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4 November 2021, Sopron

PANDÉMIA – FENNTARTHATÓ GAZDÁLKODÁS – KÖRNYEZETTUDATOSSÁG / PANDEMIC – SUSTAINABLE MANAGEMENT – ENVIRONMENTAL AWARENESS

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Szerkesztette / Edited by: OBÁDOVICS Csilla, RESPERGER Richárd, SZÉLES Zsuzsanna

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Smart Development with Digital Intelligent Cities in Cross-Border Regions

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Abstract
Test and Experimentation Facilities and Digital Innovation Hubs are new tools for supporting the digitalisation of companies and their development can be especially useful in countries of Central Eastern Europe where innovation performance is lower than the European average. This paper examines the development of digitalisation with artificial intelligence in Hungary and Romania as well as presenting examples of successful implementation of the European policies in regional and national context. The analysis compares the national strategies for artificial intelligence and highlights the current development of DIH network in these countries as well as the prospects for the new European DIH network and their linkage to other European initiatives. Finally, the paper describes the experience of regional innovation centres as practical examples and complements the conclusions with recommendations for further research within the subject.

1. Foreword

The research work that is presented within this paper has been carried out in the last 4 years in the framework of "Smart Factories in the new EU member states" and DIHELP projects as transnational cooperation initiatives for digitalisation. Smart city development as digital innovation is presented based on the work of Gassmann et al. (2019). Datasets and actual information were obtained from openly available resources that are made possible by the open access policy of the European Commission.

Further research work is carried out with the professional support of the Doctoral Student Scholarship Program of the Co-operative Doctoral Program of the Ministry of Innovation and Technology financed from the National Research, Development and Innovation Fund.

2. Overview of European initiatives

The Coordinated Plan on Artificial Intelligence (European Commission, 2018c) represents a joint commitment by the European Commission and Member States to work together to maximise Europe's potential to compete globally. It laid the ground for cooperation, defined areas for investments and encouraged Member States to develop national strategic visions on AI. It followed the Declaration of Cooperation on Artificial Intelligence, signed by all Member States and Norway (European Commission, 2018b).

The European Commission issued in 2020 the White Paper on AI (European Commission, 2020) where it was stated that Europe can combine its technological and industrial strengths with a high-quality digital infrastructure and a regulatory framework based on its fundamental values to become a global leader in innovation in the data economy and its applications. The objective is to achieve an 'ecosystem of excellence' along the entire value chain, starting in research and innovation, and to create the right incentives to accelerate the adoption of solutions based on AI, including by small and medium-sized enterprises (SMEs).

The 2021 review of the Coordinated Plan (European Commission, 2021b) was the next step because it puts forward a concrete set of joint actions for the European Commission and Member States on how to create EU global leadership on trustworthy AI. It calls for accelerating private and public investments by leveraging EU funding available through Digital Europe (DEP), Horizon Europe (HE) programmes and the Recovery and Resilience Facility (RRF).

RRF is the largest stimulus package ever financed through the EU budget because it provides Member States with frontloaded financial support in the form of an unprecedented EUR 672,5 billion of loans and grants for the crucial initial years of the recovery from COVID-19. The 'digital expenditure target', which is 20% of this funding, corresponds up to EUR 134 billion in the lifecycle of the RRF (European Commission, 2021a). The intention is to make it a game changer in boosting investments, e.g. to build data, cloud, and computing infrastructures, to further research excellence, to support innovation, testing and experimentation, and to increase its use by the public administration and by businesses.

The 2021 review of the Coordinated Plan sets out an outlook with concrete proposals and recommendations for further action, identifying areas where the partnership between the EU and the Member States is particularly effective in making Europe a hub for the development and use of cutting-edge, human-centric AI. It proposed actions that provide tools through an AI-on-demand platform and an environment for developers to test and experiment (via Test and Experiment Facilities, TEFs), and for SMEs and public administrations to take up AI via European Digital Innovation Hubs (EDIHs).

3. TEF and EDIH in the review of the Coordinated Plan

This section focuses on measures that help bring innovation from the lab to the market to ensure the broad uptake and deployment of AI technologies.

Facilities for testing and experimenting with innovative AI systems are essential for deployment and uptake of AI technologies. This is especially important for small and medium-sized enterprises which face difficulties in taking full advantage of the fast developments in digital technologies to become competitive and innovative. In collaboration with Member States, the EU has proposed two sets of measures:

Testing and Experimentation Facilities (TEFs) are technology infrastructures with specific expertise and experience in testing mature technology in a given sector, in real or close-to-real conditions. The aim is to provide developers with an infrastructure for testing AI technology before bringing it to the market.

Digital Innovation Hubs (DIHs) are 'one-stop shops' that help all companies interested to use AI to become more competitive with regard to their business/production processes, products or services by using AI technologies. European Digital Innovation Hubs provide companies with a possibility to test AI technologies before investing as well as related services, such

as financing advice and advice on training and skills development that are needed for a successful digital transformation.

3.1. Testing and experimentation facilities (TEFs)

The 2018 Coordinated Plan stated that to optimise investment and avoid duplication or competing efforts, a limited number of specialised large-scale reference sites should be developed and opened to all actors across Europe. Following the adoption of the Coordinated Plan and in preparation for the Digital Europe programme, the Commission took preparatory steps to develop this concept and to prepare AI Testing and Experimentation Facilities. Specifically, starting from 2019 the Commission has worked intensively with Member States to refine the concept of TEFs and to prioritise relevant sectors. In January 2020, the Commission organised five workshops, involving stakeholders from industry, academia and Member States, to discuss TEFs for specific sectors (agri-food, manufacturing, healthcare and smart cities) and technologies (edge AI).

The results of the preparatory work and exchanges with the stakeholders suggest that experimenting and testing state-of-the-art technology in real-world environments is an essential element in bringing technology to the market and is a part of the innovation chain where Europe's AI system needs significant support to remain globally competitive.

The edge AI TEF plays a special role for the AI ecosystem of excellence. Edge AI offers clear benefits as a hardware technology: it provides real-time operations, as well as advantages in terms of security and privacy of data and energy consumption. The edge AI TEF aims, as a European platform, to enable companies of any size to test and experiment innovative edge AI components based on advanced low-power computing technologies, such as neuromorphic computing. Given EU's current dependency on computing technologies, the high costs of the necessary semiconductor equipment and need for long-term investments, the edge AI TEF is necessary to close the funding gap so that European companies get access to low-powered AI computing hardware. In other words, the edge AI TEF will endow Europe with an ecosystem of excellence that will serve as an essential instrument to achieve technological leadership in AI (European Commission, 2018a).

3.2. Digital Innovation Hubs (DIHs)

In order to help European companies (especially SMEs) to make the most of new technologies, the Commission launched the 'Digitising European Industry' initiative in 2016. One of the pillars of this initiative is to establish and support Digital Innovation Hubs which provide access to technical expertise and experimentation possibilities, so that companies can test before they invest.

DIHs also provide innovation services, such as financing advice, training and skills development that businesses need for a successful digital transformation. Member States and regions have been investing in Digital Innovation Hubs and the Commission (through Horizon 2020 projects in 2019 and 2020) has made available over EUR 200 million for networking of the DIH. Around half of this funding was related to innovations in AI-relevant areas, including robotics and big data, and special activities were implemented for regions with few DIHs.

The Horizon 2020 projects typically cascade funding through open calls to SMEs to allow them to participate in innovative experiments with DIHs in a cross-border context. The European Court of Auditors (ECA 2020) assessed this dimension of the Digitising European Industry initiative and recommended that the Commission, in coordination with Member States, should take further action on the funding and monitoring of DIHs which be implemented via the network of European Digital Innovation Hubs (EDIHs).

The EDIHs will stimulate the broad uptake of AI, HPC, cybersecurity and other digital technologies by industry (in particular SMEs) and by public-sector organisations in Europe. They will also support them in the use of digital technology, to improve the sustainability of their processes and products, in particular with regard to energy consumption and reducing greenhouse gas emissions. They will ensure a broad geographical coverage and have both local

and European functions. The EDIHs will use the tools and resources made available by the AI-on-demand platform and they will be multipliers for TEFs: EDIH will help companies in need to make use of the relevant TEF to innovate their new products and services and make them market ready.

3.3. European implementation plan

In order to help to bring innovation from the 'lab to the market' and to ensure the broad uptake and deployment of AI technologies, the Commission together with Member States will co-fund Testing and Experimentation Facilities under the Digital Europe programme in order to provide a common, highly specialised resource to be shared at the European level and foster the speedy deployment and greater uptake of trustworthy AI across Europe. In this context, the first calls (in 2021-2022) focus on the following identified sectors: manufacturing, health, agri-food, smart communities and edge AI.

The network of up to 210 EDIHs are planned to be selected during 2021-2022, covering all regions of Europe. Regarding AI, it is foreseen to have at least one EDIH in every Member State with AI expertise. The network of EDIHs can share best practices and effectively collaborate with each other to offer the best support to SMEs and public sector organisations everywhere in Europe. The network of EDIHs will work closely with the AI-on-demand platform, the TEFs, and the data spaces, and they will promote the use of these infrastructures to SMEs located everywhere in Europe.

Further research work is planned to analyse the role of TEP and DIH as well as the impact that artificial intelligence as new digital technology can make on the economic development in underdeveloped regions. Consequently, the next sections provide an overview of AI strategies in Hungary and in Romania. Afterwards, comparison of the national network of digital innovation hubs is presented.

4. AI strategies as part of national policies in Central Eastern Europe

The primary source of the information presented in this section were the country reports of AI Watch service of the European Commission which monitors industrial, technological and research capacity, policy initiatives in the Member States, as well as the uptake and technical developments of Artificial Intelligence and its impact in the economy, society and public services. It provides several analyses necessary to monitor and facilitate the implementation of the European Strategy for AI.

Source of information about top research institutions and publications on AI was the STIP Compass database of the OECD on Artificial Intelligence which is comprehensive online source of data for the AI sector.

4.1. AI strategy in Hungary

Hungary's AI strategy was published in October 2020 and is based on input from the member organisations of the Hungarian AI Coalition. The strategy aims for a comprehensive approach across the AI value chain, such as the development of the Hungarian data economy, development of the necessary infrastructure, widespread education and training activities, incentivising the uptake of AI solutions (both in the private and public domain), as well as a regulatory environment that strikes a balance between safety and innovation. The execution of sectoral goals is based on multilateral cooperation between the relevant actors, i.e. in agriculture, transportation, health and public administration.

The Hungarian national AI Strategy was completed and published in the second half of 2020. The comprehensive strategic document aims to support and boost all relevant sections of the AI value chain from data generation and management, through basic and applied research, to utilization of the technology and raising awareness of the possibilities inherent in practical AI applications.

In terms of data infrastructure, the action plan includes the establishment of a National Data Asset Agency to ensure a responsible and efficient data utilisation in the public sector.

This initiative is complemented with the creation of a public data portal, big data collections (e.g. on education, health, and transport data), and data market platforms with GDPR compliant data. Inventories of public-data assets and best practices facilitate the implementation of these initiatives further.

In October 2018, the Hungarian government formed a Coalition on Artificial Intelligence as a partnership between governmental institutions, prominent academics and practitioners from leading IT businesses. Made up of more than 230 members, the AI Coalition has been working on the development of Hungary's AI Strategy and various AI-related proposals.

With respect to education in AI, the action plan's goal is to educate at least 1% of the population (or approximately 100,000 citizens) in AI-related subjects. To foster networking and improve the visibility of AI efforts in the country, the AI coalition also launched an AI portal in which AI developers can showcase local case-studies to foster collaboration and awareness.

The increase of AI developments can be achieved through the establishment of a National Lab for basic research in AI: this lab is created through a consortium of the Institute for Computer Science and Control (SZTAKI) and institutions of the Eötvös Loránd research network.

The top scientific institutions and their publication on AI are indicated in the *Table 1* below which show that most of the institutions are in Budapest (the capital of Hungary) which hinders take-up of industrial innovations in the provincial parts of Hungary.

Table 1: Number of publications in AI by Hungarian institutions

Name of institution	Number of publications (in 2019)
Budapest University of Technology and Economics	301
Hungarian Academy of Sciences	275
Eötvös Loránd University	253
University of Szeged	157
University of Debrecen	126
Semmelweis University	114
Óbuda University	101

Source: AI Watch (2021)

4.2. AI strategy in Romania

Romania has initiated multiple efforts towards drafting and implementing the AI national policy framework. In 2020, Romania launched an EU-funded project on creating a national framework in the AI field for the 2021–2027 period. The AI framework will include aspects such as the development of education and skills in AI, increase the R&D and innovation in AI both in the academic and industrial areas, strengthen cooperation in developing AI infrastructures, adopt ethical AI and data protection parameters at best practice level and overlap the cybersecurity priorities of these pillars. This effort involves expertise from the government, academic and private sector, is supported by technological and legal consultancy services, and can result in the national strategic framework for AI. The objective shall be implemented throughout 2021 and 2022.

The top scientific institutions and their publication in AI are indicated *Table 2* below which show that the number of publications by Romanian institutions is significantly lower than similar data for Hungary even though the number of researchers is higher in Romania than in Hungary. One possible explanation for the difference can be the longer tradition of AI strategy and the more developed research community in Hungary.

Table 2: Number of publications in AI Romanian institutions

Name of institution	Number of publications (in 2019)
Politehnica University of Bucharest	276
Technical University of Cluj-Napoca	163
University of Bucharest	107
Romanian Academy	84
University of Craiova	68

Source: AI Watch (2021)

5. European DIH network – planned national structures

This section describes the planned structure of the E-DIH network that has been defined by national authorities and joint financing shall be committed for it by the European Commission and the Member States. Geographical information is taken from the European catalogue of Digital Innovation Hubs (DIH tool, 2021) which is maintained as part of the S3 platform.

5.1. E-DIHs in Hungary

Hungary has selected only 3 organisations which is the minimum number of E-DIH foreseen for Hungary. As all of them are located in Budapest, they will provide their service on national level and, consequently, these organisations are focused on different technology sectors.

- Artificial Intelligence EDIH: MOBIL (Smart City), E-health, Industry 4.0 Circular economy.
- Cybersecurity, Advanced Skills EDIH: Education, Fintech, Blockchain.
- Data and HPC EDIH: Agriculture (processing of agricultural data is the main purpose).

The open process of national selection of Hungarian E-DIH candidates has raised considerable interest in 2020 therefore several applications were submitted which proposed different geographical coverage of the country. As next step, negotiation process was conducted and the applicants with good scores were invited to join forces in order to build large consortia with significant expertise in different technology areas. The final result of selected E-DIH candidates can be considered as a thematically „super focused" arrangement (one single location on national level as shown in *Figure 1*) but the good coverage of services toward the whole territory remains a challenge to be tackled.

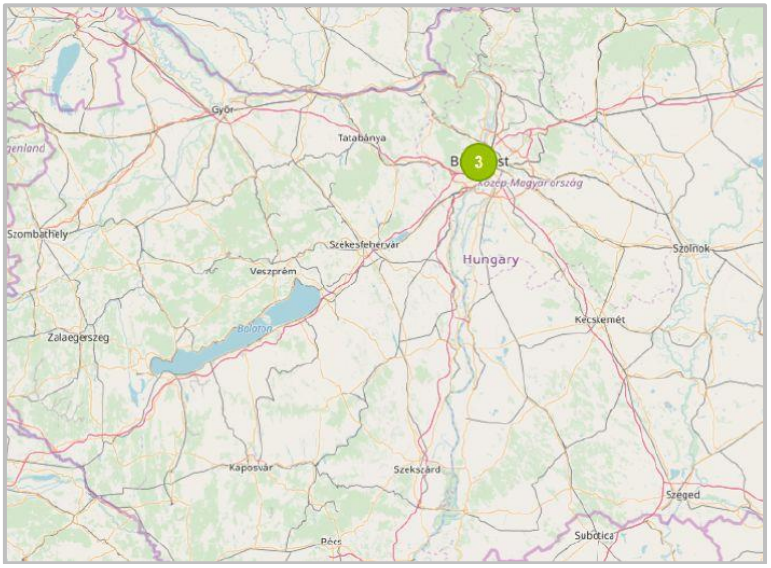

Figure 1: Candidate E-DIHs in Hungary
Source: DIH tool, 2021

The concentration of E-DIHs in Budapest can – at least partially – be justified by the fact that the majority of universities with considerable number of publications on AI are located in

Budapest. Universities in Debrecen and in Szeged are exceptions and, according to preliminary plans, these universities also intend to be members of national consortia of E-DIH.

The DIH catalogue includes currently only a few registered organisations and only 3 of them are outside the national capital. The DIH organisations that received professional support from the Smart Factories project in 2018 became registered in 2019 and currently they take active role in transnational cooperation and have good geographical presence as shown in *Figure 2.*

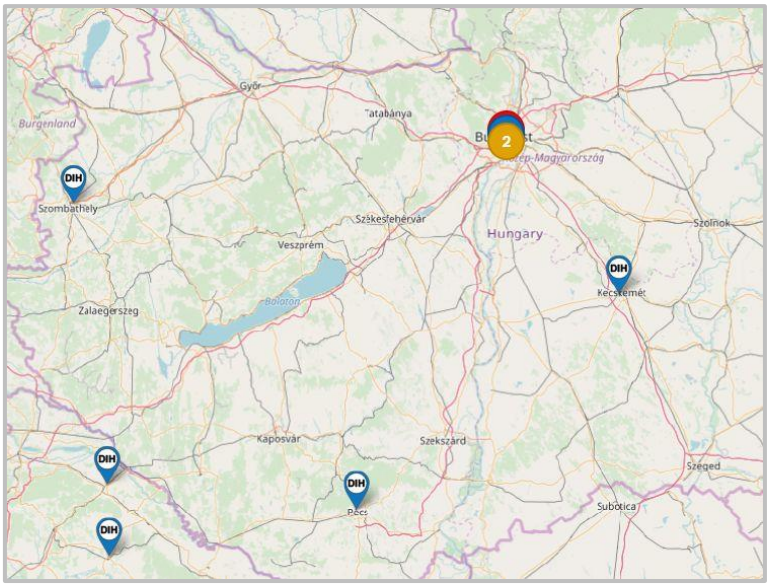

Figure 2: DIHs currently in Hungary
Source: DIH tool, 2021

The functioning DIH can complement the geographical coverage of EDIH network therefore integration of the functioning DIHs and the new EDIHs would be a logical step from 2022. Consequently, the evolution of DIH network in Hungary is worth to be followed in the future.

5.2. E-DIHs in Romania

Romania has selected E-DIH candidates on regional basis. The objective was to select one DIH candidate from each region therefore national selection of Romanian E-DIH candidates included negotiation process to merge applicants that reached good score. Consequently, the final selection of E-DIH candidates is the result of a successful optimisation process both for thematic specialisation and territorial coverage as shown below in *Figure 3*.

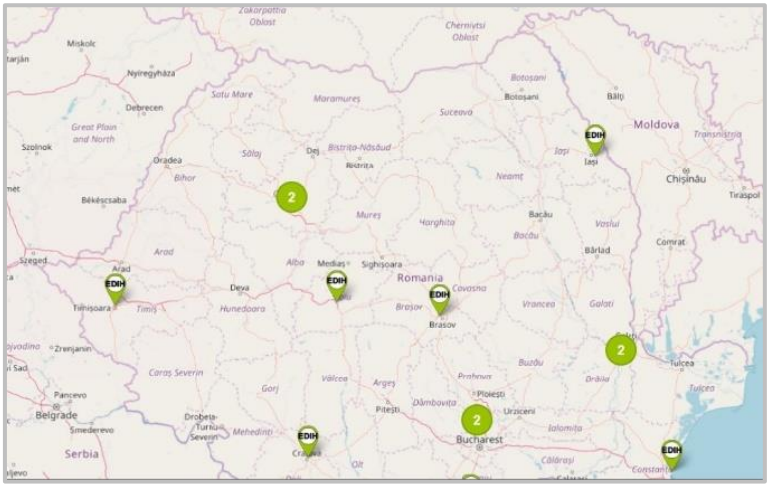

Figure 3: Candidate E-DIHs in Romania
Source: DIH tool, 2021

It can be stated that the European support actions that Horizon projects implemented with the objective to widen the network of DIH have produced good results in Romania. The national government implements the national policy for digitalisation in synergy with these actions because several of DIH that are operational currently (as shown in *Figure 4*) can become E-DIH because they take part in the new E-DIJ consortium of the given region.

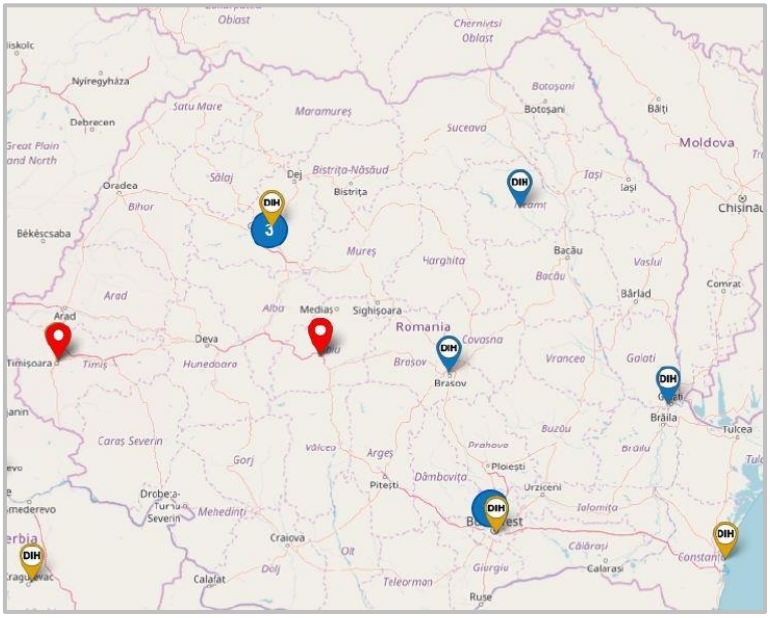

Figure 4: DIHs currently in Romania
Source: DIH tool, 2021

The concentration of E-DIHs can be observed in Bucharest and in Cluj-Napoca (2 E-DIHs in both cities) where the local universities have considerable number of publications on AI therefore these knowledge centres can be providers of local expertise via the E-DIHs, as well.

It shall also be noted that the geographical coverage of existing DIH and of the new EDIH network is similar (as comparison between *Figure 3* and *Figure 4*) therefore it also shows clearly the evolutive nature of governmental policy for digital innovation in Romania.

6. TEFs as Learning Factories – new tool for Industry 4.0

The industry 4.0 concept was born from the initiative made by academics, industrial companies and the German Government with the objective of strengthening the competitiveness of the manufacturing sector in the country through the convergence between industrial production and Information and Communication Technologies (Kagermann et al., 2015). This trend makes use of technologies as the Internet of Things, Cyber Physical Systems, industrial automation, continuous connectivity and information, cybersecurity, intelligent robotics, semantic technologies, industrial big data and computational vision to improve the productivity of the manufacturing industrial systems (Posada et al., 2015).

Learning Factories (LF) have shown to be effective for developing theoretical and practical knowledge in a real production environment where the final aim is Industry 4.0 in practice by SMEs. The LF concept was mentioned for the first time in an initiative of a group of universities from the United States in 1995 (Baena et al., 2017). Currently, a LF is defined as an idealized replica of sections of the value chain industry where informal, non-formal and formal learning take place (Tisch et al., 2013). These LFs have been used for educational purposes, research and training in areas, for example, such as manufacturing at TU Darmstadt (Abele et al., 2015) and energy efficiency in Green Factory Bavaria (Kreitlein el al, 2015). Good example from Hungary is the Smart Factory at the Fraunhofer Project Center at MTA SZTAKI which carries out Learning Factory function. Its architecture and key design principles were described by Kemény et al (2016) which are presented below.

The Smart Factory comprises a simplified environment that still retains a physical representation of relevant processes found in the manufacturing industry, including material handling, transformation of goods, product diversity, resource constraints, and planning and execution controlling higher abstraction levels of the IT infrastructure. The composition and functionalities of the equipment implement focal principles of the Cyber-Physical Systems and Industry 4.0 concepts in a simplified manufacturing scenario. The users can also be involved in the design and construction of the facility, emphasizing architectural characteristics that remove several burdens users may perceive when they take first steps in automation and IT-related domains in an Industry 4.0 setting.

The facility consists of components that exhibit context-awareness, autonomy, and allow the interaction and mutual representation of virtual entities in the IT infrastructure and of the physical entities in the physical subsystem. Interaction is bi-directional because sensors and interfaces allow the exact, real-time acquisition of states and process characteristics. The actuators influencing the processes are accessible by the virtual subsystem which characterized by a networked infrastructure of interacting autonomous virtual entities (agents).

Remote access and advanced human–machine interfaces will allow the coupling of the facility to remote systems, as well as human operators and users of various skill levels. Consequently, the Smart Factory can already be considered a scaled-down representation of an Industry 4.0 production environment in its structure and architectural characteristics. The facility represents the robustness, resilience and self-organization attributed to Industry 4.0 production systems.

The role of the Smart Factory – as Learning factory – is that the facility can host individual projects and companies in a "maker space" manner, providing technical and social background for synthesizing a practice-oriented view of the world from existing explicit knowledge, newly gained knowledge related to their specific problem, as well as knowledge and social skills. Consequently, DIH can contribute to Industry 4.0 with cooperative regional actions therefore examples of DIH are presented below from Hungary and from Romania.

6.1. Example for DIH in Hungary

KET-DIH is located in the Eastern part of Hungary with primary technology focus on advanced manufacturing and photonics as Key Enabling Technologies. Services as competence centre are provided by STEPP Cluster that is the Science, Technology and Educational Platform for Photonics in Hungary. Among their members, most important contributor is the University of Szeged as member of the European Digital Innovation Hub consortium for Artificial Intelligence in Hungary. STEPP Cluster (in Szeged) and IQ Kecskemét Industrial Research Centre (in the nearby town of Kecskemét) act as supporting organisation within the ADMA community that provides technology development and testing services in advanced manufacturing and robotics. Technology development for business applications in photonics is implemented in cooperation with KETGATE network and KET-DIH also contribute to the development of start-up community in Szeged as well as to exploitation of research results.

Ecosystem development services are implemented in partnership with industrial clusters (MIÉNK, Archenerg) and the Digital Platform for Architecture, Engineering and Construction. The actions of the DIH are complemented by the BRILLIANT project that is one of the Cluster Excellence (ESCP-4x) projects with European support.

Development and monitoring of digitalisation strategy for Szeged and its region is coordinated by the Regional Innovation Agency of South Great Plain region which makes innovative actions on regional level and they are complemented also by cross-border cooperation projects implemented with digital innovation centres in the neighbouring regions.

6.2. Example for DIH in Romania

Futures of Innovation and Technology Digital Innovation Hub (FIT DIH) is created by the community and for the community, having a non-profit purpose in the Central Region of Ro-

mania. The DIH represents a partnership formed by different entities from the non-profit, public, private, but also from the academic field, all serving the same common goal: to develop and implement a complex process in order to facilitate the digital transformation of SMEs, organizations and public administrations with the purpose of increasing the economic, social and administrative competitiveness of the region at European level.

The non-profit objective of FIT DIH is important in this regard and could encourage local companies to improve the overall impact of the local economy. When it is possible not to find the right local partners, the digital innovation hub can connect to the network with other DIHs to find a partner that fits elsewhere in Europe. By implementing good practices regarding the management of digital innovation centres transferred through the participation of the FIT team in the technical assistance projects *"Smart Factories in New EU Member States"* (Iceberg in Brasov) and *DIHELP (innoHUB in Sfantu Gheorghe)*. Implementing the conclusions drawn from the pilot project dedicated to DIHs, a series of value chains of digital transformation were developed at the level of the region involving the centres of competence, consultants and designers, technology suppliers and integrators, innovators and start-ups, beneficiaries and users.

The DIH's partners aim to capitalize on existing skills in digital technologies (such as *AI, Big Data, AR / VR, robotics, IoT*) but also in the emerging ones ***(****Blockchain, 5G, CPS, HPC, cybersecurity****)*** in order to meet the needs of 4 key application areas:

- Smart cities & digital administration,
- Industry 4.0 and digitalization industry,
- E-health,
- Tourism 4.0.

7. Role of clusters in DIH cooperation as recommended by TCI Network

As conclusion from experience, it is very important that trust need to be built between clusters and DIH actors and clients. Clusters and DIHs are often seen as competitors for the same clients with similar services being offered. There is a need to overcome this mentality, and make all sides understand that taking an integral part in each other's functioning would strengthen their respective organisations and clients. Learning process need to be encouraged among clusters, DIHs, public authorities, and private actors, so that they all understand the structures and objectives of each other. However, the use of different and loose definition of clusters and DIHs makes this learning process challenging.

The further development of the analysed DIHs can be implemented with the support of Digital Europe programme via the European DIH network. EDIH collaboration can take various forms, for example, building EDIHs' local capacity to serve more than one region/country, to export a DIH's excellence, and to connect ecosystems. Two focus areas were identified within this scope and, consequently, recommended for implementation.

Exporting / Importing EDIH excellence: Based on complementary competence and infrastructure, EDIHs could export their specialisation to SMEs in other member states, in the form of opening up their facilities and knowledge to clients outside of its own region. Vice versa, if an EDIH misses certain expertise or facilities to support its own regional clients, they can ask the support of other EDIHs who would have this expertise, and that way import expertise offered by other EDIHs. This could be done on an individual basis, starting from the needs of individual customers, but also in a more proactive way where several hubs together combine their knowledge and facilities to develop common services for their stakeholders.

Connecting ecosystems: Just like EDIHs at the local level build ecosystems by bringing into contact actors along the value chain to develop new innovations, at a European level several hubs can connect different ecosystems together by identifying innovation opportunities for users and suppliers coming from different regions. This will help SMEs expand and tap into other markets, develop EU value chains, create new business opportunities for companies or help commercialise earlier innovation experiments or pilots. Other types of common interest projects

(e.g. open platforms, standards, standardised services, shared infrastructure, etc.) in collaboration with companies and stakeholders from the different regions can connect ecosystems and can help avoiding unnecessary duplication of investment or can give access to infrastructure at a lower cost.

7.1. Example for cross-border DIH in Hungary

The DIH has been established in Szombathely by Pannon Business Network Nonprofit Kft (PBN) to provide services to businesses and social actors and to act as catalyst for digitalisation and transformation processes by using the EU funding available in the 2021–2027 budget period. The DIH in Szombathely provides services under the name "am-LAB" by covering a wide range of advanced manufacturing technologies: additive prototyping and mass production, custom computer animation, augmented reality applications, data analysis based on artificial intelligence algorithms, and practice-oriented experimental development. The effectiveness of the DIH function is demonstrated by the fact that – after four years of operation – am-LAB was selected as the best DIH centre in Europe in 2021. This honorary award proves that it is possible to achieve recognition at European level from Central and Eastern Europe, as well.

PBN and am-LAB have successfully joined an international cooperation in the CENTROPE region (Bratislava, Brno, Vienna, Győr, Szombathely), which has developed how partners can jointly provide IT and communication services to businesses. Cross-border cooperation has thus led to the creation of an innovation network covering several Austrian counties (as shown in *Figure 5*) over the years.

Figure 5: Cooperation of digital innovation centres between Austria and Hungary
Source: Pannon Business Network (pbn.hu)

7.2. Example for cross-border DIH in Romania

The leading coordinator of the strategy planning process in the West region of Romania is the Regional Innovation and Technology Transfer Centre "Tehimpuls", which has been in operation as an association since 2007. Its mission has been defined to increase the competitiveness of the region's economy and to promote cooperation between businesses, universities and research organisations. The leading organization behind Tehimpuls is the regional development agency of the West region and founding members of the association include several local universities from Arad and Timisoara, as well as some professional organisations and local businesses.

Tehimpuls has carried out several cross-border initiatives that included also the Regional Innovation Fair, which was launched as a joint project with the Regional Innovation Agency of South Great Plain region as Hungarian partner in 2013 and it has become an annual event since then. Tehimpuls' services were extended since 2015 to include the regional representation of the Enterprise Europe Network that helps local businesses to enter the international market. Consequently, cooperation between Tehimpuls and the Hungarian partner organization has created the necessary framework that can bring the DIH services to the benefit of SMEs on both sides of the national borders between Hungary and Romania.

The establishment of a regional DIH was implemented by Tehimpuls in 2019 with the professional support from the DIHELP project. The partnership and governance for the DIH is built on Tehimplus, the Regional IT&C Cluster and the regional development agency. As service provider in the field of innovation and technology transfer, Tehimpuls applied successfully during the pre-qualification procedure and was given the opportunity to apply for partnership – as a selected candidate on national level – in the European DIH network.

The vision of EDIH in the West Region has focus on scaling innovation through the digital transformation of companies, providing them with tools, training skills and international networks through which to benefit from the technological trends. The map of the services that shall be offered by the EDIH from 2022 is presented in *Figure 6*.

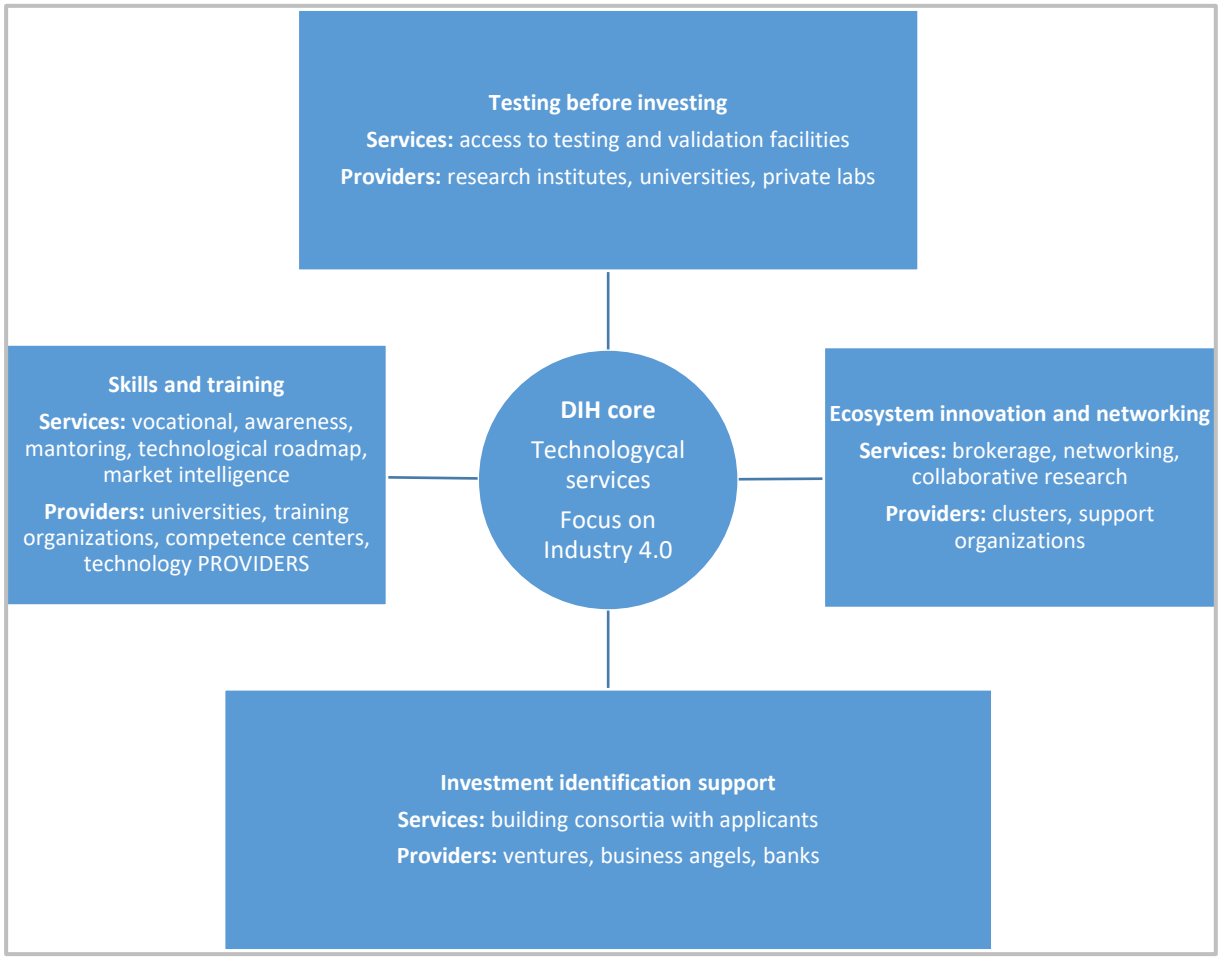

Figure 6: EDIH Service portfolio by Tehimplus and partners
Source: Tehimpuls website (tehimpuls.ro)

Tehimpuls as coordinator of EDIH works with several partners on the development of research and innovation projects within the cross-border region. It means practically that organisations that act as technology providers to SMEs can come from both sides of the national borders and, consequently, it is an exemplary practice that follows European cooperation principles.

8. Summary of conclusions and further areas of research

The presented examples highlighted the relevant European policy framework and the national strategies in Hungary and in Romania for the development of Artificial Intelligence were described. The analysis that was presented has shown that national policy for digitalisation follows the European recommendations and models fully in Romania and partially in Hungary.

It was also highlighted that the geographic allocation of DIH structure within the new European DIH network that shall start operation in 2022 can be developed in synergy with the most important knowledge centres in Romania. On the other hand, the DIH network in Hungary has been decided to take a different structure therefore efficiency and user orientation should be monitored and analysed because further research can identify new directions for improvements.

Examples of successful DIH were presented from Hungary and Romania together with recommendations for creating cooperation between smart factory initiatives and DIH centres in cross-border arrangements. The DIH initiative in Szombathely is especially relevant example because it has been acknowledged as model case not only within Hungary but also on European level. Consequently, their experience can be useful example especially for DIH that operate within reach of SMEs in a neighbouring country.

The example of Tehimpuls in Romania was shown as another model case because of their regional DIH function which can be built efficiently on the service offers of regional partners on regional, national and transnational level. The partnership within the Enterprise Europe Network can complement it with cross-border service development and with actions for transnational innovation projects with SMEs.

Our research team intends follow the development DIH and TEP implementation also in other countries within Central Eastern Europe with the objective to identify good practices that can be shared between the professional partners within European transnational cooperation projects.

Our objective in research is to develop a model for making comparisons of the impact of artificial intelligence in smart city developments. The cooperating cities within the Intelligent Cities Challenge can provide practical examples and data sources for such research project.

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