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DIGITAL BUSINESS

The Digitization of European business

The Digital Innovation Hubs, what is next?

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ABSTRACT

This paper can help to better understand the state of the art Industry 4.0 in Europe and the best policies to fulfil its adoption by European business. Digitization or Industry 4.0 represents the future of business, providing ample opportunities for better productivity, efficiency and different business strategies based on digital tools. Using a critical literature review method, this study's aim consists of offering a real picture of the role of the European Commission's efforts in enabling and fostering the digitization of business through Industry 4.0 initiatives by supporting the creation of Digital Innovation Hubs (DIHs). The DIHs are one-stop shops for promoting digitization through collaboration and open innovation among economic actors on an open innovation basis. DIHs are promoted and sponsored by the European Commission and complement different national and regional initiatives to foster digitization of business, industries and regions. Results suggest that DIHs promote open innovation but are neither coordinated with national and regional initiatives, nor fully support SMEs. The digitization of Europe, however, remains uneven, complicating the potential effect of DIHs.

KEYWORDS

Digitization, Open innovation, Europe, Industry 4.0, Digital Innovation Hubs

JEL CODES

O3, R1

Objective
To show how Digital Innovation Hubs (DIH) for fostering the digitization of business.

Methodology
Critical literature review.

Results
DIHs promote open innovation but SMEs fail to utilize them. The digitization of Europe, however, remains uneven, due to structural differences across countries.

Limitations
The methodology.

Practical implications
DIHs should coordinate with national-level and regional initiatives, targeting better SMEs.

1. INTRODUCTION

Digitization or Industry 4.0 represents the future of business, providing ample opportunities for better productivity (Porter and Heppelmmen, 2015). The introduction of digital technologies in production and operation activities is going to complement the well-studied phenomenon of ecommerce and the digitization of markets and marketing activities (Taiminen and Karjaluoto, 2015). In particular, the digitalization of the production system through the concepts associated with Industry 4.0 represents a qualitative leap in the organization and management of companies' value chain, where commercial and productive relations entail a constant connection between customer, supplier, distributor - logistics and manufacturer. Digitization enables the transformation of entire industries and products. In this study, our aim is to offer a real picture of the role of the European Commission's efforts in enabling and fostering the digitization of business through Industry 4.0 initiatives. In particular, we are going to analyze the Digital Innovation Hubs (DIHs). Specifically, using a critical literature review method, this article reviews the state-of-the-art of the Digital Innovation Hubs, which are like one-stop shops for promoting digitization through collaboration and open innovation amongst economic actors such as firms, universities, technology centers or business associations, among others. DIHs are promoted and sponsored by the European Commission and complement different national and regional initiatives to foster digitization of business, industries and regions. The main contribution of this paper points out that, despite promoting open innovation and fostering Industry 4.0 adoption, DIHs are not coordinated with other national or regional innovation policies to digitize business. Also, when one of the main goals is enabling SME digitization, we observe that DIHs are primarily interacting with large firms, which are the ones leading and utilizing them. Lastly, DIHs should be sensitive to specific places, that is, they should also take into account the

level of preexisting digitization in the country (*digital divide*). The paper presents implications for policy makers.

The remainder of this paper is as follows. After this introduction, we explain Industry 4.0 in Section Two, then we present the state of the digitization process in European countries in Section Three. Section Four analyzes the Digital Innovation Hubs and Section Five concludes.

2. WHAT IS INDUSTRY 4.0?

Recent literature discusses Industry 4.0, presenting its state of the art and limitations (e.g. Rejikumar *et al.*, 2019; Kosacka-Olejnik *et al.*, 2019; Sony and Naik, 2019; Ghobakhloo, 2020). According to Buchi, Cugno, and Castagnoli, (2020).), Industry 4.0 means varying the strategies and the organization of companies, and business models. It also means changing the value and supply chains, processes, products and the relationship with the stakeholders. In this sense, Industry 4.0 has generated opportunities and weaknesses that must be managed to positively impact firms and society. Industry 4.0 is a new stage of the different evolution of the industrial revolutions that have occurred throughout history.

- The first revolution began in the 18th century and developed throughout the 19th century. In this revolution, mechanical elements were introduced to facilitate production tasks, through the use of hydraulic energy, steam power or machine tools.
- The second industrial revolution took place at the end of the 19th century. According to Herčko, Slamková, and Hnát (2015), this industrial revolution follows the introduction of electrically-powered mass production based on the division of labor.
- The third revolution came more recently, approximately in 1970, when electronics and information technologies began to be used in order to automate production tasks, using electronics, IT and computers. This revolution is also known as the digital revolution, and its use has been extended until today, even incorporating the Internet.
- The fourth and last industrial revolution, such as Frank *et al.* (2019) argue, is still occurring at this time, and there are sectors that are changing more noticeably and faster than others. The main novelty is the Cyber-Physical systems and Artificial Intelligence

Industry 4.0 is a representation of the fourth revolution that has occurred in manufacturing, complementing other business-related activities previously digitized, such as e-commerce, social networks or online platforms. Industry 4.0 is directly related to manufacturing in the industrial sectors. According to Buchi *et al.* (2020), the expression "fourth Industrial Revolution" was named "Industry 4.0" after the German industrial plan "*Industrie 4.0*". The industrial plan "*Industrie 4.0*" was launched by the federal government of Germany along with universities and private companies with the aim of implementing advanced production systems in order to enhance the productivity and efficiency of national industry. The concept of Industry 4.0 takes into account the increase in the digitalization of manufacturing industries, where physical objects are perfectly integrated into the information network (connected to the Internet), which allows decentralizing production and its adaptation in real time to the future. For this reason, Industry 4.0 is articulated by a set of digital enablers (technologies that allow the achievement of the challenges posed by the new revolution), which apply to different areas of the company.

Dalenogare, Benitez, Ayala, and Frank, (2018) state in their article that Industry 4.0 is a new industrial stage in which the integration of the vertical and horizontal manufacturing processes and the connectivity of the products can assist firms to obtain a superior industrial performance. Concretely,

the so-called CPS are formed by the integration between the manufacturing operations systems and the information and data flows. So, the core factor that distinguishes this new industrial stage is the complex variation in the manufacturing systems' connectivity due to the integration of Information and Communication Technology (ICT), Internet of Things (IoT) and machines in CPS. Thus, the objective pursued by Industry 4.0 is to create a coherent framework in order to gain competitiveness from the increase in value delivered to customers through the double route of performance improvement and cost reduction based on greater efficiency in the processes. Industry 4.0 utilizes algorithms and databases to increase productivity and enhance the value of products for the markets.

According to Buchi *et al.* (2020), there are two key factors for the success of Industry 4.0: integration and interoperability. *Integration*, on the one hand, is referred to how integrated industrial automation systems lead to greater innovative characteristics through networking with stakeholders and also contribute to developing connections between the cyber and physical worlds. This would mean the integration of different manufacturing systems that were isolated and even the integration of the supply chain with suppliers and customers. *Interoperability*, on the other hand, improves production processes, inside and outside the boundaries of a business, interconnecting systems that speak different languages and exchanging knowledge and skills. Put differently, subsystems of production (maintenance, production, stocking, etc.,) are going to be integrated and communication flows between them.

According to Lasi, Fettke, Kemper, Feld, and Hoffmann, (2014), organizational factors driving digitization and facilitating its implementation generally serve two different aspects. The social or economic ones, on the one hand, are the following:

- *Short development periods*. Shortening the time it takes for a product from when it is conceived until it reaches the customer begins to be an important competitive advantage for many companies.
- *Demand individualization*. There is a clear trend towards lot size, as many customers are looking for a product differentiated from the rest or customized.
- *Flexibility*. Flexibility is essential for being competitive, since the system must be able to adapt to demand changes effectively.
- *Decentralization*. For greater speed when making decisions the hierarchical scales within the company should be reduced.
- *Resource efficiency*. Optimization of resources is required to achieve sustainability in the context of the industry.

As regards technological factors, on the other hand, these are represented by:

- *Mechanization and automation*. Increasingly more technical aids are used to facilitate manufacturing tasks. In addition, there is a clear trend towards automating productive tasks through the use of automated workstations.
- *Digitalization*. The growing installation of sensors in the field of manufacturing results in a large amount of data in digital format that must be controlled and analyzed. This trend also leads to the birth of other complementary technologies such as digital protection or augmented reality.
- *Miniaturization*. The technological tendency to achieve better performance in smaller spaces derives in more complex products whose manufacture cannot be addressed only through human labor.

Apart from that, the new model of data-centric industry needs a deep transformation based on the intelligent integration of ICT within business. In this sense, as Frank, Dalenogare, and Ayalac, (2019) explained in the article, Industry 4.0 considers the total integration of the different sub-systems in a company, connecting the entire product life cycle manufacturing and supply chain activities through the implementation of digital technologies. The integration of digital technologies allows companies to collect information in real time and also add value to the whole product life cycle. The enabling technologies used by industry 4.0 are listed as follows (Buchi *et al.*, 2020):

- Advanced manufacturing solutions
- Augmented reality
- Internet of Things
- Big data analytics
- Cloud computing
- Cyber security
- Additive manufacturing
- Simulation
- Horizontal and vertical integration
- Other enabling technologies

Table 1 shows the enabling technologies as well as the opportunities derived for industry 4.0.

As shown in Table 1 and according to Buchi *et al.* (2020), the opportunities of Industry 4.0 can be classified into six central typologies or clusters:

- Production flexibility;
- The speed of serial prototypes;
- Greater production capacity;
- Reduced set-up costs and fewer machine shutdowns;
- Higher product quality and less rejected production;
- Better opinion of the customers about the products;

Also, we can add others such as environmental effects (materials and energy reduction, reducing waste, etc.), as well as social ones (protection of the environment, automation of routine processes for the improvement of workers, etc.). Other ecological and social benefits such as enabling better and versatile working environments (Birkel Veile, Müller, Hartmann, and Voigt,, 2019).

According to Dalenogare *et al.* (2018), three advantages that distinguish Industry 4.0 are:

- **Vertical integration,** that concerns the integration of ICT systems in various hierarchical levels of an organization, improving the integration among the production and management levels in a company. Integration technology and organization and fostering better productivity.
- **Horizontal integration,** which refers to the collaboration between companies, with resource and real time information sharing. Collaboration for joint productivity in the supply-chain.
- **End-to-end engineering,** that consists of the integration of engineering in the entire value chain of a product.

Industry 4.0 can support firms to properly address the growing volatility of the markets, the expanding demands and complexity of products and services, as well as the reduction of innovation cycles. In addition, it is anticipated that the flexibility of products and services will be expanded, increasing the complete efficiency of industrial value generation.

Table 1. *Pillars of Industry 4.0 enabling technologies*

INDUSTRY 4.0 enabling technologies	Opportunities
Advanced manufacturing solutions	– Decreases set-up costs, errors, and machine downtimes, due to the capacity to learn tasks from the operator. – Flexibility, given by the participation of the employees in the work and control stages and removing the technological limitation of systems. – Higher production capacity through the possibility of modifying the criteria, to distribute work activities among operator and machine and allow more efficient work.
Augmented reality	– Higher speed in prototyping through design with augmented virtual reality – The reduction of set-up costs, errors and machine downtime, caused by the reception of information in real-time, which enhances work and decision making procedures. – Superior product quality and less production waste
Internet of Things	– Higher product assessment from the customer. This is achieved through a greater knowledge of customer preferences, the inclusion or customers in production and a more effective trace of the product from the factory to the customer. – The decrease of set-up costs, errors, and machine downtime, the enhancement of the quality of the products and the reduction of production waste. All of this achieved by a better interconnection along the supply and distribution chains and by the possibility to detect machinery breakdowns in real-time
Big data analytics	– Better product assessments from the customer, because of faster communications, personalizing products and a better understanding of customer needs. – Flexibility as a result of the possibility to estimate the demand. – Greater product quality and less production waste. Since the enhancement in the efficiency and distribution of the warehouses optimizes the supply chain
Cloud computing	– Better product assessments from the customer. – The decrease of set-up costs, errors, and machine downtime. – The enhancement of product quality and the reduction of production waste.
Cyber security	Cyber security technologies are designed to assist other technologies by restricting the threats associated with the distribution of information.
Simulation	– Faster speed in prototyping, which improves production times. – The reduction of set-up costs, errors, and machine downtimes.
Additive manufacturing	– The quicker times in the complex design stages allow greater speed in prototyping. – The decrease of set-up costs, errors, and machine downtimes, a better product quality and a reduction in the production waste. Given the smaller production costs and waste because of the development of smaller and customized production lots and the reduction of the lead times.
Horizontal and vertical integration	– The decrease of set-up costs, errors, and machine downtime, the enhancement of the quality of the products and the reduction of production waste. This is achieved due to lower costs, the capacity to detect and tackle problems and the better connections in the supply chains. – Increased production capacity.
Other enabling technologies (for particular fields, such as the agri-food and bio-based economy)	– Better product quality and lower production waste in order to optimize production and to reduce waste costs.

*(**Source:** own elaboration based on Buchi et al., 2020)*

3. THE DIGITIZATION OF EUROPEAN BUSINESS: WHAT DO WE KNOW?

Digitization is a critical driver for companies and the public sector with a view to accelerating business growth and improving operations. However, the implementation of digital technologies is still a challenge throughout Europe. As will be seen in this section, the level of digitization remains uneven, depending on the sector, country and size of company. For example, only 20% of SMEs in the EU are highly digitized. Moreover, the overall adoption of *eGovernment* services is 53%, with some countries reaching more than 75% and other countries below 30%. In this sense, European Digital Innovation Hubs have a key role to play to address these gaps.

According to the annually published *Digital Economy and Society Index Report 2020a (DESI)*, over the past year, EU countries have improved their overall digital performance, although at very different speeds. The Digital Economy and Society Index (DESI) supervises the digital performance of Europe and monitors the progression of the European countries in digital competitiveness. The DESI index is composed of the following 5 dimensions*: Connectivity, Human Capital, Use of Internet, Integration of Digital Technology and Digital Public Services*.

Figure 1, which follows, presents the advance of Member States regarding the level of digitization of society and economy during the last five years. As can be seen, the most significant progression (not the total score accumulated) has occurred in Ireland (IE), the Netherlands (NL), Malta (MT) and Spain (ES). It should be noted that robust policies and specific investments have been applied in these states in all areas measured by DESI. See Figure 1.

As seen in Figure 1, the majority of the countries which are below the EU average in the level of digitization, have not progressed much in the last five years. This is the case of Bulgaria, Greece and Romania. However, all these Member States have recently launched several initiatives in the various areas monitored by the DESI so results may be visible in the coming years.

Figure 2 presents the ranking of Member States on the DESI in 2020 based on 2019 data. While the digital economies in the EU with most progress are Finland, Sweden, Denmark and the Netherlands, the lowest rating on the index belongs to Bulgaria, Greece, Romania and Italy.

Comparing the two previous Figures, Finland and Sweden are among the leaders in overall digital performance. Again, the northern European countries outperform.

The five dimensions that composed the DESI are briefly analyzed below:

3.1. The connectivity dimension of the Digital Economy and Society Index (DESI)

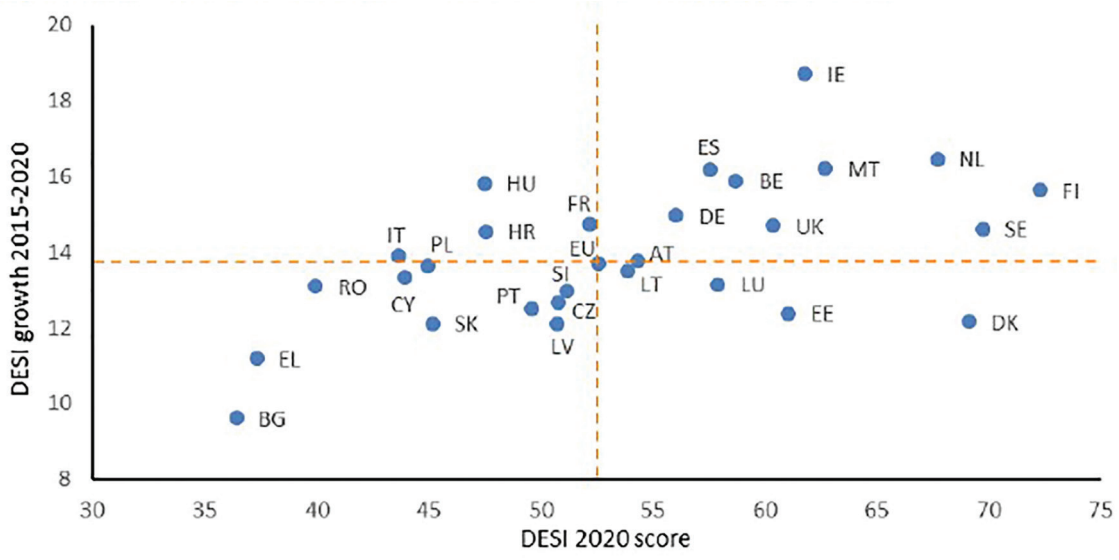
The connectivity dimension of the DESI contemplates the demand and the supply side of fixed and mobile broadband. Curiously, Digital connectivity is considered a social right in the EU. See **Figure 3**.

As seen in Figure 3, regarding connectivity, Denmark had the highest rating, followed by Sweden and Luxembourg. Greece, Cyprus and Bulgaria registered the lowest scores for this dimension of the DESI.

3.2. The human capital dimension of the Digital Economy and Society Index (DESI)

The human capital dimension of the DESI ranges from internet user skills that allow people to contribute in the digital society to advanced skills that enable the labor force to use digital goods and services. See **Figure 4**.

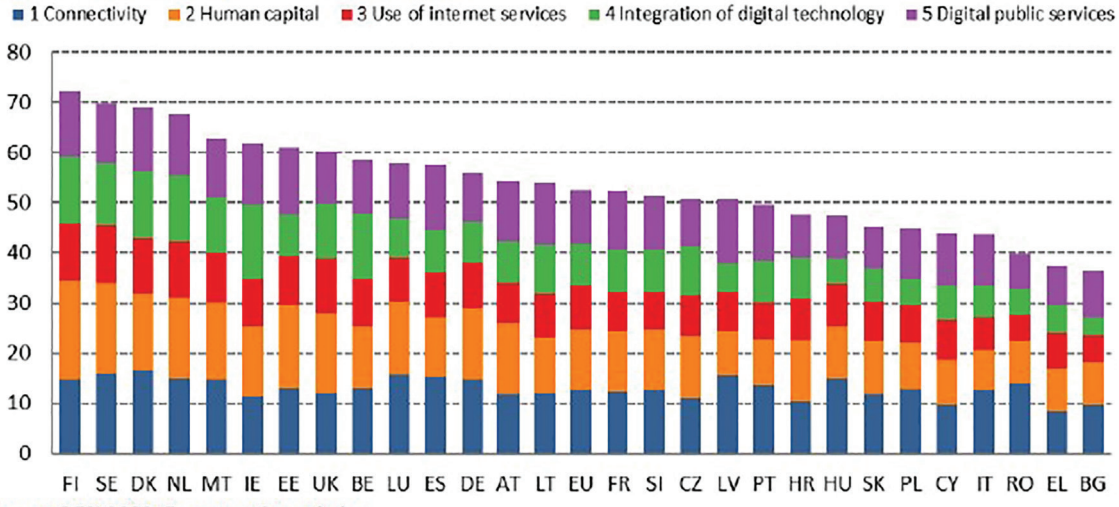
Figure 1. *Member States progress in terms of Digital Economy and Society Index, 2015-2020*



Source: DESI 2020, European Commission.

(**Source:** *Digital Economy and Society Index Report 2020)*

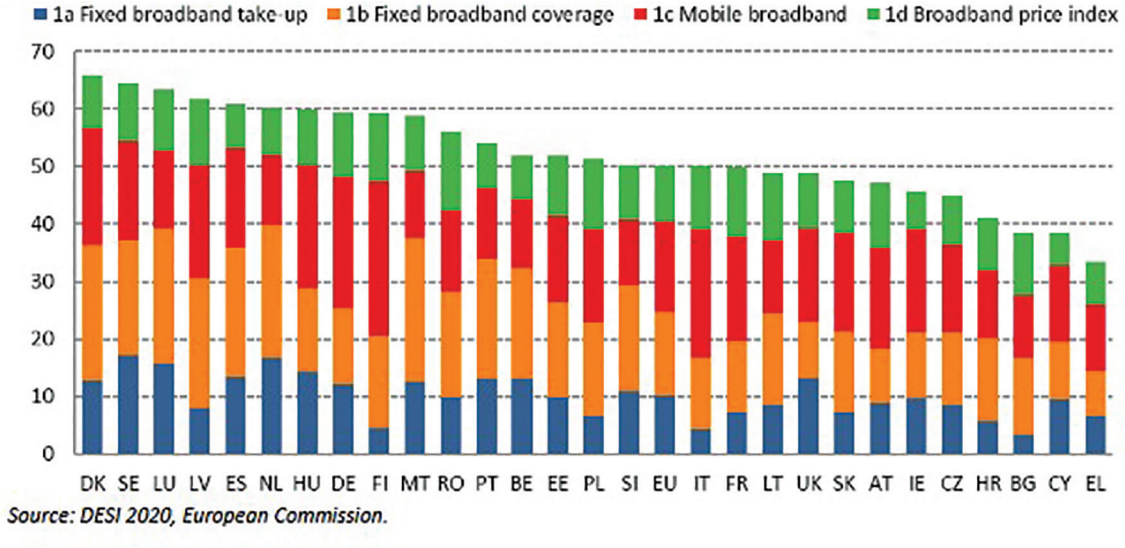
Figure 2. *Digital Economy and Society Index, 2020*



Source: DESI 2020, European Commission.

(**Source:** *Digital Economy and Society Index Report 2020)*

Figure 3. *Digital Economy and Society Index 2020, Connectivity*



(**Source:** *Digital Economy and Society Index Report 2020)*

According to Figure 4, Finland is frontrunner in both sub-dimensions of human capital, followed by Sweden, Estonia and the Netherlands. On the other hand, Italy, Romania and Bulgaria present the lowest scores.

Focusing on the advanced skills and development sub-dimension and according to the Digital Economy and Society Index Report 2020, around 9.1 million people worked as ICT specialists in 2018 throughout the EU (EU, 2018). Moreover, in 2019, 20% of companies, mostly large enterprises, employed ICT specialists to develop and operate ICT systems. In this sense, companies are offering more training to their personnel to develop their ICT skills. Looking at countries, Finland and Belgium are leaders in this domain. Looking at company size, large companies stand out in terms of the proportion of ICT training (70%), while only 23% of SMEs provided this training in 2019.

3.3. The Use of internet services dimension of the Digital Economy and Society Index (DESI)

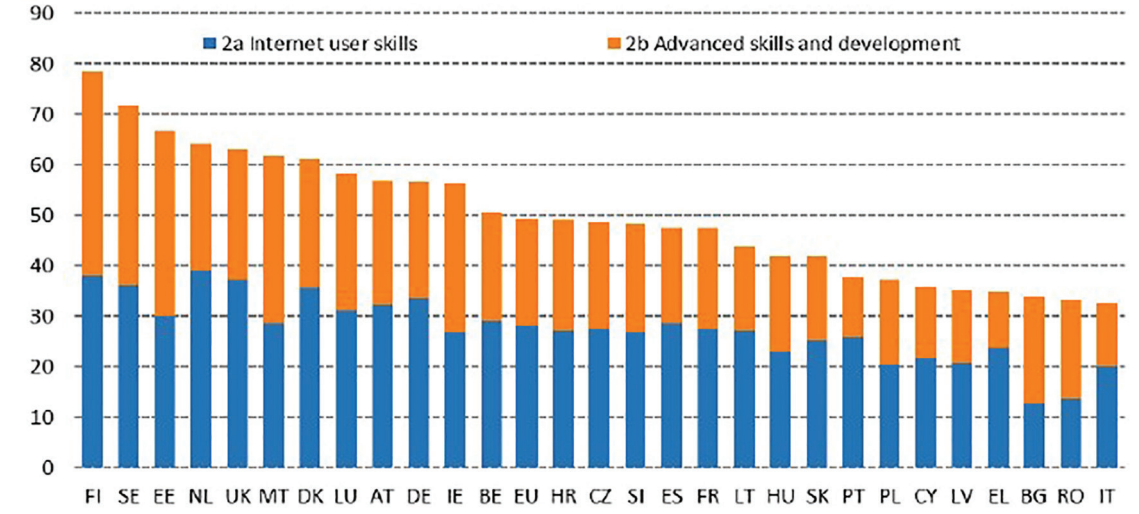
The Use of internet services dimension measures how many people use the internet and the type of activities they undertake online. See **Figure 5**.

Figure 5 shows the inequalities throughout EU Member States in relation to the use of internet services. Finland, Sweden, the Netherlands and Denmark present the most energetic internet users. In contrast, Romania, Bulgaria and Italy are the least active.

3.4. The Integration of digital technology dimension of the Digital Economy and Society Index (DESI)

With the integration of digital technology dimension of the DESI, the digitization of businesses and e-commerce is evalu-

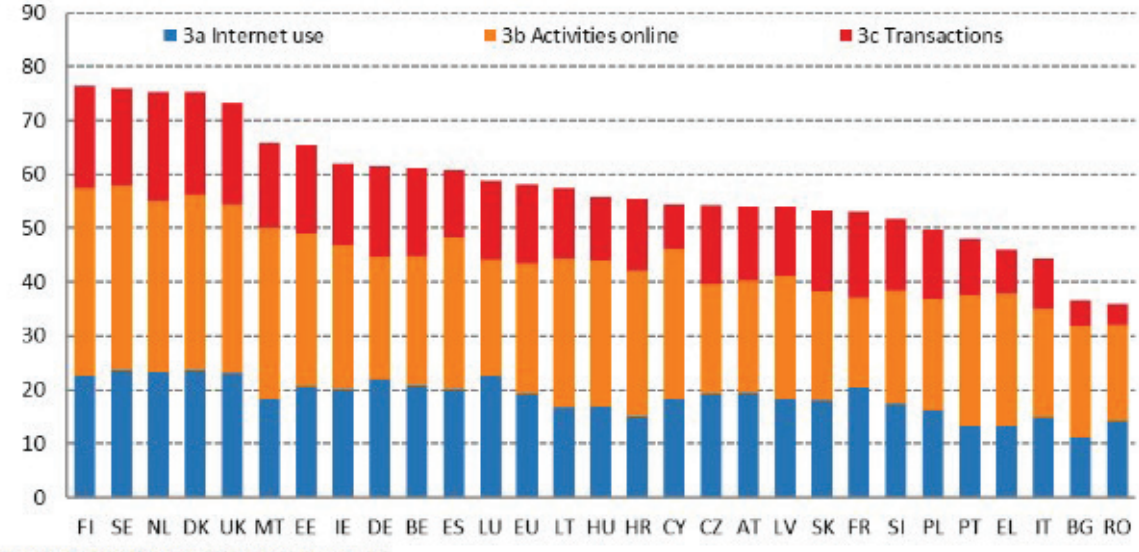
Figure 4. *Digital Economy and Society Index 2020, Human capital dimension (Score 0-100)*



Source: DESI 2020, European Commission.

(**Source:** *Digital Economy and Society Index Report 2020)*

Figure 5. *Digital Economy and Society Index 2020, Use of internet services (Score 0-100)*



Source: DESI 2020, European Commission.

(**Source:** *Digital Economy and Society Index Report 2020)*

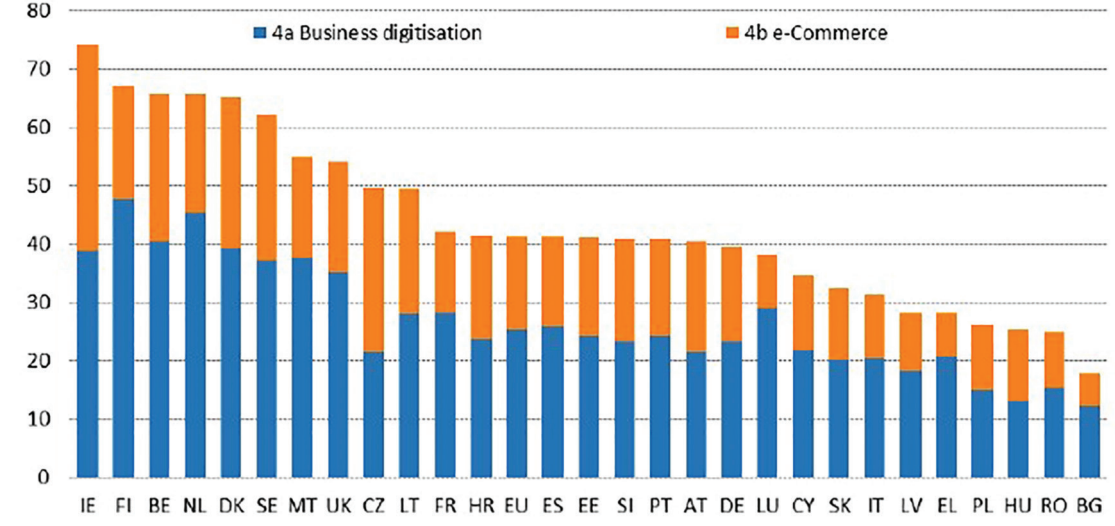
ated. For businesses, the digital transformation allows new opportunities and enhances the evolution of reliable technologies. See **Figure 6**.

The performance of countries, regarding this dimension, is presented in Figure 6. Regarding this dimension, Ireland, Finland and Belgium present the greatest scores. However, Bulgaria, Romania and Hungary are at the other end of the scale, with scores below 43 points, the EU average.

The following **Figure 7**, shows the **Digital Intensity Index (DII)** by level in the different countries. According to Digital Economy and Society Index Report 2020, this index evaluates the availability at firm level of 12 different digital technologies: internet for at least 50 % of people employed; recourse to ICT specialists; fast broadband; mobile internet devices for at least 20 % of people employed; a website; a website with sophisticated functions; social media, paying to advertise on internet; buying medium-high cloud computing services, sending e-invoices suitable for automated processing; e-commerce web sales accounting for at least 1 % of total turnover; and business-to-consumer (B2C) web sales of over 10 % of total web sales. So, the DII score (0-12) of a company is measured by the selected digital technologies it uses.

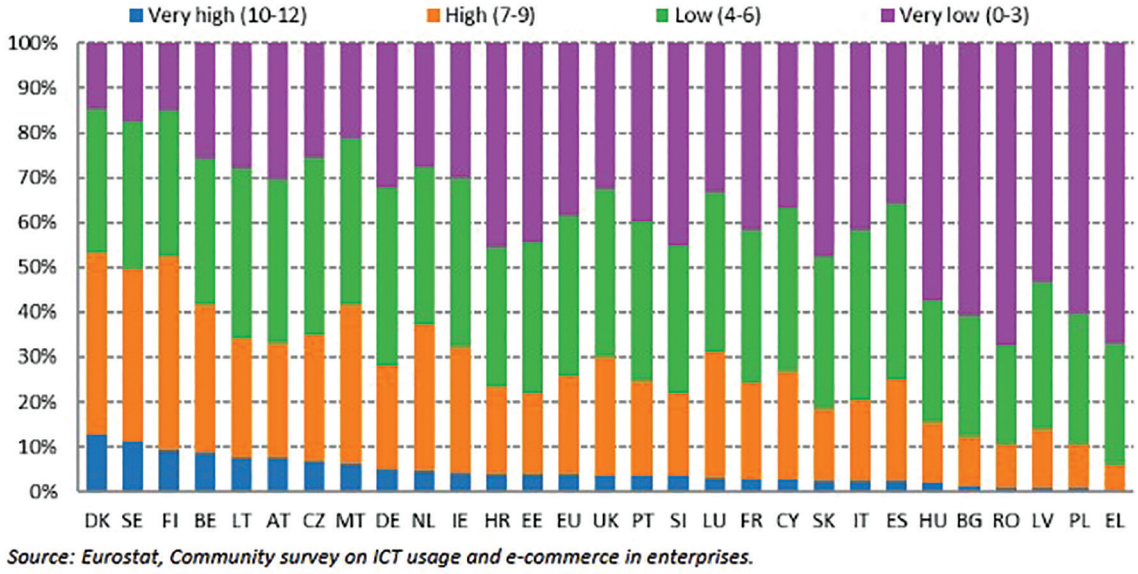
The North-South effect observed in **Figure 8** should be highlighted. As noted, in Denmark and Sweden the percentage of firms with a very high DII is above 10 %, followed by Finland. By contrast, in countries such as Bulgaria, Romania, Greece, Latvia and Spain, the majority of businesses (over 55 %) have had low investments in digital technologies, so they show a low DII.

Figure 6. *Digital Economy and Society Index 2020, Integration of digital technologies*



(**Source:** *Digital Economy and Society Index Report 2020)*

Figure 7. *Digital Intensity Index 2020*



(**Source:** *Digital Economy and Society Index Report 2020)*

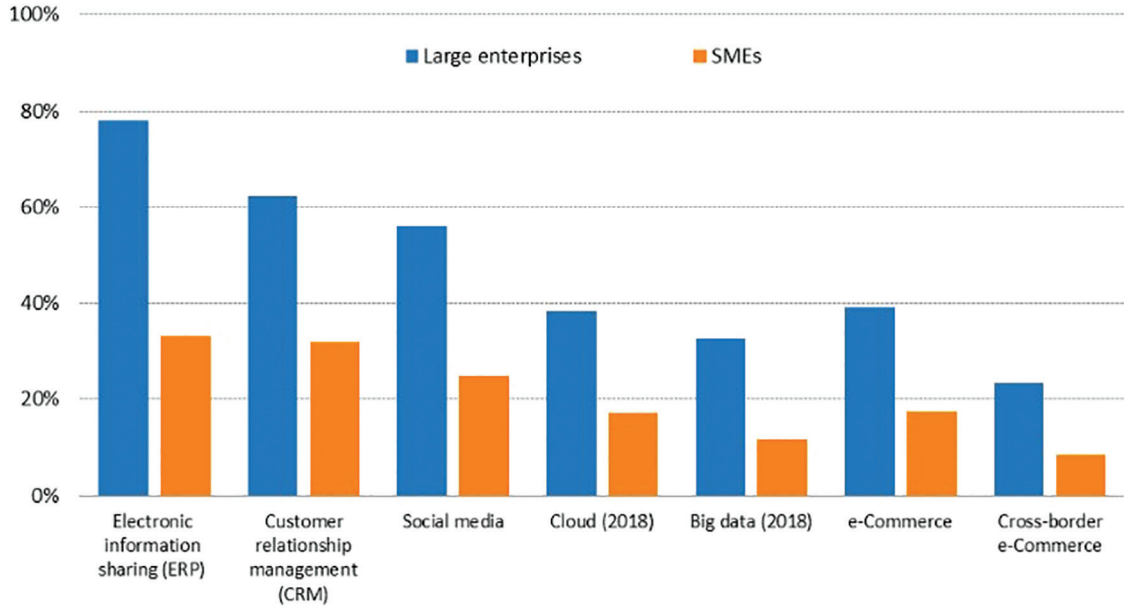
Regarding the integration of digital technologies by enterprises, the use of advanced digital technologies, such as AI, Internet of Things, cloud computing and big data analysis will improve productivity and efficiency and open up new opportunities for European businesses in all sectors. As shown in Figure 8, large enterprises adopt new technologies more often than SMEs. In addition, there are technological opportunities that have not been exploited by SMEs like cloud services and big data. The gap that exists between large companies and SMEs also affects basic digital solutions like enterprise resource planning (ERP) software packages and e-commerce.

As previously mentioned, the utilization of digital technologies in industry differs among large companies with the capacity to invest in innovations and SMEs that fight to keep up with the pace with technological development. There are also discrepancies between sectors, especially between high-tech areas like aerospace and more conventional areas like construction.

Depending on the sector, more than 50% of companies in the ICT, telecommunications and media sector are highly digitized, compared to only 10% of sectors linked to manufacturing, such as construction (4%), basic metal manufacturing (9%) and food processing (13%) (Digital Innovation Hubs: Mainstreaming Digital Innovation Across All Sectors, 2017).

Expanding information and as Frank *et al.* (2019) argue, the degree of implementation of the Industry 4.0 concept is dependent of the size of the company. Thus, small and medium-

Figure 8. *Adoption of digital technologies 2020 (% enterprises)*



Source: Eurostat, Community survey on ICT usage and e-commerce in enterprises.

(**Source:** *Digital Economy and Society Index Report 2020)*

sized enterprises (SMEs) do not completely benefit from the opportunities of new business models unlike larger enterprises. Moreover, in accordance with Buchi *et al.* (2020), openness to enabling technologies of Industry 4.0 are more likely to occur in the manufacturing sector (such as the chemical and oil, plastic material manufacturing, and mechanical engineering and transport industries).

3.5. The Digital public services dimension of the Digital Economy and Society Index (DESI)

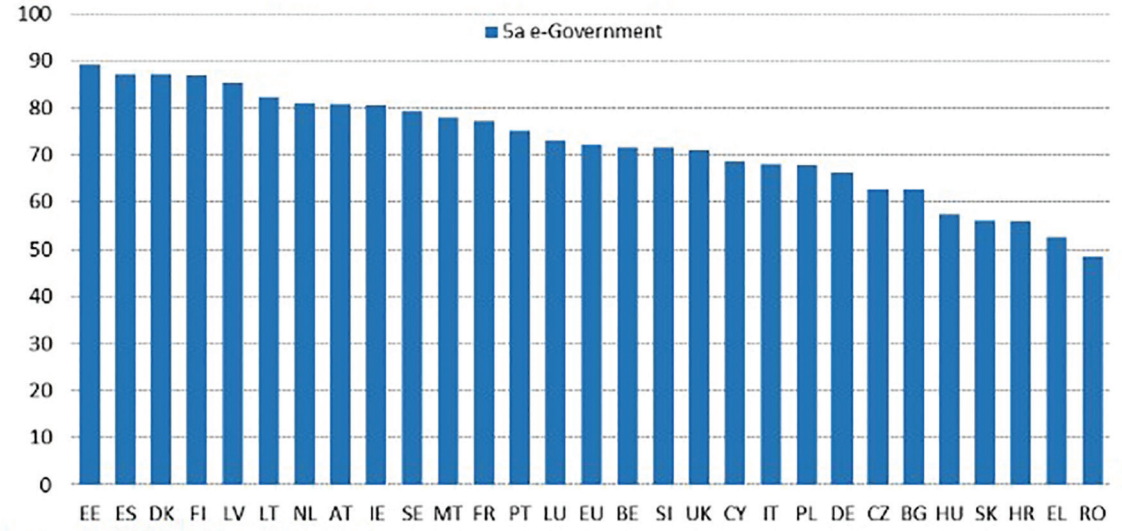
Digital technologies incrementally place new requirements on the public sector. For governmental organizations, to exploit the potential of these technologies is a core challenge.

The digital public services dimension evaluates the supply and demand sides of digital public services and open data. In **Figure 9** we can see the ratio of the different countries regarding this dimension. On the one hand, Estonia (EE), Spain (ES), Denmark (DK) and Finland (FI) achieve the highest scores in the ranking. On the other hand, Romania, Greece and Croatia have the lowest scores, all the scores being below the EU average of 72.2.

4. DIGITAL INNOVATION HUBS

Among the plans and strategies to boost Industry 4.0 and digitalization in companies are the Digital Innovation Hubs (DIHs). The European Commission launched the Digitizing European Industry initiative (DEI) in April 2016. This initiative is designed

Figure 9. *Digital Economy and Society Index 2020, Digital public services*



Source: DESI 2020, European Commission.

(**Source:** *Digital Economy and Society Index Report 2020)*

to strengthen the competitiveness of the European Union in digital technologies and guarantee that every business in Europe can procure the benefits from digital innovation. The DEI measures are structured around the following five core pillars:

i. European platform of national initiatives on digitizing industry
ii. Digital innovations for all: Digital Innovation Hubs
iii. Strengthening leadership through partnerships and industrial platforms
iv. A regulatory framework fit for the digital age
v. Preparing Europeans for the digital future

In line with the aforementioned, Digital Innovation Hubs are the leading instrument for the Digitizing European Initiative to foster the digital transformation of industries. A Digital Innovation Hub is a support facility that helps companies to become more competitive by improving their business/production processes as well as their products and services by means of digital technology (Pelayo, 2017). Briefly, the idea of a DIH is to help existing industry with digital transformation. In this sense, DIHs are intended to be one-stop shops offering services to business in the region through multi-partner cooperation. Thus, collaboration and open innovation (e.g. Laursen and Salter, 2006; Chesbourg, 2003) are an essential driver to exchanging knowledge and fostering learning from inter-firm interactions. These DIHs are built upon open innovation and for this reason they are bottom-up adapted to local/regional contexts and their actors (see more at Hervás-Oliver *et al.*, 2021a). According to the European Commission, a DIH facilitates the following services:

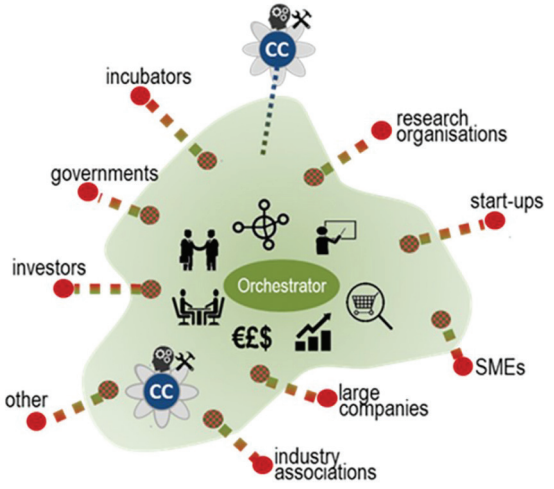
- Provides access to digital technologies and competencies;
- Provides access to infrastructure and tests digital innovations ("test before invest");
- Offers training and skills development;
- Offers support in finding finance for digital transformation;
- Helps in networking and connecting users and suppliers of digital innovations.

4.1. Actors, role and services provided by a Digital Innovation Hub

DIHs address the technology and the business development side, are capable of doing effective outreach and have appropriate links to companies and public sector organizations. As can be seen in **Figure 9**, the DIHs are based on technological infrastructures (competence centers), such as technology centers, universities and companies, which provide any company access to the latest knowledge, experience and technology to test and experiment with digital innovations relevant to their products, processes or business models. In this sense, the portfolio of services provided by DIHs is conFigured around three main areas: training, innovation and entrepreneurship. All in all, these collaboration platforms are organized around open innovation: interactions, knowledge exchange and new capability (digitization) building. These centers are also place-based, being organized around local capabilities, technologies and actors. They are not one-size-fits-all centers, but specific centers adapted to local specificities. As regards actors, local/regional ones are orchestrated on a relational basis, fostering collaboration and reciprocity.

In addition, as shown in Figure 10, many DIHs act as network organizations bringing together different types of actors, including organizations like universities, companies, industry associations, chambers of commerce, incubators and accelerators, regional development agencies and even governmental

Figure 10. *The ecosystem of a Digital Innovation Hub*



(**Source:** *European Commission*)

organizations. What is new and different about DIHs is that they will bring all these actors together in a region and implement a coordinated set of services that are necessary to assist those companies (particularly small enterprises or companies from sectors with low tech) that face difficulties with their digitization through a one-stop-shop.

Moreover, every DIH will have its own specialization, in line with the smart specialization priorities of a region. In this sense, through the networking of DIHs, competences not available within the regional DIH may be found in another DIH. Thus, this mechanism will lead to specialization and excellence, and will avoid that every region needs to invest in all competences necessary for digital transformation. Apart from that, the roles of the competence centers are as follows:

- Provide access to knowledge and technological platforms
- Provide experience in digitalization and its implementation

- Support tests in real manufacturing environments
- Promote the manufacture of new products
- Demonstrate best practices
- Show new technologies in pilot factories
- Provide awareness, education, training

In broad terms, the services available through DIHs may be classified under three pillars:

- *Innovation activities*, related with recognizing opportunities for digitization, and implementing and validating innovative solutions based on leading technology.
- *Business development*, interested in helping companies to implement their solutions, evaluate the business implications, and manage the resultant changes
- *Skills creation*, concerned with developing innovation capacity through enhancing human capital.

Applying the aforementioned, the services provided by a Digital Innovation Hub are:

- Access to Specialist Expertise and Infrastructures
- Brokering/matchmaking
- Awareness Creation around Digital technologies
- Innovation Scouting
- Digital Maturity Assessment
- Visioning and Strategy Development for Businesses
- Mentoring
- Training
- Access to Funding and Investor Readiness Services

According to Hervás-Oliver *et al.*, (2021a) and Pelayo (2017), due to their regional orientation, DIHs act as a first regional point of contact for digitalization efforts, but also to reinforce the link between digitalization and the regional innovation system. In this sense, DIHs resemble, to some extent, cluster organizations, and in some regions cluster organizations have rebranded themselves as DIHs. Nevertheless, it is important to note the main difference between them. While cluster organizations try to promote regional growth from a supply-side approach, the DIHs try to promote digitalization efforts within existing industries from a demand-side approach.

Finally, it is important to highlight the characteristics of the DIH activities. In this sense, the main characteristics of the service offer, and the way Digital Innovation Hubs operate, will cover the following:

- Complementing and bringing together existing service provision, building an ecosystem
- Staged services offering companies a clear path towards digitization
- Digital Maturity Assessment as a core service
- Core focus on technology validation and demonstration
- Training and skills will be essential in building capacity within businesses
- A strong face-to-face relational dimension
- Nurturing a digital culture
- Access to funding as a key service
- Addressing public awareness and the social dimension

4.2. Digital Innovation Hubs and European Digital Innovation Hubs: What is next?

As presented below, it is convenient to differentiate between DIHs and the new European Digital Innovation Hubs (EDIHS). Focusing on the Digital Innovation Hubs, these are funded by Horizon 2020d (Horizon 2020 program) and European Regional

Development Funds (ERDF, New Cohesion Policy, 2020e). Horizon 2020, on the one hand, pursues the policy that DIHs be funded to assist SMEs with experimentation and testing of advanced digital technologies in their production process, products or business models. With European Regional Development funds, on the other hand, DIHs are funded to offer services to assist the local economy with its digital transformation.

From 2021, Horizon Europe will succeed Horizon 2020c (Horizon Europe - the next research and innovation framework program), continuing to fund SMEs to experiment with advanced digital technologies and fostering the EDHIs (European DHIs). It is important to note that DIHs may turn into EDIHs if they are chosen to be part of the European network through the Digital Europe Program (Digital Europe Program, 2020b). The idea is to keep only one in each region, centralizing all the expertise in only one hub and especially supporting *Artificial Intelligence and High-Performing Computing and Cybersecurity*. This new approach indicates that not all DIH will turn into new EDIHs. This centralization seeks to improve efficiency and better use of technologies, but we are not sure that this would be better for SMEs.

The European DIH Program, starting in 2021, strengthens the capacity of the EDIH to deliver services locally, nationally and at a European level. In addition, all EDIHs will be co-funded by the Digital Europe Program and by national regional funding sources, which can include ERDF. In addition, the selection process of the Digital Europe Program will be composed of 2 steps: First, Member States designate their list of potential candidates. Then, the EC will choose the EDIHs based on quality, relevance and geographical coverage. EDIHs can support the digital transformation of SMEs or public sector organizations by delivering all 4 previous functions: test before invest, support to find investments, ecosystem building and networking, skills and training.

To sum up, it is expected that European Digital Innovation Hubs (EDIHs) will stimulate the broad uptake of digital technologies such as *Artificial Intelligence, High Performance Computing (HPC)* and *Cybersecurity* by industry and public sector organizations in Europe. Each EDIH will provide services based on a specific focus, which will support the region's industry and public sector with their digital and green transformation. In addition, each EDIH will act as an access point to the European network of EDIHs, helping local companies to get support from other EDIHs in case the needed competences fall outside the competence of the local EDIH. We think that this is an important improvement of the system, as firms in each region will have better access to knowledge and technology through the EDIHs in Europe.

5. CONCLUSIONS

The overall purpose of this article consists of offering, through critical literature review, a general overview of digitization and Industry 4.0 policies from the European Commission. Specifically, our aim is to offer a real picture of the role of the European Commission's efforts to enable and foster the digitization of business through the Digital Innovation Hub (DIH), presenting the state-of-the-art DIH program, a kind of system of one-stop shops for promoting digitization through collaboration and open innovation amongst economic actors such as firms, universities, technology centers or business associations, among others. DIHs are promoted and sponsored by the European Commission and complement different national and regional initiatives to foster digitization of businesses, industries and regions.

DIHs are based on open innovation for fostering digitization among European businesses. Built upon collaboration of firms and organizations (universities, local business associations, etc.), DIHs seek to support digitization of SMEs. This policy resembles firm-level open innovation search strategies (e.g. Chesbourg,

2003; Laursen and Salter, 2006; Hervás-Oliver *et al.*, 2021b), as the DIHs promote networking, collaboration, knowledge exchange and the circulation of information. The effects of DIHs, however, seem to be more important for large firms than for SMEs (Hervás-Oliver *et al.*, 2021a). The latter implies that, despite targeting SMEs, DIHs are led and organized by large firms that interact and learn much better with other organizations such as universities or technology centers. Another important implication of DIHs is the fact that they are not coordinated or coherently aligned with other national or regional digitization initiatives, as stated by Hervás-Oliver *et al.*, (2021a). Results from data analysis also suggest that existing digital heterogeneity in Europe complicates the rates of adoption and the DIH performance for digitizing business. This *digital divide* in Europe, requires specific tailored policies for each country depending on their previous digitization condition or their capability to absorb the new digital shift, one-size-fits-all initiatives not being recommended.

Important implications for policymakers, therefore, arise from the analysis. First and foremost, DIHs should be coordinated with ongoing national and regional policies, even being sensitive to specific places, that is, that they also take into account the level of pre-existing digitization in the country (*digital divide*). This calls for avoiding one-size-fits-all initiatives. In addition, national/regional policy makers need to consider DIHs in their agenda. Furthermore, the prominent role of leading firms needs to be addressed, offering more incentives to SMEs that are the main target of the policy initiative. Large firms interact and source knowledge more easily from other sources (e.g. universities, etc.) but SMEs are less efficient in that respect. Thus, SMEs need to be central.

As a concluding remark, the new forthcoming European Digital Innovation Hubs (EDIHs) will primarily support Artificial Intelligence, High Performance Computing (HPC) and Cybersecurity. Therefore, national and regional policy makers need to embrace the new topics for their own initiatives in a fruitful attempt to coordinate with the European Commission. There is no doubt that the digitization of European business is at stake!

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