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The emergence of digital transformation in the automotive industry – Industry 4.0 in Hungary

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Digital transformation can be understood not only as a technological revolution, but also as a kind of paradigm shift (Perez, 2010, Mergel, et al., 2019). In order to investigate the preparedness to embrace digital transformation of the Hungarian automotive industry, we conducted an empirical research study in October - December 2020. The main goal was to determine the level of automotive actors in the digital transformation process. Company leaders were primarily asked about their progress in the digital transition process, its opportunities and challenges, organizational culture, and potential human resource management responses. This study focuses on the digital transition concentrating on the following dimensions: strategy and leadership, human resources, business processes, supply chain, manufacturing, products and services. Based on the results, we classified the examined Hungarian automotive industry actors into clusters.
Keywords: industry 4.0, digital transformation, automotive industry, maturity
Jel-code: L29, L62, M14

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1. Significance, advantages and disadvantages of digital transformation

In the 21st century, fundamental changes are taking place in societies, as well as in industries and economies. In terms of production, these changes manifest themselves mainly in the interconnection of digital machines and devices based on the analysis of a huge amount of data, and the integration of not only factories, but also corporate networks and entire national economies, into an intelligent information system. The processes taking place today are defined as the fourth industrial revolution. This process primarily concerns the industrial application of information and communication technologies. Production systems, previously expanded with computing, have now been supplemented with a network connection, allowing systems to communicate with each other and communicate information about their own operations, which is the next step in production automation. Networking systems already create the notion of smart factories in which manufacturing systems, components, and people communicate with each other through a network, and production is carried out almost automatically, without human labour. The continuous development of information technology, such as cyber physics systems (CPS), the Internet of Things (IoT), the Internet of Services (IoS), robotics, cloud and cognitive computing, big data and augmented reality (AR), results in significant changes in production systems (Schmidt *et al*., 2015; Pereira and Romero, 2017).

1.1. Digital transformation as a paradigm shift

It is no exaggeration to say that the digital transformation can be seen as both a paradigm shift and a real technological revolution (Perez, 2010, Mergel *et al.,* 2019). This transformation has inevitably appeared in both the private and public sectors (Mergel *et al.,* 2019), and brings such radical changes as a result of which consumers and organizations become extremely close to each other, which can result in joint creative, production and marketing processes (Berman, 2012). According to KPMG Hungary (2018a), digital transformation is "not a mystical technology project, but a recognition of the needs of the consumer and an attempt to satisfy it in a complex way, which is a purely business task, but even in the digital age". The transformation is a complex process: codification (automatic routine task) is followed by digitization (including the use of robots), and only then can digital transformation (which already involves the introduction of a new business model) take place (Verhoef *et al.,* 2019).

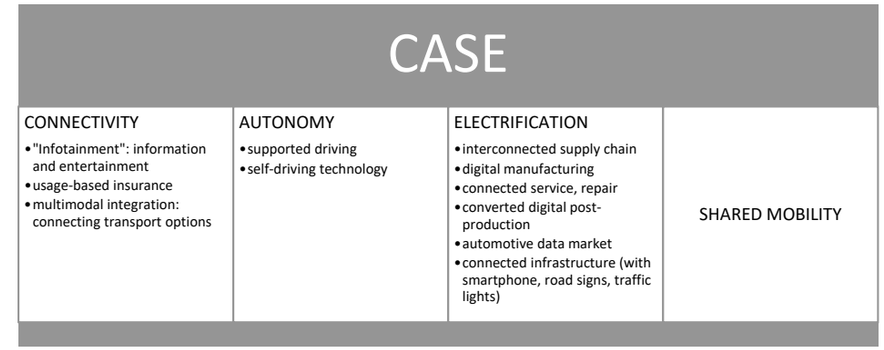
The MIT Center for Digital Business and CapGemini Consulting Report (2011) and KPMG Hungary (2018b) emphasize that successful digital transformation stems from the vision of new opportunities in which digital technology contributes to increased performance, production and customer satisfaction – going

beyond that approach, which sees only the application and introduction of new technologies. Because of digitalisation, the consumer makes a number of imprints that can be predicted after analysis. In other words, the consumer actually becomes a partner of the company, and the business can adequately respond to and among others, build on consumer needs - this can increase consumer satisfaction, efficiency and profit. After all, digital transformation and innovation are closely related, as they reinforce each other within a given organization (Poór *et al.,* 2019).

Digital transformation promises significant benefits for the future at both the macro and micro levels. Governments expect significant macroeconomic improvements and firms expect to make significant micro-level performance improvements (Losonci *et al.,* 2019). Implementing digitization has many benefits for a company: the process increases a company's efficiency, makes it easier to reach and increase markets, and it is also an important catalyst and opportunity for innovation.

The automotive industry is still part of an industry-wide digital transformation process. Toyoda, the head of the Toyota group of companies, put it this way: "the biggest transformation of the last century is underway (IotZone, 2020a). This transformation can bring countless benefits, but it also carries dangers. Digitalization is built around specific industry terms, which are summarized in Figure 1, by the acronym CASE (self-driving cars, autonomous, car-sharing, electric mobility, connected) (IotZone, 2020a, IotZone, 2020b). Other industry characteristics, such as internationality, the important role of external suppliers, and functional organization, open up many opportunities for digital transformation (Chanias and Hess, 2016).

Figure 1: CASE technologies of the automotive industry



Source: own edition based on World Economic Forum White Paper, 2016, IotZóna, 2020a, IotZóna, 2020b

1.2. The process of digital transformation, inhibitors and success criteria

1.2.1. The process of digital transformation, inhibitors

Digital transformation is the result of a longer process that takes into account those values of a company that can help or otherwise even hinder digital transformation. These include sales methods, distribution channels, the products themselves, the partnerships, consumer information, corporate culture, product innovation and the brand. The transformation also affects the consumer experience, the operational processes and the business model. Digitization offers excellent opportunities for getting to know and segmenting customer needs. At the same time, this process involves even more contradictions and evokes ambivalent feelings and approaches from some leaders. According to KPMG Hungary's research, almost all of the interviewed business leaders perceive new opportunities, but only around 50% have a specific vision, and even fewer have a specific plan for doing this (KPMG Hungary, 2018a).

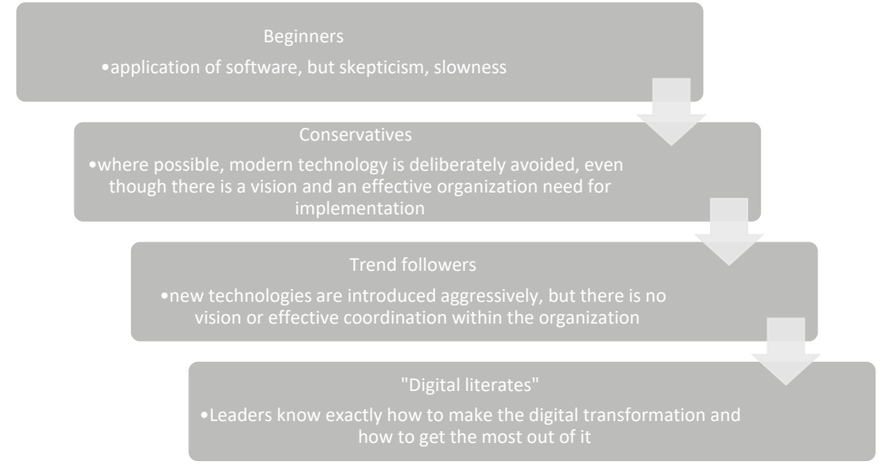
Table 1: The process of digital transformation

I. Digital transformation vision			
II. Strategic instruments, aspects: inventory, assessment			
Sale	Products	Partner network	Consumer knowledge
Distribution channels	Product innovation	Brand	Culture
III. Digital building tools, pillars			
Consumer experience	**Operational processes**	**Business model**	
Knowledge of consumer needs (analysis based segmentation)	Digitization of processes	Digitally modified business	
Top-line growth (digitally enhanced sales, improved customer processes, predictive marketing processes)	Empowering employees	New digital business	
Customers contact points (customer services, coherence between channels)	performance management	digital globalisation	
Digital skills			
⇧			
Digital investment			
Skills		Initiatives	

Source: Own edition based on MIT Center for Digital Business and CapGemini Consulting, 2011. p. 59.

Businesses can be grouped in several ways based on their relationship to the digital transformation. Issa and colleagues (2018) classified them based on their maturity in terms of digital transformation. Fitzgerald *et al.* (2013) distinguished four basic groups: from 'beginners' to 'digital literates'.

Figure 2: Categorizing businesses by digital maturity



Source: own edition based on Fitzgerald et al., 2013. p. 4.

There are many pitfalls on the path to digital transformation, which can be summed up in three basic areas: leadership, organization and implementation. Such inhibitory factors include the fact that the leaders feel that there is no urgency to implement the transformation, or that they have no idea or vision of how to implement it. The attitude of the employees, the organizational culture, the lack of financial resources, or the unclear definition of responsibilities in the organization can also appear as problems.

1.2.2. Success factors of digital transformation

If we want to provide a kind of guide for successful digital transformation, we need to focus on five basic issues: the transformation affects the entire organization as a whole; there is a need to focus on the fundamentals of leadership, employees, tools and communication.

Transformation must always take place in unity with the organization, as it affects the entire organization: operational processes, human resources, but even consumers. One of the conditions for success is that the company can permeate all

activities and undergo digital transformation in all areas: not just marketing and distribution, but the products, services, processes, business ecosystem and supply chain, as well (Bughin *et al.,* 2017). It is essential that digital transformation should be initiated at the highest strategic level of the company. Thus, the first step in the entire process is to develop a strategic vision, followed by investing in digitization processes (Bughin *et al.,* 2017, IoT Zone, 2019, MIT Center for Digital Business and CapGemini Consulting, 2011, Fischer *et al.*, 2020). In preparing for digital transformation, careful planning is essential; the future development programs and projects should fit into this digital strategy (Fischer *et al.,* 2020). After all, a real business transformation is needed, not just a forced solution to some of the digitization problems that arise. Currently, the steps taken by companies are only "rather imprints of digital expectations on company managers or island-like solutions" (KPMG Hungary, 2018b).

Appropriate, digitally savvy and committed leadership are needed to achieve digital transformation; which is true both at the top level and for the leaders of each subtask. A team must be appointed to be responsible for carrying out the transformation, and each organizational unit must be represented in the in order to cover the whole organization (McKinsey & Company, 2018, McKinsey & Company, 2017).

The second success factor is the building and development of the appropriate skills of the employees of the future. The roles and responsibilities must be redefined so that they are in line with the needs of the organization. To reach this goal, educational programs should be initiated (McKinsey & Company, 2018, Fischer *et al.,* 2020).

The third element of success is to enable employees to apply new working methods and tools. They should be brave and creative to dare to apply and to experiment with new methods. Of course, this requires a change in attitude and culture: the keywords are risk-taking, a high degree of cooperation and customer focus. These new methods are supported not only by the introduction of new working methods (e.g. the method of continuous learning), but also by the fact that the opinion of employees is taken into account in the processes in which digitalisation can be enforced or worth introducing at all (McKinsey & Company, 2018, McKinsey & Company, 2017).

In addition, it is essential that people holding key positions in the operation of the company should also play an important role in carrying out the transformation – all in line with the heads of the other departments, and in doing so encourage their subordinates to try new ways of working.

Digital upgrading of devices is also needed for the successful digital transformation. Within the framework, a special role will be given to the use of digital technology in the transfer of information within the organization, to the introduction of self-service technologies in communication with employees, business partners and customers. Of course, detailed information about the digital transformation must also be provided to the employees – with a precise explanation of its reasons and benefits (McKinsey & Company, 2018, McKinsey & Company, 2017, Müller, 2019).

Table 2: Summarized success criteria of the digital transformation

Strategic issue for the whole organization	Do not start the digital transformation only just for the sake of following the trend.
	Initiate at the strategic level, this should be part of the cor porate strategy (vision).
	Since digital transformation affects the entire organization, thorough, company-specific planning should precede its implementation. A digital strategy must be developed by setting well-defined goals and steps. New development programs that arise later must also be integrated into the digital strategy in order to avoid conflicting goals and processes.
	The process must be supported by a flexible organization constantly responding to environmental changes and challenges.
	Transformation needs to be communicated properly: both within the organization and to the company's partners. Stakeholder support must be won by emphasizing the benefits.
	A campaign should also be pursued to change the mentality.
	The transformation must be carried out in the whole organization in a holistic way.
Leadership	Appropriate, digitally savvy, committed leadership.
	A responsible team must be appointed - each department must have a representative in it.
	People in key positions should have a role in the process, encouraging employees to use new working methods.
	Establish control mechanisms: the progress should be continuously monitored by key leaders and respond to changes as needed.
Employees	Educational program: building and developing the appropriate digital (and other) skills for future employees.
	Redefine the roles and responsibilities of employees in line with the goals of the organization.
	Enabling employees to apply new working methods: dare to use new methods.
	Creating a new organizational and corporate culture: creativity, risk-taking, increased cooperation, customer focus.
Tools	Digital modernization of everyday work tools.
	Put digital technology at the service of the information flow within the organization.
	Introduction of self-serve technologies.
Communication	Continuous communication about the purpose, cause and process of digital transformation.
	Clear communication of key performance indicators and the transformation agenda.

Source: Own edition based on IoT Zóna, 2019; KPMG Hungary, 2019; McKinsey & Company 2018; McKinsey & Company, 2017, Fischer et al., 2020, Bughin et al., 2017, Bauer et al., 2015

Based on Kane et al., it is difficult to predict the technologies of the future because business success depends not only on the used technologies, but lies in a company's ability to innovatively apply new technologies to create new products and services, as well as to build these novelties into its strategy and organizational culture (Kane *et al*., 2015).

2. The importance of the automotive industry and the digital transformation

2.1. Characteristics of the Hungarian automotive industry

By Hungarian automotive industry, we mean all automotive companies operating in Hungary. We consider Eurostat NACE Rev.2. nomenclature category C29 to be authoritative. By definition, the category also includes the manufacture of motor vehicles for passenger and freight transport, trailers and semi-trailers, and motor vehicle part producers, as well (Rechnitzer *et al.,* 2017). It also follows from the definition that in addition to the mechanical engineering industry, metallurgy, the electronics industry, the chemical industry, the rubber industry, the glass industry, the textile industry and the plastics industry also receive significant orders, as a car is made up of many components.

In a broader sense, the industry provides jobs not only to assembly plants but also to dealers, service and repair plants (Hornyák, 2013). The players in the automotive industry are therefore not only end-product manufacturers, but also suppliers. The peculiarities of the automotive industry are thus presented through the individualities of the end-product manufacturers and the supplier network.

In Hungary, vehicle production has been the largest sector of the manufacturing industry since 2011, in 2018 it accounted for 27% of the total industrial production value. In addition, it has an impact on other manufacturing activities through its extensive supplier relationships, so its performance has a significant impact on the development of industrial production as a whole (KSH TÉR-KÉP, 2018). Based on the data, it can be clearly concluded that the impact of Hungarian vehicle production on the national economy is significant (461,000 cars were produced in Hungary in 2018), so the labour market situation of those employed in the automotive industry also has a significant impact on national employment numbers. In 2018, almost 4% of Hungarian employees worked in the automotive industry (172,500 people). The role of the automotive industry in the economy is also well reflected in the volume of investments. In 2018, almost 7% of investments in the national economy could be attributed to the automotive industry. The cornerstone of the Hungarian automotive industry is Original Equipment Manufacturers (OEM) established with Greenfield investments (Hornyák, 2013). The term

OEM refers to the situation where a company buys a product from the original manufacturer and then passes it on as its own, often as part of a larger product. OEMs in the automotive industry are also at the top of the supplier pyramid, as they are the so-called end product manufacturers or car assembly companies. They perform basic activities such as final assembly and only manufacture the essential parts, sourcing the other parts from a wide range of suppliers.

By the beginning of the 21st century, global companies emerged in the automotive industry that organize their activities globally along the value chain, placing certain elements of the value chain in the country that provides them with the most favourable conditions (Hornyák, 2013).

Transnational corporations were characterized by the Fordist corporate structure model developed in the mid-20th century, in which there was a very strong vertical integration and suppliers were not closely associated with the integrator. From the last third of the 20th century, the principles of toyotism began to prevail in company organization, which means, above all, leaning the company, concentrating on basic activities, and outsourcing all other activities to suppliers (Hornyák, 2013). The automotive industry is clearly a pioneer of toyotism: this type of corporate organization was the first to appear in the automotive industry, setting a pattern for other industries as well.

Four different types of installations can be differentiated in the field of automotive localizations based on the motivation of the activities and the qualitative evaluation of the localization (Rechnitzer *et al.,* 2017). Based on the model, the Hungarian automotive centres correspond to the three types of location. The main installation factor is cheap labour and the developed infrastructure, and the installation motivation is to rationalize the production processes and minimize their costs. The degree of integration into the value chain remains low or medium, with production typically orienting to foreign markets, so a significant part of sales is made up between the foreign parent company and the domestic subsidiary. According to the theory, in this model, low value-added activities are outsourced and development remains almost entirely the responsibility of the parent company (Rechnitzer *et al.,* 2017). In the case of Hungarian OEMs, therefore, low value-added activities have been located, and Hungary has been put in a competitive position by cheap labour, as labour costs in car production represent on average 25-30% of the value of the final product. The main motivation of the parent companies was to rationalize costs, so most of the Hungarian factories produce for foreign markets and are absolutely exposed to the parent company. It is important to emphasize this relationship, because in addition to such a degree of vulnerability, the economic crisis caused by the coronavirus created a domino effect within the Hungarian automotive industry.

Table 3: Net sales and production volume of the largest domestic automotive actors

Manufacturer	Net sales revenue 2018 (EUR million)	Production volume 2017/2018
Audi Hungária	7 376 515	In the 2018 business year, the Company manufactured a total of 1,954,301 engines and produced 105,491 vehicles.
Magyar Suzuki	1 953	In 2018, Hungarian Suzuki sold 171,885 cars.
Mercedes-Benz Manufacturing Hungary	3 561	In 2017, Mercedes-Benz Manufacturing Hungary produced more than 190,000 cars.
Opel Szentgotthárd	74 027	In 2018, OPEL Szentgotthárd produced 312,987 engines.
Rába group (Rába Automotive Holding, Rába Chassis, Rába Vehicle, Rába Vehicle Parts)	151	Metal seat frames: Suzuki Vitara, S-Cross 175,000 pcs / year, Wire frames: VW UP 280,000 pcs / year, Suzuki Vitara, S-Cross 175,000 pcs / year, Audi Q8 / Lamborghini Ursus 53,000 pcs / year

Source: own edition based on e-report officially published data

Examining the largest players in the Hungarian automotive industry, Audi Hungária Ltd. is the most important actor in the Hungarian automotive industry, based on both net sales and production volume. Audi has become a key player primarily in the engine industry, secondarily in the complete car production, thanks to its expansion in 2013. One order of magnitude behind Audi, the Mercedes-Benz plant in Kecskemét is also a significant player in the Hungarian automotive industry. The factory produced more than 190,000 cars in 2017. The third most influential player is undoubtedly the Suzuki factory, whose profile typically includes the sale of low and medium category vehicles.

2.2. Automotive suppliers

Due to the complexity of the automotive product, the smooth running of production can only be imagined based on an efficiently organized supply chain. A significant supplier network is also connected to the primary manufacturers in Hungary. The basic principle of automotive production is that the finished product manufacturing plant itself produces only basic parts, the other parts are procured from an external supplier. In this way, they can achieve lean company and focus on core activities.

The situation of the Hungarian automotive industry is reflected in the study of Gelei (2006), who examined the supplier types and their basic competencies in the Hungarian automotive supply chain. The dissertation shows the capability structure of automotive suppliers, according to which we can differentiate between domestic suppliers with competencies in capacity, product, adaptation, network and innovation. The main finding of the study is that the development of corporate competitiveness can be promoted not only between each supplier type, but also through internal quality development within each supplier group, the keys to these are available capital and knowledge. The competitiveness of the SME sector depends on economic policy supporting domestic enterprises in acquiring capital and knowledge (Rechnitzer *et al.,* 2017). Thus, suppliers present in the Hungarian automotive industry can currently increase their competitiveness by implementing quality improvements, for which not only physical capital, but also human capital and the development of human resources are essential. The more up-to-date competencies an employee in the automotive industry has, the more his or her exposure to the labour market will decrease due to a possible structural change.

A similar conclusion is reached by Gelei and Mandják's (2011) analysis, according to which the priority of Hungarian economic policy should be to support domestic suppliers in building competencies and capabilities, through which they can meet more complex customer expectations and thus move forward in the automotive pyramid. According to the study, a competitive supplier base has now been established in Hungary, within which some innovative, complex domestic companies capable of meeting customer expectations have been established.

The findings of Németh and Topár can also be linked to this line of thought. In recent years, structural changes have taken place in the structure of the supplier network, which has resulted in a decrease in the value added of manufacturing companies - they only add about 20% of the value produced to their products - and an increase in the role of suppliers (Németh and Topár, 2014). Development is therefore no longer solely in the hands of OEMs, and it is not only their responsibility to innovate.

3. Digital transformation of automotive actors

In order to understand the situation and preparedness of the Hungarian automotive industry players, we conducted an empirical research study from October 2020 - December 2020. The main goal of the empirical study was to determine the level of maturity of automotive actors in the digital transformation process.

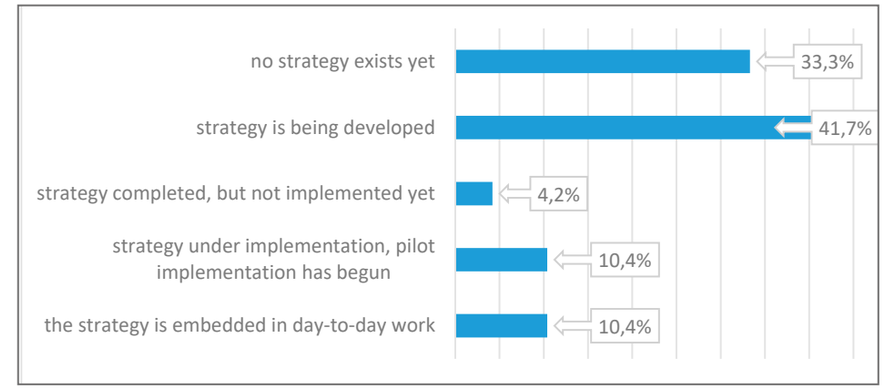
3.1. Research methodology, sample composition

In the course of our research, we used a quantitative measurement method and contacted the organizations involved in the automotive industry with a structured questionnaire. Our basic population consisted of a database provided by the National Association of Hungarian Vehicle Parts Manufacturers (MAJOSZ), which contains approximately 250 organizations. In order to explore the scope of the problem completely, we surveyed two target groups. Company leaders were primarily asked about their progress in the digital transition process, organizational culture, and potential labour market responses. In the case of employees, the survey primarily provides an assessment of digital skills, in addition to which we also explored the industry 4.0 challenges experienced by employees, and the perceived and desirable organizational culture. The current study presents the results of the survey of leaders focusing on digital transformation. The data collection took place in a self-completion form. The distribution of the questionnaires was coordinated by MAJOSZ through personal and telephone inquiries. In the study, we aimed to interview the entire population, and MAJOSZ employees contacted a total of 95 companies and sent them a questionnaire. A total of 48 managers completed the questionnaires.
81.3% of the interviewees were male and 18.8% were female. 31.3% of surveyed managers do not have children, 25% have 1 child, 33.3% have 2 children, and 10.4% have 3 or more children. 79.2% of the leaders in the study graduated from college or university, most of them are engineers. 16% have a high school education, 2.1% have finished only the 8 grades of elementary school, and 2.1% have a technical or other education. In terms of their positions, 54.2% of them are top managers, 29.2% middle managers and 16.7% group leaders. 18.8% of the interviewed managers work as project managers, 16.7% as production managers, 14.6% as quality controllers, and 12.5% work in the economic department. At the same time, 6.3% came from the HR and marketing departments, and 4.2% deal with procurement and logistics.

3.2. Results on digital transformation

Starting the digital transformation process and managing it at a strategic level is a complex issue. 33.3% of the interviewed managers do not have a digital transformation strategy, and 41.7% of them are developing one. Nearly a tenth mentioned that a kind of pilot implementation has begun, and 10.4% of them already use it in their daily work.

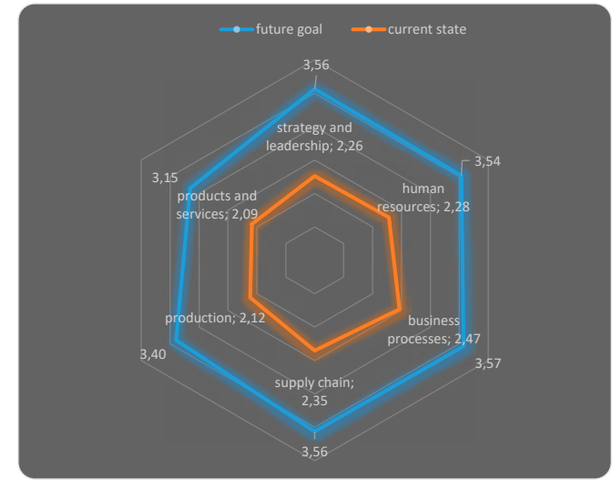
Figure 3: Company's position in raising digital transformation to a strategic level (distribution)



Source: own results, 2021

To measure the maturity of Industry 4.0 specifically, we used a series of questions already used in a previous study that examines the maturity of organizations in digital transformation in six dimensions, analysing the current state and the desired goal. Summarizing the results obtained in the management questionnaire, the averages are presented below.

Figure 4: Industry 4.0 maturity dimension averages



Source: own results, 2021

As shown in the figure, organizations reported values between 2.0 and 2.5 on the four-point scale for their current industry 4.0 maturity. The lowest value was given to the products and services dimension, which suggests that while organizations are able to customize products and extract digital information, they use the data primarily for error correction.

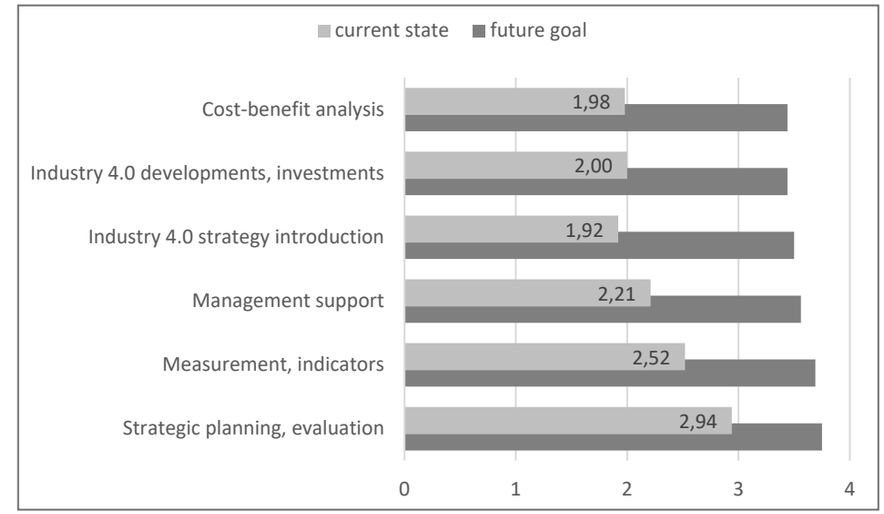
Future plans marked in blue clearly show the need to develop in all dimensions.

In the strategy and leadership dimension, we examined the extent to which industry 4.0 appears in the leadership approach, whether the firm took steps to implement the strategy, or whether it made developments in this area. As shown in Figure 5, based on the average of the responses received from managers:

- organizations have almost no measurable industry 4.0 type expenditures that could perform a cost-benefit analysis;
- industry 4.0-related developments have taken place in one or two areas (e.g. robotics, cloud-based solutions);
- industry 4.0 is not really part of the corporate strategy, goal setting has been possibly done so far;
- at the same time, management has already recognized the potential benefits of industry 4.0;
- related indicators have been introduced in several areas (e.g. performance, scrap, production), which, although not specifically related to industry 4.0, are essential for the development of the strategy;
- organizations basically carry out annual planning and evaluation.

According to the managers, the future goal is an annual cost-benefit analysis of the planned and implemented Industry 4.0 investments in several areas; elements of the Industry 4.0 strategy are implemented and communicated throughout the company; which is widely supported by management with its own tools. A complex set of indicators is used in line with the Industry 4.0 strategy throughout the company, resulting in a multi-annual strategic plan and regular (e.g. quarterly) back-testing and evaluation within a year.

Figure 5: Industry 4.0 Maturity – Strategy and leadership dimension averages, current status and future goal



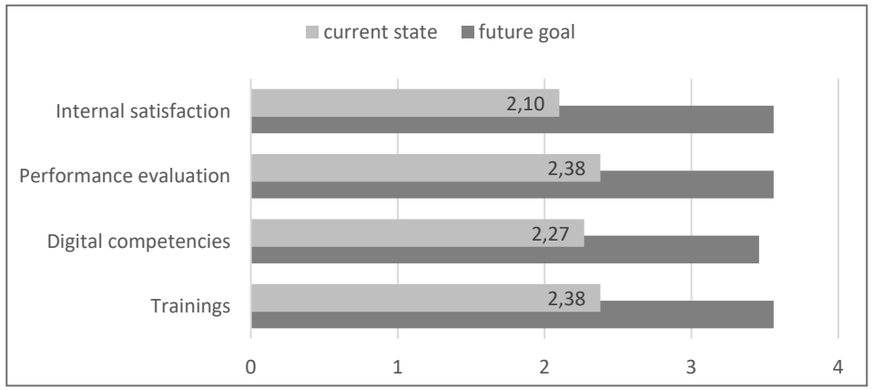
Source: own results, 2021

In the human resources dimension, the focus was on employee satisfaction, competency development and performance appraisal. As shown in Figure 6, based on the average of the responses received from managers:

- employees can express their opinions at least once a year;
- employees' performance is assessed regularly, rather orally, using a partly structured method;
- there are some digitally trained colleagues, mainly in the technical field;
- during the trainings, they focus primarily on professional development, digital competence development is rare.

Summarizing management opinions, a more structured, company-wide measurement of internal satisfaction and employee performance, increasing the proportion of colleagues with ICT and digital competencies across multiple work phases and areas can be considered to be a future goal. In the field of competence development, the goal is to implement digital trainings and / or human competence development trainings on a regular basis in addition to professional trainings.

Figure 6: Industry 4.0 Maturity – Human resource dimension averages, current status and future goal



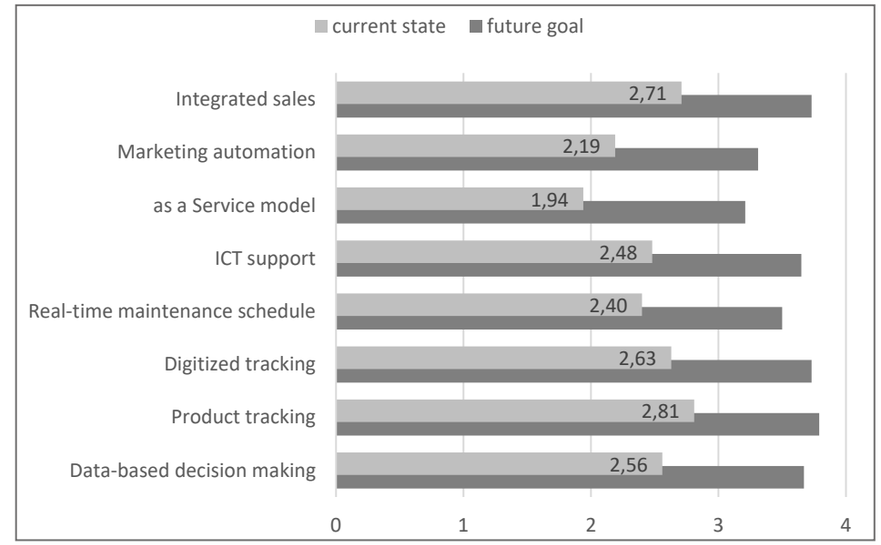
Source: own results, 2021

Regarding business processes, we examined management opinions on issues such as product (digitized) tracking, the existence of service-based models, and the automation of various systems. As shown in Figure 7, based on the average of the responses received from managers:

- a kind of integrated sales has been realized among the Hungarian automotive actors, as the production planning is based on the weekly / monthly sales forecast;
- in the field of marketing and sales, businesses use online solutions (e.g. online advertising, campaigns, online ordering), but their automation has not been implemented;
- there are no ideas for the introduction of the "as a service" model;
- ICT support for several business processes has been implemented, but their integration and compatibility with each other is not complete;
- basically pre-scheduled, preventive maintenance activities are typical, but in some cases already built-in diagnostics help with maintenance;
- in addition to the production process and the movement between departments, the monitoring of raw materials / products takes place until an external logistics centre is established;
- the monitoring of raw materials / products is partly manual and partly digital;
- extensive data collection and data analysis takes place in several areas (finance, performance appraisal), but these are only partially the basis for business decisions.

Based on management feedback, organizations have set a goal to keep sales focus in sync with product availability / inventory management / lead times, operate a kind of automated marketing and sales (e.g. email marketing, content based marketing, chat bot, automated web-shop) and at least start implementing the 'as service' model. It is considered to be important that ICT support for all business processes in the company are implemented through a unified, integrated system, as a result of which the machines / devices have built-in diagnostics, so they can predict the necessary maintenance themselves based on real-time data. An important goal is to track the products throughout their life cycles, possibly with the incorporation of digital tracking. It also aims at extensive data collection and analysis, which also serves to support decision-making.

Figure 7: Industry 4.0 Maturity – Business Processes dimension averages, current status and future goal



Source: own results, 2021

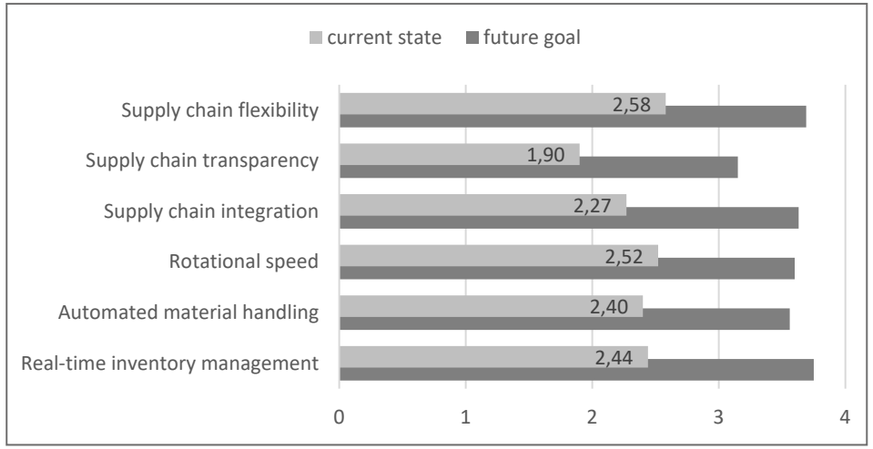
In the supply dimension, its transparency, flexibility, and integration were analysed, with a focus on material handling and rotational speed. As shown in Figure 8, based on the average of the responses received from managers:

- the organization's ability to respond to changes in market trends and key customers in the medium term;
- customers and suppliers may not, in principle, see any internal data, but certain capacity, stock and production data are available to key suppliers and customers;

- the organization communicates regularly, proactively with suppliers and customers;
- steps have already been taken to optimize stock levels and turnover rates in case of the most important raw materials / products;
- primarily the combined use of manual and machine material handling is typical;
- organizations use electronic inventory, supported by manual, sometimes "smart" tools.

Summarizing management opinions, immediate response to changes in market and individual customer needs can be considered to be a future goal, and it is important that all relevant capacity, stock and production data should be available to first-tier suppliers and customers, thus achieving a higher level of integration. The goal is to achieve fast rotation speeds, low stock levels (e.g. make-to-order) and mechanical, partly automated material handling. In the case of inventory, the future goal is to have digitized, real-time inventory with "smart" devices without manual intervention.

Figure 8: Industry 4.0 Maturity – Supply chain dimension averages, current status and future goal



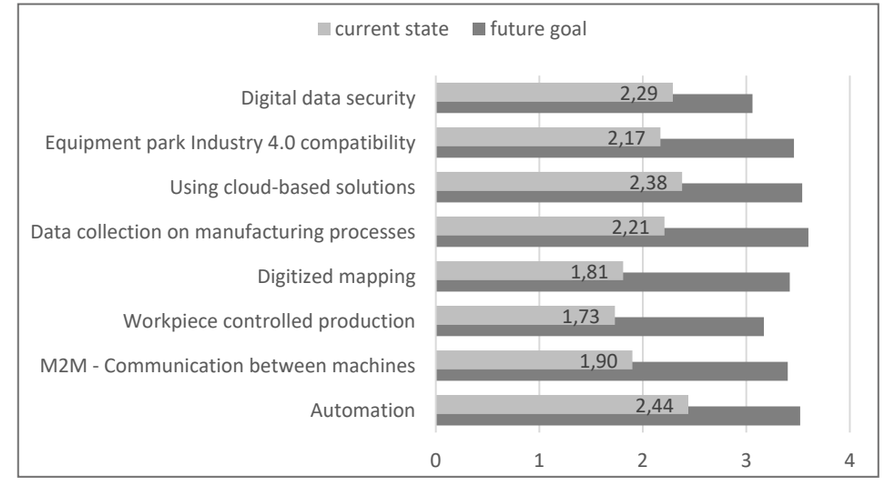
Source: own results, 2021

In terms of manufacturing, management opinions were examined on issues such as available equipment park industry 4.0 compatibility, cloud-based solutions, data collection and data security and automation. As shown in Figure 9, based on the average of the responses received from managers:

- digital data security solutions have been partially implemented;
- the company has some machines capable of providing digital data;
- the use of cloud-based solutions for data storage and processing is planned, and in some cases these methods have already been introduced;
- data from individual production areas are collected partly digitally;
- the digitization of the processes did not really take place;
- there is no product for which the work pieces would independently control the production, plans are being prepared for this;
- some machines and devices communicate with each other, but it is not typical;
- multiple machines and devices are automatically controlled.

Based on the management opinions, the organizations have set the goal to implement comprehensive digital data security solutions, to have as many machines suitable for digital data provision and communication as possible, and to introduce cloud-based solutions in several areas. Another important development goal is to create a comprehensive and automated digital data collection system, preferably in all processes, and in connection with this, most processes can be mapped digitally. Companies are planning to introduce work piece-controlled production in certain areas, as well as automated control of machines and devices as much as possible.

Figure 9: Industry 4.0 Maturity – Manufacturing dimension averages, current status and future goal



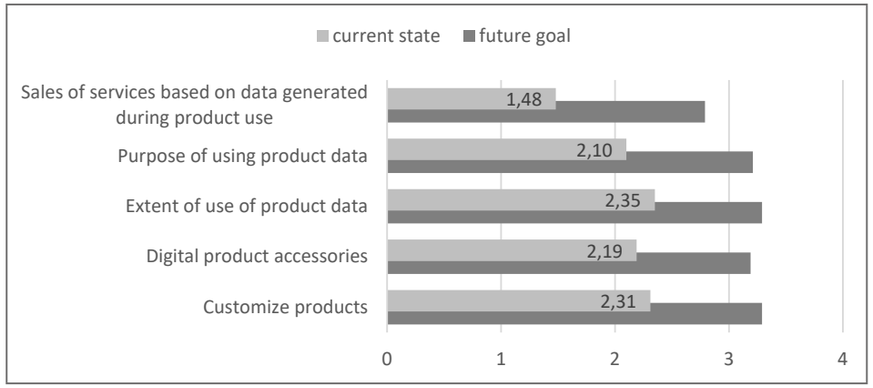
Source: own results, 2021

Within the products and services dimension, we examined customizability, the use of product data-and related services. As shown in Figure 10, based on the average of the responses received from managers:

- organizations have no service revenue based on data generated during product use;
- digital product data generated during use is utilized only to correct any errors;
- companies have little or no access to digital data generated during product use;
- the company's products also have intellectual added value;
- it is possible to customize the products, but apart from some special customer needs, series production and a large number of batches are typical.

Summarizing the opinions of the management, it can be considered as a future goal that the sales revenue of the services based on the data generated during the use of the product exceeds 3%. Digital product data generated during use is utilized to improve the product. The companies also set the goal that some of their products should already have accessories based on digital technologies, and that there should be several products for which it is possible to customize them according to individual customer needs, even in small batches.

Figure 10: Industry 4.0 Maturity – Products and services dimension averages, current status and future goal



Source: own results, 2021

4. Conclusion

We found, based on our research, that the majority of Hungarian automotive industry players are in the first stages of the digital transformation process. Least of all, they were able to take action in the products and services dimension, suggesting that while organizations are able to customize products and extract digital information, they use the data primarily for error correction. At the same time, there is a clear need to make serious efforts in the future to make the digital transformation in all dimensions.

According to the literature, one of the conditions for success, if the digital transformation permeates all the activities of the company, starting the initiative from a strategic level. The success requires:

- digitally savvy, committed leadership,
- equipping future employees with the right skills (education),
- employees are able to apply new working methods and tools (attitude),
- digital modernization of devices,
- communication.

Our empirical research revealed that in the case of Hungarian automotive industry players, the issue of strategy and management is currently moderate, i.e. industry 4.0 is not really part of the company's strategy, but at the same time the management has already recognized its advantages. In the field of education and attitude development of employees, the main focus was on those working in technical fields, and in the course of training, the main emphasis was on professional development, and digital competence development is rare. Digital modernization of devices has been one of the main steps companies have taken to make the digital transition: in most companies, more devices are automatically controlled, and some machines and devices also communicate with each other. However, it can be stated that of the examined dimensions, the companies achieved the second lowest value in the area of digitization of production processes.

It can be seen that the companies surveyed placed less emphasis on human resources among the success factors presented above, and did not include communication at all. In the light of these, it is not surprising that the Hungarian automotive industry players we are examining are at the beginning of the digital transformation process.

To summarize and conclude our research, we used cluster analysis to look for similarities between organizations and create clusters based on the results achieved in different dimensions of industry 4.0. The SPSS software package and the K-means cluster were used for the study.

As a result of the study, the following categories were obtained:

Table 4: Clusters created based on the Industry 4.0 maturity dimension

	Clusters and dimension averages			
	Locals (4)	**Beginners (25)**	**Advanced (18)**	**Leader (1)**
strategy and leadership	1,21	2,09	2,63	4,00
human resources	1,00	1,96	2,96	3,25
business processes	1,34	2,26	2,94	3,63
supply chain	1,42	2,14	2,76	4,00
production	1,22	1,88	2,54	4,00
products and services	1,20	1,94	2,38	4,00

Source: own results, 2021

Locals: no real step has been taken in any of the dimensions of Industry 4.0. In particular, they are lagging behind in terms of human resource development, i.e. the issue of Industry 4.0 is not considered to be relevant in either training or competence development. In contrast, with regard to the supply chain, initial steps have been taken in terms of communication and information transfer with partners, in particular along its transparency and integration. Basically, for these 4 organizations, understanding and emphasizing the importance of digital transformation would be the primary task. It is also a characteristic of these organizations that they do not have a digital transformation strategy. In terms of the spatial location of their partnerships, they are basically active in the local market. Due to these characteristics, presumably these companies do not see fantasy in the digital transformation, they do not consider it important.

Beginners: the 25 organizations which are classified into these clusters have taken the first steps in digital transformation, but have focused all of their related activities on a few dimensions. Industry 4.0 is showing signs in business processes and supply chain in particular. Businesses already use a variety of digital solutions in product tracking, marketing, and data-driven decision-making, but revenue from manufacturing (e.g. machine-to-machine communication, cloud-based services) and product and service development revenue is still to come. They do not yet have a strategy in place for digital transformation or are currently developing it. The vast majority of their customers are in the domestic market, but several companies have foreign partnerships.

Advanced: organizations in this group have already taken serious steps in all the examined 6 dimensions of Industry 4.0 and achieved above-average results. Among these human resource development (in the form of training on digital topics

or the use of staff with ICT knowledge in several functional areas) and support for business processes are outstanding. These organizations are characterized by ICT support for business processes, extensive data collection and analysis to support decision making. For Advanced, the digital transformation strategy is mostly under development, but several organizations have already implemented and embedded it. Their customers tend to be present in the international market, which presumably requires keeping pace with technological change.

Leader: there was an organization based on feedback from interviewed executives which can be considered at the forefront of Industry 4.0 maturity. It marked maximum values in the dimensions of strategy and leadership, supply chain, production and products and services. It means e.g. they work with a complex scorecard in line with the Industry 4.0 strategy for the company as a whole; maintain digitized, real-time inventory records using "smart" devices without manual intervention; all machines and devices are fully automatically controlled; the company's products have outstandingly high intellectual added value and also have accessories based on digital techniques. True for the Leader organization is that digital transformation has been raised to a strategic level, and is now embedded in everyday operations. Their customers tend to be present in the international market, which presumably requires keeping pace with technological change.

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