Andrea Éltető,* Magdolna Sass** & Marta Götz***

The dependent Industry 4.0 development path of the Visegrád countries

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* [elteto.andrea@krtk.hu] (Centre for Economic and Regional Studies, Institute of World Economics)
** [sass.magdolna@krtk.hu] (Centre for Economic and Regional Studies, Institute of World Economics)
*** [m.gotz@vistula.edu.pl] (Vistula University, Warsaw)

Abstract

The dependency of the Visegrád countries on foreign direct investment has been emphasized in the typologies of capitalist models. Today, the question is whether this development path can be sustained. In past years democratic backsliding and a change towards more inward-looking policies have taken place in this region that may also change their attractiveness to foreign investors. The general slowdown in capital flow can weaken the dependency of these countries on FDI, but the fourth industrial revolution can conversely strengthen it. Based on interviews we conducted with business and academic experts in the Visegrád countries, it is shown that the implementation experiences of Industry 4.0 point to the reinforcement of the duality of firm-level developments and dependency on foreign-controlled enterprises. Therefore, we argue that the FDI-based economic growth path of the Visegrád countries has led to the development of FDI-led industrial transformation.

Keywords: Industry 4.0; Visegrád countries; FDI; Varieties of Capitalism

1 Introduction

The slowdown in global trade and investment flows and the reorganization of global production chains have been further intensified by the pandemic. The Visegrád countries are strongly integrated into these global value chains (GVCs) based on labor-intensive activities. Foreign multinationals have established subsidiaries in the analyzed countries since the 1990s. Scholars have recognized the dependence of the Visegrád countries on foreign capital (FDI) and even created a separate model of capitalism (the Dependent Market Economy; DME model) for them. Other authors have used or simply abandoned the 'Varieties of Capitalism' concept (VoC), but the determining role of FDI is widely acknowledged.

Digital transformation may fundamentally alter the landscape of international production with important consequences for those economies which are highly integrated into GVCs. The main aim of this article is to map these consequences and the most important factors that influence them. We would like to contribute to the literature through analyzing

this problem in general, and in the case of the Visegrád economies. The reference point of our article is the Varieties of Capitalism approach – mainly, the aforementioned DME model. We assess the potential effects of Industry 4.0 on the strategic interactions between various actors in the economies, which are basic pillars of the VoC approach. However, the DME model considers neither the impact of technology changes, nor pays attention to the modifying impact of political changes which have happened in the past decade. These are the two gaps in the literature we address in this article.

Although the slowdown in international capital flows and the rise of nationalistic ideas may even question the DME model, according to our hypothesis Industry 4.0 can maintain or strengthen the dependence of the Visegrád countries on foreign capital – although perhaps this dependence will take a different form. We rely on the methodology of semi-structured questionnaire-based interviews conducted with representatives of companies and various organizations, which reinforce this opinion. To weaken the latter dependency, or benefit from it, a well-grounded economic and education policy would be necessary. Policy changes from the perspective of Industry 4.0 are important, because the interests of the increasingly autocratic Central European regimes can contradict economic rationality. Therefore, these countries may not significantly benefit from the development-related effects of this new type of FDI dependency.

The structure of the article is the following: first, we briefly summarize the VoC literature and experiments aimed at creating development models for the Central-European countries. Then we describe the essence of the Industry 4.0 concept. Based on statistics we also show the relative position of the Visegrád countries in terms of Industry 4.0 adaptation. In the second part we present the results of our research based on interviews, and then finally draw conclusions.

2 Theoretical and literature review

This article relies on three main strands of literature. First, the VoC approach is presented; and second, concepts related to Industry 4.0 that are important from the point of view of our analysis. Third, we present the results of the research, which deals especially with Industry-4.0-related developments in the Visegrád countries.

The 'Varieties of Capitalism' literature is large. The original work of Hall and Soskice (2001) founded the concept of 'coordinated' and 'liberal' market economies based on institutional coordination mechanisms. Strategic interactions (corporate governance, industrial relations, inter-firm relations, training and education, employees) among economic actors are the focus of this theory (see Table 1). Regarding the Central-European countries, a study by Nölke and Vliegenthart (2009) introduced the new concept of the Dependent Market Economy (DME) model, creating a separate model for this region. They pointed out that the economic development of these countries depends on foreign capital, foreign-owned firms, and investment decisions by multinational corporations. Indeed, foreign-owned enterprises play a determining role (have a 35–60 per cent share)[1] in production, value-added, exports, and employment. At the beginning of the transformation process, the social, economic, and

[1] Eurostat 'fats' (foreign affiliates statistics) data, 2018 [fats_g1a_08].

political characteristics of the Visegrád region together with external factors (FDI, international organization, integrations, financial markets, level of foreign debt) determined to a great extent the development path of these countries (Bohle & Greskovits, 2007). Considering this, pursuing the DME model was not a question of choice, but practically the only possibility.

Nölke and Vliegenthart (2009) claim that multinational enterprises (MNEs) prefer to hierarchically control local subsidiaries from their headquarters as an alternative mode of finance and governance rather than accept financing by international or domestic capital markets. MNEs prefer to maintain the most innovative activities at their headquarters. Innovation takes place mainly via the transfer of technologies within firms, resulting in a passive innovation system. Dependent market economies are used mostly as assembly platforms; the interest of foreign investors is to maintain rather low labor costs and take advantage of considerable tax breaks in DMEs. For the Visegrád countries, the dependency on intra-firm hierarchies within global value chains serves as a coordination mechanism.

The VoC concept has had many followers who have applied this analytical framework to various economies, but it has also received criticism (see a summary in Farkas, 2018 and Jasiecki, 2018). Especially for the Central and Eastern European (CEE) economies, other capitalist models have been created. Bohle and Greskovits (2012) distinguished three versions of capitalism: a purely neoliberal type in the Baltic states, an 'embedded' neoliberal type in the Visegrád countries, and a neo-corporatist system in Slovenia. They analyzed welfare state institutions and labor relations, structural changes, macroeconomic stability, political systems, the legacy of the socialist system, EU accession, and FDI. Farkas (2016) used a wide range of indicators to create clusters of the CEE countries. The conclusion was that the CEE countries represent a distinct model, even if there are very substantial differences among them.

The DME model was also criticized because it regards FDI as a powerful explanatory factor that determines overall relations between Western investors and the Visegrád countries and which is shaping these linkages in the form of pure dependence instead of more asymmetric interdependence (Farkas, 2016; 2018).

Drahokoupil and Myant (2015) also criticize the word 'dependent' because foreign ownership does not always mean dependency. They suggest the denomination 'FDI-based market economy' for these countries. Following the financial and economic crisis of 2008/9, the thus-far established development model of the Visegrád countries began to change. The role of the state strengthened, and *democratic backsliding* and the spread of *illiberal* or *hybrid* regimes became evident (first in Hungary), and model typologies were questioned. Kornai (2015) wrote about Hungary's 'U-Turn' that began in 2010, meaning a turn away from democracy and to some extent from a free-market economy. While the timing and extent of these trends have differed among Visegrád countries, in all of them more autocratic political parties and anti-Western, anti-liberal discourses and policies have strengthened.

The literature on democratic backsliding in Central Europe is huge; however, few scholars have touched upon the question whether the decrease in democracy (increasing nationalism) translates into a decrease in dependence on foreign capital. With political changes the economic policy of the Visegrád countries has also changed (Sallai & Schnyder, 2018), and state intervention has increased. The Hungarian and Polish governments have decreased foreign ownership in certain domestic market-oriented services. At the same time, export-oriented sectors were not affected (Hunya, 2017; Sass, 2017) – on the contrary, foreign companies in the latter still receive a high level of state support. We can say that nationalistic

policies – with some exceptions – have not manifested against foreign capital, and the path of dependency has remained FDI-based (Bohle & Greskovits, 2019), and this can be shown by the statistics that are available (Sass, 2021). For this reason, foreign investors have not reacted negatively to political changes that have harmed democracy.[2] Foreign affiliates have adapted themselves to the political changes and built their own lobby networks and contacts with the prime minister (Sallai 2020). Financial dependence on non-domestic resources is still a given fact; political changes have not modified this significantly; and foreign capital even contributes to the maintenance of the oligarchic systems. This can also be connected to the fact that, apart from 'traditional' Western capital, Asian (South Korean, Indian, Chinese) investors are increasingly active in the region.

These were just some examples of explanations for the political turn that has occurred in the Visegrád region. Together with the above-mentioned political changes, international FDI flows have slowed down. Apart from this, a new kind of economic revolution has also taken place: a boom in Industry 4.0, which represents a kind of external shock for the Visegrád countries. The reactions of the latter's firms and policies can influence whether they remain stuck in their present dependent/asymmetrically interdependent model or create a new path. The question is if a new path is possible at all. Based on the concept of in-betweenness by Szűcs (1983),[3] Farkas (2018) argues that the historical legacy of the region does not support a change to a knowledge-based economy with more symmetrical interdependencies. Let us see what the characteristics of the Industry 4.0 concept are, and why the phenomenon represents a challenge for these countries.

An increasing body of theoretical and empirical literature deals with the emergence and proliferation of Industry-4.0-related technologies. The definition of Industry 4.0 is complex and composed of many pillars (like robotization, the Internet of Things, additive manufacturing, cybersecurity, and cloud computing). Today it is acknowledged by scholars that the Industry 4.0 concept refers to a whole ecosystem, including labor market, innovation and production networks. Industry 4.0 requires model-based enterprise manufacturing, simulating every production process.

In our article we regard terms such as *digital business transformation, Industry 4.0, I4.0,* and *the fourth industrial revolution* as largely synonymous, while remaining, of course, fully aware of the fact that they do not stand for exactly the same issues. Yet our intention was to move beyond other types of studies which intentionally pick up on and focus only on selected Industry 4.0 technologies (like 3D printing, or the Internet of Things or robotics); rather, our ambition in this research project was to cover a full range of related technologies and aspects of the wider term I4.0, not limiting our study to some predefined and narrowly defined technologies.

The fourth industrial revolution can be associated with the emergence and diffusion of advanced digital production technologies that radically alter manufacturing, blur the boundaries between physical and digital production, and accelerate innovation. This approach

[2] Sallai et al. (2020) concluded based on interviews with German CEOs that foreign investors have no moral problem with the Hungarian authoritarian regime because they separate their own personal opinions from their role as company managers.

[3] Szűcs (1983) positioned Central Europe as lying in between Eastern and Western Europe and as having been different for at least one thousand years.

modifies preexisting definitions of the vertical integration of companies and the importance of this in the strategy of enterprises (Cséfalvay & Gotskis, 2020). It is also difficult to define in which industry it occurs, because only a synergy of activities creates final value for the client. Szalavetz (2020a) showed that digital transformation may facilitate integration into global value chains (GVCs) for so-called factory economies, including the Visegrád countries, which are specialized in labor-intensive processes. On the other hand, labor-intensive processes are now not necessarily transferred to lower-wage countries as they can be carried out by robots. Therefore, automation has increased the phenomenon of backshoring or nearshoring from low-wage (Asian) countries. Studies have also proved that automation slows down the offshoring process (De Backer et al, 2018). Backshoring initiatives imply that some firms have relocated manufacturing activities back to their home country (Dachs et al., 2019), which is claimed to reduce costs and enhance quality control and customer responsiveness (Ancarani et al., 2019). Nearshoring, on the other hand, denotes transposing previously offshored activities closer to the home country or neighboring region, hence facilitating the management and supervision of value creation.

Digital transformations impact international production in different ways on different levels. Thanks to big data, firms can better anticipate and commit resources. The Internet of Things and 3D printing help reduce transaction costs and simplify GVCs. Industry 4.0 can speed up productivity growth and production improvements, and thus help firms to catch up. Therefore, we could argue that the application of Industry 4.0 elements can help to decrease the inequalities between domestic and foreign firms. Robotization, for example, reduces the investment outlay for small and medium enterprises (SMEs) – e.g. by avoiding the need to build large warehouses.

However, there are also arguments that, on the contrary, Industry 4.0 exacerbates the dependency and differences among firms. An analysis by Veugelers et al. (2019) confirmed the trend towards a digitalization divide between European companies. Several SMEs so far have not implemented any digital technology, and have not even developed plans to start investing in digitalization. (Certainly, the coronavirus pandemic gave significant impetus towards digitalization, but small firms are coping only poorly with this.) The main risk of such polarization is a further accumulation of differences and the widening of the digital gap. As demonstrated by Veugelers et al. (2019), persistently non-digital firms are less likely to be innovative, to generate new jobs, and to apply higher mark-ups compared to digitalization frontrunners. Smaller firms are also generally slower to adopt Industry 4.0 data-driven technologies. Key barriers include a lack of awareness, limited risk-taking, and sparse financial resources for investing in ICTs and a lack of human resources and capabilities (OECD, 2020a).

A World Bank report (Hallward-Driemeier et al., 2020) focuses on three types of process technologies within Industry 4.0 whereby differences can be observed according to the size of firms. *Transactional technologies* (like digital e-commerce platforms, and blockchain) reduce transaction costs and therefore can strengthen globally fragmented production and help firms' market inclusion. The use of digital platforms by SMEs in the EU is not notably different from that of large firms. Transactional technologies have been useful in pandemic lockdowns because they enable many services to be undertaken virtually. *Informational technologies* exploit the exponential growth of data and the reduced cost of computing; examples include business management software, cloud computing, big data analytics, and machine learning. Their use is uneven among European countries and firms; over time, the newest

information technologies are deployed in a pattern more reminiscent of operational technologies, with benefits being realized by larger firms in leading regions and knowledge hubs. *Operational technologies* combine data with physical automation; examples include smart robots, 3D printing, and the Internet of Things. According to the report, operational technologies tend to weaken market inclusion, while the installation of robots entails high fixed costs and is thus likely to benefit larger enterprises. Scale matters for 3D printing too, and this is also used more by large firms.

Similarly, Stiebale et al. (2020), based on firm-level analysis, concludes that robotization seems to disproportionally benefit the top firms in an industry. Firms with initially high productivity and profitability can profit from a higher degree of robotization, while for others this may have insignificant or even negative effects. Thus, the size of the firm matters in terms of the intensity of the use of Industry 4.0-related technologies. This is important for the Visegrád countries, as domestic firms are predominantly SMEs, while large firms are often foreign owned. Industry 4.0 thus may deepen the productivity and innovation gap between them.

Industrial associations and governmental organizations have launched programs in the Visegrád countries to inform and help SMEs to apply elements of Industry 4.0. Regarding the use of certain information technologies of companies/organizations (like ERP and CRM software, and Big Data analytics), the latter countries, just like a decade ago, are situated in the bottom half of the European ranking (see Figures 1–3 in the Annex) with Hungary in last position. Regarding fast broadband internet, the situation is somewhat better (see Figures 1a–d in the Annex). In the case of operational technologies, Visegrád countries have rapidly increased their industrial robot stock and density,[4] but are still among the laggards. Most of these robots, however, have been installed in the automotive and electronics industry, dominantly in foreign multinational affiliates.

Only a small number of studies have addressed Industry 4.0 related technologies in the Visegrád countries in international comparison. These studies usually underline the similarities of the four countries compared to their more developed Western European counterparts and less developed competitors from Eastern and Southeast Europe. On the other hand, they highlight differences within the Visegrád countries in terms of the Industry 4.0 intensity of various industries.

Naudé et al., (2019) analyzed the Industry 4.0 readiness of the CEE countries. The study analyses three dimensions: (1) technological competencies, (2) entrepreneurial and innovative competencies, and (3) governance competencies. In each dimension, the authors evaluate several international indices and rankings, and a composite normalized score is calculated. The study finds that Czechia and Hungary are more ready for Industry 4.0 than Slovakia and Poland.

Cséfalvay (2020) states that the development of robot stock and robot densities in Central Europe (CE) cannot be understood without GVCs and FDI. These stimulate robotization in these countries and give rise to 'dependent robotization'. According to Cséfalvay (2020), this can take place at two levels; as sectoral dependence on a single industry (e.g. car

[4] The industrial robot stock per 10,000 employees increased 3 to 6-fold between 2010–2020 (Industrial Federation of Robotics data).

manufacturing), and as a structural category, as robotization in a region mainly relies on the localization decisions of MNEs. Regarding sectoral dependence, automotive specialization obviously supports the introduction and adaptation of robots and training of employees. However, robotization could become dependent on the automotive sector and changes/challenges in this industry might block the deployment of robots in the future. Regarding localization, as is known, the Visegrád region has become an automotive production hub, but it is possible that in the future low-skilled, labor-intensive production activities might continuously be offshored to these countries, while complex production processes (capital-, skills- and R&D-intensive activities) could be reshored in the most developed European countries.

Szabo (2020) points out that leaving aside the foreign-controlled automotive industry, the Visegrád countries are less prepared for the transition than many of their Western European peers. More than half of all industrial robots installed in the V4 are used in car manufacturing (in Slovakia, the share of robots in car manufacturing reaches almost 80 per cent of the total). Robot density and digital transformation in manufacturing remains rather low.

Szalavetz (2020b) focuses precisely on the digital transformation of firms based on a sample of 24 large, export-oriented companies, subsidiaries of global automotive companies, and main suppliers operating in Czechia, Hungary, and Poland. Results show that because of labor shortages, additional investments have been made in the automation of production and support processes. The motivation for automation is remaining competitive and the decreasing price and improved features of robotic solutions. The present semi-automated or manual production technologies in CE are obsolescent; there is no specialization in advanced activities or increasing unit value added. (At some of the companies, however, functional upgrading has intensified.) The study concludes that while there are no signs of digital-transformation-induced new drivers of growth, the traditional engines of growth in Visegrád factory economies are eroding.

Considering the Visegrád countries individually, the literature on Industry 4.0 is more abundant. Slovakia Johanesová et al. (2019) assess that two-thirds of companies realize the importance of Industry 4.0 and also apply such technologies in some form. However, a relatively large proportion of respondents consider the importance of Industry 4.0 applications to be less critical to their company's future. The barriers to Industry 4.0 are generally the low level of innovation, and a lack of financing. Papula et al. (2019) found that the greatest need for the application of Industry 4.0 in Slovak companies is in the automotive and electrotechnical industry, and the main challenges are corporate culture and in the information of people. Ulewicz et al. (2019) implemented a survey among Slovakian and Polish SMEs that showed that Slovak companies use robots and predictive maintenance to a much greater extent than Polish companies, but Polish firms use large amounts of data, and mobile devices. The survey also defined some mistakes with the application of Industry 4.0: a lack of IoT synchronization with communication infrastructure and the ability to process big data, a lack of compatibility with pre-existing solutions, excessive system complexity, the generation of unnecessary data, a lack of specialists and appropriate training. Regarding the Polish automotive sector, Stawiarska et al. (2021) assessed the maturity of Industry 4.0 implementation and posited that the main objective of implementing Industry 4.0 has been increasing efficiency and effectiveness, and less often, product innovation. The highest level of maturity was achieved by large enterprises and chassis manufacturers, while tire and wheel manufacturers had the lowest level of maturity. Gajdzik and Wolniak (2022) analyzed the effects of

implementing Industry 4.0 in the Polish steel sector and found that it increased the quality and the level of customization of products. Apart from this, there was greater speed and agility of operations. The survey of Rosak-Szyrocka et al. (2021) in Poland showed that the main barrier to the implementation of Industry 4.0 in companies is low awareness, high cost, and a lack of support for implementing the concept. Regarding Czechia, Krajčík (2021) examined the digitalization of SMEs and found a slow transition, lack of strategy, and lack of funds. Olšanová et al. (2021) revealed that most large Czech companies have already implemented Industry 4.0 elements and the critical threat is a lack of skilled labor. Managers expect some state incentives. Vrchota et al. (2020) examined the preparedness of human capital for Industry 4.0 in Czechia and pointed to mixed education results and relative computer illiteracy compared to the rest of the EU. In Hungary, Nick et al. (2019) described the results of a survey that showed that most Hungarian companies have recognized that data collection is indispensable if they want to remain competitive in the future. However, the entire volume of data that is collected is not evaluated, and Hungarian companies are not strong at offering special services based on the data they collect. Nagy et al. (2020) point out that at Hungarian SMEs the application of Industry 4.0 could be supported by highly qualified employees who have possibly obtained experience at multinational corporations. Without skilled labor, the inherited disadvantages of SMEs will be strengthened, further increasing the gap between large corporates and medium-sized companies. Spatial differences may be reinforced based on the manufactured products that influence the possibilities associated with Industry 4.0. More developed industrial clusters and cities can gain additional benefits.

Altogether, Industry 4.0 may have a mixed effect on the dependent Visegrád economies. Table 1 shows specific dimensions of these effects, concentrating on the main analytical areas (strategic interactions) of the VoC approach. Industry 4.0 can reinforce pre-existing coordination mechanisms (the role of multinational companies) but can change the connections and strategic direction of companies. As is obvious from Table 1, the directions of such changes are not clear and straightforward in all the areas.

In this paper we argue that the dependent nature of the Visegrád model will further be strengthened not only by robotization, but by all Industry 4.0-related technologies. Thus, we can speak of a 'dependent Industry 4.0' (meaning the modern production-control process) economic model of the Visegrád countries. We base this argument on the fact that, according to Table 1, the gap between foreign and domestic firms regarding Industry 4.0 has increased and is increasing further. Consequently, a kind of vicious circle can be created whereby foreign firms lean less and less on technologically laggard domestic companies. On the other hand, the continuous development of employees' skills and knowledge will be increasingly valuable with the application of new technologies. Company- and technology-specific knowledge – because of the traditional focus of educational systems – can be created and utilized mostly at foreign firms, further deepening the gap between the two groups of companies. To test this hypothesis, we conducted survey-based research among company, academic, and industrial experts.

Table 1 Strategic interactions in dependent market economies [DME] and possible changes due to Industry 4.0

	Dependent market economies	**Possible impact of Industry 4.0**
Distinctive coordination mechanism	Business-led	
	Multinational companies	Further strengthening of the role of multinational companies in the absence of a high number of competent domestic firms; possibly: emergence of new domestic innovative companies.
Corporate governance	Headquarters of multinational companies	Headquarters of multinational companies, but Industry 4.0 may decrease coordination costs or necessity of coordination, and may decrease risk of certain activities (Buckley & Strange, 2015).
Location of production	Visegrád countries	Industry 4.0 technologies may result in further slicing of GVC processes, further decoupling of labor-intensive activities and their transfer to lower-wage countries. Additive manufacturing (3D printing) with the decrease in presently high costs (Laplume et al., 2016) may result in reshoring of the production of certain components produced in small series back to developed countries (Strange & Zuchella, 2017); Robotization and automatization may lead to concentration and economies of scale in the fore and thus change the regional structure of industrial production (UNCTAD, 2020); With the increase in the speed of data flows, specific data-related activities may be relocated to other countries (Strange & Zuchella, 2017) Industry restructuring due to the impact of Industry 4.0 (UNCTAD, 2020); Big data and customization of production will push the majority of value added to the end of the GVC (UNCTAD, 2020), thus the relative share of value added of companies operating in the middle (production) of GVC will decrease further; The net impact on various industrial locations is unclear (Ferrantino & Koten, 2019).
Industrial relations	Plant-level and company level coordination in the areas of wages and working conditions	The bargaining power of local workers will decrease due to Industry 4.0 (e.g. robotization [Strange & Zuchella 2017]; automatization [UNCTAD, 2020], changes in working conditions, mental problems [Kovács 2017a; b]).

Table 1 (Continued)

	Dependent market economies	**Possible impact of Industry 4.0**
Vocational training and education	Few vocational training opportunities at the workplace; Relatively high education level	Further increase in the importance of vocational training, but still little of this at the workplace. In international comparison, relatively low educational level from the point of view of disseminating use of Industry-4.0-related technologies (Nick, 2018; Szabó et al. 2019).
Inter-firm relations	Standard market relationships between subsidiaries of multinational firms and indigenous firms	Standard market relationships of the subsidiaries of multinational firms with indigenous firms – due to the low number of competent local firms, the number and intensity of such relations may decrease; Industry 4.0 (e.g. IoT; 3D printing) (Strange & Zuchella, 2017) may reduce these relations further; at the same time, digitalization may enhance modularity – changing requirements for suppliers.
Employees	Firm-specific skills Long-term tenure	Firm-specific skills and long-term tenure in certain areas; in other areas less skills and more flexible tenure; Increase in number of jobs in certain auxiliary industries (Mandel, 2017 or Ferrantino & Koten, 2019); Unclear net impact of relocations on the labor market (Ferrantino & Koten, 2019).

Source: authors' compilation based on the literature

3 Methodology

The semi-structured questionnaire-based interviews were conducted between December 2019 and August 2020, live, or via Skype or phone. To assure confidentiality, all respondents remain anonymous. Phone-call interviews were taped, and the interviewers took notes. The analysis of collected data was conducted in three steps – data reduction, data display, final conclusion-drawing and verification.

In Poland, 16 interviews were conducted with seven experts, five scholars, and four companies. The sample contains persons representing academia, business, and public authorities; from small and large firms such as IBM and Microsoft, governmental bodies, as well as Polish universities. In Hungary, 13 anonymous interviews were conducted. The respondents were the following: four representatives of Hungarian subsidiaries of foreign MNEs (three large-sized and one mid-sized company); four representatives of Hungarian-owned firms (two SMEs and two large firms operational in various industries, including automotive, electronics, and financial services); three academic experts (working in aca-

demic institutions or universities) and two industry experts (a leader in one EU-financed Industry 4.0 program, and a representative of an industry association). The interviewees were selected on a different basis in the two countries. For academia, we had a look at publication lists and contacted those experts who had recently published articles on the topic of Industry 4.0 and FDI or competitiveness. In terms of business, we tried to include companies of different sizes and ownership (foreign and local) – here, the attitude of companies (not all were welcoming) and the size of the project proved to be a major limit to the number of the interviews. Industry experts were selected from membership lists of relevant organizations. Government representatives were chosen based on their participation in various related fora.

For Czechia we use the results of Bič and Vlčková, (2020), whereby interviews were conducted with six experts, including two CEOs of multinational technological companies operating in Czechia, one of Czech origin, and one foreign citizen. One respondent was an entrepreneur and at the same time the head of an association representing companies. Two respondents were from a governmental organization, and one respondent was a researcher in a big international organization. In Slovakia, six interviews were conducted, as explained in Ferencikova and Zacharova (2020), with representatives and experts from government, business and academia: the state secretary of the Ministry of Economy, an HR director of a global pharma company, a professor of international business, a head of a local car industry manufacturing association, and two SME owners. We have thus a relatively small sample, but one which includes representatives of many different institutions, companies, government, agencies, etc., so we had access to the opinions and standpoints of various groups with different relationships to Industry 4.0.

4 Results and Discussion

Our results reinforce the tendencies we perceived based on statistics and previous surveys. On the one hand, most domestic firms in all Visegrád countries are not really prepared for the application of various Industry 4.0 related technologies, and they usually lack strategies for addressing Industry 4.0. On the other hand, most foreign-controlled firms and multinational subsidiaries are way ahead in terms of implementing Industry 4.0. in all Visegrád countries. Below, we summarize the opinions of the experts who were interviewed, grouping them into four major topic areas.

We evaluated the *Industry 4.0 related maturity, opportunities, and challenges* of the countries. According to the interviewed Polish experts, the adaptation of Industry 4.0 is time-consuming, requires accompanying changes and appropriate preparation, and piloting and testing are essential. Changes in human resources and psychological adjustments at the executive level are critical. It is a challenge that the classic factory is disappearing, being replaced by distributed service-oriented production. Similarly, a Hungarian industry expert also pointed out that Industry 4.0 is part of a longer-term strategy, as related costs arise immediately, while benefits occur only a significant time lag. Most Hungarian companies are not applying new technologies or new modes of organization. However, many firms are in the process of generational change (old owners are retiring and transferring their companies to their successors), leading to the overview and inventorying of the firms' characteristics, assets and flaws. This process of firms' 'self-discovery' can be helped by Industry 4.0 related

technologies, especially big data. Otherwise, if there is no such important change in the life of the company, it does not change by itself; an ongoing culture of development is lacking in Hungarian firms (unlike in foreign ones).

Hungarian academic experts think that especially the digitalization of local SMEs is below the EU average, while the related infrastructure is well developed. Further efforts are needed to increase the digital maturity of domestic firms and skills and education to maintain the international competitiveness of Hungary in the future. The importance of lifelong learning was also emphasized, which is still missing from Hungarian business culture. Company representatives found the lack of skills and education to be the most pressing problem, mentioning that the lack of available and properly skilled workers induced them to introduce robots.

Concerning the digital maturity of Czech firms, two institutional respondents consider this to be good (Bič & Vlčková, 2020), but business representatives were more critical, qualifying it as rather poor. The generational change which is now taking place in many firms heralds not only a threat but also an opportunity, similarly to in Hungary.

In Slovakia, business experts think that Industry 4.0 is not yet perceived as a necessity, and a large proportion of companies are just beginning to think about related solutions. The main barriers to the introduction of Industry 4.0 are risk capital exposure, low R&D corporate expenditure, and the innovation capacity of SMEs. The low level of innovation can result from the existence of various other barriers such as a lack of financial resources (Jeck, 2017). Respondents agreed on the fact that Industry 4.0 will require a growing amount of investment into services and knowledge-intensive industries. They expressed their worries about whether Slovakia is prepared enough, given the underdevelopment of the educational sector and infrastructure in the country. They also believe that changing nature of the investments will result in a war for talent that is becoming more and more visible in the country (Ferencikova & Zacharova, 2020).

Our results show – in line with previous surveys – that there is still a lack of proper preparation and a kind of incompetence in the case of domestic firms, which contradicts policy makers' rhetoric and ambitions. The respondents confirmed the cited studies in Table 1 regarding the increasing importance of education in Industry 4.0.

Another topic was the relation of *multinationals (MNEs) and local firms* concerning Industry 4.0. In Poland, respondents think that in the long-term classic business models and GVC cooperation will inevitably change due to the application of various Industry 4.0 technologies. In the spread of Industry 4.0, not only is a willingness to share the knowledge of parent companies essential, but also a willingness to adopt new technologies by subsidiaries.

For Hungary, industry experts emphasized the differences among companies according to their activities and sectors/areas of operation. Experts emphasized 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 respective multinational company, thus Hungarian subsidiaries will benefit from this process. Decisions about the use of Industry 4.0 related technologies are made locally by the management of the subsidiaries in question. Hungarian respondents agreed that foreign companies bring in organizational and technological culture, and they develop themselves constantly, partly due to pressure from customers.

In Czechia, the capabilities of foreign subsidiaries are considered good by all respondents (Bič & Vlčková, 2020). They mention that there is often pressure from the parent com-

pany and that automatization has been ongoing for over 15 years. The situation is very similar in Slovakia too, thus our results confirm the problem indicated in Table 1: a further decrease in the contact between multinational subsidiaries and domestic firms.

The topic of *production location* was also raised in the interviews. Responses are similar to the indications in Table 1, with the net effect uncertain. Some Hungarian respondents expect more backshoring to Hungary, but according to others, no mass backshoring can be forecast, but some more nearshoring may take place. In Poland, respondents think that no massive relocation and closing of factories will happen due to path dependency and sunk costs. Instead, according to the experts, current investors can transplant modern solutions. Czech respondents (Bič & Vlčková, 2020) believe that Industry 4.0 will give more power to MNEs (through concentration and the market dominance of the few).

The location decisions of investors are influenced by several factors related to the *countries' attractiveness*. According to the respondents, Poland's attractiveness to FDI remains high because of a stable macroeconomy and the digital competencies of the whole society. Hungarian academic experts emphasized that there will surely be a change in location-based advantages – more concentration can be expected, with capital cities leading in terms of attracting FDI, thereby increasing polarization and inequalities. They emphasized the primary importance of education, training, and skills. Regarding Slovakia, all respondents agreed on the fact that Slovakia is an attractive investment location because of its good development, eurozone membership, stable legal and political environment, the central location of the country, and educated and skilled labor force. However, they stated that there has been a brain drain of the best talent, there is a lack of specific kinds of labor force in some regions, lower digital literacy compared to the neighboring countries, big regional differences, and shortages of infrastructure (Ferencikova & Zacharova, 2020). In Czechia, respondents consider the infrastructure to be rather poor; backbone data lines are missing, and digital communication with the public sector is insufficient and the quality of education is inadequate (Bič & Vlčková, 2020).

Based on the interviews, we can observe a duality concerning the application of Industry 4.0. This duality is partly the same as everywhere else (see OECD, 2020a): i.e., between SMEs and large firms. But foreign ownership and control adds a further factor to this, as the features of domestic and foreign firms are quite distinct in terms of understanding and applying industry 4.0. In general, domestic firms are not prepared enough, while foreign firms are the leaders in Industry 4.0 technologies (see Table 2). The relation between multinational headquarters and local suppliers is asymmetrical in terms of the advantage of the former in know-how and knowledge development.

Thus, Industry 4.0 strengthens foreign dependency and duality in the Visegrád region. Supported by this study we argue that 'FDI-based economic growth' or the DME model of the Visegrád countries, has led to developments in 'FDI-led industrial transformation' too. No real modernization of technologies and of corporate organization/governance system is possible without foreign capital and multinational companies.

As we have written before, populist tendencies and governments have appeared in the past decade in the Visegrád region. These usually use nationalist and anti-foreign arguments in their rhetoric. However, real economic processes – like global production and the spread of Industry 4.0 recently – contradict these arguments and reinforce foreign dependency. This dependency is neither purely bad nor good. In our opinion, however, it is critical to ensure

the positive external effects and spillovers from these more advanced foreign firms to local companies. Accordingly, the transferal to local economies of the advantages of Industry 4.0 created by FDI should be encouraged. The consequences for economic policies are straightforward and mentioned in numerous studies: the relevance of a smart policy environment and adequate incentives and education cannot be overestimated in this respect.

Table 2 Industry 4.0 – local and foreign firms, main points of interviews

	Poland	**Hungary**	**Czechia**	**Slovakia**
Sample (no. of interviews)	16	13	6	6
Introduction of Industry 4.0	Mostly foreign and domestic large firms	Mostly foreign firms	Mostly foreign firms	Mostly foreign firms
Preparedness of domestic firms	Lagging behind. Innovation is weak, few enterprises have a plan.	Poor. Local firms usually do not have strategy	Poor, improving	Not enough
Opportunities for domestic firms	HR changes, mental adjustments at executive level	Generational change	Generational change	Concentration of RD centers, better use of EU programs
Challenges, problems	Needs time, benefits later, Inadequate education system	Skills needed; managerial capabilities are mostly not adequate	Lack of skilled labor	Low level of innovation, lack of finance, high labor costs, brain drain, obsolete education
Reshoring of foreign firms	Not strong backshoring from Poland	No mass backshoring from Hungary, possibly some nearshoring	Backshoring to Czechia and nearshoring	Automotive industries and services can be affected
MNE headquarter – local supplier relationship	Not only is willingness to share knowledge on the part of mother companies needed, but also subsidiaries' desire to adopt new technologies.	I4.0-related R&D is rarely conducted in local subsidiaries. Decisions about the use of I4.0 technologies made locally by the management of the subsidiaries.	MNE headquarters keep know-how to themselves, appropriation dominates. Industry 4.0 gives more power to MNEs	MNEs retain know-how and there is little sharing with local subsidiaries

Source: authors' compilation from the interviews

It is not one of the aims of this article to provide detailed economic policy recommendations. There is, however, one area where we found consensus among experts in every country: the significant importance of education. Here, the thorough reform of the primary and basic education system and better remuneration and education of teachers is necessary, because those competencies that are important for adapting to Industry 4.0 develop in the first decade of education. Pató et al. (2021) show that the latter competencies are the ability to learn, cooperation, flexibility, problem-solving, and creativity. At present, Central European education systems are not reinforcing these competencies[5] and their reform would only create long-term results.

5 Conclusion and further research

The development of the Visegrád countries – as part of the CEE region – has attracted interest among scholars who deal with models of capitalism. Not long after the former's EU accession, it became evident that this region represents a new kind of model in the VoC approach. Nölke & Vliegenthart (2009) coined this as the Dependent Market Economy model, putting the growth-engine role of FDI into focus. Dependence on foreign capital has been a fact for these countries, but in the past decade the sustainability of this FDI-dependent model has been questioned because of the deceleration in investment flows and globalization. There has been a populist and antidemocratic shift in these countries too, mostly in Hungary and Poland, which the VoC approach has not yet addressed.

At the same time, the fourth industrial revolution is taking place and becoming widespread due in part to the declining price of industrial robots. The Visegrád countries also had to react to this phenomenon and policy makers recognized its importance. Governmental organizations in all countries launched strategic papers and campaigns about Industry 4.0. The foreign-owned multinational subsidiaries present in the Visegrád countries had already been active in introducing Industry 4.0, mostly in the automotive and electronic industries.

As surveys and experience show, local firms lag behind foreign companies, not only because of their lack of financial resources. This statement only reinforces the results of previous studies (as listed in the review of the literature) and is partly related to the specialization of the analyzed countries in the automotive and electronics industry and the significant participation in foreign-led GVCs in the latter (Cséfalvay, 2020; Szabo, 2020). Our expert interviews reinforced the claim that Industry 4.0 is not just a set of technologies but a complex production-organizing system, which is more difficult to adapt. So far, most domestic firms in the Visegrád countries have not been able to absorb or catch-up in this regard, thus their managerial mentality must be changed. According to our interview respondents, generational change at domestic companies may represent a chance for this change in the longer term. Based on previous surveys, as listed in our article, and on our own results, we presume that the duality between domestic and foreign firms will remain, and Industry 4.0 will maintain or increase the dependency on foreign capital in the Visegrád countries. This dependency is not necessarily a problem if advantages for the local economy can be secured, too.

[5] See OECD (2020b) for more details.

The recent coronavirus crisis will probably further exacerbate this dependence because state resources have decreased and global FDI flows have fallen dramatically. The recovery and development of the Visegrád countries will need foreign capital later on, and FDI dependency will prevail. It is a question, however, whether democratic backsliding will reach such an extent that it disturbs the investment environment and weakens the attractiveness of these economies considerably. In our opinion this is not probable because on the one hand significant tax advantages and allowances for foreign investors continue to exist, and even if Western investment has decreased, Asian investors – being less sensitive to democratic backsliding – will still be interested. What, however, could seriously endanger the attractiveness of Visegrád countries is the lack of labor force, and skills-related problems. (The emphasis is on skilled workers, because less skilled workers can be replaced by robots but for high value-added-production skills are necessary.) Autocratic regimes usually do not aim to strongly develop education, and the emigration of talented young people from the region may further increase. Without educated and skilled people, however, these countries cannot be integrated into modern industrial systems.

Our study's limitations are mainly related to the small number of interviews. Further research could be conducted through increasing the number of interviewed companies and experts, and embracing more types of activities and industries in each country. Furthermore, creating a larger dataset that involves more interviews would enable the authors to conduct statistical analysis as well. Having a much larger sample would enable researchers to highlight country-related differences and country specificities even within such a relatively homogeneous group of countries as the Visegrád group. A larger dataset may enable researchers to study differences between companies of different sizes, in different regions, and those which engage in different activities. Furthermore, another potential avenue for further research would be the analysis of the impact of the COVID pandemic on the relationship between the reorganization of GVCs and application of Industry 4.0 related technologies, and the consequences thereof for the Visegrád countries. Because our 'interview period' only partly coincided with the crisis, we could not address this problem. Additionally, our article did not go into detail about the economic policy consequences of the change to FDI-led industrial transformation. Besides education policy, as mentioned in our article, there may be many other economic policy areas that are deeply affected by this change, and a science-based elaboration of an economic policy agenda that tries to enhance the positive consequences of this change is without doubt necessary. Further studies may look more closely at the internal heterogeneity of the V4 group. Although sharing many similarities, these four countries differ in many respects even in terms of critical macroeconomic levels (such as Slovakia being the only member of the eurozone). Such factors deserve special attention in further studies. Besides the specific limitations of our analysis that might derive from the unified general approach, we hope that our exploratory study and reflections on the V4 region may provide fresh insight and impetus for further analysis of the socioeconomic and political evolution of the Visegrád economies in digital times.

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ANNEX

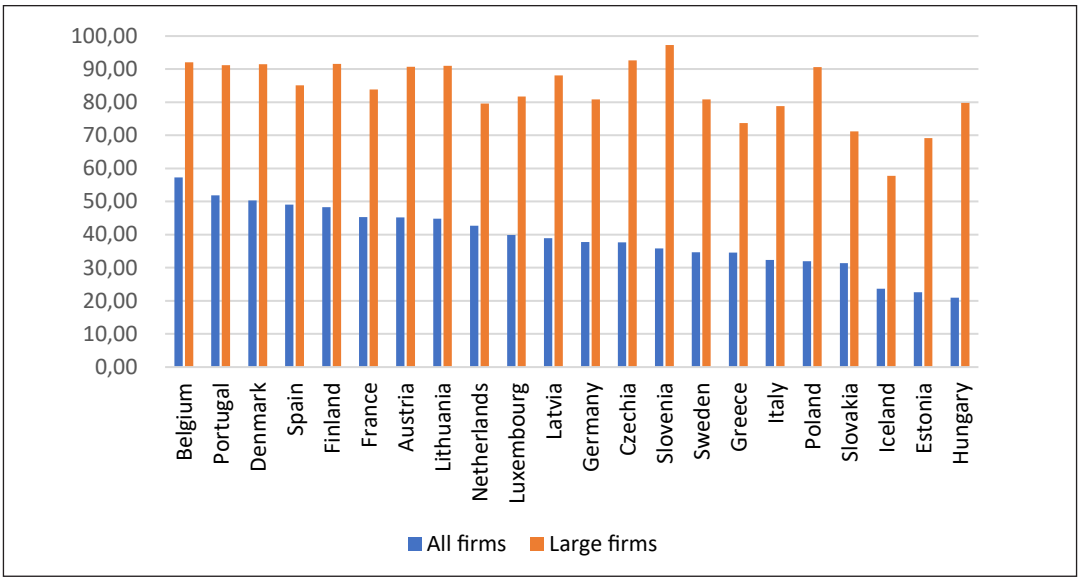

Figure 1 Businesses using ERP (Enterprise Resource Planning) software (per cent), 2021

Source: OECD dataset 'ICT access by business'

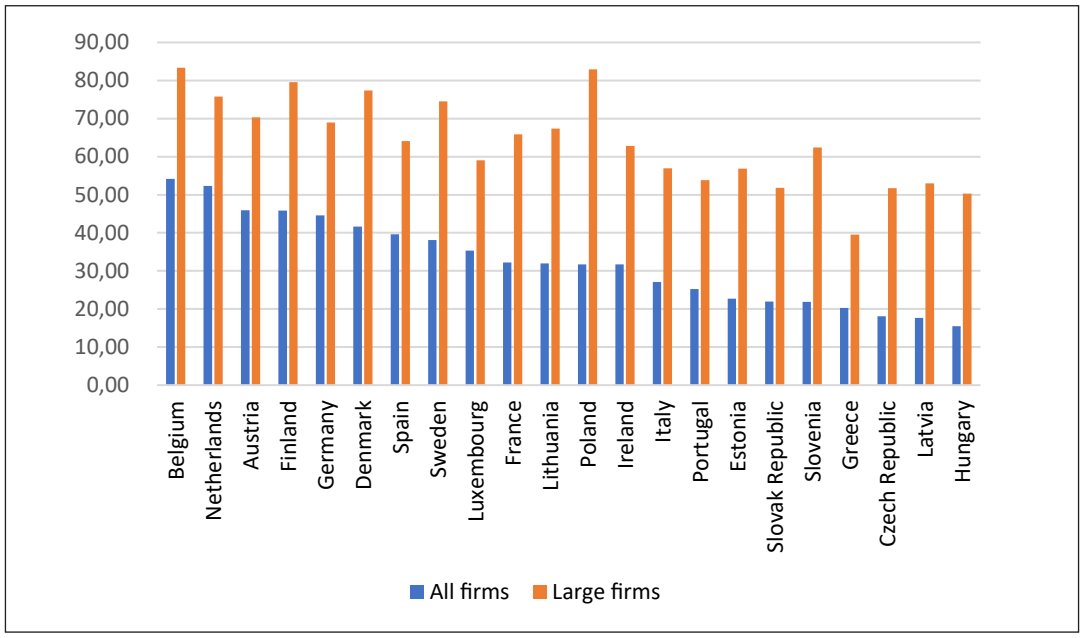

Figure 2 Businesses using CRM (Customer Relationship Management) software (per cent), 2021

Source: OECD dataset 'ICT access by business'

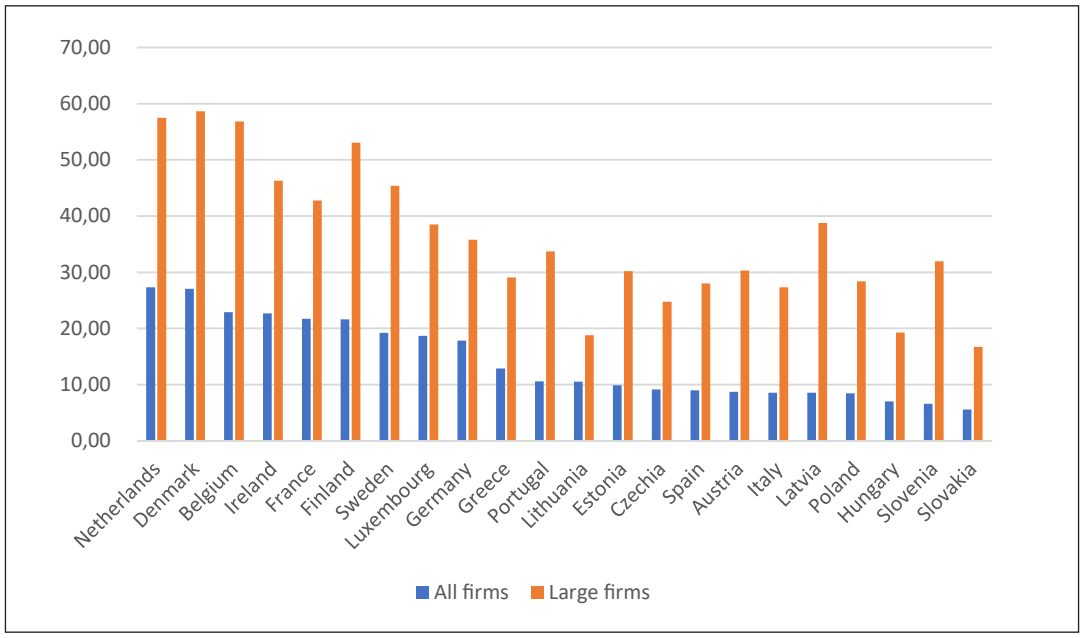

Figure 3 Businesses having performed Big Data analysis (per cent), 2020

Source: OECD dataset 'ICT access by business'

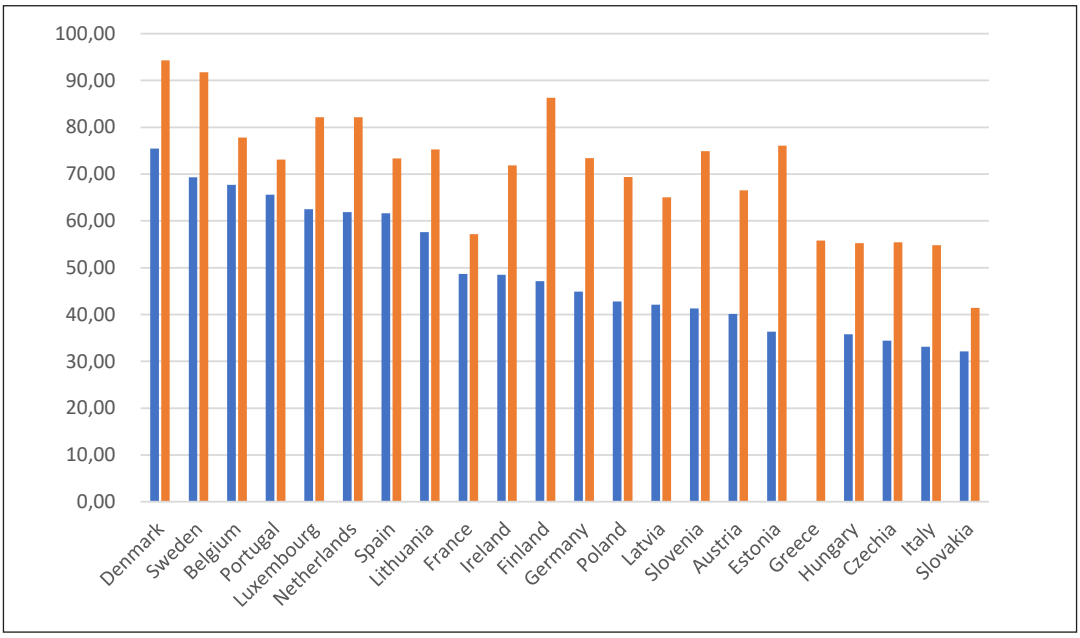

Figure 4 Businesses with a broadband download speed at least 100 Mbit/s (per cent), 2020

Source: OECD dataset 'ICT access by business'

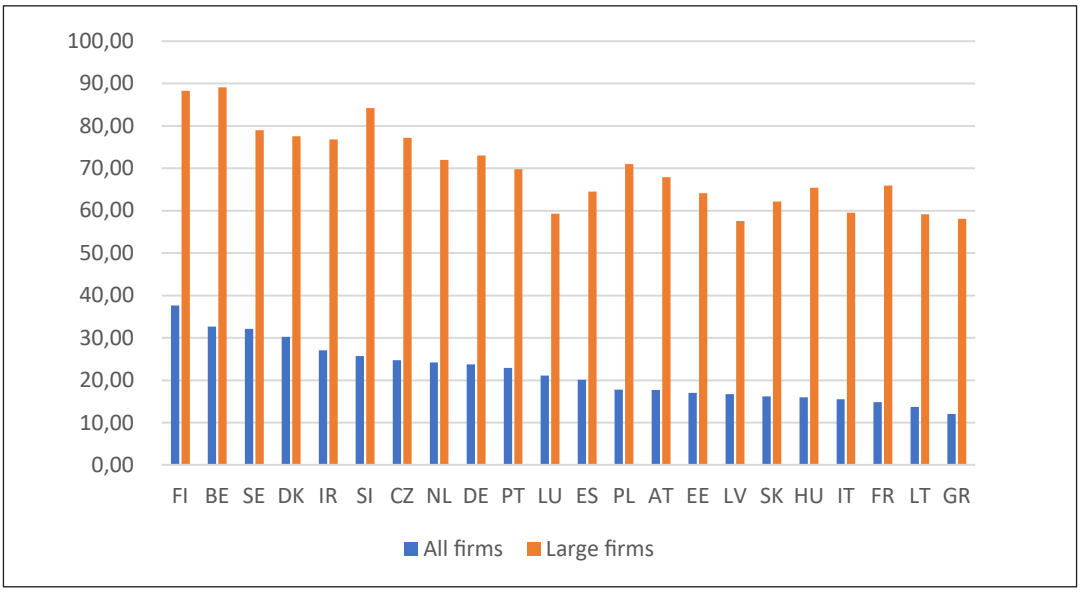

Figure 5 Businesses that provided any type of training to develop ICT related skills of the persons employed, within the last 12 months (per cent), 2020

Source: OECD dataset 'ICT access by business'