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Industry 4.0 and FDI

Experiences of Hungary

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Introduction

The definition of industry 4.0 is complex, composed from many aspects, pillars (robotisation, internet of things, additive manufacturing, big data, artificial intelligence, cybersecurity, etc.) For today it is acknowledged by scholars that the industry 4.0 concept refers to a whole ecosystem, including labour market, innovation and production networks. Industry 4.0 requires a model-based enterprise manufacturing, simulating every production process. There are certain trends related to Industry 4.0 that change and has already changed global production in the recent decade.

Consumer needs have changed for example, they are specific and personalised. This makes mass production less popular, however, individual production has remained expensive. Consumers even may become co-creators as they can directly influence the design and "content" of the product they order and by 3D printing the so-called crowd manufacturing can be realised. All this weakens the positions of brands and large factories, dominating the production of the previous decades. Industrial production has also included natural elements in the past years, there has been a kind of biological transformation of industry (Nick, 2020). The concept of circular economy has become popular, too.

The Covid-crisis will definitely have effects on global production. Long value chains will probably be shortened, local and regional sourcing will be more popular. Relocation, backshoring, even of the part of previously offshored production processes from Asia is a trend that has already begun but will be further reinforced by the crisis. The coronavirus crisis has accelerated and will also further enhance digitalisation, robotisation, and application of other elements of Industry 4.0. with less human contacts (UNIDO, 2020). However, this requires

capital-intensive investment, so financially weak small and medium-sized enterprises (SMEs) may have problems in crisis times in joining this process. All these changes indicate that Industry 4.0, together with these trends, may change completely the business environment, in which firms operate.

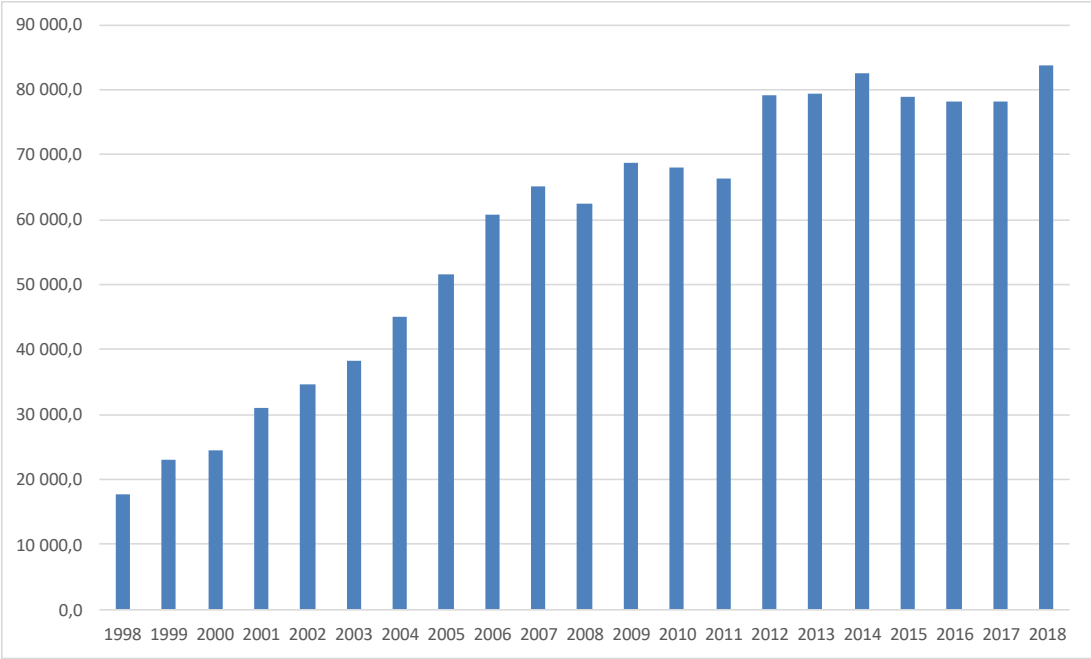
In our paper we provide an insight to the Hungarian progress in Industry 4.0 application and its state promotion. We depict the present and future effects on foreign direct investments (FDI) and consequences for economic policy.

Our country report is organised as follows. First, we provide some facts about the FDI stock and inflow in Hungary. Then we discuss Industry 4.0 in Hungary, concerning the policy tools and the literature on microeconomic experiences. In the second half of the paper we present the results of our small survey based on interviews with company, industry representatives and academic experts. The last section contains conclusions.

FDI inflow to Hungary

As well known, FDI had an important role for Visegrad countries in their transition process and economic development. Hungary was one of the main FDI-recipient countries during the nineties and later on still had substantial annual FDI inflows. As a result, the stock of FDI at present is more than 80 billion euros, representing around 70% of the GDP of the country.

Figure 1. Direct investment (stock) in Hungary (net liabilities, EURmn), 1998-2018



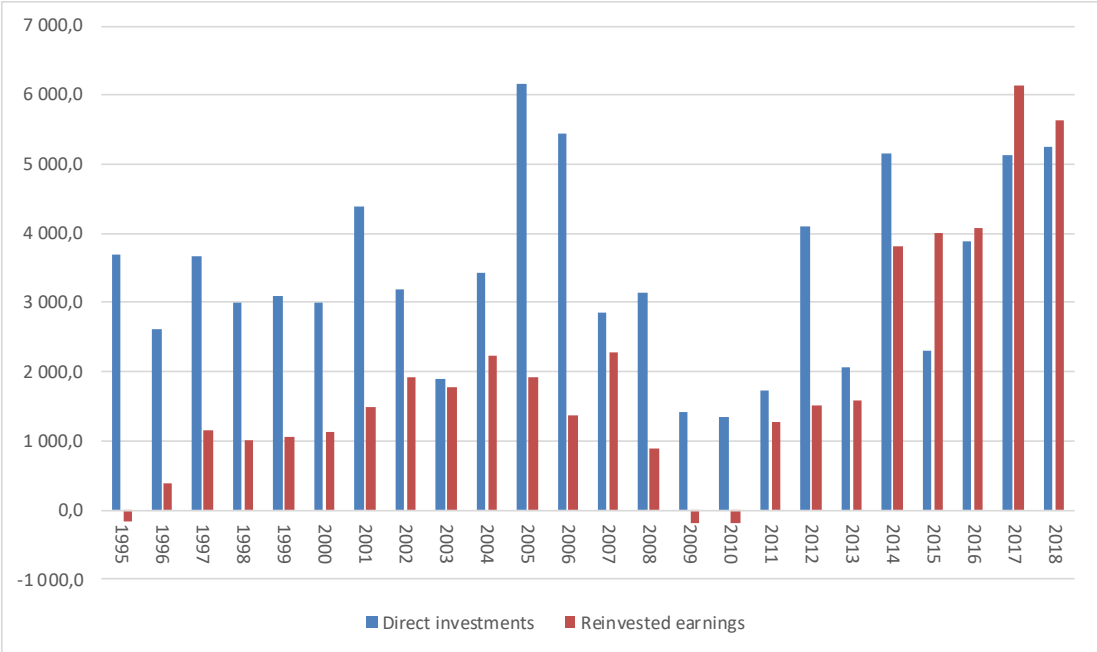
Source: Hungarian National Bank (MNB)[1]

FDI inflows have been fluctuating in the past decade (pumped up by large automotive investments in certain years, such as capacity extensions by the German Audi or new, greenfield investment by the German Mercedes) as Figure 2 shows. In 2015-2018 there has been a growing trend of FDI flow balances, but these are surpassed by the yearly amount of reinvested earnings[2] stemming mainly from European investors. Besides the advantageous locational factors, favourable Hungarian fiscal conditions thus promote investment and reinvestment of profits.

Figure 2. Direct investment in Hungary, net flows, excluding capital in transit and restructuring of asset portfolios (EUR mn), 1995-2018

[1] https://www.mnb.hu/en/statistics/statistical-data-and-information/statistical-time-series/viii-balance-of-payments-foreign-direct-investment-international-investment-position/foreign-direct-investments/data-according-to-bpm6-methodology

[2] Reinvested earnings are the portion of income due to the owners of equity in addition to distributed income (dividend). The difference between the positive or negative adjusted profit after tax and the dividend declared in the period concerned is reinvested earnings.



Source: Hungarian National Bank (MNB)

Regarding the main foreign investors in Hungary, Germany is the most important partner, and besides other European countries, Asian and North-American investments are also significant. New insights in the composition of FDI according to the nationality of ultimate investors are provided by new data, thus now we know more about who really invests in Hungary. In tracing the 'real origin' of FDI in a host country, a new opportunity is provided by the data on ultimate investors. The ultimate controlling investor of an investment project may differ from the direct investor and thus also their nationalities differ. Multinationals increasingly use their foreign subsidiaries for channelling FDI to third (or more) countries, for mainly tax optimization reasons. Further reasons include organizational ones or higher familiarity of subsidiary staff with the new location of FDI in a third country. The task of tracing the ultimate investor multinational company is in certain cases problematic and requires substantial knowledge and resources. Until now only a few national banks published two data sets, including the Hungarian national bank (Fertő-Sass, 2020).

Table 1 provides data on the main investor countries in Hungary, presenting the nationalities of both the direct (inmediate) investors and the ultimate investors, in decreasing order according to the sum of investment. Larger entities (continents) are written in bold.

Table 1. Inward FDI Positions (net liabilities) arranged by the country of the Ultimate Controlling Parent, excluding Special Purpose Entities (EUR Mn), 2017

	Inmediate investor	Ultimate investor
Europe	**70 425,9**	**53 546,3**
Germany	17 956,8	19 894,2
Asia	**2 486,0**	**11 814,0**
America	**1 094,3**	**10 016,9**
United States	-769,9	9 309,9
Austria	8 454,4	6 845,5
France	3 179,9	4 865,0
Italy	2 877,9	3 251,4
United Kingdom	1 993,8	3 183,8
South Korea	1 663,2	2 852,3
Japan	968,5	2 659,4
Not allocated	**2 461,5**	**2 461,5**
Netherlands	14 536,3	2 292,7
Switzerland	4 674,1	1 910,5
China	177,3	1 658,3
Luxemburg	3 344,5	1 409,4
Belgium	2 083,9	1 362,3
Cyprus	1 532,5	888,2
Denmark	832,0	830,5
Russia	474,8	704,2
Spain	810,4	584,9
Sweden	466,2	491,1
Norway	488,9	489,3
Ukraine	327,8	462,8
Czech Republic	433,3	455,2
Canada	492,5	348,7
Poland	1 021,1	348,5
Ireland	2 937,9	309,5
Africa	**1 550,3**	**248,3**

Source: Hungarian National Bank (MNB)

Germany is still the top investor, but in the case of certain countries, the difference is outstanding. The Netherlands for example is seemingly a large investor, but in reality Dutch investments have only an average significance; other countries invest via Netherlands (because of tax reasons, recall the so called Dutch sandwich, according to which it is beneficial in tax terms to insert a Dutch affiliate between the origin and the final host countries). One such country may probably be the USA, which has a large role as investor but not directly. Other

such intermediary countries can be Luxemburg, Cyprus, Austria or Switzerland. Asian investors also use intermediary countries to invest in Hungary.

Foreign capital has a large share in manufacturing (mainly transport equipment and branches bound to the automotive sector) and in services, too (financial services), see Table 2. Foreign-owned enterprises provide more than 50% of production and value-added and usually perform better than domestic ones (Hunya, 2017). Domestic companies have lower inclination to innovate, focusing mainly on low-technology sectors, but not on high- to medium-technology industries (Sass, 2017).

Table 2: Foreign direct investment position (stock) in Hungary, broken down by economic activities (EUR mn), 2008, 2013, 2018

NACE Rev2 code	Economic activity of resident direct investment enterprises	2008	2013	2018
A	**Agriculture, hunting and forestry**	**336,4**	**465,4**	**515,8**
B	**Mining and quarrying**	**302,0**	**241,4**	**365,6**
C	**Manufacturing**	**17 309,7**	**16 991,6**	**32 965,5**
10,11,12	Fod products; beverage and tobacco	1 769,1	1 792,7	1 951,1
13,14,15	Textiles wearing apparel and leather products	239,4	292,5	381,8
16,17,18	Wood, paper, printing and reproduction	846,7	776,6	1 544,8
19	Coke and refined pertoleum products	807,4	34,2	74,4
20	Chemicals and chemical products	486,1	544,8	1 965,1
21	Basic pharmaceutical products	1 136,2	1 434,1	3 457,0
22	Rubber and plastic products	751,5	1 429,2	2 912,7
23	Other non-metallic mineral products	1 439,5	1 310,4	1 418,5
24,25	Basic metals and fabricated metal products	1 508,9	1 371,8	2 135,6
26	Computer, electronics and optical products	1 788,7	2 149,8	3 874,3
27	Electrical equipment	755,8	749,7	1 406,4
28	Machinery and equipment n.e.c.	826,2	905,3	1 593,3
29, 30	Total vehicle and other transport equipment	4 627,7	3 515,3	9 452,5
31,32,33	Manufacturing not elsewhere classified	326,5	685,3	798,1
D	**Electricity, gas, stem**	**3 052,9**	**2 386,3**	**1 288,8**
E	**Water supply, sewerage, waste m**	**85,2**	**110,3**	**66,1**
F	**Construction**	**1 098,8**	**745,3**	**1 027,4**
	Services (G,H,I,J,K,L,M,N,O,P,Q,R,S)	**38 807,9**	**56 526,5**	**42 819,5**
G	**Wholesale and retail trade; repair of vehicles**	**8 601,6**	**8 547,9**	**9 119,4**
H	**Transportation and storage**	**1 503,5**	**1 163,0**	**1 828,7**
I	**Accomodation and food services**	**417,2**	**440,1**	**797,6**

J	**Information and communication**	**5 479,3**	**4 315,9**	**4 030,2**
61	of which: Telecommunication	4 567,5	3 228,3	2 987,2
62	of which: Information technical services	185,4	276,1	447,3
63	of which: Information services activities	36,4	3,7	-168,6
K	**Financial and insurance activities**	**7 903,6**	**12 923,2**	**9 309,1**
64	of which: Financial intermediation	6 647,4	12 217,7	8 629,1
6419	of which: Other monetary intermediation	5 526,0	4 585,0	5 327,9
65	of which: Insurance, reinsurance and pension funding	1 126,6	586,4	615,7
L	**Real estate activities**	**5 028,3**	**5 424,6**	**7 161,3**
M	**Professional, scientific and technical activities**	**8 628,8**	**20 093,6**	**5 760,9**
69	of which: Legal and accounting activities	82,4	47,0	-152,6
70	of which: Activities of head office; management consultancy activities	8 163,4	19 518,1	5 512,0
72	of which: Scientific research and development	75,6	77,5	172,3
	Other services (N,O,P,Q,R,S)	**1 245,6**	**3 618,0**	**4 812,3**
8299	of which: Other business support service activities n.e.c.	533,2	2 120,7	1 906,5
	Private purchase and sales of real estate	**1 515,8**	**1 818,0**	**4 651,1**
	Not allocated	**0,0**	**0,0**	**0,0**
	TOTAL	**62 508,7**	**79 284,8**	**83 699,8**

Source: Hungarian National Bank (MNB)

Looking back to the past two decades, while the inflow of FDI contributed considerably to the economic restructuring of Hungary, most of the expectations on FDI-enhanced competitiveness, high growth and rapid convergence with the core-EU countries were only partially fulfilled. This was due to several factors: over-high expectations, economic policy mistakes, the inability of domestic firms to become partners of foreign firms, and the generally low preference of multinationals to rely on local firms (Sass, 2017).

The problems caused by the financial crisis of 2008-9 further deepened disillusionment and FDI inflows substantially declined during the crisis and post-crisis years. The Hungarian Orbán-government's rhetoric often hinted to "bad" FDI and several legislative changes specifically targeted foreign-owned subsidiaries in certain sectors and industries (mainly those focused on the domestic market and operating in the services sector)[3]. On the other hand, export-oriented manufacturing ("good") FDI enjoys generous incentives and a supportive business environment, as witnessed by the automotive industry where foreign investment projects enjoy major privileges.

[3] Film industry, broadcasting, social vouchers, banks, energy sector.

The ambiguity of Hungarian government policy is underlined by the fact that, by lowering corporate tax, there are more and more incentives for multinational companies to transfer their profits to Hungary and thus save tax. At the same time, domestic companies usually face a higher effective tax rate than large multinationals. In 2017, corporate tax rate was further reduced to 9%, benefitting mainly large companies and incentivizing multinational companies to further indulge in tax optimisation (Sass, 2017).

As mentioned, foreign-owned firms' role is still dominant in the Hungarian economy and they successfully adapt to the changing trends (also in application of Industry 4.0 – see later). As for alternative 'growth engine' groups of companies, which would be competitive enough to take over the role of dynamising the economy from the foreign-owned subsidiaries: Hungary has only a small group of own multinational companies, dominating a few industries (e.g. MOL in energy, OTP in financial services, Richter Gedeon in the pharmaceutical industry or Videoton, an electronics manufacturing service provider) and domestic small- and medium-sized firms are not quite competitive, with a very small group of exception companies (Kovacs et al., 2016, Sass, 2017).

Approach to Industry 4.0, policy tools

Industry 4.0 has a hype cycle. After having a peak of enthusiasm and popularity in Hungary, now the curve is somewhere in the "valley of disillusionment" (Demeter et al., 2020). Probably in a short time the concept of Industry 4.0 will be evaluated as reality requires. Hungarian firms usually cooperate and innovate little. Half of them has had no innovation (of any kind) at all in the past five years (Nick, 2020). Nevertheless, policy makers, industrial organisations realised around 2015 the necessity of promoting industry 4.0, which led to the establishment of various associations, platforms, politics-related organisations or the inclusion of Industry 4.0 related aspects into the operational areas of the existing units. Below you can find some details about the most important "players" in Hungary in the area.

The *Industry 4.0 National Technology Platform Association* was established in 2016 with the participation of Hungarian Academy of Sciences, Institute for Computer Science and Control (SZTAKI), Ministry of Economy, important productive companies and other professional organisations, research institutes and universities. These more than hundred actors are grouped into seven work groups: – strategic planning, – education and training, – production and

logistics,– information and communication technologies – industry 4.0 cyber physical sample applications,– innovation and business model,– legal regulation. The platform is a national one but there are some industrially developed hubs.

IVSZ (Association for Digital Economy) is the largest and most significant leading interest group of the Information and Communication Technologies industry in Hungary. The association operates as a joint platform for the information technology, telecommunications and electronics sectors since 1991. The Association of Hungarian ICT aims to achieve the Digital Transformation of Hungary. IVSZ represents the sectorial and social interests and strategic goals of the Hungarian information society and the ICT sector. The association has approximately 450 member companies. IVSZ has a "Sample factories" project and also organises "Night of modern factories" event (72 factories participated in 2019 and 5300 guests attended).

The Hungarian government launched in 2015 the *Digital Wellbeing Program* (DWP) aiming to help citizens and companies in digitalisation. In general, it is difficult to define the digital economy and its weight. Companies are for example grouped in ISIC categories according to their main activity only. Digitalisation can be widespread in certain functions, elements of activities[4]. In DWP digital development strategies were prepared like Digital Education, Digital Export Development and Digital Startup Strategy. The VAT rate of internet usage has been decreased from 27 to 18% and then to 5% in Hungary. In 2017 the government extended the Digital Wellbeing Program and this DWP 2.0 strategy affects almost all areas of the economy, society and government[5]. At the same time the Hungarian 5G Coalition was launched in June 2017 by 46 actors of the market, government, universities, institutes.

AI Coalition was created in spring 2019 and participates in the creation of the AI strategy of Hungary and analysing social and economic effects of AI. There is an increasing number of member companies, like Hungarian Telekom, Microsoft, IBM, etc.[6]

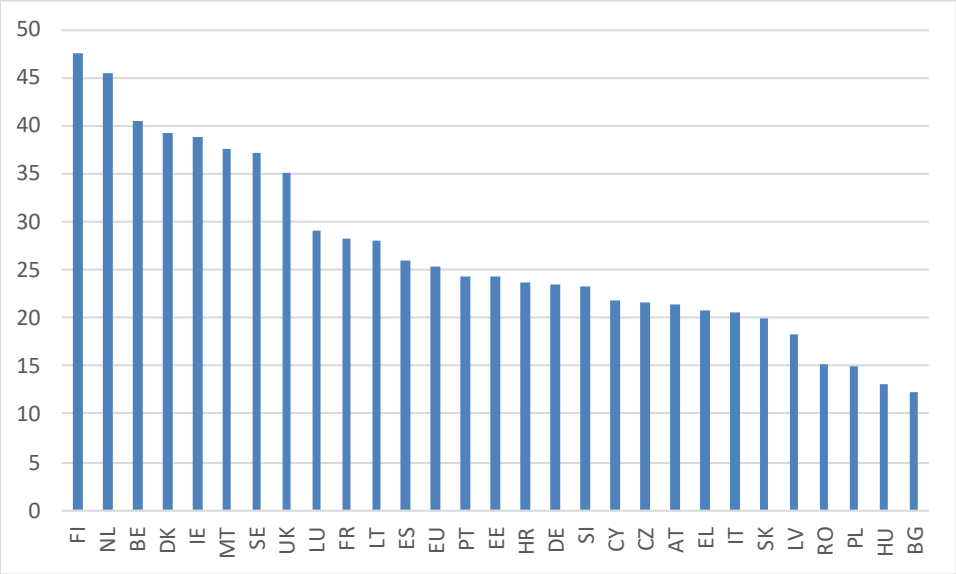
However, the creation of these organisation could not really change the disadvantageous relative position of Hungary. For example, despite these efforts, the Business Digitisation subindex of the DESI index still shows a very backward position of Hungary (see Figure 3), according to that Hungary is on the penultimate place in the European Union.

[4] http://ivsz.hu/a-digitalis-gazdasag-sulya-2019/

[5] Digital Child Protection Strategy and FinTech Strategy are also parts.

[6] https://miagyakorlatban.hu/hu/companies

Figure 3. DESI – Business Digitisation index, 2020



Source: https://digital-agenda-data.eu/datasets/desi

One explanation to this problem, i.e. the relatively large number of organisations, association etc. active in Industry 4.0 related activities and the disadvantegous ranking of Hungary in European Union comparison, is related to the relatively weak link between the real needs of the firms and the activities and support these platforms or government policies provide. It is important to know the necessities of the firms. The article of Fülep et al. (2018) based on a questionnaire describes what the surveyed companies themselves think about an effective policy. The firms' highest expectation towards the state is to be efficient in education development. This is the most important factor, others like infrastructure, finance and regulation come only far behind this. Training is the most important challenge and lack of skilled labour is the highest barrier for the companies regarding Industry 4.0.

Similar are the findings of other studies. Szabó et al., (2019) surveyed the situation of Industry 4.0 promotion and learning based on interviews with members of the Industry 4.0 National Technology Platform and policy makers, university professors. They conclude that the Industry 4.0 system is not sector-specific, but should be implemented and learned within the triple helix network (government, universities, companies). Labour force characteristics are the most problematic, skills to implement digital technologies are missing. There is not enough experience to disseminate, often the machinery park is of the highest technology, but the style of leadership/management is obsolete. Competitiveness is the biggest challenge of supporting policy, incentives for low value-added activities are not beneficial in the long run.

Effects of Industry 4.0 – Hungarian literature on company experiences

In general, the literature on I4.0 details several kinds of effects, mostly on labour force, but also on efficiency, productivity, health, etc. Hungarian literature also deals with some of these effects.

There have been studies describing the results of interviews conducted with Hungarian companies. Nagy (2019) shares the opinion of four companies already applying I4.0, selected from the members of the National Technological Platform and applying the snowball method. Three of the firms are foreign-owned big automotive companies and one is a domestic middle-sized one in the electronic industry. These firms daily deal with I4.0 they are either pilot I4.0 companies or their production is largely based on I4.0.

The companies had clear definition on Industry 4.0 emphasising big data analysis and its utilisation and network integration. The introduction of I4.0 consisted of several steps. First, data are collected with the help of relevant software. Second, they select data and convert them to a decision support system. Third, the results are used, applied in different parts of the organisation. These steps need skilled employees. The three foreign-owned firms had digital strategy, plans for the future, the domestic one had not.

Data storing and security is a challenge; they are stored either in large guarded server parks or in cloud. Three companies do not intend to share their data with business partners or consider it a very vague possibility because of trust. According to one firm, data sharing can be possible within five years.

Employees should be well-informed and taught, there were cases of resistance (deliberate damages) but at the end employees accepted I4.0. Improved performance is honoured. *A major problem is the shortage of skilled labour*, especially good data analysts. Internal and e-learning are applied too.

Companies have problems also with the lack of standards, they use own-developed and a variety of IT systems. The developed technologies are increasing the firms' intellectual property.

Szalavetz (2017) interviewed in 2016 eight large foreign-owned companies operating in the automotive and electronics industries, and two of them can also be classified as technology producers. Indeed, in several companies the implementation of production automation solutions, the use of sensors started more than a decade ago. However, there is a long way to go until becoming a fully integrated business unit, with collaborating devices. Interestingly,

these companies also *lacked a systematic digital strategy*. They faced four kinds of challenges in production: 1. Shop-floor technological problems (inefficient process scheduling, excessive downtime, long changeover times, quick tool wear, product defects, etc.) 2. Shortages of skilled labour (operators and engineers). 3. Increased production complexity. 4. Increased customer requirements in terms of time, variety, costs and flexibility.

Regarding effects of I4.0 on labour, the operators whose tasks had been automated have been reassigned to other production activities and engineers were freed from administration and could devote more time to innovative problems. Even there is sometimes an intra-firm competition for their talents, they can move to other regional or central premises to work.
The introduction of advanced manufacturing technologies has effects on production capabilities at the companies. In 2017, Szalavetz (2019b) conducted 16 interviews with technology providers and users. Respondents pointed out that *smart decision support systems are the real novelty of the industry 4.0 era*. These support production planning and scheduling, optimise capacity utilisation, maintenance and energy management, enable communication with faraway team members. The implementation of advanced robotic systems at the firms has replaced labour in selected activities, but these employees have been redirected to perform easier tasks. Technicians and engineers could dedicate more time to the analysis and identification of problems. There has been a continuous evolution of local R&D responsibilities.

Nagy et al., (2018) prepared a survey to judge how companies operating in Hungary interpret Industry 4.0, what IoT tools they use and what critical issues they face during adaptation. The sample consists of 43 firms and four expert interviews were also conducted in 2017. The results showed that real time data integration has a significant impact on the entire company. Firms reported higher level of logistic service, more efficiency, improved cooperation between functions, and higher market and financial performance and competitiveness. However, there is lack of digital strategy, fear of organisational resistance and of risks.

Another work of Szalavetz (2019c) provides the results of ten company interviews made in 2018. The firms are large ones that already successfully introduced digitalization. Evidence indicates that *digitalisation has offered upgrading opportunities in terms of both process upgrading and functional upgrading*. Even chain upgrading (inventing digital technology-enabled new business models) could be experienced. Szalavetz (2019a) analyses the effects of

Artificial Intelligence on general productivity level showing that the connection cannot be simplified.

Halmosi (2019) prepared a survey in early 2019 among early stage start-up companies, having received angel investment from technology incubators. The survey focused on how these start-ups see of the significance of Industry 4.0, what differences exist compared to traditional companies. The sample consisted of ten start-ups and ten "normal" SMEs. The companies evaluated the effects of I4.0 on the one hand and its barriers on the other hand. They think that digitalisation will significantly change the business and production model, contacts and network with partners, and smart IT tools will raise value-added. Traditional SMEs consider more as a barrier the financial capital need of I4.0 investments and the not clear definition of I4.0 than start-ups. Start-ups, however, consider it more important that I4.0 tools detect organisational weaknesses, which managers do not like.

Demeter et al., (2019) describe a Hungarian company case study, an affiliate of the TE Connectivity employing 1550 persons. The company began digitalisation five years ago: the mother company decided to make a pilot I4.0 firm here and applying later the tested systems elsewhere. IoT, big data, cloud, additive manufacturing, robots have been introduced, they expect several advantages, improving indicators. However, problems were also mentioned: the introduced solutions are expensive, operating them needs a high level of trust, they can be risky, and there is a huge need for experts and for special know-how.

A questionnaire survey with a sample of 109 respondents were made in 2018 by Szabó et al., (2019). The result shows that there is a lack of workforce with digital competencies. *Hungarian management culture and cooperation capabilities are behind the developed countries*, machines can be brand new, but leadership style is very old. Companies and universities cooperate on a relatively low level.

Losonci et al., (2019) constructed a manufacturing Industry 4.0 index based on the data of the EU Commission (partly the DESI database). Based on this index and the sample of more than 6 thousand Hungarian firms it proved to be obvious *that electronics and automotive branches are the leaders regarding I4.0 maturity*. After this, the authors used the data of the Hungarian tax office on automotive firms' balance sheet results between 2013-2016. They constructed a panel database of 213 companies and observed automation trends, but not a significant improvement of value-added production. Producing more value added is hindered by structural barriers: lack of human potential.

The article of Rekettye (2020) finds that as an effect of the Industry 4.0 companies rethink their pricing strategy making it more sophisticated and the room for price-setting is growing. The bargaining power of the customers is also growing.

Horváth and Szabó (2019) conducted semi-structured interviews with top executives of 26 companies: Industry 4.0 providers, users and both at the same time. The sample contained small and medium sized, domestic and foreign companies. Several driving forces and barriers of Industry 4.0 was formulated. The article shows that *MNEs and SMEs are different and do not have equal opportunities regarding Industry 4.0*. MNEs have higher driving forces and lower barriers than SMEs but the latter ones have lower profitability expectations. Interviews proved that lack of skilled workers, human factor is considered a serious barrier in Hungary.

Szalavetz (2020) analyses the digital transformation of Hungarian automotive companies and draws consequences for GVC integration. She describes that because of digital technology adoption there will be fewer entry points in GVCs, suppliers will have to fulfil higher requirements but even this will hardly compensate for the decline of efficiency-seeking FDI. *Digital transformation helped the examined automotive firms to integrate into GVCs to some extent* (by new forms of communication, servitization of products, better collaboration and interactions). However, these will not change considerably the destiny of the FDI dependent factory economy (Hungary).

Demeter et al. (2020) prepared case studies of three automotive producer companies. They conclude that efforts are made, large companies have own Industry 4.0 departments, but these new technologies will not lead to breakthrough.

Szerb et al., (2020) survey the Hungarian digital ecosystem. They base their analysis on the EIDES index (Autio et al., 2018) comparing the Hungarian results with other EU member countries. Hungary belongs to the "laggard" group in the European ranking. Factors that stay back are especially in the "culture and informal institutions" and "market environment" groups. This means that *social and cultural norms and values do not support high-level entrepreneurship. Digital technology is not integrated, human resource and education is mediocre, brain drain is high*.

Regarding the impact of Industry 4.0 on FDI and relocations Éltető (2019) analyses the FDI reshoring trends in connection with Industry 4.0 and Hungary. In the past decade in several developed economies companies brought back previously offshored production partly or totally. Backshoring took place mainly from China or from other far distance areas. There are some sporadic examples of backshoring from the CEE region, but *not from Hungary*. Motivations for reshoring can be various, most importantly the need for more flexibility, control

of the whole production process, prestige of the home country quality, etc. Automation and robotization proved to be also important as a tool for achieving these aims.

In the European Reshoring Monitor the author did not find backshoring cases from Hungary between 2014-2018. Theoretically nearshoring to the country (there was one such case) can be more important, because of certain location advantages and favourable tax policy. If foreign investors nearshore to Hungary, it seems better if they automatize their plants because of labour shortage and wage increase. However, new Industry 4.0 production facilities in developed home countries can make investment in Hungary superfluous.

Overall, the Hungarian literature addressed many aspects of Industry 4.0 Why we have certain important (and unequivocal) results from the various survey and analysis, such as for example on the differences in terms of adapting Industry 4.0 related elements by foreign-owned subsidiaries and Hungarian firms, differences according to the size of the firms, or the importance of and problems with education and training, we can see that there is a lack of a systematic review and analysis of this area. This is so in spite of the fact that both policymakers, academic experts and industry representatives acknowledge the growing importance of the issue and its significance from the point of view of the future of the Hungarian economy.

Methodology, our interviews

Insights into the practice of Industry 4.0 can be best gained through interviews with practitioners and experts, who have an overview of the developments in this area in the Hungarian economy. Altogether 13 anonymous interviews were conducted in Hungary in the framework of this research project between December 2019 and August 2020. The interviews lasted between 30 to 60 minutes. With companies, we had “live” interviews, while with the experts, the interviews were conducted through skype or phone. The reason for the latter was that company interviews were conducted in December 2019 and January 2020, while expert interviews were scheduled as the second step of collecting information, in January-August 2020, which happened to occur in the period of lockdowns in Hungary due to the COVID-19 pandemic.

Anonymity is especially important in the case of the interviewed companies, that is why we do not provide details (such as the location of the firm in Hungary, the nationality of the investing multinational company or its industry) about the individual companies, which took part in our

survey. Neither do we give the names and positions of the academic and industry experts, who were interviewed in the framework of the project.

Our interviewees were:

- Four representatives of Hungarian subsidiaries of foreign multinational companies (foreign-owned firms), three large-sized firms and one mid-sized company, all operational in manufacturing;
- Four representatives of Hungarian-owned firms: two SMEs and two large firms, operational in various industries (automotive, electronics, financial services);
- Three academic experts (working in academic institutions or universities), who have already published widely on Industry 4.0 and have a very good publication record in this area;
- Two industry experts (one of them a leader in one EU-financed Industry 4.0 program, and the other one a representative of an industry association-Industry 4.0 expert).

We evaluate our sample as having a good combination of theoretical and practical experts in the area and of practitioners having first-hand experience with Industry 4.0. The insights given by the industry experts were especially valuable, because they had an overview of developments in the area as they were in touch and worked together with many Hungarian companies, and had even experience with some other companies from the Visegrad region, as we will see. The companies also represented a relatively broad set of activities, sizes and industries, and they were relatively spread geographically.

Industry 4.0 understanding

Having four groups of interviewees helped us to identify the major differences in the perception of Industry 4.0 in the various groups of companies. Our academic experts all *emphasized the complexity of Industry 4.0* in terms of consisting of various technologies and introducing changes in business models (except for one expert). According to one expert, it can be defined as the use of new digital technologies to enable major business improvements (such as enhancing customer experience, streamlining operations or creating new business models). According to the most nuanced view of one academic expert, the term “Industry 4.0” originally refers to the introduction of a set of new technologies into practice but over time the original concept has been broadened. However, he thinks we should differentiate the narrow view of

"Industry 4.0" and a broader one, which also includes those changes that these technologies induce in the economy, e.g. the development of new business model, changing social relationships etc. There is a possibility to refer to these broader changes as the "4th industrial revolution" and so make it clear whether one is referring to the narrower set of changes or the broader trends. In his view the two – new technologies and new business models – are related to each other (representing a narrower or a broader perception) and sometimes it is not possible to separate them from each other. At the same time, all academic experts underlined that the common perception among companies is usually about just the set of technologies (in certain companies even just one new technology), i.e. Industry 4.0 in a narrow sense. This opinion was shared by the industry experts as well.

Indeed, this different perception of Industry 4.0 by companies was reinforced by our company interviews. Except for one knowledge-intensive Hungarian SME, *all firms perceived Industry 4.0 as a set of technologies, usually identifying it with two or three important technological fields*, such as automation, robotisation or big data. (Table 3)

Table 3 Elements of Industry 4.0 mentioned by the company interviewees

Company	**Elements of Industry 4.0 mentioned**
Foreign-owned 1	robotisation, Internet of Things, Artificial Intelligence, digitalisation
Foreign-owned 2	robotics, data collection and analysis, visualisation of data, traceability of the materials used in production
Foreign-owned 3	automation, new products demanded due to Industry 4.0
Foreign-owned 4	automation, digital technology, sensors, digitalisation (of management)
Hungarian-owned 1	automation, digitalisation, robots
Hungarian-owned 2	Big Data
Hungarian-owned 3	data collection and sampling, Internet of Things, sensors, Big Data, digitalisation, 3D printing
Hungarian-owned 4	robots, automation

Source: interviews conducted in the framework of the project

The interviewed industry experts with an overview of developments in Hungary in this field also underlined that Hungarian companies usually approach Industry 4.0 as a set of a few

important technologies; robotisation, big data and their analysis or automation are those areas, which Hungarian companies identify with Industry 4.0. This "skewedness", i.e. emphasis on a few elements is reinforced by other sources as well (e.g. Nick (2018) showed that sensors, MES/ERP/PPS systems and big data are perceived to be the most important Industry 4.0-related elements in Hungarian firms.) According to one industry expert, the most common understanding is connected to collecting data and analysing them even in fields, which were previously not covered by data collection and analysis (e.g. in the production process itself). Hungarian companies want to see more data and want this to help their decision-making process, make it more objective, and make the company more transparent (at least for the owners and managers). They hope that with big data they can improve efficiency, in terms of using less resources for production, especially in terms of manpower. Overall, many companies consider the essence of Industry 4.0 in Hungary in helping them *to rely on less labour*. Interestingly, they consider reducing their worker use as one of the most important ways of decreasing their prices, other options (e.g. innovation, improving technology, introducing new technology) they consider only in those cases, when they are forced to do so, e.g. by increased competition. Technology actually plays a role when quality questions arise. This is well illustrated by one interviewed Hungarian company. The interviewee noted that increasing wages in Hungary induce automation, digitalisation, and changes in administration and production. Through the use of Industry 4.0-related technologies (mainly digitalisation in administration and robots in production) they could significantly reduce employment in administration and the firm reduced the number of employees from 221 to 130 in one product's production through better organisation and digitalisation, i.e. through the use of Industry 4.0-related technologies.

The interviewed MNE subsidiaries had a similar, narrower perception, with the difference that they usually mentioned not two or three, but three or four dominant technologies in connection with Industry 4.0. Here also robotisation, automation, 3D printing, big data, data visualisation, use of sensors, artificial intelligence, Internet of Things, Artificial Intelligence were mentioned. (Table 1) One subsidiary identified Industry 4.0 with better, more efficient organisation of production. Interestingly, it deemed these technologies unnecessary overall, as their production organisation is so efficient that they cannot really improve it further. According to the interviewee, when technologies develop further, they may consider the introduction of sensors and big data in order to improve the efficiency of the workers in terms of. e. g the movement they make. Another company also mentioned robotics, data analysis and traceability of materials, as the most important elements related to Industry 4.0.

The only exception to that rule was the Hungarian SME with highly knowledge-intensive activities and technology-based services. (See Table 1, Hungarian-owned company 3.) This company perceived Industry 4.0 in a very complex way, embracing all of its elements and the links between them and thought, Industry 4.0 can help the company to improve its market position, to access new niches in terms of activities/products but also in terms of foreign markets. (See box Company case: The most „active" in Industry 4.0 firm in Hungary.) We assume, there can be other such innovative, usually small-sized firms in Hungary, which really understand the opportunities provided by Industry 4.0.

Box 1: *Company case: The most „active" in Industry 4.0 firm in Hungary*

This Hungarian SME was established in March 1990, it is 100% Hungarian-owned. The owners are five Hungarian private persons. The firm provides facilities and services for vehicle examination, technical tests, end-of-line tests, and they produce (or rather put together) the equipment for such services; basically, they build unique equipments for their customers.
The company started to export in 2008-9 only (which was motivated by the shrinkage of the domestic market due to the financial crisis). At present they export to 11 European countries and to India. Exports at present represent 25% of sales, thus the company can be evaluated as internationalised.
The firm employs 100 workers, of which there 45 engineers, which is the result of a gradual increase over 30 years. Their production is highly R&D intensive and they also produce equipment for R&D activities. Many activities of the firm are related to Industry 4.0, they gradually learned and adapted these technologies.
Examples of Industry 4.0-related activities:
1 Data sampling is IoT-related: the main aim of collecting and analysing a large amount of data is to find weaknesses in production, usable in wide technical fields; testing – collecting and evaluating a large number of data for partner firms.
2 The company developed oil-distribution systems for oil producing and vehicle service companies, where they handled a large set of customer data – here their system distributes oils, screenwasher fluids, anti-freezer fluids; e.g. they supplied BKV (Budapest public transport company) with that type of services.
This company considers Industry 4.0 as an opportunity through going to niches, which are perceived in two senses: one is new activities, where the leading (multinational) firms do not want to go (they consider these too small problems, and too small markets). Second, new markets, where the leading firms do not want to go (afraid of leaking technology, and deem the projects not so lucrative) – that is how the firm got to India.

Source: company interview

This *difference between Hungarian-owned and foreign-owned companies* is persistent (see e.g. Szalavetz (2017) in the survey of the literature) and the existence of this gap was explained by one industry expert. According to him, there is a large gap between the various groups of companies in this area. First of all, any understanding of Industry 4.0 characterizes around one

third of the total number of companies in Hungary, including both foreign-owned and domestically owned. In his understanding, Industry 4.0 is part of a longer-term strategy, as for around one and half- two years, companies just invest in it, and they can get the "harvest", the results after that period. Thus, costs are arising immediately, while benefits occur only with a significant time lag. In Hungary, around half of foreign-owned companies and around 13-15 % of Hungarian SMEs have a strategy for at least 2 years. (Similar results can be found in the literature. According to survey results of Nick (2018), only 8.5 % of Hungarian companies have a strategy, which is already operational or is to be introduced. Even for foreign-owned subsidiaries, this ratio is 26%. An overview of various survey results also supports the view that especially Hungarian SMEs have serious problems with digitalisation or applying other elements of Industry 4.0, in spite of the fact that they are aware of their importance in increasing competitiveness, or in some casing just helping the survival of companies (Szabó, 2018). See furthermore the literature review above, with Nagy (2019) presenting similar results: foreign-owned companies have strategies, the domestic-owned one does not.) This explains the extremities – basically firms with longer term strategy are those, which have built-in at least some elements of Industry 4.0 into their strategy, which take these elements into account when they plan the future of their firm. This is actually supported by the quote from one company representative, who noted that his company invests in Industry 4.0 (digital technology), however it is difficult to identify the return on this investment yet. Furthermore, our industry experts emphasized differences among Hungarian companies (both foreign-owned and domestically owned) according to their activities and sectors-industries of operation. Our small sample reinforced that: the SME, operational in the knowledge intensive sector stood out from the Hungarian sample in its awareness about and use of Industry 4.0 related technologies. The literature also reinforced these differences (see e.g. Nick, 2018).

In terms of using certain Industry 4.0-related technologies, our interviewed subsidiaries of foreign MNCs were without doubt in a better position, than their Hungarian counterparts (with the exception of the Hungarian knowledge-intensive SME). This is completely in line with the results of other studies on Hungary (e.g. Nick, 2018 or Szalavetz, 2017). Even the foreign-owned subsidiary, which was sceptical about the impact of Industry 4.0 on better organisation of production, used robots, automation, data collection – Big Data in its production process in Hungary. In this company, if home-country automation level is 100, then in the Hungarian subsidiary, the level of automation is 50. All subsidiaries interviewed could economise on human workforce due to a more intense use of robots and automation, induced partly by the tightness of the Hungarian labour market. All four subsidiaries declared that those workers,

which thus became redundant in their previous jobs, were employed elsewhere in the subsidiary (training provided if necessary), thus the overall impact on employment was neutral. This finding is also in line with the findings of other studies, e.g. Szalavetz, 2017 in the literature survey. Exceptions were found in cases, when the product produced by the company was directly affected by Industry 4.0-related changes, e.g. by an intense use of related technologies by competitors in the case of one subsidiary, or by expecting the complete disappearance of one product in another. (In this latter case, not the subsidiary but the headquarter is conducting research on how to change the product structure.) As it was already mentioned, *while the foreign subsidiaries found the most important impact of Industry 4.0 in better organisation of production, higher efficiency of production, less defects and downtime, Hungarian companies* (with the exception of the knowledge-intensive SME) *wanted to use certain elements of Industry 4.0 in order to lessen their workforce needs*. This difference in the perception of the effect of Industry 4.0 gives important insights into the differences in the efficiency of production between the two segments of the Hungarian economy: foreign-owned subsidiaries and Hungarian companies.

One industry expert noted that there are links between the two segments (i.e. between foreign-owned subsidiaries and Hungarian-owned firms) in terms of certain subsidiaries leasing or providing robots to their Hungarian partners. This on paper could have a beneficial impact on the Hungarian firm, a demonstration effect and knowledge transfer – however, in reality, because of the concentration of key partners of Hungarian SMEs, this just aggravates their exposure to one key partner.

The other industry expert sees a clear difference between domestic and foreign owned companies. Foreign companies bring with themselves organisational and technological culture, and they develop themselves constantly. According to two of our interviewed MNEs, this is partly enhanced by pressure from customers. However, *most Hungarian companies do not develop at all, does not apply new technologies, new modes of organisation of production etc. However, now many firms are in the process of generation changing* (i.e. the owners, who established the firm around the start of the transition process, at the end of the eighties-beginning of the nineties, now retire and they have to transfer the company to their successors). Generation change means they have to know better the company, its strength and weaknesses, its organisation and culture. This brings with itself the necessity of having an overview of the firm, an inventory of its main characteristics, assets and flaws – the owners can hand it over to the new generation, if they are aware of its main assets (in a broad sense). This process of the firms' "self-discovery" can be helped by Industry 4.0 related technologies, especially big data.

Thus, in other companies, if there is no important change in the life of the company, it does not change itself… This indicates the lack of constant development culture in Hungarian firms. (This finding can be related to that of Szabó et al. (2019) in the review of the literature about the outdated management practices of Hungarian firms.) Related to that he sees an erroneous assessment of the firm's and firm owner's capabilities and abilities as a source of problem. Furthermore, this explains that in many Hungarian firms there are no Industry 4.0 related elements in use.

According to one industry expert, there are differences according to industries in Hungary in terms of their use of Industry 4.0 related technologies, and this "cross-cuts" ownership differences. As he saw, *more regulated industries seem to excel in Industry4.0* areas, basically regardless of their ownership, as they need to have an overview of their processes, they need to be aware of various characteristics of the production process in order to fulfil the regulatory requirements. Here especially automotive and pharma firms shine (interestingly enough, food manufacturing firms do not – this was reinforced by the other industry expert as well, who emphasized that in spite of the long traditions and relatively high level of competitiveness historically in this industry, Hungarian firms do not excel here). *Moreover, there is a clear difference between internationalised* (here we perceive internationalisation in a wide sense, thus including suppliers to local affiliates of foreign multinational companies*) and non-internationalised firms in terms of their approach to Industry 4.0.* The former firms are exposed to requirements and constant changes; thus they use Industry 4.0 related elements more often than their domestically oriented counterparts. This difference is reinforced by other studies, such as for example Nick (2018).

As far as the effects of Industry 4.0 are concerned, company representatives do not expect very large (revolutionary) changes in the near future, they think, that changes will be more gradual. Our academic experts found that the effect can be seen the most in better energy efficiency (expert 1), in improved innovativeness, less defects /downtime and new smart products, new services, new business models and new efficient processes (expert 2). Expert 3 emphasized that there are different layers of effects and different time horizons related to those effects. On the short term, the most important effect of Industry 4.0 is efficiency and productivity gains (improved innovativeness, less defects /downtime and new smart products, new services, new business models and new efficient processes) on the firm level. However, on longer term we will see positive impact on sustainability (alleviated resource scarcity and better energy efficiency), which are beneficial for the broader society. In the circumstances of the pandemic, our industry experts underlined, that the effects are now influenced by the crisis impact of

COVID, which strengthens the need for more reliable and diversified supply chains, and one way of reaching this aim is may be introduce certain Industry 4.0 technologies. However, this impact at present seems to be less clear. Companies consider the most important short-term impact that of alleviating their labour needs – as it was mentioned already. Indeed, literature in Hungary analyses this question relatively frequently (e.g. Fülöp, 2018).

Impact on multinational enterprises (MNEs)

Our academic experts found that Industry 4.0 may have an important impact on MNEs in organising their production. One of them noted, that this process benefits mainly the headquarters of the MNEs, which keep knowledge and know-how to themselves, and thus there will be more power in the hands of the MNEs. Two experts were of different opinions: they felt *that sharing the know-how and technologies within the network of the MNE, i.e. between the headquarter and different subsidiaries will be more characteristic*. However, as one expert put it, the process has more shaping factors: "Technology adoption reinforces firm-specific advantages, creates barriers to entry for less capitalised firms, yet, industry 4.0 in itself is not responsible for concentration, this latter is an ongoing tendency but at the same time new businesses emerge, and new firms enter the market." Similarly, the third expert emphasized: "This is a trend that cannot be limited to the HQs of MNEs. All foreign subsidiaries need to be involved as the vertical and horizontal linkages along the whole value chain are getting more and more closely knitted. Subsidiaries will also look for partners that are capable of collaborating with their Industry 4.0 system and this may cause further concentration if the local economy, local SMEs are not prepared to make investments on their side."

Box 2 *Industry 4.0 related activities of a foreign-owned subsidiary in Hungary*

The company' s headquarter is in Asia, and it is operational in the automotive and electronics industries. They are present in Asia, in North and Central America and in Europe. In Europe it is present in three locations with production, including Hungary. The Hungarian factory was established in 1998. At present it employs more than 1500 workers, and its products are exported mainly to Europe. There is no R&D carried out in Hungary, just some production related development, which is used within the company network as well.
Concerning Industry 4.0, they started Industry 4.0-related activities quite early on in Hungary, especially data collection, display, data handling, visualisation etc. Data collection was realised earlier as well, but now they use a complex analysis of these data with the help of Industry 4.0 related technologies. There was also some external pressure from their main customers to apply some of these technologies. The main field on which they are focusing currently is robotic

process automation (e.g. in reporting, using excel macros or other solutions, to provide automated reports)
A few years ago the company announced 'next generation manufacturing', which is related to Industry 4.0, but they are still exploring the potentials of it. Related information is mainly shared within the company group, (other) external knowledge sources are not used.
The production lines are highly automated in Hungary. Furthermore, the subsidiary employs two robots, which can be used in various production activities. Over the past few years some activities have become more cost effective if robots are employed instead of humans. Workers made redundant by robots and automation are employed in other parts of the factory.

Source: interview conducted in the framework of the project

Indeed, our interviews with Hungarian subsidiaries of foreign MNEs reinforced this last view. In one company (see Box 2 above), there is a distribution of work, research and activities concerning Industry 4.0. They have started their Industry 4.0 related program 5 years ago, in which all subsidiaries take part and share the results of their own experiences and research. There is even a competition between subsidiaries in certain areas: who can find the best solution. In another MNE, the Hungarian subsidiary may see a complete disappearance of one of its products due to technology changes – the headquarter is working on a solution, which will then be transferred to the Hungarian subsidiary. In the third and fourth subsidiary, the headquarter is financing Industry 4.0 related technology changes, which will be shared with all subsidiaries. In all four subsidiaries, decisions concerning the use of robots and automation is local, made by the management of the subsidiaries. (Actually, three of the four use robots already.) This, mainly passive, but in some cases active involvement of the Hungarian subsidiaries in Industry 4.0 related developments is reinforced by survey-based analyses as well (see e.g. Szalavetz, 2016).

Company representatives mentioned the fact that their companies were *usually not cooperating* with other companies in Industry 4.0 related research and development. They have outsourced certain related activities, but overall tried to solve all related problems on their own, relying on the network of the multinational company.

The industry experts found that other factors may influence MNEs in the process of sharing or unsharing, which are related to the advantages or disadvantages of Hungary as a production location. One important factor may be if Hungary will be able to be part of the European Union's ecosystem. This problem is partly politically influenced. Another important factor is the future of Hungarian mid-skilled industrial workers – whether they will be able to adapt themselves to the smart versions of their jobs.

Impact of Industry 4.0 on FDI

Academic experts had different views on the impact of Industry 4.0 on FDI. According to one of them: "As far as I am informed about FDI trends there is no clear impact of Industry 4.0 on the direction of FDI. Currently the subsidiaries and suppliers are entering a new competition of Industry 4.0 implementation and at the moment – for me – it is not clear how the new structure of supply chains will look alike. The changing cost structure of production will surely indicate some changes in the importance of certain production locations but the new technology and the need for mass customization may also result in increased geographical dispersion. The growing knowledge- and technology intensity of production may surely result in investments creating less jobs than previously which will be the most obvious in subsidiaries focusing on production, assembly-type activities." The other expert emphasized a rather negative impact on Hungary. He also added that he expects backshoring from the Visegrad countries to core-Europe. The third expert also shares this view, but with a longer-term and gradual impact on the Hungarian economy: "My bet is the squeezing out of V4 capacities by new digital factories in European core countries (V4 capacities may slowly become obsolete). All these effects are documented in the literature (asset-light FDI, footloose – though I am sceptical in this respect and of course it will create less jobs."

Industry experts shared the view that Industry 4.0 will change FDI trends. One of them expects a strong impact on FDI. He thinks, the large amount of data increases transparency at the company level as well. Planning may be easier as well. In terms of the locational impact, less skilled people may be adversely affected, while more skilled ones have more opportunities, including working from far away, thus the regional impact is not at all clear. The other expert emphasized that he does not expect mass backshoring to the Visegrad countries from China and other faraway countries. Similar is the case for nearshoring: there can be a few instances, but no massive FDI flows can be expected.

Company representatives were of slightly different opinions. One of them expected an *increased role of both foreign-owned and Hungarian-owned suppliers* due to the collapse of the Asian parts of the value chains and their negative consequences for operation. The company in question (foreign-owned) is also making extra efforts to find more local or regionally closer suppliers. This may result in extensions of capacities and thus to some FDI. Another foreign-owned company also emphasized the importance of diversification, which may result in establishing extra capacities in the region.

The academic experts underlined that all types of FDI (upstream, design, R&D; production, assembly; downstream, sales, marketing) will be affected by Industry 4.0 developments, though the impacts will be different. Production and assembly may be impacted upon the most.
In terms of the sectors that are mostly affected by Industry 4.0 and in consequence by possible backshoring, academic experts agree that pioneer sectors are automotive and electronics, which is in line with the literature (e.g. Nick, 2018 or Losonci et al., 2019). One industry expert mentioned other industries, which are important from the point of view of the Hungarian economy: pharma and food, which may be deeply affected. Nevertheless, they agree that it is not backshoring that will happen in these industries. However, there may be some nearshoring. Industry experts shared this view, emphasizing the large differences between the various industries in Hungary in that respect. As it was mentioned already, one industry expert shared the view that there may be some cases, but *no mass backshoring* or nearshoring can be expected. In the company interview, representatives also mentioned automotive and electronics and the related supplying industries to be affected. Company representatives were not aware of backshoring or nearshoring cases, which would be related to Industry 4.0 technologies.

Industry 4.0 attractiveness of host locations of FDI and FDI policies

The academic experts emphasized that there will surely be a change in the location advantages and disadvantages of Hungary, however, FDI policies do not seem to adapt to this new situation yet. They agree that *more concentration can be expected, with capital cities leading in attracting FDI* and peripheries getting into a more disadvantageous position, increasing polarisation and inequalities. They emphasized the primary importance of education, training and skills. One expert underlined the role of technical issues, mainly infrastructure. Related to that, FDI policies should put emphasis on the educational and labour market aspects as well as creating an enabling environment by improving the general ecosystem.
One academic expert suggested a complex approach for FDI policies, emphasizing not only education, but the role of knowledge and technology and sharing them, and creating a supporting environment in that respect with introducing the necessary regulatory elements. This can be helped and considered by FDI policies: “The local ecosystems will surely become more important for locational decisions as the availability of labour and/or market size will not be enough anymore. The availability of knowledge and technology – on a much broader and deeper scale – is getting more and more important. If this is fulfilled, then creating a supporting environment – including regulations – is becoming the next big thing to remain attractive for

MNEs operations. Creating knowledge-based clusters – with a variety of public research organisations – can be one way to form an attractive location/environment for FDI or the development of new generation of policies (a set of them actually) supporting the strengthening of capabilities and capacities necessary for the digital economy can be also crucial." The other academic expert emphasized the role of sustainability in that respect and how this can be related to Industry 4.0 and FDI policies. As he put it: „I think in FDI policies, SDGs-aware (see Box 3) FDI shaping is the most important, thus advancing sustainable development by facilitating sustainable FDI, promoting CSR, designating Recognized Sustainable Investors, and giving home countries a role, as it is well described by Karl Sauvant."

Box 3: *SDG – Sustainable Development Goals and FDI policy*

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.
The 17 goals are the following:
No poverty, Zero hunger, Good health and wellbeing, Quality education, Gender equality, Clean water and sanitation, Affordable and clean energy, Decent work and economic growth, Industry, innovation and infrastructure, Reduced inequalities, Sustainable cities and communities, Responsible consumption and production, Climate action, Life below water, Life on land, Peace, justice and strong institutions, Partnerships.
The new generation of investment policies (the fourth generation) emphasizes the importance of sustainability. Sustainable FDI can be defined as FDI projects that yield profits sufficient to maintain effective corporate engagement without harming vital host country interests while producing positive net benefits for the country's long-term development goals as evaluated on prioritized economic, environmental, social and governance indicators. FDI policies in this respect have to be integrated in national (sustainable) development strategies and plans and they should look at FDI holistically and cross-sectorally, whereas FDI can be attracted and used for the following purposes: Productive capacity / linkages; Industrial upgrading; Human resources/skills; Technology & know-how transfer/upgrading; Infrastructure. Furthermore, FDI policies have to be reviewed in order to ensure they support sustainable development; that investment agreements leave enough policy space; that investment promotion efforts and incentives should be linked to sustainable development criteria and to national sustainable development priorities (quantitative and qualitative). There should be a pipeline of bankable SDG projects (e.g. PPPs) developed and regional collaboration should be promoted (regional investment compacts, joint zones etc.)
Sources: https://sdgs.un.org/goals and https://www.un.org/sustainabledevelopment/sustainable-development-goals/ and https://unctad.org/en/PublicationsLibrary/diaepcb2015d5_en.pdf and http://mci.ei.columbia.edu/mci/files/2012/12/Sustainable-FDI-Guidance-Paper-Kline.pdf#:~:text=Sustainable%20FDI%20can%20be%20defined%20as%20FDI%20projects,goals%20as%20evaluated%20on%20prioritized%20economic%2C%20environmental%2C%20social and https://www.unescap.org/sites/default/files/15.%20Marit%20Nilses%20-%20Sustainable%20FDI%20-%20December%202016.pdf

The industry experts similarly expected more concentration of activities geographically. The most pressing host country challenges concern the labour market: *education and training*. This is completely in line with the findings of the literature, see e.g. Losonci et al. (2019). One expert underlined that traditionally everybody thought that lack of resources is the major barrier. This is not true, resources are there, their distribution however should be more transparent, because with lack of transparency, many potential applicants lose their motivation. According to his opinion, training and education are especially important, and information should be transferred more efficiently about these to the Hungarian SMEs themselves and to their workers. He found mentoring, coaching and lifelong learning are important ways of improving skills, especially for Hungarian-owned companies. While previously there were programs available for firms in these areas, in the last few years these are absent. It would be important to improve the links between companies and academic experts as well as between academic experts and the government's decisionmakers. Furthermore, it would be important to evaluate the efficiency of the present education and training systems, and to set up an inventory of these, available for companies as well.

Both industry experts emphasized another aspect, which may be very specific to Hungary. Industry expert 1 underlined that there is a change in generations in Hungarian companies, as it was already mentioned, because those, who established their firms around the start of the transition process are now about to retire and hand their firms over to their children. This is not only a threat but also an opportunity to introduce important changes in the operation of these companies, especially that the new generation was trained in business-related areas more thoroughly than the predecessors. Thus this may act as a catalyst from the point of view of using Industry 4.0 related technologies more intensively in Hungarian-owned companies. Industry expert 2 also mentioned this aspect. According to his estimation, in Hungary, around the half of SMEs are family-owned. Handing over these firms to the children of the owners brings with itself not only continuity and maintaining traditions, but also the chance to renew the company, to adapt it to the new circumstances. here he sees a role for the state to help this process with various policies, including trainings.

The interviewed companies also expect further concentration to industrial and service centres (and around them) geographically – a kind of agglomeration impact related to Industry 4.0 and FDI. They basically unequivocally emphasized the role of skills, education and training as the most pressing challenges of Hungary. This opinion is in line with the findings of the literature on Industry 4.0 in Hungary, presented in the section on the review of the literature. All of them

had daily experience of problems with the availability of workers with suitable skills. That is why they all are of the opinion that the government is expected to provide more general training for the companies. Overall, they deem the regulatory system and infrastructure satisfactory, but the level of human resources not high enough – certain skills are especially missing – computer skills, analytical skills, language knowledge etc. Here they expect a more active role of the government and the increase in the efficiency of the education system.

Country aspects – Hungary's readiness for Industry 4.0

The academic experts were of the opinion that *Hungary is basically unprepared for Industry 4.0 applications from the point of view of FDI*. As one expert put it: "Hungary is somewhat lagging behind in preparing the economy for the challenges of Industry 4.0. Especially the digitalisation of the local economy (local SMEs) is below the EU average while infrastructure is very well advanced. Further efforts are needed in digital maturity of domestic firms and skills and education to keep the international competitiveness of Hungary in the future." Expert 2 also underlined these missing capabilities in digital maturity of domestic firms and skills, education. Expert 3 also mentioned these shortcomings in the first place, adding problems with infrastructure and with the capabilities of foreign subsidiaries to the list.

One industry expert emphasized the role of skills and education, mentioning especially the case of those mid-skilled workers, whose jobs will change completely and who do not own the capabilities to adapt themselves to the new situation. Furthermore, he mentioned the case of young, newly graduated mid-skilled workers, who are not even interested in those (actually free of charge) trainings, which enable them to adapt themselves to the circumstances of Industry 4.0. One reason for that can be the tightness of the labour market in Hungary in these jobs, another one the low awareness and the tradition of "it will be good in the future as well like that", very common in Hungary. Thus, *awareness campaigns are needed* here. Furthermore, he emphasized the importance of *life-long learning*, which is still missing basically from the Hungarian business and workers' culture. The other industry expert added another factor to the list. According to him, the most important barrier is the organisational aspect. There is no culture of cooperation, collaboration, involving other people into processes. From that point of view, the Hungarian educational system is also very weak, and this may have negative consequences when adapting Industry 4.0 related elements and may really undermine the competitiveness of the Hungarian economy in the future.

Company representatives *found missing skills and problems with education the most pressing problems*. Two of them emphasized (foreign-owned companies), that in the present labour market circumstances, lack of available and properly skilled workers induced them to introduce robots in their production. One company even "mobilizes" these robots and transfers them to the unit where they can be the most useful given the lack of workers. Thus in the various Industry 4.0 related technologies they rather see an opportunity to address problems of the local economy hindering their efficient operation.

The importance of education, training and skills is reinforced by the literature as well as we could see in the section on the literature (we can mention here Nick, 2018, where this is the area where government intervention is the most needed according to a survey of companies and this is pointed at as the main challenge from the point of View of Industry 4.0 developments in Hungary).

Table 2 Readiness of Hungary to host FDI in Industry 4.0 – Which are the barriers?

	Foreign-owned companies (4)	Hungarian-owned companies (4)	Academic experts (3)	Industry experts (2)
digital maturity of domestic firms	1	4	3	2
infrastructure		1	1	
skills, education	4	4	3	2
capabilities of foreign subsidiaries		2	1	
other, namely				organisation aspects

Sources: interviews conducted in the framework of the project

We asked whether Industry 4.0 is a threat or an opportunity for the Hungarian economy. It was interesting, how answers differed between the various groups of experts and company representatives. First, it is obviously a threat to the Hungarian economy according to all three academic experts. One of them is pessimistic because Industry 4.0 reinforces ongoing adverse tendencies that result in the erosion of the country's attractiveness. Thus Industry 4.0 basically enlarges the weaknesses of the Hungarian economy. On the other hand, both industry experts evaluated Industry 4.0 rather as an opportunity and not a threat. As one of them put it: in spite of all the problems, he still considers it an opportunity for the Hungarian economy. One industry expert emphasized that opportunities differ in the various industries in Hungary. Certain

industries, where Hungary has long tradition and accumulated knowledge, may be able to use the opportunities provided Industry 4.0 related technologies fruitfully for increasing its competitiveness. Thus for these industries, Industry 4.0 related technologies offer a real chance. He mentioned the pharma industry, in which Hungary has long traditions and competitive companies with innovative and R&D intensive activities located in Hungary. Another such sector could be the food industry, where again, experience and knowledge is there. Furthermore, the highly knowledge intensive production of medical precision instruments, which is also based on traditions in Hungary can especially be a good candidate for using Industry 4.0 related opportunities. In this latter industry, he sees very good examples already of Industry 4.0 related elements-based, quickly growing and successful, competitive firms, for example, with activities based on software development.

Company representatives (both Hungarian and foreign) equivocally saw also more opportunities than threats connected to Industry 4.0. They are aware of the opportunities provided by these new technologies, even in those cases, where they do not use these in practice yet. This latter was more true for the Hungarian-owned companies.

Thus, experts, who have a wider picture of the economy, so a general threat, while companies, mainly focusing on themselves, highlighted more the opportunities provided by Industry 4.0 related technologies. Overall, we may conclude that for the economy as a whole, this is more a threat, while individual companies may benefit greatly from adapting these technologies.

The V4 aspect

The academic experts all deem that Czech Republic might be a little bit ahead of the other Visegrad countries, especially Hungary and Poland. However, they all expressed concerns that they do not have a full overview of developments in the four countries.

The two industry experts both admitted not having a complete overview of regional developments, however, they had anecdotal evidences, based on which they assess Hungary's position to be backward in regional comparison. However, they think that the relative positions of the four countries vary in various industries and services. One industry expert worked with Polish firms and thinks that Poland is ahead of Hungary in Industry4.0 applications, for example in retail trade ("smart shelves"). The other expert underlined the aspect of Visegrad cooperation, because according to his experience, Visegrad companies "stream" towards Western European partners (France, Germany), even in areas, where regional cooperation could be fruitful. He also mentioned industries, where individual Visegrad countries seem to be applying Industry

4.0 elements successfully, such as the case of building materials (e.g. tiles, lamps) for Poland. He is aware of other industries in Czechia and Slovakia. He mentioned the case of Czechia, where expertise and industry knowledge at universities are collected in public databases making it easy for firms to find partners if the need arises in their firm for R&D cooperation. He also mentioned problems with regional comparisons, based on publicly available indicators, such as those compiled by the European Commission, Baker and McKenzie, Price Waterhouse Coopers or Roland Berger. These actually reflect the viewpoints of those, who financed these studies, and not of the respective economies or firms. Furthermore, they usually are aimed at providing one indicator about the whole economy, thus industry and regional differences may be concealed.

One important point raised by one industry expert was the importance of the Visegrad cooperation in this area and the possible gain arising from collaboration and cooperation between the four countries. At present we can evaluate Visegrad cooperation as being at a very low level. The assumed industry differences between the four countries in terms of their Industry 4.0 readiness may be a good basis for exchanging experiences and ideas between firms, universities, institutes etc.

Managers of the interviewed companies were also rather giving anecdotal evidence for the relative position of the Visegrad countries concerning their Industry 4.0 developments. For example, two multinational companies indicated that their Czech subsidiaries have climbed higher in the value-added ladder and carry out research and development projects for the whole network of the multinational company, i.e. for the Hungarian subsidiary as well. Two Hungarian firms also indicated their feeling as being a little bit backward compared to their Visegrad counterparts in this area. However, one industry expert saw some industries in Hungary, where there are some Industry4.0 leaders, however, as he put it, they operate as an island in the Hungarian economy, having little contacts locally.

Summary of the survey results

Our relatively small survey of experts and company representatives gave some insight into certain Industry 4.0 related questions in Hungary. These are the following:

- While experts are aware of the complexity of the Industry 4.0 phenomenon, companies usually perceive it just as a bunch of various technologies. The perception is more complex in foreign-owned firms and in knowledge intensive local SMEs.

- Differences in perception and use of Industry4.0-related technologies are obvious between Hungarian- and foreign-owned companies; between the various industries and sectors and between internationalised (in a broad sense, including suppliers of local subsidiaries of foreign multinationals) and non-internationalised Hungarian firms.
- Effects of Industry 4.0 on production are deemed to be realised gradually, thus more gradual than revolutionary changes are expected, though COVID introduces a new unknown element in this equation…
- Impact on multinational companies: both experts and company representatives were rather of the view that MNEs try to cope with Industry 4.0 related developments and R&D needs on their own, but they are ready to share the results within the network of the multinational company, i.e. between the headquarter and the various subsidiaries. It seems, Hungarian subsidiaries are not involved in this work to a great extent, they are rather on the "receiving end".
- As far as the impact on FDI is concerned, the experts agreed that Industry 4.0 will have a significant impact on FDI, however, the trend is not clear cut yet and there are other factors at play, which influence the outcomes.
- The experts more or less agreed that they do not expect mass backshoring or a mass increase in nearshoring, but they expect only a few of these in the near future. On the other hand, company representatives expect more "localisation", i.e. that firms in Hungary and in Europe will try to rely more on local (geographically closer) suppliers in the future. Some companies in the sample already made steps in this direction.
- Experts and companies agree that all sectors are and will be affected, but especially automotive and electronics and their supplier industries.
- Further concentration of activities is expected by almost all interviewed experts and company representatives, which would raise inequality and polarisation, and put peripheral regions in an even more disadvantageous situation.
- FDI policies have not been adapted to the new situation. They must be redesigned, especially in terms of their links with education and skills.
- Governments must provide training and change the education system, make it more efficient and embrace Industry4.0 related skills, including ability to collaborate etc.
- Academic experts assessed that Industry 4.0 is more a threat than an opportunity to the Hungarian economy. Industry experts and company representatives however were more optimistic and saw more the chances offered by Industry 4.0.

- Concerning the Visegrad aspect: the experts saw an unused potential in the cooperation between the four countries, which is now seem to have real content. This cooperation may form a good basis for a regional approach to Industry 4.0 (which does not exist yet).
- Experts and company representatives did not have an overview of regional developments, they gave rather anecdotic evidence on one or another Visegrad country's "leadership" in regional comparison. Our impression is that Industry 4.0 abilities and capacities differ by industry, and every and each Visegrad country has some industries, where it excels.

Conclusion

During the past decade there are two main trends in global production: the spreading of Industry 4.0 and the restructuring/shortening of Global Value Chains. As a consequence of the coronavirus pandemic, both trends will be strengthened. (To put it simply: robots and virtual space can be safer than human contacts and the shorter the production chain is; the less supply-disturbances can be expected). These changes in global production affect FDI, investment patterns. FDI has (or had) been the most important tool in Visegrád countries' economic development, this region is an example for the FDI-dependent growth model. However, this model seems to weaken after the 2008/9 financial crisis. Hungary's dependence on foreign-owned automotive industry remained large but there are problems with skilled labour, education and weak local SMEs. Furthermore, FDI policies, which played an important role in attracting FDI to these countries (besides the locational advantages), do not seem to fully reflect the changes in the business environment and do not seem to be fully adapted to the new situation connected to the rise of Industry 4.0 (and the COVID-pandemic).

The Hungarian literature is quite rich and addressed many aspects of Industry 4.0 Why we have certain important (and unequivocal) results from the various survey and analysis, such as for example on the differences in terms of adapting Industry 4.0 related elements by foreign-owned subsidiaries and Hungarian firms, differences according to the size of the firms, or the importance of and problems with education and training, we can see that there is a lack of a systematic review and analysis of this area. This is so in spite of the fact that both policymakers,

academic experts and industry representatives acknowledge the growing importance of the issue and its significance from the point of view of the future of the Hungarian economy.

Our small survey, conducted in the framework of the project, provided important insights into Industry 4.0 related developments in Hungary. We could document the different perceptions and use and their explaining factors, the expectations concerning Industry 4.0's impact on FDI and multinational companies. The expectations concerning the changes in international productions and their possible implications for FDI policies were also addressed. The Visegrad aspect was analysed in terms of cooperation and competition between the four countries.
The limitations of our analysis are obvious: the smallness of the subsamples hinder generalisations. However, we still find very useful this type of exercises, especially in the circumstances emphasized by one industry expert: the available data (indicators) are usually too complex, do not give region- or city-level or industry-level information. Furthermore, comparative studies prepared by well-known international firms (PwC, Roland Berger, etc.) are usually influenced by the aspects important for those organisations or firms, which finance their studies (or by the interests of the firms themselves, who actually prepare these studies). Thus, this type of qualitative surveys are of special importance when we want to map the changes and impacts related to Industry 4.0.

Our survey confirms that FDI promotion policies should be redefined, adapted and education and training system should be developed. Company-experiences show that the quality of human capital remains important even in the age of robots. In the nineties, qualified labour force was the most important location advantage of Hungary and a major factor in attracting FDI. This advantage has been largely lost and cannot really be compensated by tax benefits on the long term.

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