Udvari B. (ed) 2020: Proceedings of the 4th Central European PhD Workshop on Technological Change and Development. University of Szeged, Doctoral School in Economics, Szeged, pp 61–78.

Testing the importance of 4th Industrial Revolution characteristics in the Hungarian environment

Comparison of SMEs' and Business students' perception

Eszter Megyeri – Gabriella Tabajdi

The 4th Industrial Revolution, or IR 4.0 for short, is being embraced by academics and practitioners alike. However, business readiness to meet the changes of the 21st century shows us a very diverse landscape. The most responsive players are progressive companies who must deliver a new way of thinking, creating, and operating to stay competitive. In our research we chose to analyse the perception of these developments from the point of view of Hungarian small and medium-sized companies, and students, who are likely to generate the next new waves of innovation, technology orientation, and value creation. We approached Hungarian SMEs who are involved in and impacted by IR 4.0 challenges to analyse their understanding and ranking of the literature-driven characteristics of the 4th Industrial Revolution. In our study, we want to understand how Hungarian business students – soon to be employees and future entrepreneurs – perceive the pressure of IR 4.0 developments. Our aim was to identify links, dependencies, and gaps between Hungarian SMEs and business students who together will conjointly create new industrial opportunities.

Keywords: industrial revolution 4.0 characteristics, SMEs, entrepreneurship

1. Introduction

In today's turbulent environment, there is an increasing expectation on higher education to contribute to the development of competitive and high-quality human resource development. One component of the demanding external environment can be linked to the 4th Industrial Revolution. In this study we review the key features of this revolution in general, and detail its relevance for the Hungarian ecosystem with special emphasis on small and medium-sized enterprises. SMEs are potential future employers of graduates. As future employees, students bring significant value-added knowledge and competencies to SMEs which are meant to be developed during higher education training. We aim to articulate and deliver messages for lecturers in higher education to sensitize students for future technology demands in the context of local Hungarian business settings. In order to deliver that, we compared student and SME perception on the following three main themes (1) the perceived importance of technology challenges; (2) the relevance of 14 IR 4.0 characteristics from the respondents' point of view; (3) respondent group alignment on the perceived importance of IR 4.0 characteristics. The 4th Industrial Revolution, often also called Industry 4.0 or IR 4.0, is a new phenomenon which calls for clarification to assure that the responses in the primary analysis relate to the same business observations.

2. The 4th industrial revolution

The development of industry is of historical relevance regarding world growth. At the present time there are numerous discussions regarding the 4th Industrial Revolution both among academics and practitioners. The occurrence of this revolution can be at least partly ascribed to the expansion of globalization and to the technological changes that affect all spheres of life. Meanwhile researchers are trying to grab its elements in an exact way, the actors of economic life tackle with the opportunities and pressures of the operationalization of new factors in order to maintain competitiveness. We do not know how long this will last and what milestones we have already passed, and what others are in front of us, but it is sure that due to this new industrial revolution the global economy and society is going to change intensively. Therefore, it is inevitable to organize these changes and processes and to identify them in the various aspects of practical economic life. The aim of this section is to organize the relevant literature in a way that the elements of the 4th Industrial Revolution can be apprehended and understandable specifically regarding start-ups and small and medium-sized enterprises (SMEs).

In general, we can speak about an industrial revolution when due to new technology solutions the effectiveness of production systems increases considerably. Prior to IR 4.0 there were 3 other industrial revolutions; however, the length of time elapsing between two revolutions has decreased. While between the 1st and 2nd about one century elapsed but between the 3rd and 4th just about one decade did. Innovations and technologies affecting the economy, to a great extent, are evolving at an ever accelerating pace.

We can define IR 4.0 in a broad and in a narrower sense. In a broad sense it is a bundle of technologies adopted in manufacturing and in its related supporting activities over recent years, but in a narrow sense it refers to the adoption of cyber-physical systems (CPS) that result in the digitalisation of production (Szalavetz 2017, Kagermann et al. 2013, Monostori 2015). Angela Merkel, the German Chancellor defined Industry 4.0 as the following: "*the comprehensive transformation of the whole sphere of industrial production through the merging of digital technology and the internet with conventional industry*" (Davies 2015, p. 2.).

However, there are several other definitions for the ongoing 4th Industrial Revolution. Some concentrate on production, especially on the ever tighter connectedness of information technology and automated facilities, thus on the faster and more autonomous features of production[1]. Others include the processes of supply and logistics because due to Industry 4.0 through cyber physical systems we can connect real objects with data processors via virtual processes and information systems (Abonyi–Miszlivetz 2016). Another definition is: Industry 4.0 is such a phenomenon that raises the transparency of processes, integrates firms' value chains and the supply chain and increases customer value creation to a new level through

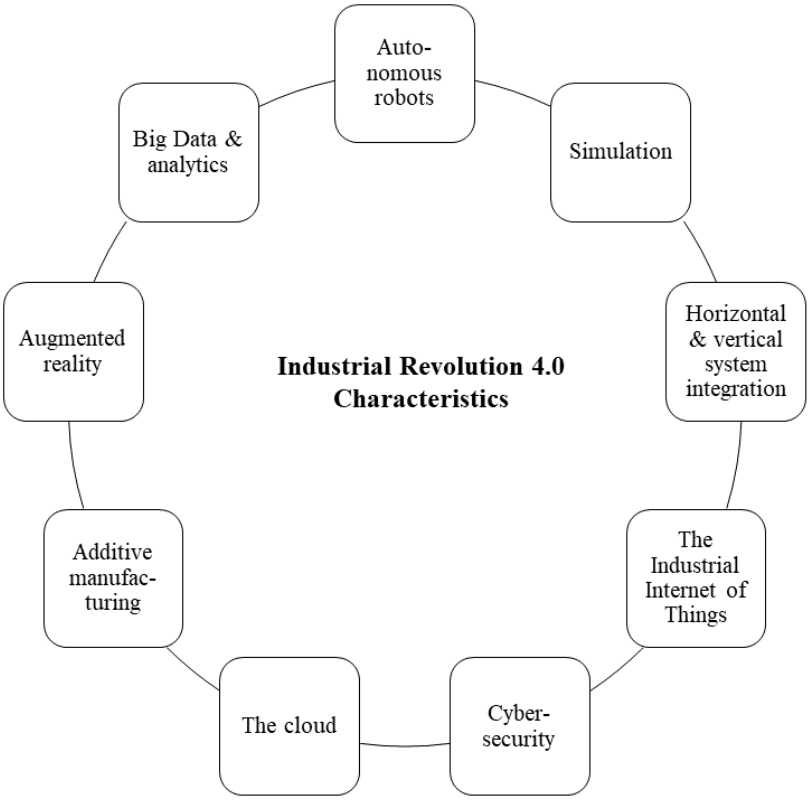
[1]*Source*: https://www.tablazat.hu/ipar-4-0 Last accessed: 28. April 2019.

technological instruments and activities and with the exploitation of the opportunities in digitalization (Nagy 2017, Davies 2015).

We can summarize the definitions of the 4th Industrial Revolution "*as a revolution enabled by application of advanced technologies (like IT) at production level to bring new values and services for customers and organization itself*" (Khan and Turowski 2016, p. 442.). This also brings quality and flexibility in production systems (Khan–Turowski 2016).

To be able to grasp this ongoing revolution, we summarize the main technologies characterizing companies that are developed with regards to Industry 4.0, this is also shown in Figure 1. The most important elements are: autonomous robots, simulation, horizontal and vertical system integration, industrial Internet of Things (Industrial IoT), cyber security, additive production, cloud-based services, augmented reality, Big Data analytics and production visualization (Rüßmann et al. 2015). In short, let us summarize the main attributes of these elements.

Figure 1 Technologies transforming industrial production



Source: own construction based on Rüßmann et al. (2015)

Regarding the first technology, autonomous robots, and the use of them in production is not new; manufacturers have been using robots to solve complex issues for decades now. However, these robots are evolving, they are becoming more cooperative, more autonomous, more flexible, and can solve more complex tasks (Rüßmann et al. 2015, Van der Elst–Williams 2017), and their adoption in industries is becoming more widespread. This is a consequence of several factors. Most importantly the cost of robotic systems (both hardware and software) has fallen considerably and is expected to decrease further, also their usage was limited but their development makes their use possible in several fields of production. Lastly, as their use needed substantial capital expenditures and the usage of specialised operatives, mostly large companies were able to adopt them, but as their cost and functionality improved, now many SMEs are also able to implement robotic systems (Strange–Zucchella 2017).

Robotization and the appearance of autonomous or cooperative robots have reshaped both production and services sectors causing substantial increase in efficiency (Nagy 2017). When designing these robots, a main aspect to be considered is that they should be able to detect the change in the operation of other robots and should be able to adapt their own operation accordingly. Robotically aided production and the efficiency increase caused by using collaborative robots are highly promising for companies. However, their adaptation is not that simple. Many obstacles might make it more difficult than the hype suggests. Among the obstacles we can mention the financing of such investment, the guarantee of enough return, or the ability to quickly adapt to dynamic developments and the fast rate of change in technology platforms themselves.

As for the second element, simulation is basically the modelling and visualization of product designs and their establishment in the manufacturing processes (Davies 2015). Similarly, to robotics, simulation is not a totally new technology, it being used in the engineering phase of products, materials, and production processes for years now, but their use is becoming more extensive, and in the future, simulations will be used in plant operations too (Rüßmann et al. 2015). Simulation with the help of virtual and augmented reality enables operators to see and compare actual production with the ideal, expected performance in real-time, thus supporting the effective operation of devices and the optimization of processes (Nagy 2017). Moreover, simulation allows operators to optimize and test the settings of machines virtually before the physical changeover, so machine setup times can be reduced while quality can be increased (Rüßmann et al. 2015, Van der Elst–Williams 2017).

The third is horizontal and vertical system integration. The collaboration of the supply and value chains can only be optimized if their systems are vertically and horizontally integrated. Nowadays the systems of suppliers, producers, and retailers or customers are integrated in a limited way, but with IR 4.0 this can be changed. Companies, departments, capabilities, and functions will be more cohesive as universal and cross-company data integration networks evolve. This enables the creation of a truly automated value chain (Rüßmann et al. 2015). Moreover, the integration enables the optimization of production and inventory planning managed across several business entities to best fit to market needs and links all involved partners within the supply chain.

The next technology to be presented briefly is the Industrial Internet of Things (Industrial IoT). IoT is a crucial if not the most crucial element of the 4^{th} Industrial Revolution. Although this technology has existed for some time now, the concept has gained importance in recent years only, as the relevance of connectivity has been understood (Sniderman et al. 2016, Baldassare et al. 2017). Today, a growing number of physical products are equipped with sensors that can process, capture and communicate data (Strange–Zucchella 2017). These sensors enable information exchange at high speed anywhere in the world, and can retrieve real-time information about the devices' and their surroundings. This way we are also able to monitor and operate technology infrastructures over large physical distances (Kagermann 2015).

The Industrial IoT is similar, it is about integrated machines and sensors and cloud-based solutions that have unique identifiers, making it possible to monitor all the processes of the supply chain (Nagy 2017). Thanks to these identifiers we will have information regarding the use, destination and provenance of devices, so there will be no need to synchronise and coordinate information, and product flows (Strange–Zucchella 2017). With Industrial IoT, more devices can be enriched with embedded, connected and computing technologies allowing these devices to interact and communicate with each other. Moreover, this also decentralizes decision making and analytics, making real-time responding possible (Rüßmann 2015). Industrial IoT might also reduce transaction costs associated with international production and might promote a deeper international division of labour (Strange–Zucchella 2017, Buckley–Strange 2015).

With the increasing use of these technologies, the importance and relevance of cybersecurity is also growing. Along with the expansion of networks and the dynamic vertical and horizontal movements of data, the stability of networks, of confidentiality, and cybersecurity systems is indispensable (Nick 2017). These are specifically important to avoid cyber-attacks. The continuous monitoring of cybersecurity is now inevitable (Nick 2017). The need for protection of critical industrial systems and manufacturing lines is increasing rapidly, so secure and reliable communications, sophisticated identity and access management of users and machines are now essential (Rüßmann et al. 2015).

The cloud is another essential driver of today's technology change. Cloud-based services are already used by firms for analytics and some enterprise applications; however, with Industry 4.0 their use will become more widespread and they will be used for several purposes. As production-related undertakings will need an increased share of data inside and outside the company, the relevance of the cloud will rise. The cloud contributes to the continuous assurance of the availability of systems and makes possible safely sharing and having access to data between different sites of the company and between companies. Furthermore, as the performance of cloud technologies improve, the whole process will become faster and the reaction time will only be some milliseconds, so we will be able to get the necessary information right away (Rüßmann et al. 2015).

A further technology is additive manufacturing. It is also known as 3D printing. This method is called additive because it creates objects by adding successive layers instead of subtracting them (Van der Elst–Williams 2017, Janssen et al. 2014). This way, customized products can be manufactured offering construction advantages, for example with complex and lightweight designs. Decentralized and high-performance additive manufacturing systems will reduce stock on hand and transport distances but also production time can be considerably decreased (Rüßmann et al. 2015, Nagy 2017). This will also shape international business. As products designed by CAD software can be produced anywhere in the world where there is a 3D printer, manufacturing will not need to be factory specific but could be be conducted close to the end-user, resulting in savings in transportation costs and delivery times, and in a minimised risk of supply resulting in simplified and more cost-efficient value chains (Strange–Zucchella 2017).

Augmented reality (AR) is also one of the nine technologies transforming industrial production. Due to AR, products and product components have digital data transmission capabilities to better monitor, observe, and inspect product characteristics and the state of these products during manufacturing and consumption. With the use of the results, the production process or the product itself can be optimized. One practical field of the use of AR nowadays is maintenance (Nagy 2017). Yet, their utilization is still in its infancy, and in the future AR will have a much broader use to give real-time information and improve work procedures and decision making (Rüßmann et al. 2015).

When introducing the main elements and technologies forming and driving Industry 4.0, Big Data and analytics cannot be left out. Big Data and its analytics mean the collection and comprehensive evaluation of data from various sources, from production equipment through enterprise management to customer management systems. Analytics based on huge data sets have appeared in manufacturing only in the past years. Yet it can help in the optimization of production quality, in energy savings and in equipment service improvements (Rüßmann et al. 2015). Furthermore, firms will be able to monitor trends and possibilities in faraway markets without having to make big resource commitments there. They will also be able to more effectively optimize their production, supply, and distribution activities by the analysis of the vast amount of data (Strange–Zucchella 2017).

All these above-mentioned technologies bundled in Industry 4.0 are expected to have a great impact on the global economy. There are estimations that the 4^{th} Industrial Revolution can bring an annual efficiency gain in manufacturing of 6–8%. Just in Germany alone, IR 4.0 will contribute to the country’s GDP by 1% per year over the next 10 years and will create 390,000 jobs. Globally, by 2020, investments in the Industrial Internet will be 25 times that of investments in 2012, and the value-added is expected to grow from 32 billion USD in 2012 to 1.3 trillion USD in 2020 (Davies 2015). Besides the figures, Industry 4.0 will have a serious impact on the way goods are produced, how companies do business, how economies operate, how markets function and on how societies react (Van der Elst–Williams 2017).

Although IR 4.0 is a global process, the readiness for it among countries and regions differs to a great extent. Employing the technologies of Industry 4.0 is critical as it can be a competitive advantage for countries that are able and willing to use these technologies, and a competitive disadvantage to those who are not. In the following section we interpret Hungary's position.

3. The 4th Industrial Revolution in Hungary and in Hungarian SMEs

When looking at Hungary's position we find that Hungary is a traditionalist country, meaning that the share of manufacturing in GDP is high but the countries readiness for the 4th Industrial Revolution is low (Dujin et al. 2014). An indicator of readiness is gross expenditure spent on R&D (GERD). The European Union has a target of 3% of GDP regarding R&D expenditure to be achieved by 2020 to improve the EU's competitiveness and readiness for the changes of this new era. Even the EU as a whole is far from reaching this goal (in 2016 GERD was 2.04 %); Hungary is among the moderate performers. The gross domestic expenditure on R&D in this country was 1.2% in 2016 (Eurostat 2017). This low value already indicates to some extent Hungary's weak readiness for Industry 4.0, yet in their study Kuruczleki et al (2016) pointed out the same by constructing their own index to measure the readiness for the 4th Industrial Revolution in the European Union. To create their own index, they used the following indicators: the above-mentioned GERD, total intramural R&D expenditure, community trademark applications, community design applications, total R&D personnel and researchers, tertiary educational attainment, ICT specialists, and digital single market. According to their analysis Hungary ranked 18th in the EU lagging behind most of the West European countries, and even behind some Central and East European country. Their analysis underlies that there is much room for improvement and that Hungary has to improve a lot to embrace the technologies and opportunities of IR 4.0.

Another way to present that Hungary has to do a lot to improve its readiness is looking at its performance regarding the EU's digital transformation index. This index has 7 dimensions: digital infrastructure, digital transformation, investments and access to finance, supply and demand of digital skills, changes in ICT start-ups environment, entrepreneurial culture and e-leadership[2]. Based on these dimensions Hungary is a modest performer in digital transformation, yet improvements can be observed in particularly in the field of investments and access to finance and entrepreneurial culture but also in digital transformation, supply and demand of digital skills and changes in ICT start-up environment. To these improvements a big contribution is made by a generally favourable investment climate that creates incentives for ICT firms (both domestic and foreign) to invest in Hungary. Yet the country's performance is rather poor in terms of e-leadership and of digital

[2] More on the EU's Digital Transformation Scoreboard: https://ec.europa.eu/growth/tools-databases/dem/monitor/scoreboard Last accessed: 28 April 2019.

infrastructure indicating that further policy efforts are needed. Regarding these fields, the country is performing far below the EU average. Digital infrastructure is a great challenge for the country; and special efforts should be made to increase the integration of ERP software by businesses and to improve internet bandwidth's quality (Probst et al. 2018).

All these pose a big challenge for the country, and to overcome it and to boost developments in the field of technological readiness, R&D & innovation, and digital transformation, several strategies have been implemented. In February 2016 a strategy for industrial development initiated by the Ministry for National Economy was adopted. This national strategy, called the Irinyi Plan, includes the most important directions for economic development for the time period of 2016-2020; moreover, this plan is a framework for the development of an Industry 4.0 strategy in all the key sectors concerned (Nick 2017, Klitou et al. 2017).

The Irinyi Plan also concretizes the Hungarian economic development strategy as a target has been set to increase the share of industrial value-added in GDP from 23.5% in 2016 to 30% in 2020. The plan names these key sectors as well. They are: the already strong automotive industry, specialized machine and vehicle production, healthcare, tourism, food industry, the IT sector, the green economy, and the sector of shared service centres (SSCs). There is a goal of improving the processing industry as well, which should be achieved using new technologies, the improvement of energy and material efficiency, and the more extensive use of Hungarian resources[3].

Based on the Irinyi Plan a national initiative was also adopted. Industry 4.0 National Technology Platform (IR 4.0 NTP) is an initiative of the Ministry for National Economy and the Hungarian Academy of Science Institute for Computer Science and Control (Klitou et al. 2017, Haidegger–Paniti 2016). The objective of this platform is to enhance manufacturing and industry transformation in the country to get Hungary ready for Industry 4.0. The expected effects of IR 4.0 NTP are to prepare the industrial sector for the 4th Industrial Revolution and adapt it to the requirements of IR 4.0, but also to boost the countries competitiveness. This initiative is an indispensable element in improving Hungary's readiness for digital transformation. The five main objectives of IR 4.0 NTP are: responding to challenges in a prompter way, fostering bold steps toward innovation, supporting the readiness of the country's economy for innovative adaptation, accelerating innovation particularly in digitisation and in production, and fostering information exchange, partnership establishment and cooperation between all actors of economy (Klitou et al. 2017).

To reach the set strategic targets several organizations were set up. These organizations help to roadmap the above objectives. One of such organizations is the Excellence in Production Informatics and Control (EPIC) (Fülep et al. 2018). The goals of EPIC are to improve innovation culture in Hungary, to speed up the innovation process, and to introduce and promote new technologies and

[3] *Source*: https://piacesprofit.hu/kkv_cegblog/ipar-4-0-az-uj-szabvany/?hf=1 Last accessed: 28 April 2019.

methodologies, also to strengthen the institute's research potential, especially in the field of Cyber Physical Systems (Nick 2017, Haidegger–Paniti 2016). Besides multinational companies, a special focus is put on the development of Hungarian SMEs. EPIC supports competitiveness increases and the strengthening of supply industry from a practical point of view. Among its objectives are: improving high-quality trainings and constructing and promoting sample solutions for the 4th Industrial Revolution (Nick 2017).

It is of key importance that all economic actors change their development systems from extensive to intensive development, and this is particularly true for SMEs, which in many cases still use traditional methods. SMEs are affected negatively by both their lack of knowledge and lack of capital, which are critical in the realization of high value-added production methods[4]. The value-added contribution of SMEs is lower than the EU average in Hungary, which lowers the country's competitiveness[5]. Yet as Table 1 presents, Hungarian SMEs make up around one quarter of the Hungarian business expenditure on R&D (BERD), which was even higher during 2011-2013 when, BERD by SMEs exceeded 30%. This indicates that despite their size, SMEs are crucial for Hungarian research and development as these enterprises are also highly committed to R&D activities and are investing in R&D. By supporting SMEs R&D activities not only show their readiness for the 4th Industrial Revolution can be improved, but also the competitiveness of the whole country.

Table 1 The share of SMEs in Business Expenditure on R&D (BERD) in Hungary, 2008–2016, % of total Hungarian BERD

Number of employees	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
10–49	9.26	9.72	9.45	11.09	11.57	12.06	11.73	8.78	9.20
50–249	8.58	11.57	15.76	18.93	19.17	20.95	16.84	15.09	13.67
SMEs total	17.83	21.30	25.21	30.02	30.74	33.02	28.57	23.87	22.86

Note: micro enterprises (enterprises of 1–9 employees) are left out from the investigation, however if we include them, the latest values exceed 25%, and between 2011–2013 the share of micro, small and medium-sized enterprises in total Hungarian BERD was close to 40%.

Source: own calculations based on Eurostat data[6]

[4] *Source*: https://evkszakkollegium.blog.hu/2016/12/06/negyedik_ipari_forradalom_avagy_tenyleg_elveszik_a_robotok_a_munkankat Last accessed: 28 April 2019.

[5] *Source*: http://www.mkt.hu/wp-content/uploads/2016/05/Lepsenyi_Istvan_05_12.pdf Last accessed: 28 April 2019.

[6] *Data source for calculations*: https://ec.europa.eu/eurostat/web/products-datasets/-/isoc_bde15ar2 Last accessed: 28 April 2019.

So, it is not surprising that IR 4.0 development plans have a special focus on SMEs and the help and support given to them. Several programs give SMEs the opportunity to implement their own development ideas, while others help them in conversion. One such program, called the Program of Modern Entrepreneurs, is organized by the Hungarian Chamber of Commerce and Industry (HCCI). This program supports the IR 4.0 developments of SMEs with professionals and consulting. Moreover, the Industry 4.0 Model Factory program was established with the aim of helping Hungarian suppliers of multinational companies to meet the growing needs of MNCs regarding the quality of products and services[7]. Five model factories were set up with government support to familiarize and prepare SMEs for the use of IR 4.0 technologies. Representatives of SMEs can see these technologies in real-life operation in functioning factories[8]. As a part of this program, participating SMEs can test their readiness for Industry 4.0 but can also find firm specific ideas to foster and motivate their aspiration to improve. In these Model Factories SMEs can meet new technologies, for instance they can find autonomous robots or the various uses of AR[9]. An important goal is to increase SME readiness for IR 4.0 so that they have better chances of becoming suppliers to multinational companies.

Besides SMEs, a special focus is put also on start-ups and their improvements. For this a special strategy was set up, the Digital Start-up Strategy[10]. The main aim of this strategy is to boost the cooperation between multinational companies and start-ups in Hungary. The synergies could be beneficial for both parties, because while multinationals have a lot of capital, they can only react to changes slowly, while start-ups are innovative enterprises that are able to react to market changes fast and effectively; however, they have lack of capital (Ritter et al. 2016).

Although, Hungary's position regarding Industry 4.0 should be improved, as it is presented in this section, there are several kinds of actions and plans that aim at this improvement. The focus is not only on multinationals, as they alone cannot bring change. There are special programs specifically dedicated to SMEs and start-ups and their development. These programs aim at the integration of SMEs and start-ups to the supply chains and value chains of MNCs by improving their readiness for technological change, and increasing their adaption ability so that they will be able to embrace the new technologies and enhance their competitiveness.

---

[7] *Source*: https://piacesprofit.hu/kkv_cegblog/ipar-4-0-kkv-k-is-elkezdhetik/ Last accessed: 28 April 2019.
[8] *Source*: https://piacesprofit.hu/infokom/ipar-4-0-tanuljunk-mintagyaraktol/ Last accessed: 28 April 2019.
[9] *Source*: https://piacesprofit.hu/infokom/ipar-4-0-tanuljunk-mintagyaraktol/ Last accessed: 28 April 2019.
[10] *Source*: http://www.kormany.hu/download/d/8c/e0000/Magyarorsz%C3%A1g%20Digit%C3%A1lis%20Startup%20Strat%C3%A9gi%C3%A1ja.pdf Last accessed 28. April 2019.

4. Research method and research questions

In our study we used a quantitative method: questionnaires distributed among students and Hungarian SMEs. To examine student answers, we used printed and online questionnaires to reach respondents. SMEs were directly asked to fill out the questionnaire sent out to them via e-mail. Both groups were asked to evaluate the importance of the attributes of the 4^{th} Industrial Revolution on a 1–5 Likert scale. Data was collected directly. Students and SMEs were asked to fill in the questionnaire handed out to them. We wanted them to evaluate the following 14 characteristics that we articulated based on the Hungarian Irinyi Plan and literature review (Nick 2017, Klitou et al. 2017):

1. Visualization of production, real-time collection of data about production and resources
2. Supply chain visualization (real-time visualization of actual and expected quantity of stocks, of the place of stocks and their status, both inside the company and with the other actors of the supply chain)
3. Supply chain collaboration (sharing of production plans and stock information through electronic data exchange)
4. The optimization of supply chain, production planning and stock planning: making optimal stock, production and procurement plans to sufficiently meet market demand, doing so with the help of ERP, SCM and Advanced Planning systems
5. Predictive maintenance
6. Big Data solutions
7. Intelligent energy utilisation
8. Robot-aid production, collaborative robots
9. Modern warehouse and production logistics solution
10. Solutions supporting unique production and small-scale production
11. Internet of Things, Machine to Machine communication, autonomous robots
12. The use of augmented reality (AR) in maintenance and in remote assistance
13. 3D printing, additive production technologies
14. Fast prototype-making, involving customers to prototyping.

We used purposive sampling. We were interested in the opinions of students familiar with management, economy and finance, so we asked only the students of the University of Szeged, Faculty of Economics and Business Administration. We decided to select this group of students as we assume that their theoretical knowledge on economic processes must be above average, therefore their perception should at least be partly based on solid knowledge, also they will constitute the future entrepreneurs and economic employees of current enterprises. Moreover, we wanted to get to know the view of SMEs operating in Hungary. Hungarian SMEs were chosen assuming that they have a greater understanding of happenings in the Hungarian economy.

The sample of our study consists of 216 answers from students and 21 answers from SMEs. Table 2 contains a summary of the attributes of the respondents.

Table 2 The composition and main attributes of the research sample

STUDENTS	**SMES**
216 responses	21 responses
Female: 137, male: 75, no answer: 4	Field of operation: services 8, industry 11, agriculture 1, no answer 1
Working:81, owning an enterprise: 9	Years of operation ranges: some month to 31 years (average: almost 9 years)
Both BSc and MSc students (190 BSc, 23 MSc, 3 no answer)	Number of employees' ranges: 2–200 (average: 29)
Age group: 20–25; average age: 21,5	Operating mostly on the global scale

Source: own construction based on questionnaire responses

Our investigation focused on three main areas comparing SME and student perceptions on IR 4.0 related themes. The first one investigates the *perceived importance of technology challenges*. This topic is covered by Q1 detailed below. The second area is studying the *relevance of 14 IR 4.0 characteristics from the respondents' point of view*. This topic is addressed by Q2 and Q3. The third theme is comparing *respondent group alignment on the perceived importance of IR 4.0 characteristics*. This is reviewed using Q4 and Q5.

During our research, the following specific questions were raised and analysed to measure respondent perceptions:

- Q1: How important is the overall technology challenge based on the respondents' view?
- Q2/3: What are the top 3 most / least important characteristics of Industry 4.0 according to the respondents?
- Q4/5: Where is group alignment /misalignment on the perceived level of importance of the characteristics?

The analysis and results are presented in the next section.

5. Analysis and Results

We will review the summary of responses for each question with the objective of extracting the key observations and messages on the selected 3 themes.

The perceived importance of technology challenges is addressed in the first question. We were investigating the overall technology development challenge from the students' and SME's point of view (Table 3 Q1). This score represents the overall aggregated number derived from the technology characteristics taken them into account with equal weight.

On a 5-point scale, the aggregate score for students was 3.306 as a grand mean score, while for SMEs' this figure resulted to be 3.389. These numbers show that there is a difference in Industry 4.0 perceptions between students and SMEs. The impacts of Industry 4.0 are sensed more strongly and intensively by the enterprises. On the other hand, it shows that students undervalue the importance of IR 4.0 characteristics compared to companies who might be potential employers for them in the future. We can conclude that through the education process it is important to place stronger emphasis on and awareness of the importance of business technology for students to be more qualified for the demands of the job market.

Table 3 Summary of questions and responses

Q1. HOW IMPORTANT IS THE OVERALL TECHNOLOGY CHALLENGE BASED ON THE RESPONDENTS' VIEW?		
	SME	Student
Grand Mean	3.389	3.036
Q2. What ARE the top 3 most important characteristics of Industry 4.0 according to the respondents?		
Rank	SME	Student
1	Big Data	Intelligent energy utilization
2	Unique and small-scale production	Big Data
3	Supply chain optimization	Supply chain visualization
Q3. What ARE the top 3 least important characteristics of Industry 4.0 according to the respondents?		
Rank	SME	Student
1	Robots	Robots
2	3D printing, additive production	Use of AR
3	Intelligent energy utilisation	3D printing, additive production
Q4. Where is group alignment on the perceived level of importance of IR 4.0 characteristics?		
Rank	SME	Student
1	No alignment	Intelligent energy utilization
2		Robots
3		Use of AR
Q5. Where is misalignment on the perceived level of importance of IR 4.0 characteristics?		
Rank	SME	Student
1	3D printing, additive production	Supply Chain optimization
2	Use of AR	Modern warehouse and logistics
3	Internet of Things, Machine to Machine communication, autonomous robots	Prototype making

Source: own construction based on questionnaire responses

The relevance of 14 IR 4.0 characteristics from the respondents' point of view is investigated in Q2 and Q3. In the second question, that we raised during our analysis, we were interested in seeing how respondents rank the characteristics of Industry 4.0 (Table 3 Q2). Here we wanted to capture the top three most important elements based on the perception of students and SMEs.

We observed that SMEs capture the basic, traditionally developed elements of IR 4.0 such as collecting large amounts of data; being prepared for small scale customization; and working closely with partners in the supply chain to improve responsiveness while reducing cost. Students put more weight and importance on managing environment impact more closely through intelligent energy utilization. Big data was their second most important factor. Students demonstrated strong demand for visualization and clearer interpretation of the supply chain which comes as a natural desire based on their digital maturity.

As a message we can conclude that understanding integrated data management is an essential requirement for both from the students and the SMEs side. Developing business system understanding and system development concepts transferred from the educational experience is critical. A hint of ERP is not adequate as basic knowledge. Therefore, it is recommended to embed and teach more simulation, data management and visualization aspects at least as elective courses in higher education programmes.

The third question we studied focuses on the respondents' rank of the least important characteristics of Industry 4.0 (Table 3 Q3).

In both respondent groups we can observe that the newest technologies resonate with all respondents as less important factors than robotization or 3D printing or additive production. One key difference between the groups is the importance of environment impact, where SMEs considered intelligent energy utilization among the least important factors.

As a message we can articulate that the latest technology development is an area where awareness is to be raised for both students and companies. However, we can also state that this is a field where educators most likely will need to be educated as well. An option could be to purchase expertise from the practitioners and link it to relevant courses.

Respondent group alignment on the perceived importance of IR 4.0 characteristics is studied through Q4 and Q5.

With the fourth question we were looking for intra-group alignment concerning the IR 4.0 characteristics investigated (Table 3 Q4). Concerning SMEs, we found all standard deviation above 1.1, which indicates that there is no alignment and agreement across the respondents. Companies of this size face a variety of challenges which have diverse links to the 4^{th} Industrial Revolution. Students on the other hand have similar perception and „consensus" both on the most and least important features. It is important to note, that students are to be prepared for a very diverse environment. To address that, educators must work two ways: partly to take new technologies into the classroom, but also by taking students out of the classroom to experience the full diversity of challenges.

With the fifth question we were looking for intra-group misalignment concerning the investigated IR 4.0 characteristics (Table 3 Q5).

SMEs and student have a completely different list of characteristics, where their perception is misaligned. SMEs consider 3D printing and additive production among the least important but with a high standard deviation, which indicates, that there are some companies, who are impacted and involved in their use of technologies. Interestingly students consider supply chain management as an area where the largest misalignment is experienced.

As a take-away message we can conclude that SMEs are strongly encouraged to take development opportunities offered by technology development in order to stimulate learning and develop knowledge and technology-based improvement capabilities.

6. Conclusions & Recommendations

Many aspects of current economic and social life are impacted by the 4th Industrial Revolution. However, different actors play different roles and take part in the evolving developments in a variety of ways. Technological innovations can be asset intensive changes in this new era, which requires significant capital and knowledge investment for those who want to stay competitive. SMEs might not be the leading actors of these changes unless they are specifically set up to focus on driving certain innovations as start-ups.

In Hungary, there is a significant effort being made to stay competitive in the European and global environment driven by the Irinyi Plan, which serves as an economic strategy for Hungary. This strategic plan not only emphasises the importance of the development of IR 4.0 characteristics in the Hungarian environment, but also initiates the set-up of specific tools and support for SMEs to be able to stay in the game. This serves as a top-down approach for the small and medium-sized players in the Hungarian economy. The development of higher education in respect of IR 4.0 features contributes to the human resource development of the younger generation. As the world is in a period of fast change, the revitalization of higher education is increasingly important. Indeed, higher education revitalization is essential. Students absolutely thrive on technology, but not in a business context which is to be bridged by education. Large business players do develop young candidates intensively to meet challenges, but SMEs lack the knowledge and resources to capture all relevant development opportunities for the company, including young talents.

The importance of technology challenges is experienced more sensitively by SMEs, which necessitates that educators link the latest technology developments more intensively to specific business needs. Students with their high technological agility are ready and eager to face this challenge but their economic and business understanding must be developed to materialize their digital capabilities as a business competency. The relevance of 14 IR 4.0 characteristics from the respondents' point of view shows a mixed picture when comparing students and SMEs. The list of the most important IR 4.0 characteristics for SMEs contains technological and digital capabilities which are in general practice in the developed economies. In contrast, students rank more recent innovations at the top of their list. This results in a gap which is natural and healthy. Concerning the least important characteristics, SMEs and students strongly overlap. The respondent group alignment on the perceived importance of IR 4.0 characteristics shows that SMEs have very diverse views and no alignments, while students are sensitive and responsive to the latest developments.

Education must provide stronger awareness of the importance of business technology, even if all knowledge is not internally available. New technologies need to be brought into the classroom for students and educators. Involving leading companies or other education institutes in the network can bring great value and quality improvements to the education process.

Also providing that opportunity to SMEs could bring mutual gains for all participating parties. Education that cooperates with SMEs can provide mutual benefits for students, educators, and companies, helping them to remain on top of the new waves of industrial technology developments.

Our study has a number of limitations, partly due to the low sample size of SMEs on the business investigation side. On the education side, the questionnaire was distributed only at a single university. These limitations are to be addressed in the next phase of the project. The results of this study bring many insights which validate the continuation of in-depth investigation of the impacts of IR 4.0 on SMEs in the Hungarian environment, in parallel with identifying the necessary changes demanded of our higher education partners.

References

Abonyi, J. – Miszlivetz, F. (2016): *Ipar 4.0 megoldások kialakításának feltételrendszere*. Pannon Egyetem, Veszprém, https://www.researchgate.net/publication/301892028_Ipar_40_megoldasok_kialakitasanak_feltetelrendszere Last accessed: 27. March 2019.

Baldassare, F. – Ricciardi, F. – Campo, R. (2017): The Advent of Industry 4.0 in Manufacturing Industry: Literature Review and Growth Opportunities. *Dubrovnik International Economic Meeting*, 3, 1, 632–643.

Buckley, P.J. – Strange, R. (2015): The governance of the global factory: location and control of world economic activity. *Academy of Management Perspectives*, 29, 2, 237–249.

Davies, R. (2015): *Industry 4.0 Digitalisation for productivity and growth*, EPRS Briefing, European Parliamentary Research Service, Brussels, Belgium

Dujin, A. – Geissler, C. – Horskötter, D. (2014): *Industry 4.0 The new industrial revolution – How Europe will succeed*. Roland Berger Strategy consultants, Operations Strategy Competence Center, Münich, Germany http://www.iberglobal.com/files/Roland_Berger_Industry.pdf Last accessed: 31. March 2019.

Eurostat (2017): *Smarter, greener, more inclusive? Indicators to support the Europe 2020 Strategy*. Eurostat Statistical Book. Eurostat, Luxembourg, Luxembourg

Fülep, I. – Nick, G. A. – Várgedő, T. (2018): Zászlón a digitalizáció – Ipar 4.0. *E-KÖZIGAZGATÁSI TANULMÁNYOK.* http://kozszov.org.hu/dokumentumok/UMK_2018/2/07_Ipar_4_0.pdf Last accessed: 14. April 2019.

Haidegger, G. – Paniti, I. (2016): Industry 4.0 Platform Activities in Hungary, Past – Present – Plans. *International Scientific Journal Industry 4.0*, 1, 1, 7–10.

Janssen, R. – Blankers, I. – Moolenburgh, E. – Posthumus, B. (2014): The Impact of 3-D Printing on Supply Chain Management. *TNO Transport and Mobility* The Hague, Netherlands

Kagermann, H. – Helbig, J. – Hellinger, A. – Wahlster, W. (2013): *Recommendations for implementing the strategic initiative INDUSTRIE 4.0: securing the Future of German Manufacturing Industry*. Forschungsunion Federal Ministry of Education and Research, Frankfurt/Main, Germany https://www.din.de/blob/76902/e8cac883f42bf28536e7e8165993f1fd/recommendations-for-implementing-industry-4-0-data.pdf Last accessed: 28. April 2019.

Kagermann, H. (2015): Change Through Digitalization – Value Creation in the Age of Industry 4.0 In Albach, H. – Meffert, H. – Pinkwart, A. – Reichwald, R. (eds.): *Management of Permanent Change*, Springer Fachmedien Wiesbaden Publisher, Wiesbaden, Germany, 23–45. DOI: 10.1007/978-3-658-05014-6_2

Khan, A. – Turowski, K. (2016): A Perspective on Industry 4.0: From Challenges to Opportunities in Production Systems. *Proceedings on the International Conference on Internet of Things and Big Data (IoTBD 2016)*, 441–448.

Klitou, D. – Conrads, J. – Rasmussen, M. – Probst, L. – Pedersen, B. (2017): *Hungary: "IPAR 4.0 National Technology Platform"*. European Commission Digital Transformation Monitor, European Commission, Brussels, Belgium

Kuruczleki, É. – Pelle, A. – Laczi, R. – Fekete, B. (2016): The Readiness of the European Union to Embrace the Fourth Industrial Revolution. *Management (Slovenia)*, 11, 4, 327–347.

Monostori, L. (2015) Cyber-physical production systems: roots from manufacturing science and technology. *Automatisierungstechnik*, 63, 10, 766−776.

Nagy, J. (2017): *Az ipar 4.0 fogalma, összetevői és hatása az értékláncra* (The definition of Industry 4.0, its components and impacts on the supply chain), Budapesti Corvinus Egyetem Vállalatgazdaságtan Intézet, Budapest http://unipub.lib.uni-corvinus.hu/3115/1/Nagy_167.pdf Letöltve: 2018. 10. 27.

Nick, G.A. (2017): *Az Ipar 4.0 Nemzeti Technológiai Platform támogató szerepe* (The supporting role of Industry 4.0 National Technology Platform). XXIV. NMK Plenáris ülés, Balatonalmádi, 2017. szeptember 14. https://www.isoforum.hu/media/programnaptar/files/NickGabor-eloadas.pdf : Last accessed: 04. April 2019.

Probst, L. – Lefebvre, V. – Martinez-Diaz, C. – Bohn, N. U. – Klitou, D. – Conrads, J. (2018): *EU businesses go digital: Opportunities, outcomes and uptake*. Digital Transformation Scoreboard 2018, European Commission, Brussels, Belgium

Ritter, M. – Török, J. – Pongrácz, F. (2016): Hogyan használható a mesterséges intelligencia, az innovációmenedzsmentben a Negyedik Ipari Forradalomban a kis-és középvállalkozások növekedési pályára állításában? (How to apply Artificial Intelligence in Innovation Management to support the growth of small and medium businesses in the area of industry 4.0?). *Logisztika - Informatika – Menedzsment*, 1, 1, 111–127.

Rüßmann, M. – Lorent, M. – Gerbert, P. – Waldner, M. – Justus, J. – Engel, P. – Harnisch M. (2015): *Industry 4.0 The Future of Productivity and Growth in Manufacturing Industries*, Boston Consulting Group, https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries.aspx Last accessed: 04.April 2019.

Sniderman, B. – Mahto, M. – Cotteleer, M.J. (2016): *Industry 4.0 and manufacturing ecosystems – Exploring the world of connected enterprises*, Deloitte University Press. Deloitte, Westlake, USA

Strange, R. – Zucchella, A. (2017): Industry 4.0, global value chains and international business, *Multinational Business Review*, 25, 3, 174–184.

Szalavetz, A. (2017): Industry 4.0 in 'factor economies. In Galgóczi B. – Drahokoupil J (eds.): *Condemned to be Left Behind? Can Central and Eastern Europe Emerge from its Low-Wage Model?*, European Trade Union Institute, Brussels, 133–152.

Van der Elst, K. – Williams, A. (2017*): Industry 4.0: The new production paradigm and its implications for EU policy*. IN European Commission: Report of the Expert Group 'Strategic Foresight for R&I Policy in Horizon 2020' Background Papers. European Commission, Brussels, Belgium