


The adoption of industry 4.0 and digitalisation of Hungarian SMEs

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ABSTRACT

Hungarian small- and medium-sized enterprises are facing the challenges of digitalisation and innovation to survive fierce competition in the era of Industry 4.0, and particularly of COVID-19. Survival in the heavily hit sectors depends on the degree of digitalisation and involvement in e-commerce. This paper aims to examine Hungarian SMEs' current scale of digitalisation and adoption of Industry 4.0 technologies. It also analyses the role of the Hungarian government's support for SMEs' digital transformation. To this end, secondary data were collected from Eurostat, the European Commission and the Hungarian Central Statistical Office, including the Digital Economy and Society Index (DESI), indices of skills and innovation from SME performance reviews and sectoral business statistics. In processing the data, the study strictly followed the European Commission' classification protocol, complemented by a qualitative analysis of reports and programmes related to digitalisation and Industry 4.0 in Hungary. The findings reveal that there is a further need for strengthening the digitalisation and innovation capacities of Hungarian SMEs. The effects of introduced measures could not be seen yet. Hence, the Hungarian government should continue to support SMEs' digital transformation in order to increase their role in high-tech manufacturing and knowledge-intensive services.

KEYWORDS

Hungarian small and medium-sized enterprises, digitalisation, industry 4.0, skills and innovation

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1. INTRODUCTION

The Fourth Industrial Revolution and its technological developments affect every country's economy and society. The adoption of new innovations and digitalisation can significantly improve companies' — thus countries' — productivity, corporate competitiveness, and social well-being. The First Industrial Revolution (Industry 1.0) introduced mechanised production by using repurposed water and steam power. Industry 2.0 used electric power to achieve mass production. The Third Industrial Revolution instituted automated production by applying electronics and information technology. Now a Fourth Industrial Revolution is emerging from the Third, the digital revolution that has been in progress since the middle of the last century (Schwab 2015). The [European Parliament \(2016: 20\)](#) describes Industry 4.0 as the

organisation of production processes based on technology and devices autonomously communicating with each other along the value chain: a model of the 'smart' factory of the future where computer-driven systems monitor physical processes, create a virtual copy of the physical world and make decentralised decisions based on self-organisation mechanisms. The concept takes account of the increased computerisation of the manufacturing industries where physical objects are seamlessly integrated into the information network.

The role of small and medium-sized enterprises (SMEs) is important both in the European Union and in the Hungarian economy as well. SMEs account for 99.8% of total companies, for more than two-thirds of employment (68.2 and 66.6% respectively) and for more than half of value added (56.4 and 54.1% respectively) ([European Commission 2019](#)). The capacities of SMEs to adapt new technologies are low, and they also face constraints in internal resources (given their size such as human capital or financial resources) and external resources (due to market failures and fierce competition). Thus, the role of governmental support was increased to help SMEs in their adjustment to the changed environment. It can be observed that Industry 4.0 has a significant impact on small and medium-sized enterprises through several changes, which are the consequences of technological development such as 3D printing, the development of online sales services such as car services, medical examinations from home, food delivery directly from the store to the refrigerator. Moreover, the pandemic has placed small and medium enterprises (SMEs) under huge pressure to survive, requiring them to respond effectively to the crisis by adapting digital solutions. However, the resources of SMEs remained restricted. As a result, nowadays the adoption of Industry 4.0 technologies and digitalisation is appreciated and so is the role of government in helping it.

In recent years, the Hungarian government has adapted several programmes to help SMEs to improve their skills and innovation capabilities and adapt Industry 4.0 technologies. We can highlight its 'Industry 4.0 Sample Factories' flagship project, which provides experience and knowledge to productive micro, small and medium-sized enterprises to learn about industry 4.0 technologies, their applicability, and thereby increase their competitiveness ([IFKA-IVSZ 2021](#)). Furthermore, it launched the 'Digital Welfare Financial Programme' to develop SMEs' digital infrastructure and digital competencies ([Hungarian Government 2021](#)).

The main aim of this paper is to investigate the status of Hungarian SMEs in adapting Industry 4.0 technologies and digitalisation and whether there is any effect or need for further public measures in order to support SMEs in these activities.



First, the concepts of Industry 4.0 are described and related terminologies and challenges are explained for clarity and completeness. Then, the Hungarian strategy and measures for Industry 4.0 are summarised and Hungary's status in digitalisation and in skills is introduced, which are necessary to adapt Industry 4.0 technologies. The former is achieved by a qualitative analysis: information is collected from national strategies, laws and governmental portals. For the latter, data is collected from Eurostat, the European Commission and the Hungarian Central Statistical Office to show Hungary's performance in digitalisation, skills and innovation, high-technology manufacturing and knowledge-intensive services. A conclusion with possible topics for future discussion is presented in the final section. The paper draws the attention to the need of supporting Hungarian SMEs in digitalisation and in adaption of Industry 4.0. More governmental programmes should be introduced in order to accelerate their digital transformation and to improve their skills and innovation.

2. LITERATURE REVIEW

Even though we regularly use the expression 'Industry 4.0' as an everyday terminology, a single definition of it cannot be found. There are different classifications for definitions (see [Culot et al. 2020](#) or [Saucedo-Martínez et al. 2018](#)), within the framework of this paper it is impossible to introduce all the existing definitions and classifications. Definitions regarded relevant to the purpose of this paper are kept in focus.

The concept of Industry 4.0 was introduced in 2011 at the Hannover fair. Originally, it was 'a strategic initiative of the German government that traditionally heavily supports development of the industrial sector' ([Rojko 2017](#): 80) and a proposal for the development of a new concept of German economic policy, which is based on high-tech strategies ([Roblek et al. 2016](#)). Nine pillars of Industry 4.0 were identified, when it was first announced: cyber-physical systems, the Internet of Things (IoT), big data, 3D printing, robotics, simulation, augmented reality, cloud computing and cyber security ([Yang – Gu 2021](#)). As [Schuh et al. \(2014\)](#) described, Industry 4.0 refers to the integration of information and communication technologies in an industrial environment.

According to [Zhong et al. \(2017\)](#) as intelligent manufacturing systems are based on advanced information, they become flexible, smart, and customisable to answer the needs of the dynamically ever-changing global market. The key is to have all information about manufacturing supply chains and all relevant industries. [Shafiq et al. \(2015; 2016\)](#) argue that the main goals of Industry 4.0 are (1) to provide IT-enabled mass customisation of manufactured products; (2) to ensure that production chains adopt automatically and flexibly; (3) to track parts and products; (4) to facilitate communication among parts, products, and machines; (5) to apply human-machine interaction paradigms; (6) to achieve IoT-enabled production optimisation in smart factories; and (7) to provide new types of services and business models of interaction in the value chain. Similarly, [Posada et al. \(2015\)](#) and [Roblek et al. \(2016\)](#) identified five key elements of industry 4.0: (1) digitisation, optimisation, and personalisation of production; (2) automation and adoption; (3) human-machine cooperation; (4) value-added services and warehousing, and (5) automatic data exchange and communication. [Zezulka et al. \(2016\)](#) further identified three interrelated factors related to industry 4.0 such as (1) digitisation and network integration, (2) digitisation of products and services, and (3) new market models.



In digitisation, traditional products are replaced by digital products, or at least digital features are added (Prem 2015). Digital transformation refers to the integration and exploitation of digital technologies to increase productivity and social welfare. Digitalisation goes beyond products; it affects the business model, business organisation, management systems, and entire value chain processes (Bleicher – Stanley 2018). Scholars (Bharadwaj et al. 2013 or Vial 2019) argue that digitalisation refers to the use of digital technologies such as information, computing, communication, and connection technologies to promote organisational changes. Török (2020) concluded that only companies with a management of which can make decisions based on digitalisation can gain competitive advantage.

Schwab (2015) examined Industry 4.0 in the broadest perspective. He states that it ‘is characterised by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres’ (Schwab 2015: 1). It is disrupting almost every industry in every country and spurring exponentially. It transforms entire systems of production, management, and governance (Schwab 2015).

The current challenges of adapting Industry 4.0 are: (1) the lack of autonomy in many current systems; (2) lack of bandwidth (Wang et al. 2016); (3) improving quality and integrity of recorded data; (4) developing, modelling and analysis of complex systems; (5) adjusting the current production routes to adapt a large dynamic reconfiguration for individualised and customised products; (6) ensuring cyber security and data privacy and (7) identifying the best ways for different sectors (e.g. small and medium-sized enterprises vs Fortune 500) to invest and the optimal support from the government of each country. It is undoubtedly true that continuous development and practical applications of Industry 4.0 rely on government policies and support. At the same time, it is to the governments’ benefits to materialise the outcomes of various Industry 4.0 practices (Yang – Gu 2021).

Until recently, just only limited researchers examined the adoption of Industry 4.0 by SMEs. In relation to German SMEs, Sommer (2015) stated that corporate size ‘matters’: large enterprises are better prepared than small enterprises due to their financial, technological and staffing strengths. By examining British SMEs, Masood and Sonntag (2020) concluded the same by adding that constraints of awareness and knowledge are also important factors of adoption. Similarly, Ingaldi and Ulewicz (2019) concluded that in case of Polish SMEs, the lack of financial resources and specialised support in obtaining new technologies is the main problem in industrial transformation. The role of managers was highlighted by Agostini and Nosella’s (2020) analysis of six Central European regions. Szabó et al. (2019) argued that the most important barrier to the spread of digital transformation and Industry 4.0 was the human factor; managers are not ready to move to a significantly more efficient, but significantly different operating model, and even middle management is explicitly resistant to change, fearing its own role. Szalavetz (2021), by examining Hungarian companies which have developed digital solutions for automotive companies, argued that the I4.0 solutions cannot be seen as radical disruptive solutions and specialized on the domestic market. Cserhádi and Pirisi (2020) highlighted that in Hungary, the structural changes in skills, occupations, and the ratio of people with tertiary education is not sufficient yet, these should be speeded up in order to benefit from Industry 4.0 technologies. In case of family-owned businesses, these (financial and human resource) constraints can be more relevant (Nagy et al. 2011), since these businesses are conservative and are averse to risk (Nagy 2013).



In sum, based on the literature review, definitions, benefits, and challenges of I4.0 are well determined with many existing frameworks and tools. Further research would be essential as no existing paper can be found that would examine the adoption of I4.0 by Hungarian SMEs focusing on digitalisation and the role of government in it.

3. METHODOLOGY

Due to the applied dataset, the definition and terminology of the European Union are used. Based on EU recommendation 2003/361, small and medium-sized enterprises (SMEs) are categorised by staff headcount and turnover or balance sheet total as the following (Table 1):

In accordance with the above-mentioned classification, 99.8% of Hungarian companies are SMEs. This is one of the drawbacks of the applied methodology, however, this allows us to use macroeconomic data when there is no data available for SMEs (see e.g., some components of thew DESI index).

To illustrate the position of Hungarian SMEs in digitalisation and adapting Industry 4.0 technologies, the paper uses statistics from Eurostat (Structural Business Statistics) and/or the Hungarian Central Statistical Office, when the latter is necessary.

Based on the available data, the following indices are analysed:

1. Digital Economy and Society Index (DESI) between 2015 and 2020 to gain knowledge about where SMEs stand at digitalisation. The DESI has five dimensions: connectivity (data about broadband and its prices), human capital, citizens' use of the internet, integration of digital technology and digital public services (European Commission 2020a). From these, we analyse the integration of digital technology in detail since it refers to business digitisation and e-commerce directly. However, the other aspects (connectivity, human capital, and digital public services) will also be considered as these can be linked to business digitisation in an indirect way.
2. Indices of skills and innovation from SME Performance Reviews. SMEs' skills and innovation capabilities are crucial to adopt I4.0 technologies and digitalisation. The European Commission has been preparing these reviews since 2010 and measures SMEs' innovation and training activities and their employees' ICT skills. Minor methodological changes can be observed mainly in the area of SMEs' training activities, so data that has been available for the longest period of time will be analysed.
3. Structural business statistics. Eurostat (2021) collects data for SMEs. According to the classification of economic activities, the European Union identifies which manufacturing

Table 1. The EU's SME classification

| Company category | Staff headcount | Turnover | or | Balance sheet total |
|------------------|-----------------|----------|----|---------------------|
| Medium-sized | <250 | ≤ € 50 m | | ≤ € 43 m |
| Small | <50 | ≤ € 10 m | | ≤ € 10 m |
| Micro | <10 | ≤ € 2 m | | ≤ € 2 m |

Source: European Commission (2021a).



industries use high-technology or medium-high technology and which use low-medium technology or low-technology. The two-digit economic activity classification is used for this purpose (see Table 2).

A similar classification can be drawn for services as well (see Table 3); in this case we differentiate between knowledge intensive services (knowledge-intensive market-services, high-tech knowledge-intensive services, knowledge-intensive financial services and other knowledge-intensive services) and less knowledge intensive services (less knowledge-intensive market services and other less knowledge-intensive services). These classifications are based on NACE Rev.2 classifications.

In this paper, the number of enterprises, employed workers and value added at factor cost in relation to SMEs are used to determine how the share of high-technology manufacturing and high knowledge-intensive services changed. This data is available from 2008 to 2018. Not all data is available in the Structural Business Statistics dataset, in this case we used the data from the Hungarian Central Statistical Office. In some cases, when data still was not available, we

Table 2. Classification for manufacturing industry

| Manufacturing industries | NACE Rev.2 codes and activities at 2-digit level |
|--------------------------|--|
| High-technology | 21 - Manufacture of basic pharmaceutical products and pharmaceutical preparations; |
| | 26 - Manufacture of computer, electronic and optical products. |
| Medium-high-technology | 20 - Manufacture of chemicals and chemical products; Manufacture of electrical equipment; |
| | 27 to 30 - Manufacture of machinery and equipment n.e.c.; Manufacture of motor vehicles, trailers and semi-trailers; Manufacture of other transport equipment. |
| Medium-low-technology | 19 - Manufacture of coke and refined petroleum products; |
| | 22 to 25 - Manufacture of rubber and plastic products; Manufacture of other non-metallic mineral products; Manufacture of basic metals; Manufacture of fabricated metals products, excepts machinery and equipment; |
| | 33 - Repair and installation of machinery and equipment. |
| Low technology | 10 to 18 - Manufacture of food products, beverages, tobacco products, textile, wearing apparel, leather and related products, wood and of products of wood, paper and paper products, printing and reproduction of recorded media; |
| | 31 to 32 - Manufacture of furniture; Other manufacturing. |

Source: European Commission (2021b: 1).



Table 3. Classification for services based on NACE Rev.2 codes and activities at 2-digit level

| Knowledge based services | Codes and activities |
|--|--|
| Knowledge intensive market services | 50–51: Water transport; Air transport; |
| | 69–71: Legal and accounting activities; Activities of head offices, management consultancy activities; Architectural and engineering activities, technical testing and analysis; |
| | 73–74: Advertising and market research; Other professional, scientific and technical activities; |
| | 78: Employment activities; |
| | 80: Security and investigation activities; |
| High-tech knowledge intensive services | 59–63: Motion picture, video and television programme production, sound recording and music publish activities; Programming and broadcasting activities; Telecommunications; computer programming, consultancy and related activities; Information service activities; |
| | 72: Scientific research and development; |
| Other knowledge intensive services | 5: Publishing activities; |
| | 75: Veterinary activities; |
| | 84–93: Public administration and defence, compulsory social security; Education; Human health and social work activities; Arts, entertainment and recreation; |
| Less knowledge intensive market services | 45–47: Wholesale and retail trade; Repair of motor vehicles and motorcycles; |
| | 49: Land transport and transport via pipelines; |
| | 52: Warehousing and support activities for transportation; |
| | 55 to 56: Accommodation and food service activities; |
| | 68: Real estate activities; |
| | 77: Rental and leasing activities; |
| | 79: Travel agency, tour operator reservation service and related activities; |
| | 81: Services to buildings and landscape activities; |

(continued)

Table 3. Continued

| Knowledge based services | Codes and activities |
|---|---|
| | 82: Office administrative, office support and other business support activities; |
| | 95: Repair of computers and personal and household goods; |
| Other less knowledge intensive services | 53: Postal and courier activities; |
| | 94: Activities of membership organisation; |
| | 96: Other personal service activities; |
| | 97–99: Activities of households as employers of domestic personnel; Undifferentiated goods- and services-producing activities of private households for own use; Activities of extraterritorial organisations and bodies. |

Source: [European Commission \(2021b: 2–3\)](#).

Note: due to lack of data, knowledge intensive financial services are not included in this paper.

estimated the data from the previous years and/or based on business statistics reviews published by the Hungarian Central Statistical Office.

The data analysis is complemented by the qualitative analysis of reports and Hungarian programmes, which aim at supporting the adopting Industry 4.0 and digitalisation.

4. INDUSTRY 4.0 AND DIGITALISATION STRATEGY IN HUNGARY

In its 2016 study, the [European Parliament \(2016\)](#) classified Hungary as a ‘traditionalist’ country, which has a solid industrial base, but just a few initiatives were introduced to take it to the new, I4.0 era. Even though Hungary has implemented the Irinyi plan in 2016, there is no direct hint to Industry 4.0, only indirect ones. The main aim of the Irinyi plan was to reindustrialise the Hungarian economy by putting a great emphasis on SMEs’ innovation capacities and to strengthen SMEs in industries beyond the automotive and electronics industries. To realise the plan, several calls have been introduced for SMEs until 2020 with quite significant budgets ([European Commission 2017](#)). However, the Hungarian Central Bank (HCB) in its growth report published in December 2016, highlighted the elements of Industry 4.0 as a strategic field of industrial development. The HCB mentions big data, custom mass production, the Internet of things, cyber physical systems, and integration as parts of Industry 4.0 and identified labour market, trainings; R&D&I; infrastructure and regulation (protection of property rights) and cyber security as areas which can contribute to Hungarian competitiveness and can be influenced by governmental policies ([Hungarian Central Bank 2016](#)).

In case of digitalisation, the Digital Welfare Programme was announced in 2015, which’s aim was to recognise the importance of digital transformation and help entrepreneurs and the society



in it. In relation to domestic companies, two main strategies were accepted within this strategy: the Digital Export Development Strategy (to enhance export by using ICT tools) and the Digital Start-up Strategy (to support the creation and development of innovative start-ups with high growth potential) (VV – WIK Consult 2019). Since then, these strategies have been harmonised to emphasise the relevancy of Industry 4.0 for Hungarian SMEs and to increase Hungary's competitiveness. Table 4 summarises the main programmes and measures implemented to help SMEs to adopt Industry 4.0 and digitalisation in recent years with their main characteristics. The EU-funded measures are not directly linked to the Supplier development programme or Industry 4.0 programme, however there are some links in the Economic Development and Innovation Development Programme (EDIOP), mainly in the so-called Priority Axis 1 (SMEs), 2 (R&D&I) and 8 (access to finance), which help SMEs to adopt Industry 4.0. In Priority 3, measures related to ICT tools can be found, therefore the previously introduced measures related to SMEs' digitalisation can be found here (Palyazat.gov.hu 2021; Kiss 2021).

Table 4 shows that the implemented programmes mainly focused on SMEs' digitalisation and to learn the implementation processes of I4.0 technologies from larger companies. A good example for this is the Industry 4.0 Sample Factories: SMEs can get practical knowledge in a so-called sample factory, which was established by the most relevant manufacturing MNCs (Continental, Eltec, Festo, Macher, Roto), the subsidiaries of which operate in Hungary. The programme has three phases. In the first phase, the sample factories introduce how a modern factory using Industry 4.0 technologies works. In the second phase, SMEs participate in training and learning on how to adopt and use Industry 4.0 technologies. In the third phase, selected companies get a mentor and a detailed, concrete development plan for adopting Industry 4.0 technologies (Ipar 4.0 2018). The budget of these programmes can be considered remarkable if we compare these with the other elements of the budget; however, it is not sufficient if we see the number of domestic SMEs (826 516 in 2019, according to the Hungarian Central Statistical Office 2021).

5. HUNGARIAN SMES' PROGRESS IN DIGITALISATION

Hungary ranks 21st out of 28 EU member states in the Digital Economy and Society Index (DESI) 2020 (including the United Kingdom, to allow easy comparison with the previous years). Since 2015, its score improved broadly in line with the EU average (European Commission 2020a). However, just a small number of Hungarian SMEs (10–20% of total SMEs depending on the specific DESI index) is getting increasingly digitalised. In business digitisation and e-commerce, Hungary remained one of the worst performing EU countries (26th out of 28 in 2020) and this is the area where Hungary performs the worst among the components of DESI (European Commission 2020a). In addition, the gap between Hungary and the EU average is increasing instead of decreasing in this field (see Fig. 1). ICT adoption is low across all indicators measured in this area (see Fig. 2).

Figure 2 shows that just 14% of Hungarian enterprises have information electronically and just 12% of them use social media platforms during daily operations, while these are 34 and 25% respectively in the European Union. In the latter case, we can observe a decreasing trend, while an increasing one in the EU. So, the role of social media is still important, however, for Hungarian SMEs it seems less relevant. Related to advanced digital technologies, only 6% of companies rely on big data solutions (it is 12% in the EU) and 11% use cloud computing (18% in the



Table 4. Implemented measures to help SMEs in I4.0 adoption and digitalisation between 2016 and 2020

| Name of measure | Aims | Timeframe | Budget (in billion HUF) | Results |
|---|---|-----------|---|--|
| Support for the Contribution of Complex Info Communication and Mobile Developments, Cloud-based Online Business | Introduce complex information communication and mobile developments, cloud-based online services. | 2016–2019 | 39.4 (supported by the European Regional Development Fund and from the national budget) | Almost 1,300 SMEs have received this support. |
| Programme for Modern Enterprises | Develop SMEs IT skills, to promote the digitalisation. | 2015–2020 | 6.4 (supported by the ERDF and from the national budget) | 12,300 SMEs have received advice on how to advance in terms of digital transition. |
| Advanced Digitisation of Competitive Companies' Activities Programme | Help digitalised companies to adopt more advanced solutions by procuring Industry 4.0, IoT and other advanced business digitisation solutions. | 2017–2020 | 6.5 (supported by the ERDF and from the national budget) | No measured output, but 64 SMEs were planned to receive supported. |
| Supplier development programme | Help integrators to develop their smaller suppliers. To support SMEs in implementing technologies of Industry 4.0, organisational development, training, innovation, R&D activities. | 2017– | National budgets 2020: 1.9681 2019: 2.5 2018: 3.0 | There are no measured outputs yet. Expected results: capacity enhancement, investments for a fundamental change in the production process, optimisation of management processes, increased R&D activities. |
| Industry 4.0 programme (Industry 4.0 Sample Factories and Industry 4.0 Technology Centre) | Facilitate the digital transformation of domestic SMEs operating in the manufacturing industry and increase their absorption capacity towards I4.0 solutions and automatisation. Learn from larger companies. | 2018– | National budgets 2020: 1.4314 2019: 1.5 2018: 1.5 | Within the framework of Industry 4.0 Sample Factories I4.0 possibilities were demonstrated for 1000 SMEs, 350 SMEs were prepared for it and 50 SMEs were developed between 2017 and 2019. |

Source: authors, based on Palyazat.gov.hu, [Budget Law for Hungary \(2017\)](#), [Budget Law for Hungary \(2018\)](#), [Budget Law for Hungary \(2019\)](#).



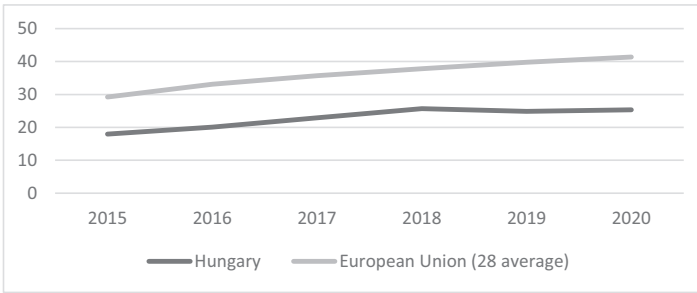


Fig. 1. Hungarian companies' digital technology integration scores
 Source: authors, based on data of European Commission (2020b).

EU). As for e-commerce, online shopping by individuals increased in recent years, yet only 12% of SMEs sold goods online in 2019 compared to 18% in the EU. Based on the turnover, it can be seen that online and cross-border sales are highly profitable for SMEs. Selling online cross-border increased almost in line with the EU average, but only 5.2% of Hungarian SMEs sell their products abroad online, while this share is 8% in the EU (see Fig. 2). Hungarian companies are not exploiting the opportunities offered by digital technologies, such as cloud computing and big data, and just few of them sell online (European Commission 2020a).

The pandemic also highlighted that e-commerce can be the key to SMEs' survival in a crisis situation. However, the pandemic did not bring about mass digitisation of SMEs. This result is shown by a Hungarian research series launched in March 2020 about measuring SMEs' digitalisation. Digimeter (2020) highlighted that much of the domestic SME sector has just

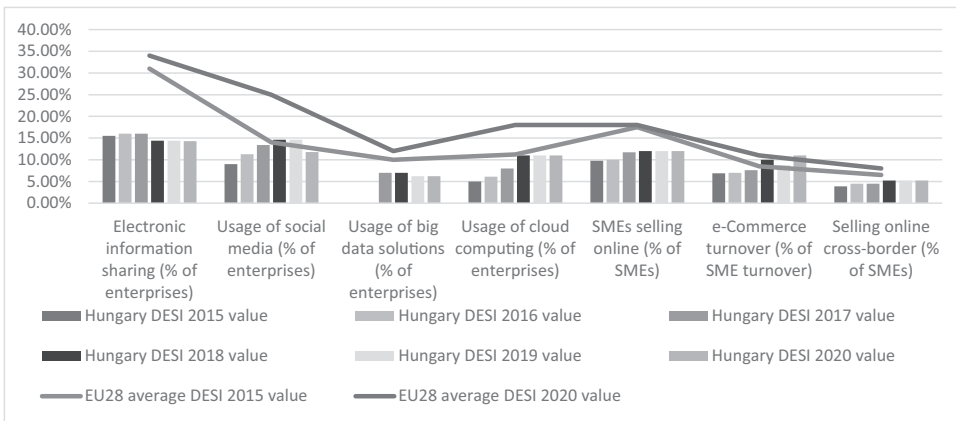


Fig. 2. Sub-indices of integration of digital technology
 Source: authors, based on data from European Commission (2020b).



embarked on the digitalisation path. The results are based on a survey. 777 SMEs were observed during the summer of 2020. Each sample SME had a turnover below HUF 18 billion, and between 5 and 249 employees. Digimeter measures six fields of SMEs' digitalisation: digital finance, digitisation of sales and marketing, IT security, digital presence, digital everyday life, business management. Each field is expressed on a scale from 0 to 100. The results show that Hungarian SMEs are the strongest in digital finance (61 points) and weakest in the digitisation of sales and marketing (17 points). IT security received more points than average values (57 points), while the results of the remaining issues were around the average (the average was 40 points). The findings are in line with the literature: larger companies are more digitalised ([Digimeter 2020](#)).

Based on these results it can be stated that the adoption of digital technologies and business models lags the EU average. Digital technologies are mainly applied by larger enterprises. Hungary lags in the adoption of e-business technology, scoring below the EU average (25 points versus 41 points) based on DESI. Just over 55% of Hungarian businesses have made small investments in digital technologies. This is reflected in the country's low digital intensity ranking and the little use of big data by Hungarian SMEs. However, there is an opportunity to improve this performance since the digital infrastructure (connectivity) is above the EU average, people's use of internet is also good in Hungary and populations' digital skills are also close to the EU average. Moreover, digital public services for businesses are also available and Hungary performs relatively well in this field (in 2020 the DESI value for this was 85, while the EU average is 88) ([European Commission 2020a](#)). It can be concluded that there are only a few programmes to enhance SMEs' digitalisation and these only reach the minority of SMEs; more programmes with more significant budgets would have been necessary to improve SMEs' digitalisation and digital transformation. We can state that digitalisation is one of the most important challenges of Hungarian SMEs.

6. SKILLS AND INNOVATION OF HUNGARIAN SMES

To adopt Industry 4.0 technologies, it is crucial to analyse skills and innovation capabilities of SMEs. To do that we use the data of SME Performance Reviews from 2010 until the most recent. We exclude those indicators (SMEs selling online and turnover from e-commerce) which can be found in the DESI index as well. For the innovation rate, data is only available for 2020, so we also excluded this from the analysis. The data shows that Hungarian SMEs lag behind the EU average in all aspects ([Fig. 3](#)).

In the examined period, the number of Hungarian SMEs that carried out product and process innovations and in-house innovations increased slightly (from 17 to 17.96% and from 13 to 14.54% respectively), while in some aspects – in case of the percentage of SMEs that introduced marketing or organisational innovations and in collaboration with innovative SMEs – we can observe a decrease (see [Fig. 3](#)). We can state that Hungarian SMEs are relatively moderate innovators ([European Commission 2019](#)). The national R&D resources available for SMEs are not much below the EU average. It shows that financial resources for innovation for SMEs are available, however SMEs are not participating in these research projects.

Skills are one of the reasons behind this. If we examine SMEs' activities in trainings, we can conclude that it is not sufficient (see [Fig. 4](#)). It is common for larger companies to invest in their employees' trainings ([ITM 2019](#)), however for innovation, digitalisation and adopting Industry 4.0 technologies, this is crucial for success. It would therefore be especially necessary to develop



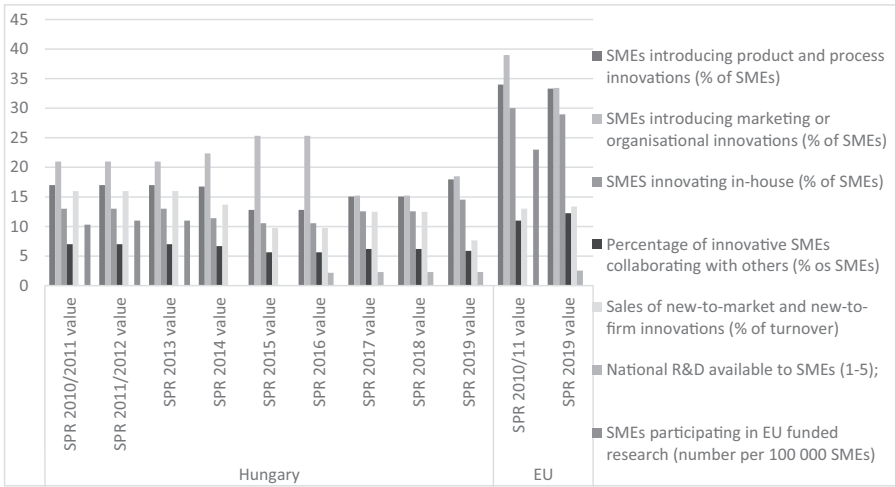


Fig. 3. Hungarian SMEs' performance in innovation compared to EU28 average between 2010 and 2018
 Source: authors, based on data from SME Performance Reviews 2010–2019.

employees' ICT skills. Only 45% of enterprises provided Continuing Vocational Trainings (CVT) in Hungary, while the EU average was above 70% (see Fig. 4). Since 2010, this number has decreased, while in the EU, it has increased. Related to trainings that develop employees' ICT skills, we can observe a similar, but stagnating trend compared to the EU average. The only aspect in which Hungary performs above the EU average is the percentage of SMEs that employ people who have ICT specialist skills. Although it is decreasing year-by-year, it is still remarkable



Fig. 4. Enterprises' activities in training
 Source: authors, based on data from SME Performance Reviews 2010–2019.



(European Commission 2019). CVT provided by Hungarian SMEs must be increased to successfully adopt I4.0 technologies and increase the digitalisation of SMEs.

7. SME STATISTICS IN HIGH-TECHNOLOGY MANUFACTURING AND KNOWLEDGE INTENSIVE SERVICES

The adoption of Industry 4.0 presumes that the SMEs statistics are more favourable in high-technology and medium-high technology manufacturing as well as in knowledge intensive services since these are the economic activities that rely on technologies and digitalisation the most.

Figure 5 shows that in manufacturing, low-technology intensive SMEs dominate; their share has decreased in total since 2017. However, the share of high-technology and medium-high-technology has not increased, their share in the total has been continuously decreasing since 2008. The share and number of medium-low-technology SMEs increased significantly in the examined period.

Figure 6 shows similar trends; less knowledge-intensive market services dominate in total services with a decreasing trend. However, we can also see that the share of SMEs in knowledge-intensive market services and high-tech-knowledge intensive services increased by almost 10% between 2008 and 2018, mainly since 2015.

If we add the number of SMEs and the share of SMEs in high-tech manufacturing and high knowledge-intensive services between 2008 and 2018 (see Fig. 7), we can state that their share is increasing slowly (from 33% to 38%), but SMEs in low tech manufacturing and less knowledge-intensive services still dominate in Hungary. Since the effects of introduced measures cannot be seen yet, we can assume that this ratio will be higher in the future.

Figure 8 shows that the value added (gross income from operating activities) after adjusting for operating subsidies and indirect taxes has increased in all aspects from 2008

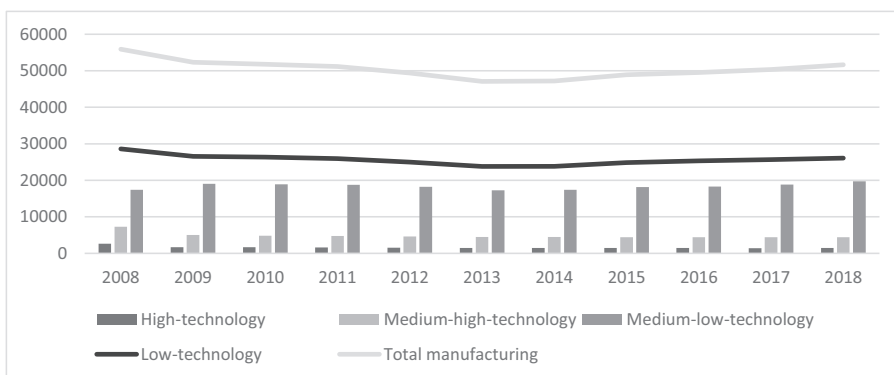


Fig. 5. Number of SMEs in manufacturing industries

Source: authors, based on data from [Structural Business Statistics \(2021\)](#) and [Hungarian Central Statistical Office \(2021\)](#).



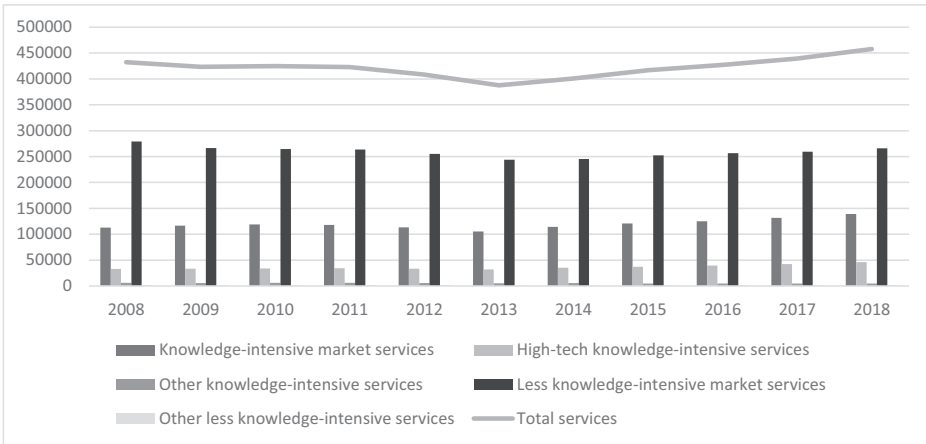


Fig. 6. Number of SMEs in knowledge-based services

Source: authors, based on data from [Structural Business Statistics \(2021\)](#) and [Hungarian Central Statistical Office \(2021\)](#).

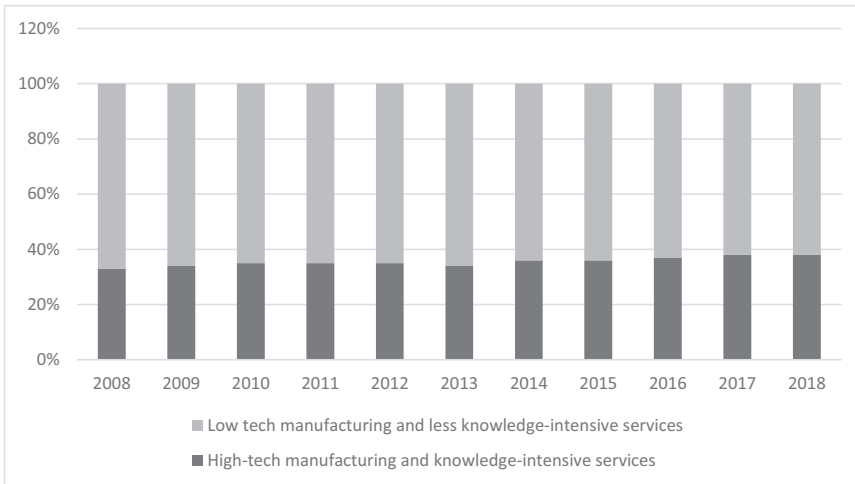


Fig. 7. Number of SMEs in total manufacturing and services

Source: authors, based on data from [Structural Business Statistics \(2021\)](#) and [Hungarian Central Statistical Office \(2021\)](#).

to 2018; in case of knowledge-intensive services, this increase was much higher than in case of high-tech manufacturing. The value added at factor cost has almost doubled in high-tech knowledge-intensive services between 2008 and 2018, while the lowest (8%) increase can be observed in case of other knowledge-intensive services such as publication



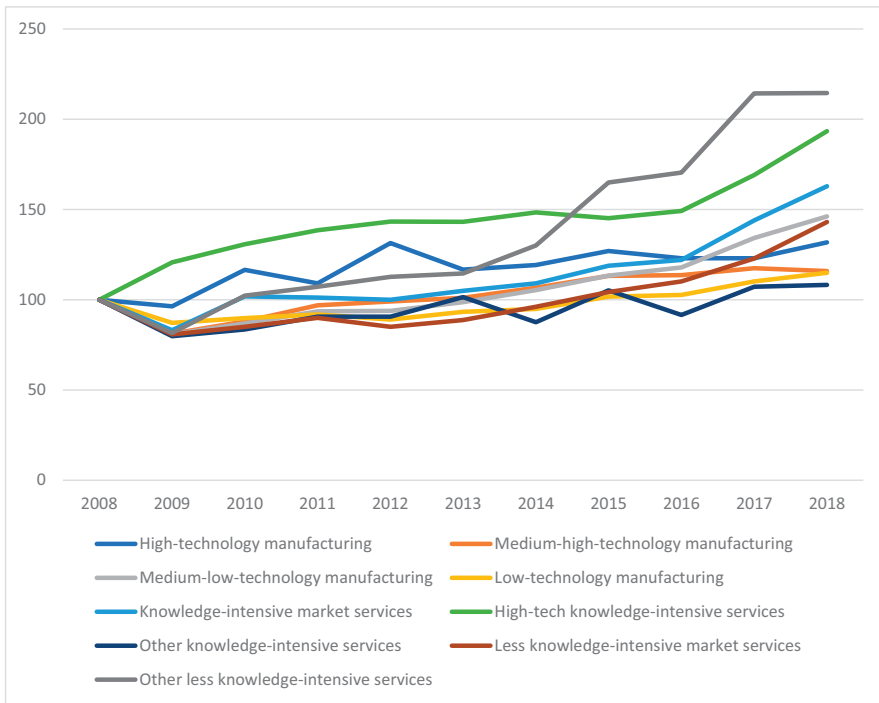


Fig. 8. Hungarian value added index at factor cost between 2008 and 2018 (2008 = 100)
 Source: authors, based on data from [Structural Business Statistics \(2021\)](#) and [Hungarian Central Statistical Office \(2021\)](#).

activities or entertainment. In case of manufacturing, the increase is much lower, ranging between 15 and 32%. Furthermore, the increase of high-tech manufacturing was higher than in low-tech manufacturing; while in case of services this is not true: the value less knowledge-intensive services grew the most in the examined period. In sum, the share of high-tech manufacturing and knowledge-intensive services in total manufacturing and services increased by 2 percentage points (from 26% to 28%) compared to the share of low tech manufacturing and less knowledge-intensive services in the examined period, still the latter dominates in Hungary. It must be emphasised that these results are independent from the received support and taxation: mainly company performance (turnover, capitalised production, other incomes, changes in stocks) determines value added at factor cost (Eurostat 2021). We can assume that these results may be mainly explained by the domestic and global business cycles. The effects of the introduced measures cannot be seen in this data; not just due to the index, but also due to the fact that results only become visible after 3–4 years following the introduction of the measure.

Figure 9 shows that almost three-quarters of people are employed by low tech manufacturing and less knowledge-intensive services, but their share has been continuously decreasing since 2008.



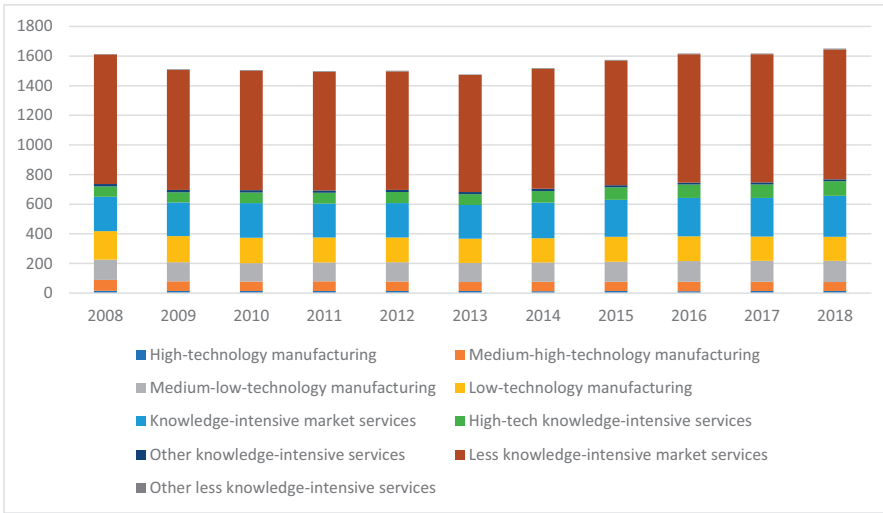


Fig. 9. Number of persons employed by SMEs in manufacturing and services between 2008 and 2018 (in thousand persons)

Source: authors, based on data from [Structural Business Statistics \(2021\)](#) and [Hungarian Central Statistical Office \(2021\)](#).

In sum, more people are employed by high tech manufacturing and knowledge-intensive services. If we separate manufacturing and services from each other, in case of high-tech manufacturing, the number of employed people decreased in the examined period by 16%. This decrease is higher than the decrease of employment in manufacturing in total. This trend is ambiguous if we examine the time period since Industry 4.0 measures were introduced. In high-technology manufacturing the number of persons employed increased, while in medium-high-technology manufacturing decreased. Usually, the effects of governmental support to increase employment can be seen earlier than in case of change in productivity, but these results can also be explained by other factors for example by Hungarian labour shortage, investment promotion policy or favourable economic environment that can be observed at the time. Moreover, based on earlier research ([Hortoványi et al. 2020](#)), the Hungarian business leaders are not ready for digital transformation, nor to create higher value-added jobs. So, it is not clear whether digitalisation and Industry 4.0 in case of manufacturing create as many new jobs as they destroy. In case of services, it seems that there is a lift from less knowledge-intensive services to high knowledge-intensive services, which predicts a change in the labour market, still most people are employed in less knowledge-intensive services. These results are in line with the literature (see e.g., [Autor 2015](#); [Hirsch-Kreinsen 2016](#)).

8. CONCLUSIONS

The adoption of Industry 4.0 is inevitable for SMEs to remain competitive in the long run. The Hungarian government introduced several measures to enhance it in recent years. The



aim of this paper was to show, by analysing SME data, where Hungarian SMEs are in the digitisation process and the introduction of I4.0 technologies, and whether the effects of the government measures can be seen. The research gap is that such an analysis has not yet been prepared.

We can conclude that more measures should have been introduced to enhance digitalisation of Hungarian SMEs, beyond the few mainly EU-funded ones. Although Hungarian companies' digital technology integration scores have increased since 2010, Hungary still performs poorly at digitalisation, much below the EU average in all aspects. This is just partly due to the fact that there is not enough (financial) governmental support, the other reason can be found in SMEs' (Budget Law for Hungary 2017; Budget Law for Hungary 2018; Budget Law for Hungary 2019) innovation and training activities. Hungarian SMEs are moderate innovators and invest less in their employees' trainings and improving their ICT skills. These results are in line with previous studies (see Szabó et al. 2019; Szalavetz 2021). The Hungarian government should promote SME owners' and managers' change of attitudes related to digitalisation and innovation. In addition, the support of employees' training activities is also crucial to improve SMEs' digitalisation and to adopt I4.0 technologies.

After examining high-tech manufacturing and knowledge-intensive services, our results are ambiguous. We cannot find a clear relationship between governmental measures and the increasing weight of these sector. This is mainly due to the lack of data. Since supplier development and Industry 4.0 programmes are relevant in Hungarian economic policy, we can expect some improvements in these fields; though we saw that it also depends on economic cycles. The economic downturn caused by the Covid-19 pandemic can hinder the achievement of the goals formulated by these programmes and decrease SMEs' adoption of I4.0 technologies. A long term crisis can impede SMEs' investments in technologies and innovation. The role of the Hungarian government is to continue to support SMEs' innovation activities and digital transformation in order to increase their role in high-tech manufacturing and knowledge-intensive services. In the long run, this can contribute to Hungarian economic growth and development.

Our study was limited by data availability and by the fact that the data were collected for other purposes and sometimes not specifically about SMEs. However, the data are reliable, collected by the Hungarian Central Statistical Office and European Commission and suitable to analyse such a topic. As a future research direction, it is worth examining these data after a few years to get a clearer picture of the relationship between governmental measures and high-tech manufacturing and knowledge-intensive services, and how the pandemic affected Hungarian SMEs' digitalisation. A comparison with other countries and competitors would also be beneficial, which could provide a broader picture about Hungarian SMEs' digitalisation and reveal existing good practices, which can be implemented by Hungary.

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REFERENCES

- Agostini, L. – Nosella, A. (2020): The Adoption of Industry 4.0 Technologies in SMEs: Results of an International Study. *Management Decision* 58(4): 625–643.
- Autor, D.H. (2015): Why Are There Still So Many Jobs? The History and Future of Workplace Automation. *Journal of Economic Perspectives* 29(3): 3–30.
- Bharadwaj, A. – Sawy, O.A. El – Pavlou, P.A –Venkatraman, N. (2013): Digital Business Strategy: Toward a Next Generation of Insights. *MIS Quarterly* 37(2): 471–482.
- Bleicher, J. – Stanley, H. (2018): Digitization as a Catalyst for Business Model Innovation A Three-Step Approach to Facilitating Economic Success. *Journal of Business Management* 4(2): 62–71.
- Budget Law for Hungary (2017): 2017. évi C. törvény Magyarország 2018. évi központi költségvetéséről [Act C of 2017 on the Central Hungarian Budget of year 2018]. <https://net.jogtar.hu/jogszabaly?docid=a1700100.tv>, accessed 15/05/2021.
- Budget Law for Hungary (2018): 2018. évi L. törvény Magyarország 2019. évi központi költségvetéséről [Act L of 2018 on the Central Hungarian Budget of year 2019]. <https://net.jogtar.hu/jogszabaly?docid=a1800050.tv>, accessed 15/05/2021.
- Budget Law for Hungary (2019): 2019. évi LXXI. törvény Magyarország 2020. évi központi költségvetéséről [Act LXXI of 2019 on the Central Hungarian Budget of year 2020]. <https://net.jogtar.hu/jogszabaly?docid=a1900071.tv>, accessed 15/05/2021.
- Cserháti, I. – Pirisi, K. (2020): Industry 4.0 and Some Social Consequences: Impact Assessment by Microstimulation for Hungary. *Society and Economy* 42(2): 105–123.
- Culot, G. – Nassimbeni, G. – Orzes, G. – Sartor, M. (2020): Behind the Definition of Industry 4.0: Analysis and Open Questions. *International Journal of Production Economics* 226(C): 107617.
- Digimeter (2020): Hazai digitalizáció: nagy lendület, kis hatások [Domestic digitalisation: high momentum, low efficiency]. https://digimeter.hu/wp-content/uploads/2020/11/Digimeter_2020.1_osszefoglalo.pdf, accessed 15/05/2021.
- European Commission (2017): 2017 SBA Fact Sheet – Hungary. <https://hupdfs.com/dokumentum/933d204/2017-sba-fact-sheet-hungary-european-commission-europa>, accessed 15/04/2021.
- European Commission (2019): 2019 SBA Fact Sheet – Hungary. https://ec.europa.eu/growth/smes/sme-strategy/performance-review_en#sba-fact-sheets, accessed 15/04/2021.
- European Commission (2020a): Digital Economy and Society Index (DESI) 2020 Hungary. <https://digital-strategy.ec.europa.eu/en/policies/desi-hungary>, accessed 17/04/2021.
- European Commission (2020b): Digital Economy and Society Index Database. <https://digital-agenda-data.eu/datasets/desi/indicators#desi-overall-index>, accessed 17/04/2021.
- European Commission (2021a): SME Definition. https://ec.europa.eu/growth/smes/sme-definition_en, accessed 15/04/2021.
- European Commission (2021b): Eurostat Indicators on High-tech Industry and Knowledge – Intensive Services. https://ec.europa.eu/eurostat/cache/metadata/Annexes/htec_esms_an3.pdf, accessed 15/05/2021.
- European Parliament (2016): Industry 4.0. [https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU\(2016\)570007_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf), accessed 10/05/2021.
- Eurostat (2021): Eurostat’s Concepts and Definitions Database. Value Added at Factor Cost. https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_GLOSSARY_NOM_DTL_VI EW&StrNom=CODED2&StrLanguageCode=EN&IntKey=16619885&RdoSearch=BEGIN&Txt



- Search=value%20added%20at%20factor%20cost&CboTheme=&IsTer=&IntCurrentPage=1&ter_valid=0, accessed 09/06/2021.
- Hirsch-Kreinsen, H. (2016): Digitization of Industrial Work: Development Paths and Prospects. *Journal of Labour Market Research* 49: 1–14.
- Hortoványi, L. – Szabó, Zs. R. – Nagy, S. Gy – Stukovszky, T. (2020): A digitális transzformáció munkahelyekre gyakorolt hatásai – Felkészültek-e a hazai vállalatok a benne rejlő nagy lehetőségre (vagy a veszélyekre)? [Effects on digital transformation on jobs – Are the domestic companies are prepared for its opportunities (or threats)?] *Külgazdaság* 64(3–4): 73–96.
- Hungarian Central Bank (2016): Növekedési jelentés [Growth Report]. <https://www.mnb.hu/letoltes/novekedesi-jelentes-2016-hu.PDF>, accessed 12/05/2021.
- Hungarian Central Statistical Office (2021): Gazdasági és nonprofit szervezetek adatbázis [Database for economic and non-profit organisations]. <https://www.ksh.hu/stadat?theme=gsz>, accessed 04/05/2021.
- Hungarian Government (2021): Digitális Jólét Program [Digital Welfare Programme]. <https://digitalisjoletprogram.hu/hu/rolunk>, accessed 13/05/2021.
- Hungarian Statistical Office (2020): A vállalkozások teljesítménymutatói kis-és középvállalkozási kategória szerint [SMEs' business performance indicators]. https://www.ksh.hu/stadat_files/gsz/hu/gsz0018.html, accessed 25/05/2021.
- IFKA – IVSZ (2021): A KKV-k számára [For SMEs]. <https://www.ipar4.hu/hu/page/ipar-4-0-kkv-knak>, accessed 13/05/2021.
- Ingaldi, M. – Ulewicz, R. (2019): Problems with the Implementation of Industry 4.0 in Enterprises from the SME Sector. *Sustainability* 12(1): 217.
- Ipar 4.0 (2018): Ipar 4.0 Mintagyárak Kiemelt Projekt [Industry 4.0 Sample Factories Priority Project]. <https://ipar4.hu/medias/47/ipar4.0ismerteto2018-05.pdf>, accessed 12/05/2021.
- ITM (2019): A magyar vállalkozások megerősítésnek stratégiája 2019–2030 [Strategy for strengthening Hungarian enterprises between 2019 and 2030]. [https://egtc.kormany.hu/download/f/9d/62000/Hazai%20gazdas%C3%A1gpolitikai%20C3%A9s%20v%C3%A1llalkoz%C3%A1spolitikai%20c%C3%A9lok%20\(Szepesi%20Bal%C3%A1zs,%20ITM\).pdf](https://egtc.kormany.hu/download/f/9d/62000/Hazai%20gazdas%C3%A1gpolitikai%20C3%A9s%20v%C3%A1llalkoz%C3%A1spolitikai%20c%C3%A9lok%20(Szepesi%20Bal%C3%A1zs,%20ITM).pdf), accessed 07/06/2021.
- Kiss, G. F. (2021): Experiences and Results of Hungarian EU funding in the 2014–2020 Budgetary Period. *Köz-gazdaság* 16(3).
- Masood, T. – Sonntag, P. (2020): Industry 4.0: Adoption Challenges and Benefits for SMEs. *Computers in Industry* 121.
- Nagy, S. Gy. – Palánkai, T. – Miklós, G. – Endrődi-Kovács, V. – Baranyi, M. (2011): Internationalisation (Transnationalisation) of the Enterprise Sector. *Corvinus University of Budapest Working Paper*.
- Nagy, S. Gy. (2013): The internationalisation of the Spanish SME sector. *Society and Economy* 35(1): 71–86.
- Palyazat.gov.hu (n.a.): Pályázati dokumentációk [Tenders]. https://www.palyazat.gov.hu/palyazati_dokumentaciok1, accessed 05/05/2021.
- Posada, J. – Toro, C. – Barandiaran, I. – Oyarzun, D. – Stricker, D. – de Amicis R, V. I. (2015): Visual Computing as a Key Enabling Technology for Industry 4.0 and Industrial Internet. *IEEE Computer Graphics and Applications* 35(2): 26–40.
- Prem, E. (2015): *A Digital Transformation Business Model for Innovation*. ISPIM Innovation Summit. Brisbane.
- Roblek, V. – Mesko, M. – Krapez, A. (2016): A Complex View of Industry 4.0. *SAGE Open* 6(2).
- Rojko, A. (2017): Industry 4.0 Concept: Background and Overview. *International Journal of Interactive Mobile Technologies* 11(5): 77–90.



- Saucedo-Martínez, J.A. – Pérez-Lara, M. – Marmolejo-Saucedo, J.A. (2018): Industry 4.0 Framework for Management and Operations: A Review. *Journal of Ambient Intelligence and Humanized Computing* 9: 789–801.
- Schuh, G. – Potente, T. – Wesch-Potente, C. – Weber, A. R. – Prote, J.P. (2014): Collaboration Mechanisms to Increase Productivity in the Context of Industrie 4.0. *Procedia CIRP* 19(2014): 51–56.
- Schwab, K. (2015): The Fourth Industrial Revolution. What it Means and How to Respond. *Foreign Affairs Online*. <https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution>, accessed 03/04/2021.
- Shafiq, S. – Sanin, C. – Szczerbicki, E. – Toro, C. (2016): Virtual Engineering Factory: Creating Experience Base for Industry 4.0. *Cybernetics and Systems* 47(1–2): 32–47.
- Shafiq, S. – Sanin, C. – Toro, C. – Szczerbicki, E. (2015): Virtual Engineering Object (VEO): Toward Experience-Based Design and Manufacturing for Industry 4.0. *Cybernetics and Systems* 46(1–2): 35–50.
- Sommer, L. (2015): Industrial Revolution – Industry 4.0: Are German Manufacturing SMEs the First Victims of This Revolution? *Journal of Industrial Engineering and Management* 8(5): 1512–1532.
- Structural Business Statistics (2021): Small and Medium-Sized Enterprises (SMEs). <https://ec.europa.eu/eurostat/web/structural-business-statistics/small-and-medium-sized-enterprises>, accessed 05/04/2021.
- Szabó, Z. R. – Horváth, D. – Hortoványi, L. (2019): Hálózati tanulás az ipar 4.0 korában [Network Learning in the Age of Industry 4.0]. *Közgazdasági Szemle* 66(1): 72–94.
- Szalavetz, A. (2021): Digitális vállalkozások Magyarországon: egy növekedési alternatíva [Digital enterprises in Hungary: a growth alternative]. In: Szanyi, M., Szunomár, Á., Török, Á. (Eds.), *Trendek és töréspontok II.* [Trends and breaking points II]. Akadémiai Kiadó, Budapest.
- Török, L. (2020): Industry 4.0 from a Few Aspects, in Particular in Respect of the Decision Making of the Management. Will the New Industrial Revolution Change the Traditional Management Functions? *International Review of Applied Sciences and Engineering* 11(2): 140–146.
- Vial, G. (2019): Understanding Digital Transformation: A Review and a Research Agenda. *Journal of Strategic Information Systems* 28(2): 118–144.
- VVA – WIK Consult (2019): Monitoring Progress in National Initiatives on Digitising Industry, Country Report, Hungary. https://ec.europa.eu/information_society/newsroom/image/document/2019-32/country_report_-_hungary_-_final_2019_0D30BE02-9661-9403-6F972D2CCBB689B0_61210.pdf, accessed 02/06/2021.
- Wang, S. – Wan, J. – Li, D. – Zhang, C. (2016): Implementing Smart Factory of Industry4.0: An Outlook. *International Journal of Distributed Sensor Networks* 2016: 1–10.
- Yang, F. – Gu, S. (2021). Industry 4.0, a Revolution that Requires Technology and National Strategies. *Complex and Intelligent Systems* 7: 1311–1325.
- Zezulka, F. – Marcon, P. – Vesely, I. – Sajdl, O. (2016): Industry 4.0 – An Introduction in the Phenomenon. *IFAC-PapersOnLine* 49(25): 8–12.
- Zhong, R.Y. – Xu, X. – Klotz, E. – Newman, S.T. (2017): Intelligent Manufacturing in the Context of Industry 4.0: A Review. *Engineering* 3(5): 616–630.

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