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The Role and Impact of Industry 4.0 and the Internet of Things on the Business Strategy of the Value Chain—The Case of Hungary

Judit Nagy [1], Judit Oláh [2], Edina Erdei [2], Domicián Máté [3,*] and József Popp [4]

1 Department of Logistics and Supply Chain Management, Corvinus Business School, Corvinus University of Budapest, 1093 Budapest, Hungary; judit.nagy@uni-corvinus.hu

2 Institute of Applied Informatics and Logistics, Faculty of Economics and Business, University of Debrecen, 4032 Debrecen, Hungary; olah.judit@econ.unideb.hu (J.O.); edina.erdei@econ.unideb.hu (E.E.)

3 Institute of Accounting and Finance, Controlling Department, Faculty of Economics and Business, University of Debrecen, 4028 Debrecen, Hungary

4 Institute of Sectoral Economics and Methodology, Faculty of Economics and Business, University of Debrecen, 4032 Debrecen, Hungary; popp.jozsef@econ.unideb.hu

* Correspondence: mate.domician@econ.unideb.hu; Tel.: +36-20-991-52580

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Abstract: In the era of industrial digitalization, companies are increasingly investing in tools and solutions that allow their processes, machines, employees, and even the products themselves, to be integrated into a single integrated network for data collection, data analysis, the evaluation of company development, and performance improvement. To study the impact of Industry 4.0 on the company we used Porter's (1985) value chain model, which is particularly useful when paying particular attention to corporate areas which have a primary role in customer value creation. Since the primary impact of Industry 4.0 is perceived in value-creating processes, and has so far had the greatest transformative effect in this area, the model can be considered to be appropriate. The objective of our research is to discover how companies operating in Hungary interpret the phenomenon of Industry 4.0, what Internet of Things (IoT) tools they use to support their processes, and what critical issues they face during adaptation. We applied a dual methodology in our investigation: We sent an online questionnaire to manufacturing and logistical service companies to investigate the IoT tools they use, and the problems they face, and received 43 answers we could evaluate. We also conducted four expert interviews with manufacturing firms to get deeper insights into the application, critical issues and development phases of IoT tools. During our research, we found that the spread of real-time data across companies—given the availability of appropriate analytical tools and methods—can have a significant impact on the entire company. In the case of CPS (Cyber Physical System), CPPS and Big Data Technologies, companies using them have been evaluated as having a higher level of logistic service, more efficient processes with their partners, improved cooperation between certain logistic functions, and higher market and financial performance and competitiveness. Applying more efficient production processes, and achieving better productivity and economies of scale, might also result in increased economic sustainability. Furthermore, we have found that companies have started on the path to digital evolution, and investments of this type have already begun.

Keywords: Internet of Things (IoT), Industry 4.0; business intelligence; Cyber Physical System; value chain; sustainable development

1. Introduction

Nowadays, the fourth industrial revolution—fourth in the sense of its innovative and qualitative nature—is taking place. On the one hand, the quality of the changes can be seen in the fact that the whole production process is managed and supervised in an integrated way, and is combined, yet flexible. In order to remain competitive in a globalized environment, manufacturing companies need to constantly evolve their production systems and accommodate the changing demands of markets [1].

These, in turn, have a large impact on industry and markets, while affecting the whole life cycle of the product, providing a new means of production and of conducting a business, allowing for an improvement in processes and an increase in the competitiveness of enterprises [2].

Computers, automation and robots existed in previous decades, but the opportunities provided by the Internet revolutionize their use, and the opportunities they provide [3–5]. The increasingly cheaper solutions allow us to monitor the activities, operation and processes of machines, materials, workers and even products themselves, and to collect, analyze and utilize data in real-time decision making.

The fourth industrial revolution is based on data. The way it can be gathered and analyzed, and used to make the right decisions and develop, has become a competitive factor. The source of competitive advantage, therefore, will not only be production on a coordinated or completely new basis (e.g., additive production), but also the embedding of products with digital services (e.g., in the event of a failure, the machine itself indicates which replacement part should be brought in), i.e., how companies filter the relevant information from the generated data in order to support decision-making [3,4].

In recent decades, manufacturing and production systems have been gradually supplemented by information technology support instruments, because controlling more and more complex technologies, the demands of multi-site production, and supporting logistic processes have become even more complex tasks. The inevitable role of IT (Information Technology) at companies has transformed both working conditions and efficiency, and its importance is unquestionable [6].

Regarding Industry 4.0 readiness, Berger [7] notes that while Hungary is among the most industrialized countries in Europe in terms of manufacturing output versus GDP, the country is below the European average in terms of indicators such as production process sophistication, degree of automation, workforce readiness and innovation intensity. "Industry 4.0" provides the relevant answers to the fourth industrial revolution.

The main purpose of Industry 4.0 is to achieve improvements in terms of automation and operational efficiency, as well as effectiveness [2]. The emerging Industry 4.0 concept is an umbrella term for a new industrial paradigm which embraces a set of future industrial developments including Cyber-Physical Systems (CPS), the Internet of Things (IoT), the Internet of Services (IoS), Robotics, Big Data, Cloud Manufacturing and Augmented Reality [8]. The adoption of these technologies is essential to the development of more intelligent manufacturing processes, which includes devices, machines, production modules and products that are able to independently exchange information, trigger actions and control each other, thus enabling an intelligent manufacturing environment [9].

The objective of this study is to discover how companies operating in Hungary interpret the phenomenon of Industry 4.0, what kind of Internet of Things (IoT) tools they use to support their processes, and what critical issues they face during adaptation.

This paper makes two potential major contributions to the body of knowledge. Firstly, and in general terms, it can provide evidence for the uptake of IoT and its impact on value chains, and secondly it provides an insight into a very specific country context (and potentially addresses both economic integration and re-industrialization as current phenomena), which can be a useful benchmark for other Central and Eastern European countries.

Following this introduction, the paper is structured as follows. At the beginning of our research, in the literature review we summarize the importance of industrial digitization and create a unified definition. Then, we will discuss the appearance of Industry 4.0 in the corporate value chain. We will briefly present the Porter value chain concept, the IoT concept, and their tools and solutions. The third section describes the materials and methods used for the analysis. In the fourth section we will present the results of questionnaire surveys and expert interviews conducted in the summer of 2017 among firms operating in Hungary. Based on the results of corporate interviews, we classified the companies according to the examined criteria, creating an Industry 4.0 profile for each company. In the fifth section we summarize the results and draw the main conclusions.

2. Literature Review

2.1. Importance of Industry 4.0

In Europe, the danger of an aging society has long been known, so that each country faces a decline in its workforce [10]. Power-generating technology such as robotization and automation has long existed. The Internet, however, revolutionizes process organization by networking robotic and automated devices. The development of the Internet and technology creates a continuous network of people, machines and companies, and through the continuous sharing of value-creating processes, it is now possible to produce a competitive, fully-customized product for the buyer.

By Industry 4.0, we mean the intelligent networking of industrial products and processes. In 2013, the Frauenhofer Institute reviewed the productivity and growth potential of companies using Industry 4.0 technologies. Its main impact comes from five technology areas: Embedded systems, smart factories, strong networks, cloud computing and IT (Information Technology) security [11].

Rüßmann et al. [12], however, collected nine technologies that characterize leading companies in the Fourth Industrial Revolution. These include technical tools and methods. These are automated robots, simulation, horizontal and vertical system integration, industrial IoT, cyber security, cloud-based services, additive production (3D printing), augmented reality, and big data analysis.

Today, in an Industry 4.0 factory, machines are connected as a collaborative community. Such evolution requires the use of advance prediction tools, so that data can be systematically processed into information to explain uncertainties and thus make more informed decisions [13]. It can be concluded that the term Industry 4.0 describes different—primarily Information Technology (IT) driven—changes in manufacturing systems. These developments not only have technological but also versatile organizational implications [14].

According to Hermann et al. [15], however, Industry 4.0 is the actual digitization of industry, which now covers a new, fairly broad conception, and includes new technologies and concepts relating to the organization of the value chain. Industry 4.0 creates a modularly structured smart factory, meaning the Cyber Physical System (CPS) monitors physical processes, maps the physical world in the virtual world, and decentralizes operational decision-making (autonomous machines).

The perception of the productivity of new technologies is influenced, on the one hand, by company-level calculations that have shown that Industry 4.0 investments have clearly increased investor productivity [16]. It is worth considering the possibility that the timing of the studies may distort the conclusions drawn from the results. Most of the large investments of the 2010s were carried out by well-equipped, high-performing leading companies with a good capital base, meaning that these observations cannot be generalized or even predicted at the macro level. At the same time, calculations have also been made at the national economy level, including reference [17], which, by examining 17 countries, clearly demonstrates the effects of industrial robots on economic growth and productivity gains. Using IT investments increases production, resulting in growing revenue and profit as well as higher product quality and performance through the introduction of new tools [18].

In their analysis, Geissbauer, Vedso and Schrauf [4] analyzed Industry 4.0 investments in each industry and found that the largest investments are now being carried out by the electronics industry, and it is expected that this will continue to be so in the future. By 2020, the value of investments will reach 243 billion US dollars a year.

Accelerated industrial digitization is trying to respond to rapidly changing customer needs. Due to ever new product variants expected by customers, the product lifecycle is considerably shortened, so work on the innovation of the product, and the technology needed to produce it, has to be kept up-to-date. Not only does the product itself need to be renewed from time to time, but a production technology must also be created that can be flexibly altered along with the ever-changing customer product specifications [19]. Due to industrial digitalization, there may be significant effects on manufacturing industries: Substantial reductions in inventory, logistics and material handling costs, shorter lead times and fewer shortages during shipment [20].

Industry 4.0's technology users at company level are expected to increase their capacity utilization and market their new products faster, in line with changing needs [21]. In Hungary, the most important success factors in the manufacturing process are IT developments and flexibility, which have an impact on financial results [22].

According to Geissbauer, Vedso and Schrauf [4], the cost of value-creating processes can lead to a 3.6% annual decrease in costs in the future (reduction in lead times, improved asset utilization and improved product quality), in return for spending 5% on digital skills and tools in the next few years.

According to Wang et al. [23], the implementation of Industry 4.0 requires (1) the horizontal integration of the value chain, (2) a networked production system and vertical integration, and (3) end2end digitization of engineering design along the entire value chain. They believe that these requirements are supported by emerging technologies, including IoT, wireless sensor networks, big data, cloud-based services, embedded systems, and mobile Internet.

Hermann, Pentek and Otto [15] and their co-authors, in their analysis of 50 studies, identified four basic tools needed to implement Industry 4.0 within the company. These are CPS, IoT, the Internet of Services and the Smart Factory. These are, in themselves, comprehensive categories, and do not specify the technical tools needed to operate the CPS (e.g., sensors).

Overall, we can conclude that Industry 4.0 penetrates the entire value chain of the corporation—although most of the value chains are interpreted as production-based, possibly supplemented with the logistics operations. The scope of Industry 4.0 can grow at the company's borders, covering the supply chain or, more broadly, the supply network. It builds on new network-linked technology (e.g., sensors, RFID), and requires new procedures (e.g., data analysis software, cloud, programming) that require new capabilities from the company (e.g., continuous innovation, life-long learning, trust, data sharing) and this may even require new business models to be developed. Industry 4.0 is thus a phenomenon that, by means of technology assets and activities, maximizes the transparency of processes by exploiting the possibilities of digitization and integrates the corporate value chain and the supply chain into a new level of customer value creation.

In this exploratory study we show how companies really use technological tools and methodologies. The novelty of the paper is that by means of a questionnaire we have obtained an insight into how IoT and Industry 4.0 technologies are used by companies. Furthermore, expert interviews have helped us to understand what advantages, challenges and problems companies face when using these technologies, and how the development process advances.

2.2. Porter's Value Chain Theory and Its Relationship to Industry 4.0

The fourth industrial revolution has an impact on the entire company, so it is very important to understand how the various elements of it are able to exploit the opportunities offered by digitization. For a structured presentation of this, there was a need for a theory by which the core process of the company is customer value creation, as this industrial revolution affects first and foremost the various elements of value creation, and—at least initially—affects production most of all. However, we should not forget the corporate activities that support value creation and how these activities can benefit from the achievements of Industry 4.0.

There is no sector in any industry that has been left untouched by digitization. Logistics is no exception, and the fourth industrial revolution has brought a tremendous increase in efficiency in this area, as well. From the production line to end use, logistics is everywhere, and now digitization is becoming more and more present [24–26].

Porter [27] value chain concept (Figure 1) suggests that a company's competitive advantage cannot be looked at in general—it is also necessary to understand the company's internal structure, i.e., how individual business elements contribute to delivering the product or service to competitors at a lower price or higher quality. One of the possible types of the value chain approach is to systematize intra-corporate activities and to find the source of competitive advantage. Not only are the value chains of companies in different industries different, but also different value chains are created by each company operating in the same industry. This structure depends on the company's strategy, its strategy implementation, and corporate traditions. The value that a chain generates is the amount that the product (service) is worth for the buyer. This price must go far beyond cost, which is the basis for every company to survive. Understanding and serving the value-based approach, i.e., customers' needs, is the foundation of corporate strategy.

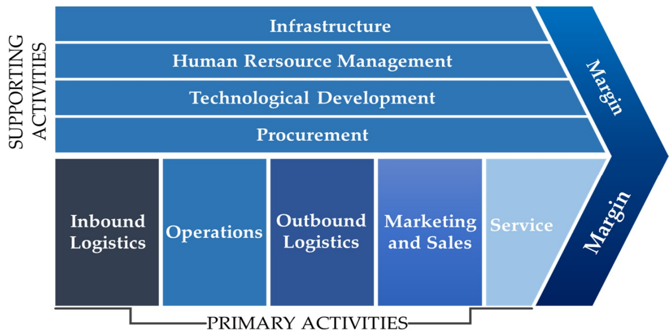

Figure 1. Porter's Value Chain. Source: Porter [27]—Chikán [28], authors' own editing.

Rayport and Sviokla [29] acknowledged the importance of structuring company activities into a value chain, but they suggested that there should be a distinction between physical and virtual chains. The physical value chain includes the processes Porter classifies as primary functions in customer value creation, while the virtual value chain embraces the entire company and refers to the information captured during the stages of physical value creation. In this way, companies can monitor the whole process of value creation, and can start performing value-adding activities more efficiently and effectively. They claim that providing information about the product, the production process, etc. can also be considered value-adding services. Their approach corresponds with the aims of applying IoT tools and Industry 4.0 technologies in production and other processes, and linking information based services to products (smart products).

Since Rayport and Sviokla [29] use the same activities in the physical value chain as Porter does in primary processes, and the virtual value chain is not broken down into activities, we use Porter's value chain model to understand how IoT tools and Industry 4.0 technologies are applied in different processes, with special attention to the methods used for information production, sharing and analysis.

2.3. Impact of the 4th Industrial Revolution on Relationships between Companies

In addition to the impact on the company's internal business areas, we cannot ignore the impact of the fourth industrial revolution on business relations. At the level of the supply chain, first of all the relationship between suppliers and customers should be mapped out. According to KPMG, the future trend will be for former competitors to work together and for sectoral alliances to emerge [30].

The structure of global value-added networks is determined by the strategies of the companies concerned, which are driven by the driving forces commonly found in capitalist conditions and by the efforts to minimize the risks inherent in the external environment [31].

With the help of the Internet, the supplier, the manufacturer, and the customer will create a single digital ecosystem where all relevant data and information can be accessed immediately in the cloud in order to coordinate activities as efficiently as possible. This is not considered a realistic goal in the foreseeable future by the experts consulted. They see a chance of this happening if the supplier, the factory and possibly the customer belong to a group of companies and this creates transparency among the subsidiaries of the central organization and provides them with opportunities for learning and benchmarking [32]. Even if no merging into a single digital network occurs in the near future, we can be sure that relations with suppliers and customers are changing. Customers' expectations come to the forefront for suppliers: They demand speed and flexibility in order fulfilment, and product development. The digital ecosystem also functions further down: It should be accessible in one place.

Thanks to cloud computing, production is completely transformed, and isolated production units merge into a fully integrated, automated, optimized, high-efficiency production process, resulting in a change in the relationship between manufacturers, suppliers and customers [33].

According to a survey by PwC [34], 72% of respondents would use data analysis to improve their relationship with customers and analyze customer data over the next five years. Improving customer relations and responding to customer needs will be achieved by product/service planning based on customers' special needs, innovation in customer service and customization, even including itemized one-piece production volumes. Data analysis enables us to better understand and consider customer needs, which can be used not only for the development of the production process, but also for the creation of a customer-centric supply chain.

Industry 4.0 organizes suppliers, manufacturers and customers in a virtual, vertically and horizontally integrated, value chain, so Hungarian suppliers should also introduce the appropriate technologies to avoid losing their position and to fully integrate into the customer's network [35].

The offline dimensions of service and e-customer satisfaction could be indirectly linked via website quality and related issues, the area studied in this paper [36].

Overall, the significant amount of data generated through digitization affects all areas of the company's business, thus improving transparency, integration, and designability, and providing much more information on customer needs and the individual tasks needed to fulfil them. Industry 4.0 also creates completely new value-creating business areas; for example, product design and development, and data security, will become much more important in the future [37].

The tools of Industry 4.0 in the corporate value chain are summarized in Figure 2. It can be seen that the effects of most of the technologies span over functional boundaries and affect the entire value creating process, or the company itself.

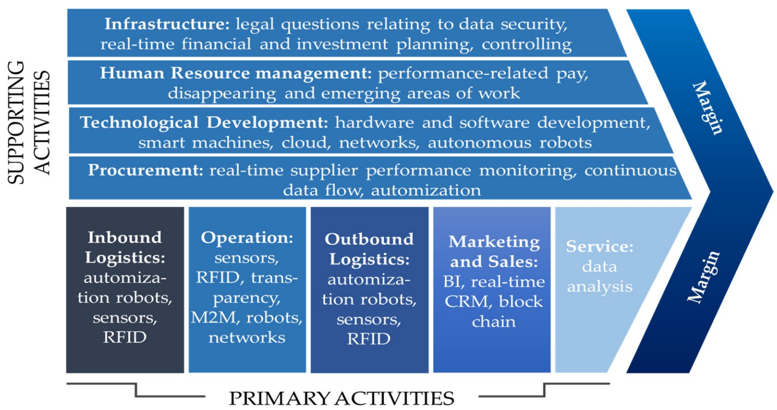

Figure 2. The tools of Industry 4.0 in the corporate value chain. Source: authors' own editing, based on Porter [27].

Overall, accessing real-time data at different points also has a positive effect on strategy, finance and process design. Data generated in each area is also available to other areas and provides information transparency. These tools contribute to system-based and process-oriented thinking and the integration of processes within the organization, and then beyond organizational boundaries [38].

Technologies help to increase the agility, adaptability and alignment of companies cooperating in a network of value chains (supply chain) in order to gain competitive advantage [39].

2.4. Factors Obstructing the Implementation of Industry 4.0

The involvement of companies in the Fourth Industrial Revolution remains, for the time being, a question of decision-making. The use and development of new, unknown technologies is a risky activity and is currently expensive, although it promises considerable savings, thus increasing revenue for those who make the decision early [40]. In some industries, progress, development and rapid deployment of applications cannot be avoided in order to stay competitive (the automotive industry, electronics). However, there are also some industries that will only embark on such developments if others have already marked out the path and the technology required is affordable for sectors operating with smaller profit margins. At enterprise level, the introduction and maximization of the impact of Industry 4.0 is dependent on the creation and consistent implementation of a corporate digital strategy [41].

Some factors may hold back or obstruct the spread of Industry 4.0. This question was dealt with in references [34,37]. PwC [34] picked up critical, risky factors, while Porter and Heppelmann [37] and his co-author focused on the pitfalls to be avoided by firms.

In 2016, PwC produced a Global Industry 4.0 survey, in which 2000 experts from 26 countries were asked about how their companies will exploit the opportunities offered by digitization. The majority of the companies surveyed (52%) said that the biggest obstacle to the implementation of Industry 4.0 is the lack of a clear digital strategy in value-creating (production and logistics) processes, and of support for corporate executives for the introduction of digital technology [34].

Porter and Heppelmann [37] argue that the company should not address fundamental issues superficially and ignore industry signals. The digital services connected to the product must be those for which the buyer is willing to pay. The fact that certain data is available does not mean it is marketable. It is therefore necessary to think carefully about what creates value for the buyer.

Data security has been mentioned several times. This is a critical point for development. Control of access must be ensured, as must the security of networks, devices, sensors, etc. and the proper encryption of information [42]. New entrants can also appear with smart products with market-related services to implement and innovate a new type of customer-centric business model, and possibly extend the boundaries of the industry. The big question is when to take the plunge. If your company waits too long, your competitors or new entrants can tailor the market and gain an advantage in the learning process. The production of smart products requires a new kind of technology, capabilities and processes throughout the value chain. The company has to realistically see what capabilities it can develop and what it needs in order to be involved with an external partner [43].

Table 1 summarizes the factors preventing the spread of Industry 4.0.

Table 1. Factors hindering the spread of Industry 4.0.

Cultural Market Obstructing Factors	Labor Market Obstructing Factors	Organizational Obstructing Factors	Technological Obstructing Factors
Distrust	Inadequate quality workforce	Lack of digital strategy	Expensive technologies
Uncertainty	Shortages among workforce	Risky investment	Lack of standards
Realistic judgment of the abilities of the organization	Old-fashioned training	Fear of loss of control over intellectual property	Security of data, uncertainty regarding the level of encryption
Lack of demand for continuous learning		Partners do not have the technology	Underdeveloped data analysis
		Failure to develop data-based services	
		Lack of senior management support	

Source: Authors' own editing, based on Porter and Heppelmann [37]; PwC [34].

In order for Industry 4.0 to enable companies to develop and create jobs, governments need to invest in training to create a highly skilled, digitally-skilled workforce.

2.5. Internet of Things: Tools and Solutions

The initial basis for industrial digitalization is the networking of devices. This is commonly known as the Internet of Things, a concept which the profession cannot define with unanimous agreement. According to Hermann, Pentek and Otto [15], this is a term for "mobile devices" which are equipped with a chip, RFID, sensor or any other device capable of networking, and are able to communicate and share data.

The main idea behind the IoT is that over the last few decades IT and telecommunications have evolved [44]. The aim is to build long-term and accurate observations using complex analytical methods to create better planning, operational, optimization and maintenance solutions than previously [45]. We are on the verge of a digital industrial revolution that will lead to a vertical (intra-corporate) and horizontal (inter-market) interconnection of sensors, machines, workpieces and IT systems across the entire supply and value chain [46].

IoT tools are the technological components that enable a product or production machine to connect to a corporate network and to collect and/or share data. These may include the previously mentioned sensors, RFIDs, 3D scanners, cameras, and so on. In the survey, two tools were highlighted; sensors, that are intended to observe the external environment of the object of observation [47], and RFIDs, capable of transmitting active or passive data on the status or performance of the observation unit [38,48].

When we use IoT tools in corporate processes and we begin collecting data, we have several options to utilize them. Large amounts of data which are unmanageable in continuous and conventional data analysis systems are called big data [23,49]. Collecting them and sharing them with authorized individuals or organizations can be done through enterprise data warehouses or clouds, possibly with cloud computing companies (such as Amazon, Microsoft) [12].

So much data is only really valuable if we have a tool to analyze it and then put it into a user-friendly form. This is big data analytics, which can be a source of competitive advantage. In order to obtain the right data and information, companies spend more and more on developing data mining software, algorithms, and Enterprise Resource Planning (ERP) interfaces, which not only represents a problem on the investment side but also in terms of finding the right workforce.

CPS connects physical devices with cyberspace. CPS uses sensors, 3D scanners, cameras, or Radio Frequency Identification (RFID) devices and provides mass data for the process. This is actually the realization of the IoT [15]. The CPS solution used specifically in production, the Cyber-Physical Production System (CPPS), is a networked system of production equipment, workers, or products in the production process [47]. This makes it possible to make the production process more flexible and improve its efficiency, and to tailor-make products with mass production methods [9]. Future production systems need to be developed considering the need for strong product individualization and, therefore, the need for highly flexible production processes [50]. To accomplish this challenge, CPPSs should be integrated into production sites in order to create smart factories. A CPS is central to this vision and should be incorporated with smart machines, storage systems and production facilities capable of exchanging information with autonomy and intelligence [51]. These CPSs monitor the physical processes, make decentralized decisions and trigger actions, communicating and cooperating with each other and with humans in real time. This facilitates fundamental improvements to the industrial processes involved in manufacturing, engineering, material use, supply chains and life cycle management [52].

Smart products can signal the current state of the production or the process supervision, the process characteristics, and the future need for maintenance, and make suggestions about the nature of the intervention, or even intervene themselves [9,48]. With the spread of robots and artificial intelligence, less and less monotonous work is needed. These tasks are performed accurately by machines, with significantly lower financial costs [53]. Smart devices, such as self-propelled vehicles and robot arms have also appeared in corporate practice, where they serve the physical supply requirements of production and logistics processes. Smart devices also connect to the network, interacting with their environment, and with the ability to react to changes, and even make decisions [54]. The implementation of robots is a relevant option in unique production systems, as an intelligent system is capable of identifying problems even at the source of failures, and therefore this allows the firm to delay and increase the precision of the operation [55].

For the implementation of Industry 4.0, tools that generate data and create big data are essential, including sensors, RFID chips, 3D scanners, cameras, and robots [56]. Machines and people use interfaces to communicate, most often in a real-time way. Additional tools such as clouds, local data warehouses, and ERP systems collect, store and distribute data. There must be platforms that provide a common base for all these machines and devices, and the most up-to-date standards and, most frequently, in-house developed software to extract the relevant information from the generated data (e.g., data mining and data analysis, simulations, algorithms) in a way which is accessible and convenient for users, i.e., on a device such a tablet or mobile phone [57]. The device itself, which displays the interface, does not need to be specialised—it may be a worker's mobile phone; the essential point is that it is easy to visualize the information needed. All of this is particularly exciting because it is attainable at low cost and the smartphone which sits in most people's pocket can become a connection and control tool [58]. In day to day operations, order forms to be filled in and other automated forms of communications can be used, besides e-mails and telephone calls, which can help when standard forms of communication are insufficient to support the exchange of services [59]. Integration is created by the internet/network connection and the real-time interconnection of all the "things" mentioned above.

The presence of the tools, methods and procedures listed above in a company is necessary to for it get started on the development path generated by the Fourth Industrial Revolution. The following steps are required for the change:

1. Applying tools and technologies to networking to ensure the transparency of the entire business process.
2. Horizontal integration, which means close, real-time connectivity and cooperation within the enterprise's field of activity.
3. Vertical integration, which primarily involves cooperation with partners in the supply chain, later with partners in the supply network, including digital connection.
4. Rethinking the business model in the spirit of a focus on customers, even by transforming the organizational structure.

The whole system is based on small structures, data mining, storage, and forwarding components, which, in built-in machines and/or products, observe some aspect of the product or production. These data will be transferred to the cloud (or the enterprise data warehouse) and embedded with an interface to Enterprise Resource Planning (ERP), Business Intelligence (BI), Market Analysis or any other software where their analysis can be carried out automatically or manually [60]. The analyzed data is displayed in a user-friendly way—whether it is the firm's own computer program, or smartphone applications—and is available for either enterprise-level decision makers at different levels of complexity and access rights, or consumers who use the product [61]. By transferring the information, some decision, approval or intervention occurs—even in an automated form. If such a complex integration is achieved through digitization, we call it a "future factory" or a "smart factory", capable of continuously optimizing production and operational processes based on accurate data-based decisions [10]. If we look at corporate boundaries and data is shared between smart factories, then we can talk about a digital ecosystem. This digital ecosystem not only includes the member companies of a group of companies—though this itself is a very big step and important for corporate processes and optimization—the really significant step is the integration of supplier and customer partners, which is a genuinely comprehensive way to achieve optimization, and an even greater trust and security issue [62].

The choice of partners in the supplier domain shapes the "co-creation involvement strategy", as well as the "co-creation technique selection", all participants being aware that collaboration will generate gains for both parties [63–65].

3. Materials and Methods

In the summer of 2017, we conducted a questionnaire survey among Hungarian manufacturing companies to assess the prevalence and the use of IoT devices, and assess uncertainty towards them. The online questionnaire was submitted to the member companies of the Hungarian Association of Logistics, Purchasing and Inventory Management and the Hungarian Association of Packaging and Materials Handling in the form of a newsletter, so we reached nearly 500 production and logistics companies. Therefore, sampling cannot be considered representative; however, our aim was to get acquainted with the practice of manufacturing and logistics companies, as IoT tools appeared primarily in operations.

After we obtained interesting—although not generalizable—results from the questionnaire, we wanted to better understand how manufacturing companies approach Industry 4.0 and digitalization, what technologies they use, and most importantly, what obstacles they face. We found that digitalization so far mainly influences operations processes, but the complexity and the extent of its use varies. For this reason, we decided to use a PwC model to try to capture the current stage of development. Besides the cyber-security issues analyzed in detail in the questionnaire, we found that there are many other obstacles which might hinder digitalization, such as data analysis capabilities and human resource issues. These real life company cases help readers to see that Industry 4.0 is not only about applying technologies, but also involves many organizational and management issues that have to be solved in order to achieve higher efficiency and performance and, above all, competitiveness.

The questionnaire was distributed by an online link and started with the general company data which made it possible to define the size, ownership structure, and industry of the respondent company, and also its role in the supply chain. These descriptive questions were open questions (number of employees, annual revenue), and multiple-choice questions (industry, supply chain role). The IoT section of the questionnaire used multiple-choice questions about whether the company uses a given IoT technology or not, and 5-point scales to assess the usefulness of these technologies. We evaluated the usefulness of the latter technologies on a 5-point scale to understand how they support internal and external process improvements and corporate performance. Multiple-choice questions helped to reveal what technologies are intended to be implemented at the respondent companies in the near future. Multiple-choice questions were used to see what kinds of cyber-security problems were experienced at the companies and how often these problems arise.

Using the online questionnaire, we received 43 answers that we could evaluate. The composition of the sample is favourable because of the large number—56%—of big companies (more than 250 employees, turnover of at least €32 million). Medium-sized companies (employees: 50–249 persons, turnover: 9.5–31.9 M €) accounted for 28%, and small businesses (1–49 persons, sales: 0–9.4 M €) for 16%. Most of the answers were given by the engineering industry (23%), but the proportions of food industry (18.6%) and logistics service providers (16.3%) were high. Most responding companies are in foreign private ownership (58%), with the proportion of Hungarian privately owned enterprises standing at 40%, and with one company having the Hungarian state as majority owner.

During our research, we asked various industries about the use of new tools (CPS, CPPS, Big Data Analytics, etc.), their benefits, disadvantages and the causes of security issues that may arise. In order to exemplify the robustness check of our estimations, we used various methodologies to measure the usefulness of various IoT tools in terms of Industry 4.0 technologies. In this paper, besides various descriptive statistics, independent sample *t*-tests are frequently analyzed to highlight the differences among our evaluations. In our hypotheses those logistics firms applying IoT technologies are evaluated as having better logistics and financial etc. performance than those that do not.

The different types of companies surveyed and those among them that have an integrated system are shown in Figure 3. We also considered it important to inquire whether the companies under investigation are planning to introduce new technologies over the next five years, and if not, why not. One of our main goals was to assess the application of new technologies among companies operating in Hungary.

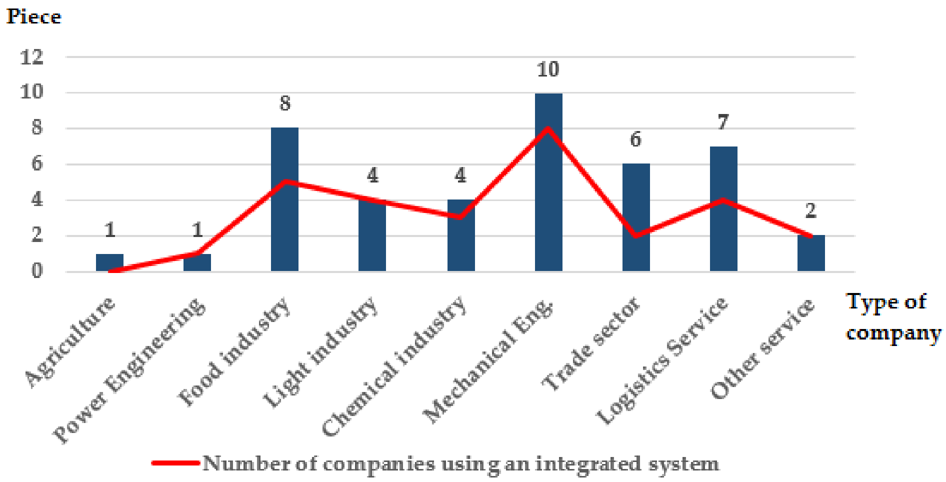

Figure 3. Types of company surveyed during the research = Number of companies. Source: Authors' own editing, 2018.

The sample used in our research is not considered representative, but as large and medium-sized companies are overrepresented, we can derive tendencies from it. Results and findings were supported by statistical analyses and several expert interviews.

Expert Interviews

Since the results of the questionnaire are not representative or generalizable, we wanted to discover real company cases illustrating how companies interpret Industry 4.0, what technologies they use and how they are adapted, as well as what problems companies perceive, perhaps in addition to those related to cyber security

The research was supported by four expert interviews, which we carried out in 2017. The selection of companies was supported by the list of members of the National Technology Platform, which is the body for Hungarian companies and Institutions engaged in Industry 4.0 developments. We selected companies from the membership list, and at the end of an interview we asked the interviewee to recommend other potential interviewees who they know and might have interesting opinions or practice in Industry 4.0. Company V1 is the subsidiary of a Hungarian holding company, manufacturing production lines quipped with Industry 4.0 technologies for other companies. It is a large company in terms of its annual revenue, and the interviewee was the CEO. Company V2 is the Hungarian subsidiary of a US-based Tier-2 automotive manufacturer, and the interviewee was the head of the corporate Industry 4.0 development team, and also a member of the regional committee on Industry 4.0 development strategy. Company V3 is a subsidiary of a Belgian Tier-2 automotive manufacturer, the Hungarian facility is an Industry 4.0 pilot factory experimenting with new technologies for the entire company group. The interviewee was the Plant manager, and also head of the Industry 4.0 development team. Company V4 is the subsidiary of a giant German company, famous for innovation. The Hungarian plant has dedicated Industry 4.0 development projects, and the interviewee was the head of the development coordinating team. We think that we found leaders who have a good insight into their companies' Industry 4.0 intentions and the firms themselves can be used as good examples of how developments need to be carried out.

The interviews were semi-structured—a list of questions was used but if interviewees wanted to discuss something in detail we did not follow the list strictly. The four interviews were then compared along the previously defined topics: Interpretation of Industry 4.0, its appearance in production, problematic issues and the development phase.

4. Results

4.1. Analysis of the Spread of IoT Tools and Solutions

The survey looked at the prevalence of IoT tools and solutions among Hungarian companies, exploring their future plans and the factors which hinder them. The tools and solutions surveyed in the questionnaire included sensors, RFIDs, cloud storage, large data analytics, CPSs, CPPSs, robot arms, AGVs (Automatic Guided Vehicle) and other smart devices, as well as smart products.

The first question was "Please indicate whether your company is using the following tools and solutions?" Table 2 shows that CPS is the most widely used tool (67.4%), especially in production (53.5%), and it can also build on data analysis (62.8%). In spite of the high rate of CPS use—and what is somewhat contradictory—the integration of sensors and RFIDs is relatively unusual. With these technologies, large companies are leading, with 18 of the 24 responding large companies using CPS, 15 using CPPS, and 15 using big data analyses. As far as industry sectors are concerned, CPS, CPPS, sensors, robotic arms and cloud storage are most common in the mechanical engineering industry, while in the rest of the industrial sector they occur on an ad hoc basis. This is also in line with international trends, where among the leading companies of the fourth industrial revolution, automotive industry companies are the most prominent.

Table 2. Prevalence of Internet of Things (IoT) devices and solutions (N = 43).

Tool	Prevalence in the Sample	Number of Observations
CPS	67.4%	28
Big data analytics	62.8%	26
CPPS	53.5%	22
Cloud	32.6%	14
Sensors	30.2%	12
Robot arms	23.3%	10
RFIDs	14%	6
Smart tools	9.3%	4
Smart products	7%	3
AGV	2.3%	1

Source: Authors' own research, 2017.

In the questionnaire, the following questions were raised in order to identify the benefits of introducing the tools listed in Question 1. Their utility was evaluated on a scale of 1 to 5. The questions were the following (numbered on the questionnaire from Q1 to Q7):

1. The efficiency of the company's internal logistic processes (higher level of logistic service) (Q1).
2. The efficiency of processes with the ordering partner in the supply chain (Q2).
3. The efficiency of processes with the supplier partner in the supply chain (Q3).
4. Cooperation between certain functions of the company (e.g., marketing, finance, logistics) (Q4).
5. Market performance of the company (e.g., ensuring greater market share (Q5).
6. Financial performance of the company (Q6).
7. Competitiveness of the company (Q7).

Essentially, sophisticated methods are needed to analyze the ways in which we can estimate the usefulness of IoT tools in terms of the increased logistics service level, the efficiency of the processes of the business partners, cooperation among certain logistics functions, financial and market performance, and the competitiveness of firms. Therefore, independent sample *t*-tests are used to determine whether those companies applying one of the IoT tools tend to estimate their utility more highly than firms without them. Here, as the methodology is assumed, the utility responses are normalized.

According to our results (Tables 3 and 4) a significant difference appeared between the two samples examined, in which those logistics companies applying IoT tools are proven to be more efficient and have better performance. In the case of CPS and CPPS, firms seemed to have a higher level of logistics service, more efficient processes with their partners, better cooperation among certain logistics functions, and higher financial and market performance and competitiveness. When using big data, we found a higher level of service, efficient logistics processes and greater competitiveness. In other cases, we found no substantial differences among the mean differences.

Table 3. Utility of IoT tools and solutions (results of independent sample *t*-tests).

	Type	CPS	Big Data	CPPS	Cloud	Sensors	Robots	RFID	Smart Tools	Smart Products
Levene's F	**Q1**	26.144	2.243	12.095	0.017	0.003	0.172	0.084	0.047	0.249
t		2.361 *	2.071 **	2.171 **	0.162	0.422	−0.431	0.552	−0.221	0.359
Mean Diff.		1.423	0.807	0.786	0.061	0.158	−0.173	0.229	−0.136	0.195
S.E.D.		0.379	0.389	0.362	0.371	0.373	0.401	0.415	0.617	0.543
Levene's F	**Q2**	5.741	0.089	2.284	0.088	2.103	1.039	0.672	0.993	0.879
t		2.674 **	1.867 *	2.809 ***	0.136	1.077	0.857	0.645	−0.184	1.266
Mean Diff.		1.415	0.773	0.977	0.051	0.401	0.343	0.269	−0.114	0.673
S.E.D.		0.379	0.414	0.348	0.374	0.371	0.401	0.417	0.618	0.531
Levene's F	**Q3**	1.041	0.006	0.004	1.198	0.057	1.512	0.442	0.152	0.962
t		2.362 **	1.452	2.427 **	−0.241	0.778	0.302	1.015	0.152	0.941
Mean Diff.		1.003	0.618	0.898	−0.091	0.295	0.123	0.421	0.094	0.507
S.E.D.		0.534	0.471	0.371	0.379	0.379	0.408	0.415	0.621	0.539
Levene's F	**Q4**	5.046	6.699	0.274	0.921	2.009	0.462	0.185	2.517	0.099
t		2.712 **	1.911 *	1.676	−0.038	−0.541	0.288	−0.687	−0.696	−0.444
Mean Diff.		0.918	0.567	0.631	−0.014	−0.204	0.116	−0.286	−0.427	−0.242
S.E.D.		0.338	0.297	0.375	0.374	0.355	0.404	0.416	0.614	0.544
Levene's F	**Q5**	2.173	0.296	2.409	0.281	0.001	5.929	2.919	4.856	1.847
t		2.902 ***	0.041	2.464 **	1.511	0.143	0.893	−0.558	−0.529	−0.103
Mean Diff.		1.182	0.018	0.881	0.544	0.054	0.357	−0.233	−0.326	−0.056
S.E.D.		0.407	0.439	0.357	0.361	0.383	0.399	0.417	0.616	0.546
Levene's F	**Q6**	0.315	0.009	5.661	2.321	0.196	1.912	0.084	0.682	0.637
t		2.467 **	1.462	0.675	0.151	−1.417	0.992	−0.168	−0.752	−0.441
Mean Diff.		1.038	0.619	0.311	0.056	−0.519	0.395	−0.071	−0.461	−0.239
S.E.D.		0.421	0.423	0.389	0.374	0.366	0.398	0.419	0.613	0.544
Levene's F	**Q7**	0.956	3.941	0.931	2.678	0.561	1.076	0.784	0.174	0.031
t		3.709 ***	3.172 ***	1.751 *	−0.039	−0.563	0.299	1.571	−0.065	0.115
Mean Diff.		1.411	0.997	0.655	−0.014	−0.212	0.121	0.633	−0.041	0.063
S.E.D.		0.381	0.314	0.374	0.374	0.377	0.404	0.402	0.619	0.546

Source: Author's own research, 2017. Note: $N = 43$, * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Nevertheless, this study has its limitations which also need to be emphasized. The main limitation of our estimations is that these empirical findings were only able to demonstrate one empirical aspect of IoT devices. Meanwhile, other determinants which may affect the utility of IoT tools and solutions have not been included due to restricted access to data, so the validity of our conclusions is limited by the bias caused by the exclusion of these variables and method.

Table 4. Utility of IoT tools and solutions (results of Pearson's χ^2 tests).

	CPS	Big Data	CPPS
Q1	15.624 ***	5.931	10.552 **
Q2	13.854 ***	5.311	7.875 *
Q3	9.092 *	5.244	6.729
Q4	4.211	4.814	5.547
Q5	10.685 **	1.611	9.568 *
Q6	9.286 *	2.289	5.443
Q7	13.333 ***	5.932	6.446 *

Source: Author's own research, 2017. Note: $N = 43$, * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

In order to demonstrate the validity and reliability of our results, an additional chi-square test for independence, also called the Pearson's chi-square test or the chi-square test of association, was used with SPSS to discover if there is a relationship between two examined categorical variables. From this perspective, there was a statistically significant association between, for example, CPS, CPSS and the efficiency of the business performances of IT companies.

Disincentives for development were also surveyed in the questionnaire. Respondents were asked to indicate what factors hold them back from using IoT solutions. The main inhibitory factor (21 responses) is, of course, the unknown level of costs. Companies feel that the new technology has uncertain costs, which do not, at present, have guaranteed returns, not to mention the lack of standards and the risk of rapid obsolescence.

A quarter of respondents identified data security as a risk factor, especially when it comes to external data or data sources. Equally, a labor force with inadequate qualifications was considered a barrier. It is an important hindering factor for the spread of Industry 4.0 features that standards, norms and certificates are not yet available to ensure the interconnection of different systems. According to the respondents, the basic technological tools of digital infrastructure are currently spreading slowly, and are not necessarily available in every supplier or customer organization, so cooperation may also be limited. A total of 14% of companies also fear losing control of the company's intellectual property.

Many respondents regard the fear of organizational resistance as a deterrent. While high cost is an obvious reason, it is not only fear of organizational resistance which can paralyze the development of a company in terms of its IoT assets. The task of a serious management is to make workers understand the inevitability of change, because it facilitates the work of the employees, and they can be involved in work which is more creative and has higher added value.

4.2. Results of Expert Interviews

The purpose of this section is to present the experiences of the four companies that were interviewed during the research in 2017. The purpose of the interviews is to illustrate all the technologies and solutions described above. Among the companies, there is an SME belonging to a majority owned Hungarian holding company in the electronics industry, two multinational large automotive companies operating in the automotive industry and a multinational automotive company functioning as a system integrator. The value chain approach seems to be appropriate since the companies have a functional structure, even though they have realized that Industry 4.0 developments have to be handled at a cross-functional or company group level. Generally speaking, Industry 4.0 has been more noticeable in the international companies, while the Hungarian SMEs—although it has begun development—prefer to wait until the technologies that are the most successful are revealed and until the purchase price falls.

4.2.1. Approach to Industry 4.0

The surveyed companies had opinions on what Industry 4.0 meant to them:

"An information revolution in the industry." (V1 interview, 2017)

> "To use and interpret the enormous amount of data, and use it to predict the future. This is the secret of success." (V2 interview, 2017)

> "Industry 4.0 Data and Behavior. Everyone gets all the relevant information, enabling them to react and decide on it in different ways." (V3 interview, 2017)

> "Linking to a smarter network that encompasses the industry" (V4 Interview)

The companies interviewed have differing degrees of affinity to Industry 4.0. One company makes the necessary improvements but does not move forward, does no piloting, and takes advantage of what is afforded by cheap and easily accessible technology. There are two companies where the Hungarian factories in the group of companies are pilot factories creating ideas, transformations and developments, and what works is transferred to other factories. These are local, stand-alone initiatives, and it can be stated that a lot depends on dynamic leadership. The innovative activity of one company has led to the development of digitalization before the launch of the German High Tech Strategy.

Among the companies asked, we identified three behavioral patterns. In one approach progress can be achieved by taking only the "low-hanging fruit"; alternatively, there can be intense internal motivation, which can even help a subsidiary of an international group of companies; thirdly, the company can socialize into an innovative environment where a high degree of innovation is expected, in which all members of the group participate and the results are applied globally.

There was a question in the interview about what phases a company goes through to actually exploit Industry 4.0's potential.

The first step is that the companies start collecting data. They install the technological tools or software that can capture the desired observations and collect data: "performance immediately increases by 30% if we start observing a process by cameras and sensors" (V1 interview).

The *second step* is to transform this data into decision support information: "we need to build up a serious IT infrastructure to store and handle the data produced in the manufacturing processes" (V2 interview). This is a critical point; in many places there is lack of capacity for data analysis and interpretation, so there is a lack of professional skills in this area. It is not only necessary to run the analysis; other tasks—from the preliminary cleaning of the database, through to the knowledge of algorithms, the recognition of errors and distorting effects, to the transparent presentation of the results—are important.

The *third level* is the use of the results gained from data: "we have specialists at group level who develop machine connectivity and big data analytics software" (V2 interview). To do this, well-trained personnel are needed who can re-program software and hardware, and write new software or algorithms, and who are able to further develop the systems. There is also a need for decision-making algorithms and decision-makers who can build this information into their decisions and achieve goals using real-time data access and analysis (V1 and V2 interviews).

4.2.2. Industry 4.0 in Production

From the interviews, it became clear—as it does from the international literature—that Industry 4.0 exerts its greatest impact on production, and that the companies surveyed have also developed varied methods and procedures. These can be termed first category when sensors are built into a machine, and sensors are incorporated into the process of monitoring a production process and indicating deviations from it. The V2 example shows how a company incorporates a sensor in the injection molding machine which indicates if the tool needs to be replaced soon, and so the new tool should be prepared by a worker. It also indicates if something stops production. It then sends a notification to the operator's mobile telephone that an intervention is required. On reaching the scene, the worker observes the machine's performance and the perceived problem on the monitor mounted on the machine. If the solution is known, the worker can intervene and restore the production process. If the problem cannot be solved, the supervisor is informed (V2 interview): "to do this we need clear escalation routes and protocols" (V2 interview). A similar system was reported in the V3 interview, where the sensor installed in the assembly station can track the worker's work speed, and if it detects a pause, reports this to the worker responsible for intervening. If it does not detect an intervention within a certain time it will notify the next level of the chain. Thus, it becomes clear that something has held up the production process and a solution can be found within a short time (V3 interview).

Sensors can be used to maintain the condition of the production line. The Czech brother firm of the V4 interviewee monitors a tool with the help of sensors. If the tool gets dirty, it may require a month to repair. The vibration-sensing sensor notifies the maintenance staff of the slightest deviation, so that the dirt can be removed before the tool is damaged. With this assistance, they have saved thousands of Euros because they have not had to buy new tools, and the old ones have not been taken out of production; in this way, unplanned maintenance has fallen by 12% (V4 interview).

The second level and category of digitalization of production processes occurs when machines are a coherent network, as, for example, in an easy-to-adapt, flexible manufacturing system (FMS). A member of the V4 Group's international group of companies is working on a rapidly networking, flexibly configurable line of machines. If the production so requires, a new machine is inserted into the production line. The machine also connects to the network—without the need to reprogram the machine—and thanks to the rapid transfer of data, the production program runs on it and production can continue (V4 interview): "We call this a Plug and Produce system" (V4 interview).

The third level is support for production in an expanded sense. During the production process, one of the interviewees cited the use of augmented reality as an example of support for quality assurance. The French member of V4's group of international companies uses ActiveGlass in quality assurance. There are steps in the production process that must be carried out in a specific order. Previously, checklists were used, whereas now the glasses are used. The lists are compiled and saved on a computer and connected to the glasses. At the beginning of the work, a small video (with sound and image) shows the wearer what work phase is next, and when and how it will occur. He/she can point to a QR code, and nod or press the button when he/she has completed the task. Meanwhile, both hands are free to work. Where glasses are used, the time required for quality control falls by half, and the error rate decreases significantly. The glasses are manufactured by an external supplier to the group, but the software is self-developed (V4 interview).

When discussing the options of Industry 4.0, interviewees also mentioned that surveillance by sensors can help identify the machines that need maintenance, and identify the replacement parts, so that the maintenance team can already bring them out, shortening the standby time caused by installation work. This can be supported by augmented reality, when the mechanic uses glasses to understand what to replace in the device and how to replace it (V4 interview).

The advantage of the solutions built into production is not only that the data can be accessed immediately, but also that the intervention protocol can be worked out in advance and the information available shortens both the decision making process itself and forced downtime (V2, V3 interviews).

4.2.3. Data Analysis, the Critical Point

The criticality of collecting and analyzing data was stressed by all interviewees. Even if they have not completely overhauled their production systems, some of their machines are already equipped with sensors, scanners, and 3D cameras to get a fuller picture of the processes taking place and to gather the data. Most of the data is stored with their own company, or (also) at the level of a group of companies. In one case, an interviewee referred to a cloud at the group of companies level, and in one case there was an outside cloud service provider (V1, V2, V3, V4 interviews). Software used for analysis and information, such as ERP system interfaces and the platforms and applications used by workers, are developed in-house, or with the involvement of consulting firms: "We develop our own interfaces and data mining and simulation software with the help of a consulting company. It costs a lot of money" (V3 interview). All interviewees referred to this knowledge as critical within the organization and expressed their concerns about ensuring a supply of professional expertise (V1, V2, V3, V4 interviews).

A data mining department is operating in the Madrid unit of the V4 group, which systematizes the production of ultrasonic sensors. Data is generated in three places in the production: In the MES, in the testing and in the production of machines. This produces 170 GB of data per day, in this section alone. They process data into a special computer cluster, and accelerate the analysis using search engines in web browsers. The system is able to connect virtually all information with everything, so very complex cause-and-effect relationships can be observed (V4 interview).

Information generated as a result of data analysis should be used in decision making: "It is a huge task to select which data to analyze, which will be useful in a given decision" (V2 interview). This can support not only the decisions made by humans, but those by autonomous robots, which is another example of the benefits of an electronic network linking everything with everything. Such an autonomous robot is already used in Hungary, in the V4 company. The machine in question engages with a metal plate. The 3D scanner detects when the disk is moved and if it is anticipated that the coating will not completely cover the next disk, it informs the robot, which adjusts it (closed loop M2M—the two machines communicate on the basis of data and then intervene) (V4 interview).

4.2.4. Human-Machine Connections, DIGITAL Ecosystems

As mentioned earlier, the development of interfaces represents significant work and investment, but quite simple equipment can be used as a platform.

The V3 firm employs a variety of simple platforms to connect machines and people. Workstations performing the final assembly of the end product after welding are equipped with tablets where the work of the workstation and workstation can be traced. This is where the worker logs in, gets the job done, and indicates when it is ready or has a problem (V3 interview).

The other day-to-day device is the mobile phone that the sends an SMS to the production line when it detects a problem. Here, there is an escalation pyramid, so first the operator, then the shift manager, the production manager, and the operating leader will be notified if there is no confirmation of the problem at each level within a given time. In addition to the SMS, an application developed for the company can be used to display individual machines, production lines, and daily production performance data (V2, V3 interviews).

The question of digital ecosystems divided the respondents. Three of the surveyed companies consider it a very distant future, but one feels it is feasible within five years, as the group of companies is in effect already working within it. Of the four companies, the latter is the largest and has a basic operational model for joint product design and development with customers. Its suppliers are members of the same group, so sharing information in this direction is less risky. Basically, those who believe it will come in the future, argued that this kind of deep, real-time data sharing would require a degree of trust between organizations and people that does not exist at present—and not just in Hungary: "I can imagine this if the company can derive a clear business value from it that can be expressed in cash" (V3 interview). Digital trust [28] is a critical factor in corporate cross-border data sharing and collaboration, and is created when there is a high level of security in terms of cyber security, data reliability and intellectual property (V1, V2, V3, V4 interviews).

4.2.5. Human Resource Issues

Negotiating the relationship between digital evolution and human resources is important for two reasons: On the one hand, many people are afraid that digital solutions and robots will lose them their jobs. This is possible, but it is necessary to show the possibilities for learning and doing a higher level of work, and the fact that the new technology makes work easier. On the other hand, other opportunities must be found for the workforce released due to robotization and automation, and not necessarily (only) at company level.

Most interviewees have tried to introduce new technologies to their employees, and the need for them. There were cases where this proved to be sufficient—workers accepted and used the new tools and the new technology. However, there were also respondents who experienced resistance. Employees damaged the sensors and interface devices, or refused to follow the instructions. Due to the termination of the signal transmission, this emerged very quickly, and turned out to be a major cost. Therefore, in this company, they have shifted to an autocratic approach: Those who are unwilling to work with new tools, must find new jobs. Despite the resistance, large scale resignations have not occurred, even though it is an area with plenty of other industrial facilities (V1, V2, V3, V4 interviews).

Informing employees should also mean telling them that their work is more closely monitored, and their performance directly affects (or will affect) the level of their salary. Good performance is therefore recognized, and poor performance can be analyzed and changed (V1, V3 interviews).

According to PwC [28], the lack of digital culture and training is the biggest challenge for companies: "We need creative people and people with strong analytical skills" (V3 interview). One major challenge in the human resource area is to find and retain these workers. It is also very important that these disciplines develop dynamically, that is, training will also have to keep employees up to date: "We have to add people to continuous learning" (V2 interview).

In the opinion of the leader of the V4 group, Industry 4.0 will also change organizational structure. Since much work is automated, mechanized, and robotized, trained workers will only be able to service these machines. Above them are machines directors, who program and maintain the machines on a daily basis. The next level is specialists who are experts in a process, analyzing data, looking for patterns, and writing algorithms and software for optimization. Above these will be a narrow leadership layer that will coordinate and steer processes, and this layer is expected to be less extensive than it is today (V4 interview).

Investigating the relationship between human resources and digitization is also important for another reason, since humans can also be a resource from whom we want to collect data; not only about performance, which we then display in performance pay, but also on the characteristic ways they carry out work. This also raises serious data protection issues.

At one of the factories in question, a pilot project is being planned, where workers are equipped with a wrist watch or a built-in sensor that always tells when and where they are in the plant and what they do (V3 interview). This method may present a legal problem in terms of the protection of personal data.

According to the V2 system, a worker who logs into a machine for work immediately sees whether or not he/she has the right to perform a given production activity, and whether he/she has the necessary ability. If not, the system will direct him/her to an e-learning interface to quickly learn, for example, how to handle the machine in question: "We call this the Digital Education Platform" (V2 interview). Both methods serve to increase the productivity and efficiency of human labor, and the machines increase the opportunity to use Industry 4.0 possibilities.

4.2.6. Smart Products

In the companies investigated—as we mentioned earlier in the previous sections—we find smart machines, but smart products have not yet really appeared. In fact, none of the factories can be considered a wholly smart factory, since high-level digital technologies have only been used on certain product lines.

A British member of the V4 group of companies is working with the Centrica gas group to develop so-called IQ boilers. These devices will also be able to connect to the Internet and can be controlled remotely. If something goes wrong, it can be remotely fixed quickly, and the engineer can come to the repair site with the appropriate parts. This can significantly shorten customer waiting time and downtime (V4 interview).

The experiences of the interviews presented here do not reflect the level of development of the entire Hungarian industry, but they help to understand the steps taken and the directions in applying the technology. It should also be noted that the companies surveyed focus very heavily on their production processes, and they have not yet addressed the impacts on any other element of the value chain. A comprehensive evaluation of companies was carried out in the following section [28].

4.3. Determining the Level of Development of Companies

Many of the solutions and technology described above do not spread like lightning. Companies have to go through a number of steps in order to adopt all the achievements of the Fourth Industrial Revolution. It is not necessary for everyone to achieve everything, the possibilities of digitization and integration are available at different levels, and it also depends on what can and cannot be achieved in the given industry. PwC [28] set up a model that differentiates the four levels of development of the companies in Industry 4.0, and gives a breakdown of the development levels in seven dimensions. These are shown in Table 5 below, and on this basis we listed the companies that were investigated during the research.

Table 5. Industry 4.0 maturity model.

	Digital Novice	Horizontal (Internal Processes) Integrator	Cooperating Vertically (with External Partners)	Digital Champion
1. Digital business model and customer access	First digital solutions, island-like applications	Digital product service with portfolio software, network (M2M, machine-to-machine) and data as distinctive features	Integrated customer solutions across the supply chain, cooperation with external actors	Development of new, disruptive business models, innovative product and service portfolio, including one-item series (Lot size 1)
2. Digitalization of product portfolio	Online and offline channels are distinct, product focus instead of customer focus	Multi-channel sales, online and offline channels are integrated, data analysis is used for customization	Unique customer approach, integrated with value chain partners. Shared and integrated interfaces	Integrated Customer Life Path Management in all marketing and sales channels, customer empathy, CRM
3. Digitizing, horizontal and vertical integration of the value chain	Digitized and automated sub-processes. Partial integration with production and/or internal or external partners. Standard processes adopted in cooperation	Horizontal digitization, standard and coordinated internal processes and data flow, limited integration with external partners	Vertical integration of processes and data flows with customers and external partners, intensive data usage in the fully integrated network	Fully digitized, partner-integrated ecosystem, self-optimizing, virtual processes, concentration on basic skills; decentralized autonomy. Near real-time access to comprehensive production information
4. Data and Analysis as a Key Capability	Data analysis is based on semi-manual data retrieval. Selected things are monitored and processed, and there are no systems for sudden events	The analytical capability is supported by a central business intelligence (BI) system. Isolated, non-standardized decision support system	The central BI system consolidates all relevant external and internal resources, some forward looking analyses are made. A special decision-support system operates and has a developed protocol for handling sudden events	Centrally uses forward-looking (predictive) analyses for real-time optimization and automatic handling of sudden events. The intelligent database and learning algorithms make analysis and decision support more efficient.
5. Agile IT Structure	Separated IT architecture, in-house	Homogeneous IT architecture in-house. The connection between different data cubes is developing	A similar IT structure in the partner network. Linked Data Lake, a powerful architecture	Unified Data Lake with external data integration capability and flexible organization. Providing service and data exchange services to partners
6. Complaint handling, security, law and tax	Traditional structures, no focus on digitization	The digital challenge has been identified, but is not dealt with in a deliberate manner	Legal risks are constantly addressed acting together with partners	Complaints, legal issues, security and taxation are optimized at the level of the entire supply chain
7. Organization, employees, digital culture	Functional silos	Cross-functional co-operations, but not structured and continuous	Corporate cross-border cooperation, the sharing of incentives is part of the culture	Collaboration is a key value driver

Source: PwC [34], authors' own editing.

Table 6 lists the four companies where the interviews were made. For each dimension, we have evaluated the present stage of development. The color of each stage of development is indicated by the appropriate color in Table 5.

Table 6. Evaluation of the Industry 4.0 development level of the firms interviewed.

Criterion Firm	1	2	3	4	5	6	7
V1							
V2							
V3							
V4							

Source: Authors' own research, 2017.

The results show trends that prove that automotive and electronics companies operating in Hungary have also started towards Industry 4.0 development. The direction of these developments is primarily production and the motivation is either the stimulus from the foreign parent company, and its newly adapted solutions, or the Hungarian leadership's aspiration to become agile and innovative. Developments can be found in the Digital Novice and Horizontal Integrator levels.

The companies surveyed are at the beginning of the exploitation of the Fourth Industrial Revolution. Companies belonging to the international group of companies have the advantage of the inspiration and encouragement of their parent company, and the not infrequent explicit expectation that a pilot project be started. In two cases, the agility of the Hungarian leadership turns the Hungarian factory into a pilot plant (V2, V3, V4). Each company has a smaller or larger Industry 4.0 team, who is looking for opportunities and selecting projects for which it is worth starting a pilot. As a result, projects are usually island-like, they are slow to link and to extend to the level of the enterprise group, but there are also examples of this (V2, V3, V4). As a first step, production lines are installed with the tools needed for data collection, and no examples were mentioned of products being converted into smart ones. As the pilot projects are island-like, the basic integration of these developments is underway and most of them are moving towards horizontal integration. There is an example of vertical integration, and a pilot project carried out at a supplier (V3, V4), or even with a customer (V4), but this is not routine. All the business leaders were already aware that data use was the key to digitalization and a new source of competitive advantage. They all perceived the ability to analyze as a key competency, and try to attract skilled workers themselves, for example, by organizing joint (dual) courses with universities (V4). All companies are making great efforts in this area, trying to grow the software development team, develop software for data analysis, and develop applications (V3, V4). The core IT system is developed at each company, and is complemented by a number of systems developed by the companies in the group. Many interviewees have pointed out that digitalization will be successful if suppliers and customers are also members of the digital ecosystem, which can only be achieved through standard platforms and interfaces, which is not yet the case (V3, V4). Data collection and management, and above all security and risk issues, are key areas for all companies. Most place more trust in their own server space or group cloud, but there are those who use a global cloud provider. Since this issue is also a sensitive one with partners, it is dealt with through continuous mutual agreement. The organizational culture is changing. Most adopt a method based on common involvement, and there are cases where manual workers themselves are involved in generating ideas, and in exploring the possibilities of digitization (V2). The international background here also has a positive influence, and ideas originating from foreign affiliates, and competitions to generate ideas also inspire workers in the Hungarian factory (V4).

5. Discussion and Conclusions

How fast the change will take place depends on how fast the technology is going to develop, how it will be accepted and what desire there is for investment—the latter depends heavily on the price of equipment and software. The greatest improvements are necessarily the storage and processing of huge amounts of data produced by the devices and generated by the systems.

Companies can hold back for a while on the decision about whether to join the fourth industrial revolution. The development and application of new, unknown technologies is risky and expensive, but significant savings and revenue growth are achievable for early starters. There are some industries where it is essential to accept competition in development, and where adaptation is an ever-present precondition for staying competitive (the automotive and electronics industries), but there are also many industries that will only go through this kind of development if the technology also brings a return in sectors with lower rates of profit.

There are very few practical examples in the specialist literature of how companies use IoT tools, and how they affect their business. There are also few people who deal with the problems that arise. In this sense, this article provides assistance by not only allowing business executives to practice benchmarking, but also by giving researchers an idea of what problems to research.

By using the structure of Porter's value chain, we identified several IoT and Industry 4.0 technologies which can affect not only production but many other company functions. We have to conclude that most of these technologies have an effect which spans over functional boundaries. The production data from a production line, for example, helps to balance the production process for production planners and to provide data for inventory managers planning warehouse space for the end product or stock for sales, as well as buyers who buy the raw material for production. The same data can be used in controlling and in new product development, too. These processes can even span over company boundaries and information can be shared with supplier and customer partners. We found that the analysis of the IoT and Industry 4.0 technologies value chain approach should be extended to a virtual value chain concept, and in a digital ecosystem this should be a virtual value chain network.

In our research we found that digitization and the use of technologies have begun in Hungary, but there is still a great lag behind the other, more developed countries. By examining the previous period and evaluating results, we can establish that the number of new investors will increase in the coming years as companies want to gather, store and process data from an increasing number of processes. The greatest barrier to the implementation of Industry 4.0 is the lack of a clear digital strategy in value-creating (production and logistics) processes and a lack of support from leadership. Many companies are afraid of the as yet unknown level of economic benefits of digital investments and the high costs of those investments. Many firms are not prepared for the safe storage and handling of data, either.

Porter and Heppelmann [37] argue that industrial digitization requires the rethinking of technology, skills, and processes throughout the entire value chain. The company needs to realistically see what capabilities it can develop and what it requires in order to be involved with an external partner, but it needs to start developing in some direction.

Hungarian companies need to be aware of how industrial digitization affects their industry, and whether their customers or suppliers are already working with technologies that will sooner or later present challenges for them, as well. It is very important that the consciousness and the methods and systems that will be used are built up on each other, as we can see from the survey. Businesses need to develop a number of capabilities that they may not have needed before (large amounts of data storage, analysis, development of relevant software), but which in the future will remain a basic requirement for staying competitive.

It emerged from the interviews, as it has from the international literature, too, that Industry 4.0 exerts its greatest impact on production, and the companies surveyed also present a variety of methods and procedures. The advantage of the solutions built into production is not only the fact that data about everything is available immediately, but also that the intervention protocol can be worked out in advance, and the information available reduces the length of the decision-making process and forced downtime.

If we look at the results of research that focus on the IoT, we can conclude that in the case of CPS, CPPS and Big Data Technologies, companies using them seem to be evaluated as having higher levels of logistic service, more efficient processes with their partners, better cooperation among certain logistics functions, and higher financial and market performance and better competitiveness. The use of IoT tools and solutions also extends to Hungarian companies. The results of the survey are not representative, and it is noticeable that the introduction of basic technologies for IoT—such as CPS, CPPS, and sensors—has already begun, and the conscious and systematic analysis of the data they produce already receives great emphasis.

Over the next five years, all respondents plan to invest in IoT tools and solutions. Fortunately, it is not only in the engineering industry that more development is planned, but the chemical industry, and trade and logistics service providers are also interested, and in more than one area.

The result of the research encourages businesses to invest in IT tools and automate their factories so as to be able to build contacts with each other on a broader scale. Speeding up product sales is also important, as meeting customer needs is the most important thing. A company's transparency is ensured by the big data applications which the companies surveyed want to introduce over the next five years.

Based on the experiences of the interviews, further research questions can be formulated which are of great interest to corporate professionals. First, how can the currently highly production-oriented developments and the data they generate be included in the entire corporate information system so that the decision-making processes of other business areas can be supported by their analysis? An important issue is to discover what will encourage companies to cooperate with their partners, extend their data collection and share data across corporate boundaries. The third interesting field of research is the creation of data security and how this field will develop, what companies think about it and what solutions they adopt.

The results cannot be generalized, but they do reveal trends. The automotive industry and electronics companies operating in Hungary have already started with Industry 4.0 developments. Their direction is primarily production and the motivation or stimulus provided by the foreign parent company, its newly adapted solutions, or the agility and innovation of the Hungarian leadership.

The results of the research help us to re-think investments in IT tools (smart devices, RFID, big data analytics), and the utility of industry 4.0. In the future, it would be interesting to carry out research on a larger sample, even in consecutive years, as we can expect rapid change and development in this area. Progress will be demonstrated not only in the propagation of assets, but also in the ripple effect across industry sectors.

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