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The value chain in the digital age

Łańcuch wartości w erze cyfrowej

Abstract. The fourth industrial revolution causes changes in the organization and functioning of many enterprises. Digital transformation is a multi-threaded process covering practically all areas of life and economy. Digital transformation means implementation information technologies in all areas of business functioning. Businesses, both large and small, must adapt to the standards of digital “reality”. Digitalization is the driving force that will shape the industry of the future. The potential of digitization can be seen throughout the value chain, from product design, manufacturing and business processes, a fully digitized customer path, to new customer acquisition and customer service, to supply automation. The implementation of digital technologies of Industry 4.0 has a huge impact on the entire value chain, streamlining production and processes, improving management and quality of products and services, optimizing relationships between customers and organizations, bringing new business development opportunities and many benefits. The value chain in the era of digitization is becoming an important element generating noticeable profits. The aim of the study is to present the value chain in the era of digitization in the context of Industry 4.0, including the identification of its most key elements, including the formulation of strategies based on digital resources that bring added value, allowing to compete in the market and at the same time set new standards and business models, and to show the significant benefits of digitization of the value chain.

Key words: management, value chain, enterprise, digitalization, Industry 4.0, digital technologies, supply chain

Synopsis. Czwarta rewolucja przemysłowa powoduje zmiany w organizacji i funkcjonowaniu wielu przedsiębiorstw. Cyfrowa transformacja to proces wielowątkowy obejmujący praktycznie wszystkie dziedziny życia oraz gospodarki. Transformacja cyfrowa oznacza wdrożenie technologii informatycznych we wszystkich obszarach funkcjonowania przedsiębiorstw. Przedsiębiorstwa zarówno duże, jak i te małe muszą dostosować się do standardów “rzeczywistości” cyfrowej. Cyfryzacja jest siłą napędową, która będzie kształtować przyszły przemysł. Potencjał cyfryzacji zauważalny jest w ramach całego łańcucha wartości, począwszy od projektowania produktów, procesów produkcyjnych i biznesowych, w pełni scyfryzowanej ścieżki klienta, poprzez pozyskiwanie nowych klientów i ich obsługę aż po automatyzację dostaw. Wdrożenie cyfrowych technologii Przemysłu 4.0 ma ogromny wpływ na cały łańcuch wartości, usprawniając produkcję i procesy, poprawiając zarządzanie i jakość produktów oraz usług, optymalizując relacje między klientami i organizacjami, przynosząc nowe możliwości rozwojowe biznesu oraz wiele korzyści. Łańcuch wartości w dobie cyfryzacji staje się istotnym elementem generującym zauważalne zyski. Celem opracowania jest przedstawienie łańcu-

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cha wartości w dobie cyfryzacji w kontekście Przemysłu 4.0, z uwzględnieniem wskazania jego najbardziej kluczowych elementów obejmujących formułowanie strategii na podstawie zasobów cyfrowych, które przynoszą wartość dodaną, pozwalając konkurować na rynku i jednocześnie wyznaczać nowe standardy i modele biznesowe oraz ukazanie istotnych korzyści płynących z cyfryzacji łańcucha wartości.

Słowa kluczowe: zarządzanie, łańcuch wartości, przedsiębiorstwo, cyfryzacja, Przemysł 4.0, cyfrowe technologie, łańcuch dostaw

JEL codes: L16, L26, O14, O32

Introduction

The economic development that can currently be observed is caused by many factors. Among them, an important role is played by the phenomenon of digitization of the economy, enterprises and social life. The fourth industrial revolution causes changes in the organization and functioning of enterprises, the foundation of which are new information technologies based on Big Data, Internet of Things (IoT) and Artificial Intelligence (AI). These new technologies open up tremendous opportunities for companies to increase productivity, increase competitiveness, and create and capture value. Implementation of artificial intelligence to manage business and manufacturing processes, including new generations of intelligent robots create the foundations for the development of smart factories and introduction of the Industry 4.0 concept [Łobejko 2018]. Digitalization makes it possible to collect and analyze various types of data not only faster but also with greater precision. Thanks to this, the data provided are much more objective, the processes can be dynamically controlled and ultimately optimized, and the decisions based on them are much more accurate. This enables even more efficient use of available resources, for example in order and delivery planning, quality assurance, better tool management or maintenance. Process data is recorded online, transparently prepared and accessible to the public [Arburg].

Digitization is impacting businesses in every industry by removing barriers between people, businesses, and things. Removing these barriers allows new products and services to be developed and more efficient ways to operate to be found. Change affects all types of organizations and all industries. However, they have several things in common: They provide opportunities for better management of processes and resources, lead to new forms of contact with customers, contribute to the transformation of business models and stimulate innovation among employees [Streżyńska 2020]. Digital transformation is a multi-threaded process. Carried out holistically and skillfully, it should be based on wide use of IT technologies in handling all, or at least most, of the processes carried out in the course of daily functioning of a company, such as production, sales, customer service, finances or distribution [Arburg].

Digital transformation is a comprehensive process that is developing new ways and practices for managing businesses and conducting the entire spectrum of business in the digital world. At the same time – it is also the acquisition of new digital skills by the company's employees, enabling them to better collaborate with technology for optimal business results. It is simply changing the entire operating model of the company [Cyfryzacja według...].

We are currently witnessing unprecedented changes across industries. After the third industrial revolution, which involved the automation of individual processes, came the fourth

– enabling the interconnection of devices within digital ecosystems, and deepening integration across horizontal and vertical value chains. The global trend that made the next revolution possible was primarily the increase in the amount of data available and the computational capabilities to process it. They have made it possible to better manage company resources, plan production, and manage the entire product lifecycle. Data analytics has given companies the opportunity to deepen cooperation with suppliers and better respond to customer needs. What does this process consist of? It is based on automatic collection and processing of large sets of data, coming from devices or directly from people. Analysis of this data allows for cost and product optimization [PWC 2017].

The value chain in the era of digitization is becoming an essential element to generate noticeable profits. However, redesigning business systems, improving value chains, and delivering new value propositions require companies to adopt new approaches and fundamentally change their business systems. The potential of digitization can be seen throughout the entire value chain, from product design, manufacturing and business processes, a fully digitized customer path, new customer acquisition and customer service to delivery automation. Digital solutions facilitate the integration of the entire value chain.

The aim of the study is to present the value chain in the era of digitization in the context of Industry 4.0, including the identification of its most key elements, including the formulation of strategies based on digital resources that bring added value, allowing to compete in the market, while setting new standards and business models, and showing the significant benefits of digitization of the value chain.

Materials and methods

The subject of the study is the presentation on the basis of the conducted literature studies of the subject, the value chain in the era of digitisation in the context of Industry 4.0, to identify its most key elements, including the formulation of strategies based on digital resources bringing added value, allowing to compete on the market setting new standards and business models, as well as to indicate the significant benefits resulting from the digitisation of the value chain. Based on the literature on digitisation and Industry 4.0, an analysis and evaluation of the scientific literature was carried out, which shows that digitisation is more than just the purchase of new computer hardware and IT systems. It is about using the opportunities provided by new technologies and the data collected with them to rethink all aspects of business processes. The analysis covered the area of digital strategy. It highlighted the important aspect of how an organization formulates and implements a strategy based on digital assets that add value to the organization, allow it to compete in the market and set new standards and business models. The analyses conducted have also identified the significant benefits of value chain digitization in Industry 4.0 at many stages of its operation. The aim of the presented study is to broaden the knowledge and also to contribute to a deeper understanding of the relevance of value chain digitization.

The value chain

The competitive environment for organizations of all shapes and sizes – and in all industry verticals – is more challenging than ever before. Technological advancements have enabled businesses to design and build more quickly, sell across multiple channels, react

instantly to changing demands, and cut costs simply by outsourcing an activity. To achieve competitive advantage, an organization ultimately delivers more value at an equal or lower cost. Value chain analysis is the method for determining the critical path to enhance customer value while reducing costs [Eby 2017].

The concept of value chain was developed by M.E. Porter as a mechanism of value creation in an enterprise. According to it, every organization has two types of activities: primary and secondary activities. The core business includes input logistics, production activities, output logistics, marketing and sales, and service. Supporting activities, on the other hand, include procurement, technology, human resource management, and company infrastructure (e.g., management, planning, financial activities, accounting) [Figure 1]. In light of contemporary knowledge, the value chain is considered to describe the full range of activities that are necessary to make a product or service available from the concept stage, through the intermediate stages of production, to delivery to final consumers. Fragmentation of production processes and the related dispersion of tasks and activities on an international scale leads to the emergence of cross-border production systems, consisting of a sequence of chains or networks that operate on a global or regional level or cover only two countries. Due to the described scope of activities, these systems are commonly referred to as Global Value Chains (GVCs). The question of terminological differentiation between global value chains and supply chains is also an important issue. Supply chains are the physical embodiment of value chains - a network of interconnected organizations engaged in various processes and activities with the goal of providing a full range of products and services to the ultimate customer. Global value chains have a direct economic impact on value-added generation, including jobs and income. For developing regions, they are also an important avenue for development in building productive capacity, which occurs through technology and know-how transfer, acquisition of new skills, and industrial upgrading. The value chain analysis allows identifying and defining action strategies for economic sectors that have a key impact on the development of the region [Łańcuchy wartości...]. The value chain concept refers to the concept of an economic path to trace a product from raw material sources through all economic links to the final user. Each enterprise is a link in a broader value chain, but it also creates an internal chain consisting of various processes, activities and resources that need to be managed. Using the value chain model, an enterprise can be simplified as a sequence of activities, successive transformations of raw materials, materials, purchased technologies, services into final products, called core functions. These functions cannot be performed well without the existence of management and consulting activities referred to as support functions. The integrated operation of the core and support functions and their linkage to the value chains of suppliers and buyers allows the company to make a profit and grow. Value chain management is therefore not a one-off act, but a process of refining the business model to increase value for the end user, while capturing the financial benefits of doing so as much as possible [Rojek 2014].

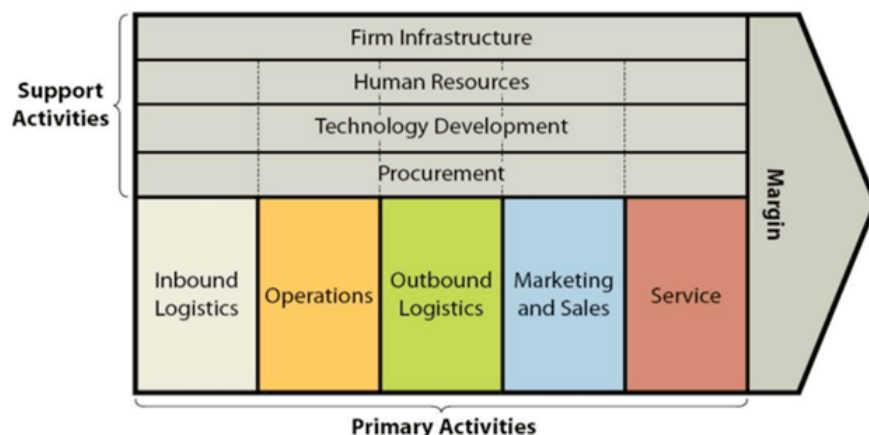


Figure 1. Porter's value chain
 Rysunek 1. Łańcuch wartości Portera
 Source: [Dudovskiy 2016].

Main activities consist of processes that add value to the product or service offered by the company, while auxiliary activities define the organizational culture of the company and resources unrelated to the production process [Szareck 2021]. Value chain through the sequence of activities (primary and secondary) in it participates in the generation of profit. But not every activity has a significant impact on the competitive advantage and efficiency of the company's operation. The selection of activities to be implemented in the company and the identification of those to be improved is therefore of fundamental importance for the company [Walas-Trębacz 2013].

To summarize, in general terms, the value chain represents the process of “adding” value to a product, beginning with the activities associated with a company's purchase of raw materials, supplies, semi-finished products, etc., necessary for the production process. The value chain then includes design, production, logistics activities, marketing, and ends with the provision of value-added services to customers. Thus, it becomes necessary to distinguish strategically important “carriers” of value creation within the enterprise. These are the subsequent activities related to the creation and delivery of value to the customer and the creation of value of the entire entity. Therefore, the concept of the value chain has entered both the stream of strategic management, through its reference to the construction of strategic advantage and competitiveness of the enterprise, and has become one of the tools of enterprise value management, actively participating in this process [Rojek 2014]. It should also be remembered that the nature and effectiveness of the created relationships in the value chain is influenced by many factors, such as It should also be borne in mind that the nature of the relations established in the value chain is influenced by many factors, including: the type of sector, the scope and scale of operations, product complexity, the number of participants in the value chain, partners' goals and expectations, partners' choices, the level of trust between partners, ways of cooperation and ways of competition between partners, coordination mechanisms in the chain, the degree of integration of the chain, the business model adopted, access

to information and knowledge, the degree of internationalisation of enterprises, cultural differences, partners' experience in existing relations, the level and scope of key competencies, the place and position of partners in the value chain, the level of risk in establishing relations, the scope and frequency of changes in technology, the progressive process of globalisation, etc. [Walas-Trębacz 2013]. It should also be remembered that in modern value chains, especially thanks to the introduction of the Industry 4.0 concept, companies no longer function as isolated islands connected to suppliers and subcontractors but are part of a whole chain of information exchange and analysis, whose processes are no longer merely internal but have an impact on processes in other entities. This coordination can be seen, for example, in production and logistics processes – in order to work more efficiently, logistic processes are managed and coordinated properly, but also resources, allowing for delivery of raw materials and certain finished products at the right time (according to the “Just-In-Time” concept). This allows for more efficient use of raw materials and energy. These two elements are of particular importance in the situation created by the COVID-19 pandemic, where supply chains have changed significantly. Old ones were disrupted or heavily modified and new, local ones emerged. This is also not without significance for the environment and its protection and energy efficiency, as well as for delivery times. It reduces the distance between actors in the supply chain and thus directly contributes, for example, to reducing the carbon footprint of the entire manufacturing process, including logistics processes. Another example of strong interconnectedness within a value chain is cyber security. When entities are so strongly connected to each other, the lack of adequate security at one point along the chain, which may be a small business for example, the consequences of a cyber-attack can affect all related entities, including customers.

Digital strategy in the value chain

A company that wants to build a digitization strategy must understand what digitization is all about. Without digitizing processes and creating a data warehouse, one cannot think about digital transformation at all. More and more Polish companies choose digital transformation. Its course, scope and role depend on the goals set. Digital transformation is a series of broad, holistic activities that should be linked by a common vision and a unified strategy. Although each company carries it out in its own way, the motivation is similar: without such a change there is no way to compete in the market [Smoliński 2019]. Digital transformation is a key component of an overall business transformation strategy, and while it is not the only component, it is fundamental to the success or failure of the effort. The right technologies, as well as people, processes and operations, enable you to respond quickly to disruptions and opportunities and meet new and changing customer needs. They prepare organizations for future growth and foster innovation – often in unexpected ways [Na czym polega...].

Digital strategy means that the organization formulates and implements its strategy based on digital resources that bring it added value, allow it to compete in the marketplace and set new standards and business models. Such a situation means, among other things, going beyond traditional thinking about IT strategy, going beyond systems and technologies (understood in a narrow sense) and basing the entire operation of the company on a resource-based approach (Resource-Based View) and intangible resources (information, knowledge, tacit knowledge, intellectual capital), linking digital strategy to the creation of value for business and operational and energy efficiency. Digitalization is also a tool which does not serve

only to digitalize processes for the sake of digitalization itself. On the one hand, it is supposed to increase the efficiency of process management, and on the other hand, the efficiency of raw materials use, including energy, which translates directly into a reduction in its consumption, and its effective management, and as a result, the reduction of contribution to CO2 emission. Value creation in traditional business models is rather understandable and the issue has been widely described within various strategic management theories [Olszak 2015]. Digital strategy highlights additional dimensions that change the nature and manner of value creation. These include the use of diverse information, the use of multi-party business models, the coordination of models across networks, and the control of network architecture [Bharadwaj et al. 2013].

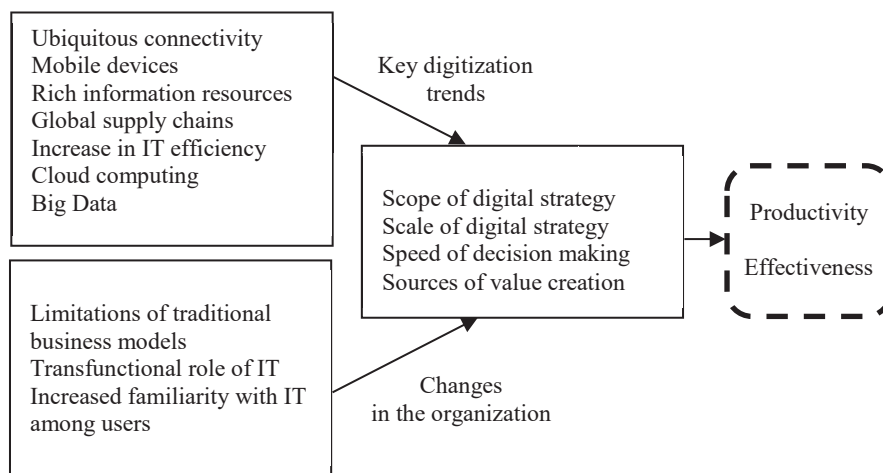


Figure 2. Key elements that shape an organization's digital strategy
 Rysunek 2. Kluczowe elementy kształtujące strategię cyfrową organizacji
 Source: [Bharadwaj et al. 2013].

The fourth industrial revolution describes a complex process of technological and organizational transformation of enterprises that includes the integration of the value chain, the introduction of new business models, and the digitalization of products and services. The implementation of these solutions is made possible by using new digital technologies, collecting and analyzing data resources, and providing communication in a network of machines, devices, and people working together. Keep in mind that the primary value in digitization is objective data, the analysis of which allows humans to make the best possible process management decisions based on it. The driver of the transformation is the increasingly individualized needs of customers and the growing trend of personalization of products and services [MBF group 2021].

Keep in mind that the primary value in digitization is objective data, the analysis of which allows humans to make the best possible process management decisions based on it. The driver of the transformation is the increasingly individualized needs of customers and the growing trend of personalization of products and services. The first is vertical integration,

which affects all systems in the traditional automation pyramid: from the field level and control level to the production level, the operations level or the enterprise planning level. Vertical integration makes the traditional view of the automation pyramid disappear. The same applies to several systems and applications that are currently at different levels. Other systems, such as ERP, for example, will change completely. This will happen when they are replaced by rapidly emerging applications in terms of Industrial Internet of Things platforms. Specifically, these will be production platforms that serve a variety of tasks and use cases in many aspects of the industry. They are gaining more and more features and are being connected in a way that requires systems, digital transformation platforms and business applications to work together. In addition, they also need to integrate with the aforementioned IoT platforms and all their functions. The second integration is horizontal integration, which is not about a hierarchical view of several systems (as in vertical integration), but a comprehensive value chain. It breaks down from the supplier and processes, information flows and IT or IoT systems as early as product development and manufacturing to logistics, distribution and the ultimate customer. This also has a significant impact on the many different systems used in industrial markets. Ultimately, however, it is all about data and how, what and where it is used [Innowacyjność w Przemysle...]. The last element is the digital end-to-end engineering along the entire value chain, which means the mutual synergy associated with the development and manufacturing of the product offered by the company. All these elements, thanks to the use of the latest technological solutions, can be interconnected and managed in order for the company to function optimally in the market. Also of key importance, according to experts, is the change of mentality and consumer profile, the form of all goods – from cars to cell phones and electronics. Also important for the development of the idea of Industry 4.0 is the influence of universities and research institutions in the context of developing new solutions to improve business processes [Bondyra and Zagierski 2019]. It should be mentioned that an extremely important element is the increasing use of cloud computing and the transfer of data processing systems to external infrastructure. Many entities are not able to provide on their own the appropriate tools and infrastructure for processing and secure storage of data. On the one hand, this has an impact on expanding the number of stakeholders in the digitization process, and on the other hand it has an impact on increasing the level of security while reducing costs.

An additional element that should also be mentioned is the ability for companies to make semi-independent and fully autonomous decisions. However, these are proving to be cornerstones in both Industry 4.0 and Logistics 4.0 [Innowacyjność w Przemysle...]. The integration and increasing digitization of industrial production will lead to more complex and digital market models, increasing competitiveness by eliminating barriers between information and physical structures [Pereira and Romero 2017]. This requires companies to review their operating models. When technology leaders introduce new advanced products, they offer new product quality and functionality, which contributes to changing customer expectations. This, in turn, must be responded to by other businesses by changing their existing business models. This process is certainly not an easy task [Li et al. 2017].

Industry 4.0 covers the entire value chain: from placing orders and supplying components for ongoing production to shipping goods to customers and after-sales services. Based on complex products, value networks will be created in which IT systems and production lines of manufacturers and suppliers automatically exchange data with each other. This will

take the “Just-In-Time” production model to the next level. Within the value network, companies will share data with each other to increase production efficiency across the value chain. What does this mean in practice? Only those manufacturers who prepare for Industry 4.0 solutions at the right time will be able to integrate into the value network and retain customers and suppliers in the long run. Whether we want it or not, Industry 4.0 is the next inevitable step in the overall global economy. Companies that implement digital solutions from the beginning even in small steps, learn new technologies and take an active part in shaping the changes. In the process, these companies gain a competitive advantage and secure their future [Piątek 2017].

Digitalization of the value chain in Industry 4.0

Industry 4.0, encompassing many modern automation systems, data exchange and manufacturing technologies, represents a potential for development in many fields. The implementation of digital technologies of Industry 4.0 has a huge impact on the entire value chain, streamlining production and engineering processes, improving management and product and service quality, optimizing customer and organizational relationships, bringing new business opportunities and economic benefits, changing educational requirements and transforming the current work environment [Ślusarczyk 2019]. Industry 4.0 is a collective term for the techniques and operating principles of value chain organizations collectively applying or using cyber-physical systems, the Internet of Things (IoT), and cloud computing [MBF group 2021].

Digitalization contributes to productivity growth in four ways: through process optimization, market expansion, product innovation, and more efficient use of human capital [McKinsey & Company and Forbes Polska 2016]. Digitization is also a tool for better resource management and is inextricably linked to building a green economy. Digitalization is the driving force that will shape the industry of the future. Digital solutions open up new opportunities to streamline operations from a sustainability perspective, but also lead to improved profitability [Bieñkowska and Lalka 2021].

Digitization of the value chain in Industry 4.0 affects the entire value chain, streamlining production and engineering processes, improving product and service quality, optimizing customer and organizational relationships, bringing new business opportunities and economic benefits, changing educational requirements, and transforming the current work environment. Digitalization is leading to profound changes in industrial and manufacturing sectors, having a strong impact along entire value chains and providing a range of new opportunities in terms of business models, production technologies, job creation and work organization [Ślusarczyk 2019].

In summary, it should be noted that there will no longer be classic value chains with clearly defined boundaries between internal company functions and external areas within Industry 4.0. Thanks to modern applications and their ubiquitous exchange of information, internal and external boundaries will merge and the classic boundaries of individual companies will be shifted. Industry 4.0 digitizes and integrates processes vertically across the organization, through all functions, from product development and purchasing, to manufacturing, logistics and after-sales service. Besides, horizontal integration goes beyond internal operations. Here, suppliers, customers and all key value chain partners are also integrated

[Blunck and Werthmann 2017]. The full digitization of these chains has the potential to increase productivity levels, but it requires precisely the aforementioned integration of vertical and vertical information sharing and decentralization of decision-making [Santos et al. 2017].

Significant benefits of value chain digitization

Digitalization brings benefits at many stages of the value chain. One of the first might be the digital design of entire production lines using the Digital Twin. It allows to design the entire plant or production line in the form of digital simulation of all production and logistics processes, and thus to identify potential hazards, weak points, increase the level of ergonomics, facilitate the functioning, optimize the time of performed operations and significantly increase the level of safety for employees and equipment. A similar area is the design of products using the same technology, which allows, already in the design phase, with the use of Artificial Intelligence and analysis of large data sets to optimize the construction of a single component to ensure on the one hand the best functional parameters, and on the other hand safety, durability or production optimization. What is more, digitalization and introduction of intelligent systems of data collection and analysis based on the Internet of Things allow for real-time analysis of the functioning of products and entire systems. This translates, on the one hand, into the use of advanced predictive analytics and the ability to react quickly in the case of an anticipated failure and not only in the case of an actual one, but also to use the data concerning the parameters of product operation to improve and develop it.

In business processes digitalization is also of paramount importance. Data collected by intelligent production systems make it possible to collect and analyze information and report objective data showing the functioning of systems, their parameters, energy and raw material consumption, as well as machines and equipment themselves. This allows for making optimal management decisions in the area of production, which also translates into business decisions and allows for a better and more flexible response to changes, micro- and macroeconomic conditions. In Industry 4.0, however, the processes of data collection and analysis go beyond a single entity and become part of a much broader ecosystem of information collection, exchange and analysis. Thanks to this, all processes, including production and logistics processes also between ecosystem entities, can be optimized in order to reduce costs, the level of consumption of raw materials and resources, increase the efficiency of all processes – from production, through logistics, to business – which directly translates into environmental protection, but also into improved quality and working conditions. This system and sample tools can work in any industry. Individual systems and processes and tools may differ due to the nature of the business. Nevertheless, the general concept and principles of functioning of Industry 4.0, areas of digitalization and values achieved thanks to its introduction, such as objective data and optimization of decisions based on them, are unchangeable for all entities.

Conclusion

The aim of the study was to present the value chain in the era of digitization in the context of Industry 4.0, including the identification of its most key elements, including the formulation of strategies based on digital resources that bring added value, allowing to compete in the market and at the same time set new standards and business models, and to show the significant benefits of digitization of the value chain.

Revolutionary changes in the business environment of enterprises caused by progressive digitalization pose many challenges to enterprises. Each enterprise nowadays, wishing to remain competitive in the market, is forced to introduce innovative solutions of Industry 4.0 increasing quality and production efficiency. Industry 4.0 forces technological, IT and organizational changes caused by the intensive process automation and in-depth digital transformation of industry.

Digitalization has become a necessity at the present moment. Nowadays, digitization, automation as well as real-time management cover almost all operations and processes of enterprises. Digitalization increases competitiveness and enterprise value, leads to profound changes in industrial and manufacturing sectors, and exerts a strong influence along entire value chains. Digitalization of each element of the value chain in Industry 4.0 affects the entire value chain. The value chain in the era of digitization is becoming an important element that generates noticeable profits and savings. In addition, digitalization brings many significant benefits to many stages of the value chain. By digitizing the value chain, companies can increase revenue, optimize costs, improve cash flow and working capital management, increase efficiency of operations, improve organization and management and quality.

In summary, the presented study aims to enhance readers' knowledge and also to contribute to a deeper understanding of the importance of value chain digitisation.

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