, new machine-man relations and the use of new manufacturing technologies in the industry. The idea assumes digital integration of the industry, energy and logistics. Thus, the transformation must apply to logistics and its systems and processes to form a new digital, flexible and efficient network structure precisely matching the economic environment and requirements of the customer [19].

3. DEVELOPMENT OF LOGISTICS 4.0

At the same time, with the development of industry in the era of subsequent industrial revolutions, the development of logistics is progressing (see **Figure 2**).

The key logistics activities of transport, inventory management, material handling, supply chain structure and information flow are affected in Logistics 4.0. The following examples can be used to describe the Logistics 4.0 environment [22]:

- real-time big data analytics of vehicle, product and facilities locations can find optimal routing for material and product transportation,

- on-site, on-demand, rapid manufacturing reduces the need for storing products in warehouses, autonomous robots and vehicles along with tracking and decision-making systems keep control over inventory,
- real-time exchange of information among different actors removes the traditional boundaries of logistics, which enables a reduction in the bullwhip effect,
- smart products and cloud-supported network keep the information flow intact.

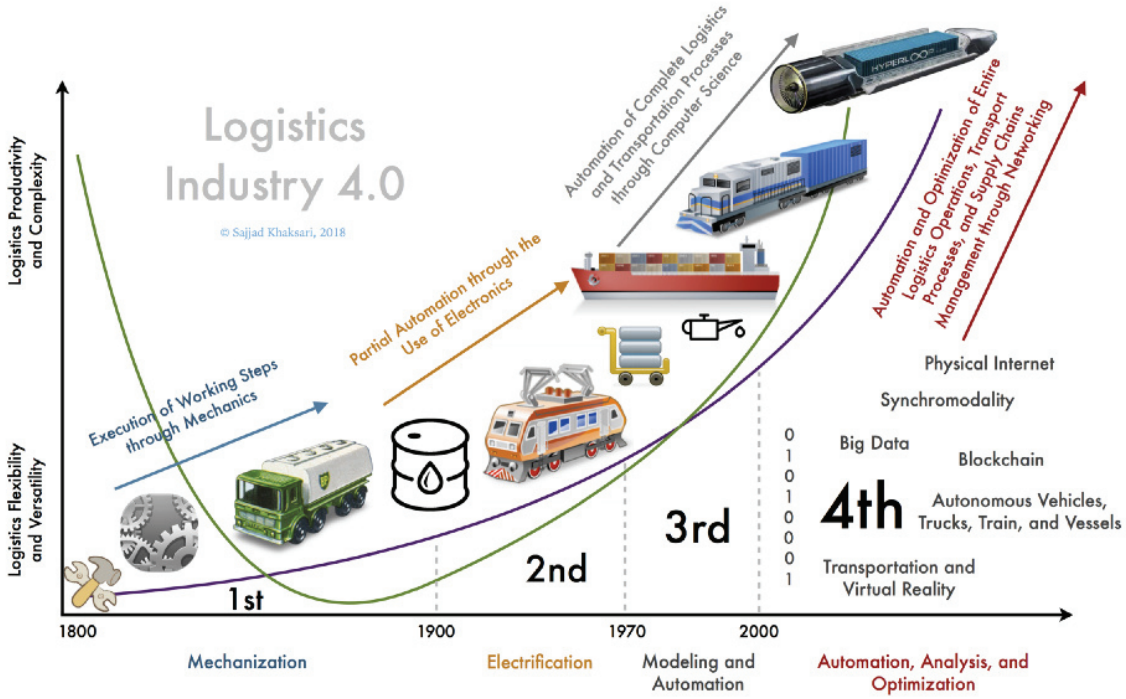

Figure 2 Development of logistics during subsequent industrial revolutions [20,21]

Logistics 4.0 comprises of five functional areas: data collection and processing, assistance systems, networking and integration, decentralization and service orientation, self-organization and autonomy [23]. These functional areas are supported by mechanisms of horizontal integration through value networks facilitating inter-corporation collaboration, end-to-end integration creating integrated networks of stakeholders, products and equipment along the product life cycle [24]. Furthermore, logistics of the future is focused on more advanced conceptions of the value stream that involves the blockchain, the physical Internet, autonomous vehicles, automated warehouse operations, and perhaps even the elimination of warehouses and advanced data analytics and (semi-)autonomous decisions enabled by AI (Artificial Intelligence).

Thus, modern Logistics 4.0 is faced with considerable challenges related not only to the use of modern technologies like CPS, IoT, the blockchain, etc. or the concept of the physical internet, but must meet the expectations related to the development of Industry 4.0. Modern logistics should, therefore, provide [22]:

- increased sharing of resources (machines, devices, tools, materials, design, know-how, software, data), especially among small and medium-sized enterprises;
- the transformation from value chain to a network (enterprise collaboration networks especially cyber industrial networks);
- the total systems approach to managing flow of materials, service and information;
- "cloud manufacturing", utilizing dispersed resources to produce the desired product;
- easier to create "virtual" and "reconfigurable" supply chains.

In order to meet the requirements and decentralization of industry 4.0, an automatic, intelligent and more independent flow of assets, goods, materials and information between all participants in the supply chain (or collaboration networks) is crucial. Thus, the main goal of future research is to develop the platform for creating Cyber Industry Networks (CINs) which will be available online on the Website. The idea of a production network called the Cyber Industry Network (CIN) means the manufacturing of joint production orders using fully automated processes of individual network partners, in which communication takes place via the Internet, and the necessary data is stored in the cloud (cloud technology). The platform will help facilitate the exchange of information between the customer, who provides information about the customized product, and enterprises with the specific production capacity sufficient to carry out that product.

4. CONCLUSION

After three industrial revolutions, the fourth is coming which moves production to sophisticated networks of companies equipped with intelligent devices, machines, means of transport communicating with each other through the use of new technologies such as cloud computing, big data and internet of things (IoT), blockchain, etc. This poses new challenges for enterprises and requires significant investments in automation, robotics and digitalization, which in the future will allow more intelligent communication technologies, especially those related to the Industry 4.0 concept, to be used. The application of the Industry 4.0 concept presents quite a challenge to modern logistics, in turn called Logistics 4.0. Today's logistics must ensure a full and instant exchange of information, implementation of automated solutions and multi-formal analysis of data in real time. It also assumes a complete integration between stakeholders in real time under actions. This means applying more advanced conceptions of the value stream that involves the blockchain, autonomous vehicles, automated warehouse operations and the physical Internet concept.

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