Social Impact of Artificial Intelligence in Europe

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Resumen– La Inteligencia Artificial (IA) puede ser una herramienta de gran ayuda para el crecimiento y desarrollo de la sociedad. Para conseguir un enfoque más cercano y una evolución más eficaz de esta tecnología, la Comisión Europea ha creado la red AI DIH, la cual centra su visión en el soporte de las pymes y sector público para implementar la IA en las diferentes regiones de Europa, ayudando a reducir la brecha entre las grandes corporaciones especializadas. En este documento se contextualiza la funcionalidad de la red DIH y como está actuando de cara a la IA, para introducir el análisis de los diferentes centros colaborativos enfocados a la IA. El resultado es una propuesta de técnicas, modelos y parámetros que pueden implementarse en esta red de centros, con el apoyo de Living Labs, para incrementar la efectividad y mejorar el producto/servicio final.

Palabras clave– Inteligencia artificial, red, cluster, colaboración, innovación, especialización, Living Labs, brecha digital, pymes, sector público.

Abstract– Artificial intelligence (AI) can be a very useful tool for the growth and development of society. To achieve a closer approach and a more effective evolution of this technology, the European Commission has created the AI DIH network, which focuses its vision on supporting SMEs and the public sector to implement AI in the different regions of Europe, helping to close the gap between large specialized corporations. This document contextualizes the functionality of the DIH network and how it is acting in the face of AI, to introduce the analysis of the different collaborative centers focused on AI. The result is a proposal of techniques, models and parameters that can be implemented in this network of centers, supported by Living Labs, to increase effectiveness and improve the final product/service.

Keywords– Artificial intelligence, network, cluster, collaboration, innovation, specialization, Living Labs, digital gap, SMEs, public sector.

1 Introduction

The current technological growth is leading on our way to develop the best facilities and competencies in society. We use technology as an instrument to understand, define, clarify, explore and solve the problems that concern us. It is a tool that is helping us to become more intelligent, efficient and competitive. But, it is also true that technology is not available to everyone. And if its methodology only applies to small groups, who benefit from technology, the world will observe and attend the segregation of resources, knowledge and societies.

The purpose of this report follows the growing involvement of collaboration and innovation models to achieve growth in societies in an effective, fast and cooperative way. Motivated and founded by the European Commission, the European Digital Strategy search the digital transformation of organisations and business around Europe. Where these enterprises, that are in a digital gap with any technology, can find support through a collaborative European network. This network instigates to understand the different ideas that the companies are researching and how it can be managed to achieve an expected result, considering the dimensions of the project, exploring the different aspects that it can cover. In the same way, inciting to promote collaborative methods and innovative models to reach a common objective, the constant growth, and not stagnation, of society. Given the basic digital skills and facilities that a small enterprise could acquire from the Digital Innovation Hubs (DIHs), the level of digital technology in the region will increase to overcome new obstacles and gaps. It is interesting that promoting organizations at the same level of business and innovation will focus them on more unique problems, and if there are more people behind the same problem, it will be easier to find the solution. So, scaling this approach, the regions will adopt newest technologies and

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effective methods to achieve their goals. It will lead to advanced technologies, where small companies and start-ups could be at a similar knowledge technology level of large corporations, collaborating on 21st century problems.

New advanced technologies that could support us nowadays and are rising in research centers are Artificial Intelligence, High Computer Performance or Cybersecurity. So, aiming to new business models and innovative projects, a more specialized network about implementation and development of these advanced technologies could take part and support researchers' projects and organisations around Europe to reach maturity on Artificial Intelligence or High Computing Performance systems. This collaborative network would boost the uptake of innovative advanced technology models, facing the technology complex problems and growing faster thanks to cooperation between researchers. This will make a quicker approach to Artificial Intelligence, that would enhance its impact and implementation on society. Meanwhile, the people that may be not experts on this topic can also help through Citizen Science projects. Just consuming a small bit of our day time, filling surveys or even ReCaptchas[1], it is possible to contribute to the data that researchers and programmers will use in its training, becoming a problem in which we all participate, and being able to escalate to other types of initiatives and concerns.

1.1 Report content

This report is divided into 6 sections, where Section 1 is the introduction already treated. The content of each section will be briefly introduced below:

- Section 2. Contains the contextualization of the situation and the main ideas and initiatives of the paper: Digitization, Digital Innovation Hubs, Living Labs and Artificial Intelligence.
- Section 3. Describes the methodology used to identify the main objectives of this paper.
- Section 4. Presents the results and evidences that conduct to further opinions.
- Section 5. Discussion from the evidence collected and the situation described in previous sections.
- Section 6. The main conclusions from the discussion and previous points are briefed.

2 Contextualization

2.1 Digitization

The amount of data that flows through our computers and business models and capabilities has grown 45 times since 2005 and is projected to increase by an additional nine times over the next five years as searches, communication, video, transactions, flows of information and intracompany traffic continue to surge. 50% of the world's traded services are already digitized, helping along different business models that would not work with this tool, but we have a long way to improve it.

Digitization could be defined relaying in three aspects: digitization of assets, where there are the machine connections, infrastructure, data platforms, etc; digitization of operators, referring to business models, processes and interactions with the customer; and digitization of the workforce, including the workers digital skills, tools, roles and new jobs. Those three aspects belong together to yield results (Manyika et al., 2017).

It is observed how there is a lack of this digitization of the workforce in Europe. Although already 85% of citizens used the internet in 2019, only 58% possessed at least basic digital skills, being those the backbone of digital society (López Cobo, De Prato, et al., 2019). For example, digital public services will provide more efficiency and savings for citizens, governments and business, and a successful exit strategy for the current pandemic may benefit from robust digital public services and a prosper e-government (European Commission, 2020a). Also, there is a gap between large companies and small and medium-sized enterprises (SMEs)[2], where only 25% of big companies and the 10% of the small and medium companies use big data analytics (Comisión Europea, 2018). Only one of every five small and medium companies were highly digitized and a third of the active population does not have the basic digital competencies.

Because of this digitization problem, the European Commission boost different action plans to facilitate technological access to all users, especially to small and medium companies, into no technological sectors and public administrations. The Commission will support diverse plans such as Digital Education Action Plan[3] to promote digital capacities and competencies to all citizen, Digital Opportunity traineeships[4] that provide cross-border traineeships on digital skills, Horizon 2020[5] to instigate investigation and innovation related to AI (big data, health care, transport and special investigation), AI-On-Demand-Platform AI4EU[6] where the current network of more than 400 digital innovation poles that offer specialized consulting on matters of technologies, capacities, business models, market value information and network creation (Bughin et al., 2019). All this programmes will help Europe to rise its digitization capacities between companies and sectors that are not digitized already, increasing their efficiency. It is crucial to create a solid base on companies and citizens that will power future technologies, such as Artificial Intelligence.

[1] A CAPTCHA can determine if you are a human being on the internet and receive data that machines cannot read or visualize by themselves, through ourselves. It is estimated that it takes us about 10 seconds to make a captcha. Today they are made around 100 million a day.

[2] Small and medium-sized enterprises must respect the staff headcount ($<$ 250, and $>$ 50), and the financial ceilings: the turnover ceiling ($\leq$ 50 million and $>$ 10 million) or the balance sheet ceiling ($\leq$ 43 million and $>$ 10 million), if it is less, it would be consider as small or micro enterprise

[3] https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_en

[4] https://ec.europa.eu/digital-single-market/en/digital-opportunity-traineeships-boosting-digital-skills-job

[5] https://ec.europa.eu/programmes/horizon2020/

[6] https://www.ai4eu.eu/

2.2 Digital Innovation Hubs

Digital Transformation is becoming one of the most important things to achieve visibility and positioning the companies and enterprises in the market. The different technologies that keep appearing are radically changing the way we see our customers, products and services. It remodeled how enterprises think about their marketing, production and design, bringing new innovation models that will shape the markets of the future. This transformation is motivated by the desire for innovation of organizations at all organizational levels (adaption of technologies, processes, services, manufacturing systems and its renewal). Those managers that consider new innovation models are expecting some development, adaption and design of new services or products, enhancing their quality or effectiveness, organizational robustness, changing their business models or access to new business areas and markets to increase the range and attraction for new customers.

Digitisation focuses on creating new opportunities and to strengthen the industry on Europe. Following up reports by Boston Consulting Group[7] and Pwc[8], it is possible to contrast the impact of digitisation of industry that will lead us to impressive benefits in this sector that could generate for industry in Europe additional annual revenue of €110 billion. Next to this background, the Digitising European Industry (DEI) initiative target to guarantee digital innovation for the industry in Europe, regardless of the sector, capacity or location of the organization. This initiative aims to generate a framework of co-ordination of initiatives for digitising industry, co-investing in boosting Europe's digital innovation capacities (pooling resources to boost digital innovations in all sectors such as Digital Innovation Hubs across Europe, partnerships for leadership in digital technologies value chains and platforms, and giving prioritisation and intensified efforts on reference architectures and experimentation), providing the appropriate regulatory framework conditions and boosting a human capital ready for the digital transformation with the necessary skills (European Commission, 2016a).

The level of digitisation remains depending on the country, sector and size of the company, where only 20% of SMEs in the EU are highly digitised on 2018. And if we observed the adoption of eGovernment services reaches the 53%, with some countries above the 75% (Sweden, Finland, Estonia, Denmark, Netherlands and UK) and others below the 30% (Italy, Greece and Czech Republic). Also the eCommerce grew slightly from 14% in 2013 to 17% of SMEs in 2017 (European Commission, 2018). Observing the 2019 evolution, only 17.5% of SMEs sold online, that is an increase of 0.5% compared to 2017. The basic digital skills went up slightly from 55% in 2015 to 58% in 2019. Large enterprises have a scale advantage, and as a result 75% of them employ internal ICT specialists. Small enterprises employing ICT specialists increased from 14% in 2018 to 15% in 2019 and medium-sized enterprises the increase was limited (42.5% in 2019, compared to 42.1% in 2018) (European Commission, 2020b). To tackle this digitalisation gap, the European Commission has created the Digital Innovation Hubs as tools for Digital transformation.

A Digital Innovation Hub (DIH) share facilities and knowledge that can help enterprises to become more competitive by advising and enhancing their business services and products as much as procedures and production processes by means of digital technology. DIHs can act as a one-stop-shop[9], serving companies within their local region and beyond to digitalise their business. It main target is to support SMEs and non-technology intensive industry. In 2016, DIH network was coined as a crucial pillar of the Digitising European Industry (DEI) initiative[10]. In 2020, DIHs are one of the key instruments of the Commission and Member States to boost the digitization of the EU industry. From the almost 100 organisation acting as DIHs in 2016, today there are more than 650 organisations that can be contacted through the Smart Specialisation Platform[11].

DIHs are seen as the core mechanism to create a strong collaborative regional innovation ecosystem where all innovation partners are working together to support SMEs in a specific digital technology. In this way, creating a network between innovation partners would improve the collaboration structure and will boost the uptake of innovative digital technologies (Butter et al., 2020). It is known that Europe has excellent experience in hub-types initiatives, see Annex 1, on which to base the implementation of such a network. Connecting the different hubs with transparent learning processes and action would facilitate the access to companies and mutual learning between actors. From a multifaceted posture, DIH should offer to enterprises interested a broad range of services (such as innovation scouting, mentoring and training, strategy development and testbeds). Digital Innovation Hubs have to lead on news ways of innovation. They must be trendsetters for digitisation and they must explore and be acquainted to their clients and problems to create a exemplar networking and collaboration approaches. These main points to operationalising Digital Innovation Hubs in Europe could determine a good approach to digitalization of SMEs:

- Identify **regional needs, characteristics and specialisms** to determine which circumstances affect companies, to develop the best action plan.
- Create a **vision for digital transformation** within the region to decide the role of the Digital Innovation Hub in his ambit.
- **Explore** what is already implemented and available in the region to get the basis of the Digital Innovation Hub.
- **Demarcate the services** of the hub and what should offer.

[7] The Future of Productivity and Growth in Manufacturing Industries, Boston Consulting Group (2015)

[8] Opportunities and Challenges of the Industrial Internet, PwC (2015)

[9] A one-stop shop is a firm that offers a multitude of products or services to its customers, all under one organisation. A one-stop-shop can refer to a literal roof, a specific physical location where all the business a client has can be carried out, or it can refer to a company that handles a variety of goods or services.

[10] https://ec.europa.eu/digital-single-market/en/news/digitising-european-industry-initiative-nutshell

[11] https://s3platform.jrc.ec.europa.eu/tools

- **Build links with other Hubs** is crucial to access to additional facilities that the own hub could be missing, creating a collaborative developing of new services and tools.
- Commence **engaging with companies and delivering services 'on the ground'**, bringing existing projects or initiatives.

If this steps are followed and checked over time, any region could establish on long term a sustainable Digital Innovation Hub ecosystem (European Commission, 2017).

2.2.1 Specialisation strategies

To ensure the correct functioning of the network it is needed to follow with the regional smart specialisation strategies and processes. This approach could be defined as an effective complement between policy and science. It has guided us to establish a place-based innovation-driven growth, where the main problems from the different regions have been traduced to future recommendations and solutions of those regions that have similar problems, but that have arisen later. The strategy is closing gaps in different areas due that different regions already solved or managed the same problem, and so, it is gaining interest from policy-makers and scientists. This initiative has given to communities lessons learnt about the Entrepreneurial Discovery Process (EDP), government arrangements needed to ensure diversity of stakeholders participating in the strategy, defining priorities areas to allow a powerful innovation potential to be developed on those areas, and many examples of how this strategy added value to the experience acquired with regard to the European value-chain approach (Gianelle et al., 2016).

National/regional research and innovation strategies for smart specialisation (RIS3) are integrated, place-based economic transformation agendas, focusing in the Europe priorities: smart, sustainable and inclusive growth. To guarantee a good implementation of the strategy, it is important to understand that the concentration of knowledge resources and linking it with the economic activities could lead regions and countries to be competitive in the global economy. *"Smart Specialisation is about generating unique assets and capabilities based on the region's distinctive industry structures and knowledge bases"* (Foray et al., 2012). The lack of international and trans-regional perspective, decompensation with the industrial and economic fabric of the region and the 'picking winner's syndrome' are lessons from the pass that we should avoid nowadays. Efficient, effective and synergetic use of public investment is promoted by the smart specialisation concept to support areas in strengthening their innovation capacity. Also it addresses the complex problem of prioritisation and resource allocation decisions, giving entrepreneurial actors the opportunity to demonstrate what areas of their regions are the best options to take an 'entrepreneurial process of discovery[12]', describing what region or country does best in terms of R&D and innovation because entrepreneurial actors are best placed to explore what are they good at doing and producing. To set this regional change there is required a structural change, leaded by a transition from the existing sector to the new cooperative one. Then a modernisation would follow, upgrading the level of technology of the industry through the development and application of a Key Enabling Technology[13] to improve efficiency and quality in the sector. Diversification and radical foundation of new domains can drive to potential synergies which are likely to materialise between an existing activity and a new one, giving in certain fields more attraction on previous low growth activities. Each region will have different entrepreneurial processes, identifying those sectors that can be potential resource of knowledge and innovation. Co-operation with other actors should be present to connect the knowledge between them, exchanging results with outsider regions that can lead to -not always- good outcomes (Foray et al., 2012). Smart Specialisation is a powerful tool based on regions to improve the knowledge growth of the entire EU community and global approach, that should be carefully considered to achieve the objectives of the initiative.

2.2.2 Clusters

DIHs are initiatives set-up to support digital transformation of existing industry across the European Union, and can be hosted by many types of organisations, such as cluster organisations. Clusters are multiple groups of related sectors or industries connected between them and in a specific location, creating a concentration of economic activities. What a cluster should consider are: the **critical mass**, knowing that the more companies there are in the group, the more likely it is to have higher productivity and innovation; **related industries** to focus on specific core competencies to engage with suppliers, services providers and other partners to increase success; the **location** of the cluster can be important on terms of interactions with partners, which is much richer with local partners and local talent base; and the **linkages** would create an environment that supports active collaboration, besides empowering the benefits from proximity by providing collaboration outside the environment itself (European Commission, 2016b). If those considerations are present on clusters initiatives, it could lead to a growth of experience, innovation and positive results on the group. Economic activities that are located in more than 3.000 strong clusters across Europe account for more than 54 million jobs (45% of all traded industries' wages)[14].

Clusters and S3[15] share some points and actions that should be consider to enhance the EU framework and EU initiatives approach. Both focus on productivity and innovation that drives to a competitive sector and foster

[12] Foray et al (2009) in 'Smart Specialisation – The Concept', a Policy Brief of the Knowledge for Growth Expert Group advising the then Commissioner for Research, Janez Potočnik

[13] The deployment of Key Enabling Technologies (KETs) can be an important component of a smart specialisation strategy because of their horizontal nature and transformative potential. Many future goods and services will be driven by KETs such as semiconductors, advanced materials, photonics and nanotechnology. Moreover, these goods and services will be crucial in addressing the 'grand societal challenges' facing the EU, including energy supply, public health, ageing and climate change

[14] According to the European Cluster Panorama 2016 by the European Cluster Observatory

[15] Smart Specialisation strategy

the advantages of proximity over regions. Anyway, there are some contributions that clusters could provide to the Smart Specialisation strategies. Cluster policies are able to guide the concentration and integration of economic policies around specific areas of the economy, avoiding the drawbacks of traditional industrial policies. The mix between cluster policies and S3 policies can be integrated to design an effective combination of policy instruments to outcome a smart policy mix. Also promote participation from sustained stakeholders from cluster policies to involve them in S3 policies that could benefit its bottom-up design and accomplishment. The extent to which clusters policies are appropriated for a specific cluster (the stage of cluster development), specific regions (level of regional competitiveness) and the general lessons of good practice for clusters would make an improvement on the conditions for an effective contribution of cluster policies to S3 (Foray, 2014).

2.2.3 DIH functionalities

Digital Innovation Hubs can take action horizontally, by providing digitisation support to different sectors, and vertically, by managing and coordinating the stakeholders mobility and interests towards digital innovation. Most organisations that host DIHs, such as clusters, have worked bringing different sectors to the same problem and mobilising stakeholders projects and promoting regional development processes. In terms of leadership and governance, DIHs can be both the policy outcome of a S3 part and an active actor participating in S3 entrepreneurial discovery processes (EDP), focusing in the horizontal digitalisation support and/or in the vertical interaction with stakeholders partners. One main function of DIHs that contributes to the regional development is to make a transparent and clear communication system across the regions, as acting like an one-stop shop, where SMEs could get help and guidance for its innovation systems and procedures. Some DIHs assist start-ups based on digital technologies, others support the development of products and services where there are not fully implemented the digital opportunities. Organising the innovation support system in the region and making available support easier to find are tasks that are performed by DIHs. Matchmaking is another function on DIHs, that can be done directly (e.g. through organising events) or indirectly (e.g. through the own web). It aims to connect actors by promoting complementarities between organisations with similar goals or projects, and supporting them to collaborate to create better services. The organisation of DIHs may vary (from research centres or clusters to public entities) as well as their geographical coverage. Anyway, it is important that the hubs have to provide services that are relevant to local SMEs and industry needs, because if not, the new customers engagement would not succeed. The competences that those can offer are diverse, from business development skills, support to star-ups or communication and engagement competences; however, these can be amplified by the fact that DIHs may connect with external partners skills. Several of the DIHs have reported to be connected and collaborate on regular basis with:

- Clusters, to better reach out to SMEs and industry.
- Research centres and universities, to be able to provide relevant technical support skills.
- Technology-using companies, to mobilise needs and provide development opportunities.
- Private tech suppliers, to provide solutions.
- Private consultants, to provide knowledge.
- Public innovation support actors (incubators, accelerators, etc.).
- Regional/national development agency.
- Public administration.
- Community based labs.
- Training centres.
- Professional associations.
- Congress and events.

The networking and collaboration with this organisations gives the possibility to SMEs to work with experts and technologies that have previous experience that could address their needs (Rissola and Sörvik, 2018).

2.2.4 Building blocks of European Digital Innovation Hub network

The concept that DIHs follow is based on the need to accelerate innovation conjointly through networking and collaboration, it is called **open innovation**. The organisation to achieve a functional network of EDIHs is founded in five different building blocks in a bottom-up approach:

- **Competence Centres** (CCs): the core to all innovation activities. Where surge the development of new and innovative technologies and are endowed by state-of-the-art technological infrastructures and experts. These centres focus on transforming innovative technologies developed in the CC into products and services.
- **Digital Innovation Hubs** (DIHs): in charge to transfer the technological products and services of CCs to support this transformation process with more business-oriented services. Complementing the CCs technological development, DIHs offer the services to support SMEs to make products and business. It also promotes collaboration at regional level to create an innovation ecosystem in a specific industry/technology areas.
- **Regional DIH networks** (RDN): at regional level, organize certain services and activities, achieving economies of scale. They focus on regional awareness creation and access to finance. Also, RDNs combine activities of individual DIH-nodes on pan-EU collaboration.

- **Pan European DIH networks**: established to support interregional collaboration, improving EU leadership on specific innovative areas. They connect activities between regions to make possible collaboration and cooperation inside the EU community.

The last and upcoming building block is the **European DIHs**. They will play the role related to interregional collaboration. Some DIHs and RDNs would be selected to collaborate in a pan-European level (Butter et al., 2020). These different building blocks (see Figure 1) have different tasks, missions and activities that lead to the same objective, boost less developed companies.

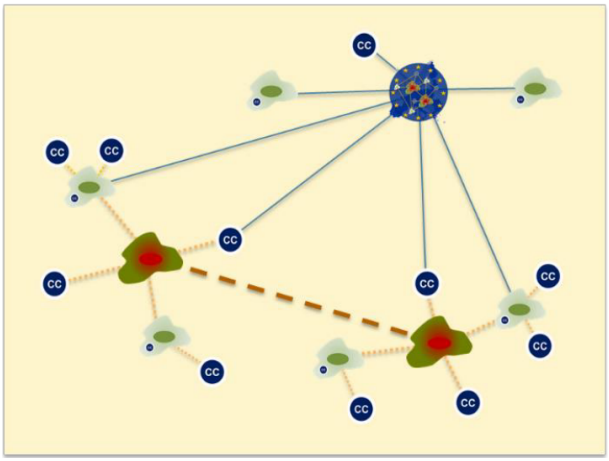

Fig. 1: Organisation of DIH building blocks in the DIH landscape. Source: DIHNET.EU.

These main building blocks of EU DIH network are working together to provide services and implement digital technologies, at the same time it aims to enhance European collaboration. Connecting the different services providers (DIHs) from different areas and enable them to establish relationships with SMEs and MidCaps outside of their region (EU-network) is the method that direct this objective.

The **European Commission** aims to create a excellent framework of collaboration across the member states, using instruments to stimulate this collaboration. H2020 is one of the most important ones for EU-DEI strategy[16]. It comes with **Innovation Actions** (IA) that focus on specific industries areas, like robotics. As the most important instrument for EU DIH community, they connect DIHs and CCs from different regions to favour the cross-border support to SMEs. **Coordinated Support Actions** (CSA) is the second instrument that coordinate activities of the different IAs inside family areas (see Figure 2).

2.2.5 European network of Digital Innovation Hubs

With the Green Deal communication of December 2019[17], the European Commission has committed to "tackling climate and environmental-related challenges that is this generation's defining task", and set strong measures against greenhouse gases emissions and economic growth from resource use.

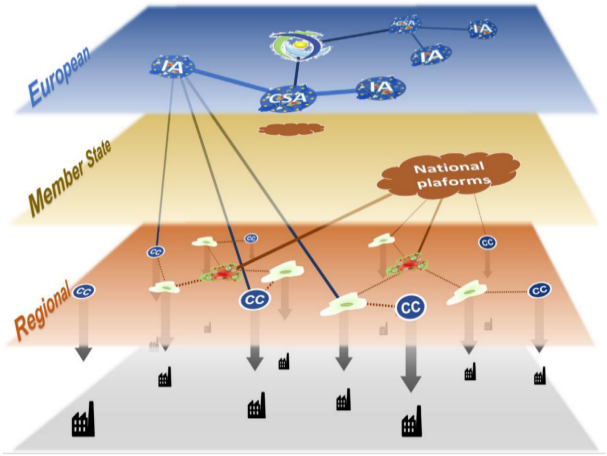

Fig. 2: Simplified three level organizing approach of EU DIH network. Source: DIHNET.EU.

The network of European Digital Innovation Hubs is helping companies to get access to digital technologies to contribute to the European Green Deal, tackling these objectives as well as the global epidemic of COVID-19, organising the different DIHs that one day may become an European DIH. An European Digital Innovation Hub (EDIH)[18] is a single organisation or a coordinated group with complementary expertise, that support mainly SMEs and public actors in their digital transformation, with a not-for-profit objective[19] (European Commission, 2020c). The following list specifies, in particular, the services and activities that offer the EDIHs:

- **Self promotion**. It is important that they are visible to to publicize their function, rising up the digital technologies on companies and promoting the upgrading of the industry (through videos, commercials, roadshows, events, etc.).
- **Diagnosis**. To improve competitiveness the hubs must be positioned at high technological level of the region.
- **Transformation plan**. After diagnosing the specific needs on the region, the DIHs should prepare different possible technologies proposes, solutions and new innovation models to adapt to the existing sector.
- **Testing**. A specific and effective method to boost innovative ideas through enterprises is **test-before-invest**. It is an excellent example of one of the

[16] The European Commission launched the Digitising European Industry initiative (DEI) in April 2016. As part of the Digital Single Market strategy, the DEI initiative aims to reinforce the EU's competitiveness in digital technologies and ensure that every business in Europe - whichever the sector, wherever the location, whatever the size - can draw the full benefits from digital innovation

[17] The European Green Deal, COM(2019) 640

[18] Digital Europe Programme has the following definition: 'European Digital Innovation Hub' means legal entity selected in accordance with Article 16 in order to fulfil the tasks under the Programme, in particular providing directly, or ensuring access to, technological expertise and experimentation facilities, such as equipment and software tools to enable the digital transformation of the industry, as well as facilitating access to finance. European Digital Innovation Hub shall be open to business of all forms and sizes, in particular to SMEs, midcaps, scale-ups and public administrations across the Union

[19] The beneficiaries should declare that for the activities covered by the grant they apply a not-for-profit objective, i.e. all money earned by them or donated to them is used in pursuing the EDIH's objectives and keeping it running

experimentation and piloting facilities offered in DIHs, that can measure the range of succeed of the project.

- **Collaborative** research projects. Where the hubs contribute to find these projects and enable connections with them, through demonstrations, living labs, start-up boosters, specialised workshops or assistance to the development of research projects.
- **Matchmaking**. It is another important function that favors the pooling of organisations with similar needs or complementary solutions. Continuous bidirectional connections with incubators, business development agencies, SME associations, clusters, regional/national development agencies, private tech developers, accelerators, Enterprise Europe Network (EEN)[20] and chambers of commerce would significantly help to reach the best brokerage function.
- **Training and skills development**. Technological education is a crucial path to support the self-growth of SMEs and public administrations. Mentoring, advertising, traineeships are some methods to develop digital skills on enterprises.
- **Promotion and marketing**. DIHs can help companies to market and promote themselves. It may be in a regional area or beyond, also leading to the **internationalization** of the company or project itself.
- **Financing**. Support to find investments is a requirement to many SMEs and start-ups to improve their competitiveness and business models.
- **Transversal initiatives to favour digitisation**. Developing and implementing technological and digital infrastructures such as high-speed Internet or access to computing systems can stimulate open innovation and the use of open data.

The services of DIHs should not replace existing services in companies. They can be modified or adapted but the service of hubs would act as complementary service to improve the final solution (European Commission, 2020c). Also, it is important to remark that the Digital Innovation Hub network may give preference to SMEs and start-ups before to other organisations, to offer the less developed enterprises equal opportunities.

DIHs, as we know, offer support to business, but thinking about what they exactly support may surge a doubt. Referencing the **TRL scale**[21] to clarify this question, DIHs emphasizes on TRL 4-7, as they facilitate the translation from research to business (Butter et al., 2020). Even so, TRL scale is oriented to a single technology, meanwhile, DIHs have multiple approaches to support companies that may not include technology as itself, but innovation and orchestrating, not measured on TRL scale.

2.2.6 Service Science: EDIHs as service systems

The academic discipline of Service Science is based on service interaction and value co-creation, one of the innovative ideas for 2005 by the Harvard Business Review (Chesbrough, 2005). The service systems are the operators of Service Science. These, independently, can be providers and clients of services, that can jointly interact and co-create value. As seen, DIHs are service providers that can be complemented between them, sharing knowledge and expertise to tackle Digital Transformation in the industry, so, they are considered as service systems.

Service systems are considered as socio-technical systems (Böhaman et al., 2014). These systems create ”dynamic value co-creation configurations of resources (people, technology, organizations, and shared information)” (Maglio and Spohrer, 2007), measures, methods and laws. DIHs are a collection of service systems acting in an horizontal an vertical perspective that interact, co-create, collaborate, cooperate to expand and create services through expertise and new knowledge. SSMED[22] focuses on service interactions, increasing productivity and innovation. Methods (Spohrer et al., 2010) to increase the interaction and productivity are:

- Identification of stakeholders entities in a network analysis, to account for possible similarities.
- Explore and analyse existing correlations and collaboration projects to reach the opportunities and challenges on the community.
- Enhance exiting co-creation mechanisms, as freeing resources and redistribution of the same.
- Creation of new systems to address new services to tackle the challenges remaining.

In the same way, European Digital Innovation Hubs are organisation that develop research, innovation and investment over the European Commission. Its initiative can be considered as the supplement of the ”Factory of the Future” (FoF; European Factories of the Future Research Association, 2016) programme, which was launched firstly in 2008 with the aim to develop a sustainable and competitive EU manufacturing (Maurer, 2021).

2.3 Role of Living Labs

Decades ago, we could already observe how collaborative movements were used in research and business fields. But it was not until the nineties that the term Living Lab began to develop, when, for first time, Lasher et al. used it to describe the use of co-operative partnerships and live field trials as early as 1991. From since, the term of ”Living Labs” have been developing in a collaborative and co-operational framework that refers to diverse meanings. According to Dutilleul et al., it can refer to an experimentation of a technology, innovation system, involving users in the

[20] The Enterprise Europe Network helps businesses innovate and grow on an international scale. It is the world’s largest support network for small and medium-sized enterprises (SMEs) with international ambitions. https://een.ec.europa.eu

[21] The Technology Readiness Level (TRL) scale was originally defined by NASA in the 1990’s as a means for measuring or indicating the maturity of a given technology. The TRL spans over nine levels, starting from ”TRL 1 – Basic principles observed” to ”TRL 9 – Actual system proven in operational environment” https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

[22] Abbreviation for Service Science, Management, Engineering and Design

product development process, organizations facilitating the network and offering relevant services or the European living lab movement. Living Lab is a concept that aims to support user-driven systems, projects and activities, situated in real-world context.

In 2006, it was established the European Network of Living Labs (ENoLL). Since its formation, ENoLL has labelled more than 440 Living Labs and the network is continuously growing. Its main residence is in Europe, but there are members operating all around the world. ENoLL[23] has provided its own definition of Living Lab: *"Living Labs (LLs) are defined as user-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings. LLs are both practice-driven organisations that facilitate and foster open, collaborative innovation, as well as real-life environments or arenas where both open innovation and user innovation processes can be studied and subject to experiments and where new solutions are developed. LLs operate as intermediaries among citizens, research organisations, companies, cities and regions for joint value co-creation, rapid prototyping or validation to scale up innovation and businesses. LLs have common elements but multiple different implementations"*. Living Labs have the mission on supporting the innovation procedures for all involved stakeholders, from manufacturers to end-users, with special attention to SMEs. Also there are different types of Living Labs environments according to (Ståhlbröst and Holst, 2012): Research LLs, focusing on performing research on innovation processes; Corporate LLs, aiming to invite and co-operate with stakeholders; Organizational LLs, developing innovations in a co-creatively way; Intermediary LLs, that instigates different partners to collaborate in a neutral arena; and time limited LLs, appearing to only support on innovation for specific projects. The **quattro helix model** is what Living Labs are aiming, ensuring the four main stakeholders: users, researchers, companies and public sector. This approach benefits the different stakeholders as introducing innovative ideas, increase return on investment or get the innovation that users want; they are all connected. It is necessary that every LL embrace five key principles: Value, Influence, Sustainability, Openness and Realism (Ståhlbröst and Holst, 2012). These will provide the foundations for design of Living Lab functions, as defining what is a LL and how are assessed the different operations they carry.

This characteristics and principles are very similar with the previously described DIHs objectives. So, knowing that Living Labs are specialized on collaboration and networking, why not follow the instructions from the European Commission and the Specialization Strategy? Living Labs can give strong support to the DIH network in diverse methods and techniques, as they were working on co-operation and sharing knowledge for many years. In a collaborative and innovative framework, LL may be the leaders as organisations connecting different stakeholders to achieve goals, project solutions or services. They bring innovative solutions and models to SMEs, companies and the public sector using their position to connect the dots. The experience of all these years could benefit and accelerate the DIH network to accomplish their organization and services. LLs can show the DIH network different methodologies to interact, present, join and organize the stakeholders involved to enhance their chances of success.

To face the challenges that SMEs are dealing with, it is crucial to support DIH with guidance to Open Innovation (Chesbrough, 2003). Living Labs can act as mentors in this path, showing the best practices, skills and methods learned in their experience. The DIHs will show the benefits from Open Innovation to smalls companies, such as value collaborative partnerships, supporting investments for SMEs, expanding geographically at lower cost and achieving greater rewards as they specialize in Open Innovation. At the same time, DIHs will be able to execute better services, communication and organization to the network, offering to SMEs more R&D capabilities and absorbing external R&D, increasing "status" with co-operation in different projects, market power and expanding their potential to capture/acquire value and talent. Living Labs can take the role of guide on innovation and collaboration procedures, accompanying the AI DIH network in its objective of reducing the digital gap and fostering the uptake of Artificial Intelligence.

2.4 Artificial Intelligence approach

2.4.1 The emerging artificial intelligence

The development of the Artificial Intelligence is a new integration of technology. Over time, various definitions of AI have appeared to indicate what or how tasks are made in the different cases of Artificial Intelligence; (McCarthy et al., 2006), (Haenlein and Kaplan, 2019), and others have contributed with their definitions, but in this report we will define it as "systems that can improve its ability to solve a wide range of tasks without the injection of specific human knowledge" (Jose Manuel Rey Gonzalez) that can describe what and how will be the AI in a future, with the importance of the self-improvement and without specific knowledge provided by humans. Artificial Intelligence can be implemented in machines through algorithms. Moravec's Paradox explains the difference between human and computational solve-problem methodology and the importance of abstract thinking. Machines can follow instructions step by step and obtain a perfect result, but if some abstract perception is applied, the problem will be harder to solve. The logical problems are easier to solve than the day by day tasks in the field of Artificial Intelligence. That is why these machines are replacing engineers and not artists (Agrawal, 2010).

In accordance to the HLEG, AI techniques and sub-disciplines can be grouped under two big strands regarding the systems' capabilities: (i) reasoning and decision making, (ii) and learning and perception. Those strands cover another 8 AI domains that will be described as follow (Desruelle, P. (ed.), 2019):

- **Reasoning** is the process that machines use to transform data into knowledge.
- **Planning** domain involves the design and execution of

[23] https://enoll.org/

strategies to perform some action, leaded by intelligent machines (robots, agents, vehicles).

- **Learning** is the ability of systems to automatically learn, predict, decide and react to changes, improving from experience, without being explicitly programmed.
- **Communication** refers to the ability of identify, process, understand and/or generate information in spoken and written human communication.
- **Perception** could be described as machines' ability to understand and become aware of their environment through senses.
- **Integration and Interaction** is the transversal domain that combine perception, reasoning, action learning and interaction with the environment.
- **Services** is another transversal domain that refers to any software, infrastructure and platform provided as services or applications available off shelf and executed on demand.
- **Ethical and philosophical** issues in AI deployment is a main topic on public administration and governments, as it is for society.

Focusing on the coming AI, it is important to promote **Trustworthy AI**, what aims that AI has three principle components: it should be lawful, complying with all applicable laws and regulations, it should be ethical, ensuring adherence to ethical principles and values and it should be robust, both from a technical and social perspective since, even with good intentions, AI systems can cause unintentional harm (Samoili et al., 2020). It is time to frame the challenges that AI can pose, because every service or device would be different and should contain rules that specify their function in what must and must not do (High-Level Expert Group on AI, 2020). AI should consider human dignity, where human beings must be free and be able to make decisions by their own. Also support equality, solidarity, no discrimination, and human rights. Artificial Intelligence is considered to have started in 1950, when Alan Turing published the milestone paper "Computing machinery and intelligence" (Turing et al., 2009), which considered the fundamental question "Can machines think?" (Turing Test[24]). Nowadays, AI can resolve complex problems and take profit of those domain studies/investigations to improve and solve its own problems, increasing its complexity and improving its capacity. A clear example of AI progression is AlphaGo[25] that is the first computer program to defeat a professional human Go player; facing the best player of each game, recognizing and identifying specific objects in images or driving (Delipetrev et al., 2020).

The overall level of AI investments is estimated to be in the range of € 7.0 to € 8.4 billion, depending on the scenario. This corresponds to 35-42% of the annual investment objective established in the Coordinated Action Plan (Nepelski and Sobolewski, 2020). From worldwide view, Europe had invested 3.2 billions € in 2016 compared to the € 12.1 billions in North America or € 6.5 billions in Asia. Also it showed a poor data access in the continent, that should improve as it is a prerequisite for developing artificial intelligence. Otherwise, Europe stands out for the strength in Machine Learning (ML) and good algorithms foundations for AI (Grupo de expertos de alto nivel sobre IA, 2018). The members that have signed the Declaration Cooperation on Artificial Intelligence[26] agree with the collaboration with the rest of the members and the Europe Commission to contribute efforts to make AI available and beneficial for all, exchanging best practices and views on ethical and legal deployment of this technology and establishing a dense network of Digital Innovation Hubs[27] at European level to accomplish this approach to the AI development.

2.4.2 Artificial Intelligence and DIHs

Due the constant development of new technologies and techniques, the European Commission and the European Parliament have agreed to carry further DIH. Aware of the potential of collaboration, DIH are expected to play a major role in the upcoming Multiannual Financial Framework 2021-2027, promoting the adoption of disruptive technologies - particularly Artificial Intelligence (AI), High Performance Computing (HPC) and Cybersecurity - by public sector and industry organisation. This impulse aims to the creation of a European Network of Digital Innovation Hubs with focus on AI. This action is managed by PwC[28], in consortium with CARSA[29] and Innovalia[30]. The AI DIH Network project involved 30 DIHs from 20 countries in a mentoring and coaching programme centred on cooperation (workshops, peer-learning program, webinars, individual tutors) (Galasso et al., 2021). These DIHs are very diverse in terms of structure, services offered, size, experience and technology focus, where all demonstrated some degree of experience in transitional activities, already developed in DIH. AI DIHs should extend the offering services to a specific AI-related support services, with a leverage specific skills, internally and accessing to the competences available in their network. With reference to the ESCO framework[31], there are some skills, competences and activities that should be reflected in their hubs:

- Use of **transversal competences**, as management and soft skills needed for all activities.
- Developed technical skills **related to AI**, to be able to offer AI-related services (computer science, ML, software design, etc.).
- Relevant skills to offer in specific services, such as knowledge on AI professional ethics and auditing techniques.

[24] https://plato.stanford.edu/entries/turing-test/
[25] https://deepmind.com/research/case-studies/alphago-the-story-so-far
[26] https://www.vlada.cz/assets/evropske-zalezitosti/umela-inteligence/SignedDeclarationofCooperationonAIpdf.pdf
[27] https://ec.europa.eu/digital-single-market/en/digital-innovation-hubs-dihs-europe
[28] https://www.pwc.com/gx/en/about.html
[29] https://carsa.es/about/
[30] https://innovalia.org/
[31] European classification of skills/abilities, qualifications and jobs: https://ec.europa.eu/esco/portal/skill

- Provide physical and virtual infrastructures to support the development of AI solutions (e.g. HPCs, IoT, etc.) to offer a testing service, as DIHs, of new business models using AI.
- Include an **ethical AI component** in the governance model of DIH (committee, member, working group, etc.).
- **Connections** with other organisations (start-ups, universities, hubs, research centres and funds) that would provide specific assets to deliver AI services.

The capability to interact and adopt services from other competences available in the network activates collaborations, a basic principle in the EDIH. Abilities as manage projects, communication, to assess issues and ethical behaviour should be present on the transversal competences to ensure a safe implementation of new products and services of SMEs. As an outcome of the AI DIH Network project and the previous services described, the potential services offered by an AI DIH, according to the DEP, should be *"Test before invest, Skills and Training, Innovation ecosystems and networking, and Support to find investment"* (AI DIH Network, 2020). It has to be noted that an individual DIH does not need to offer all these services as it may have strong relationship with o thers organisations that can borrow them. But, the DIH has to be adapted to solve the needs and challenges of the local stakeholders and specific ecosystem.

3 Methodology

To achieve the objectives described previously, the methodology has been devised considering the following conditions. Primarily, the different organisations are constantly working and exploring new innovation models and tacking action in the different technologies, that are evolving very rapidly, meaning that changes are present at any moment, and the data already analysed may vary in the future. Secondly, the European network of Digital Innovation Hubs is a recent initiative that is not fully implemented and data is slightly showing optimum results and best practices from the DIHs; at the same moment the AI DIH network is on its firsts steps of implementation. Finally, the COVID-19 pandemic has been able to divert attention in some Competence Centres and participants, thus delaying its development, while at the same time giving extra value to the DIHs initiative and its collaborative model.

With these considerations, the methodology searches for a wide coverage that explains the rapid evolution of technology, trying to describe the impact it may have depending on the organisational and geographical level of the sector. This methodology does not follows the purpose of defining a current and robust statistic nor comprehensiveness across all sectors, but to deliver qualitative and quantitative measures that can be adapted and repeated over time in different sectors on a step-wise approach.

There are four main elements to the methodology:

1. Identification of DIH network and participants.
2. Analysis of actors in AI network.
3. Definition of key experts and services.
4. Analysis of Living Labs judgment.

3.1 Identification of DIH network and participants

Due the recent development of the DIH network, it is important to inspect and recognize what type of participants are in the DIH network and their characteristics to establish a solid base of this report. With this description it is possible to understand and define the framework of DIHs and the actors that would be useful in the analysis to determine possible AI and European DIHs. Through the Digital Innovation Hubs tool[32] it is possible to map all the DIHs and Candidates to European DIHs. The data available in this web is working like "yellow pages" where the information provided about each entry is based on self-declaration, being verified by the European Commission according to the DIHs criteria.

The 678 possible results (see Figure 3) are differentiated depending on their evolutionary stage: fully operational, potential DIHs from H2020 or in preparation. They can be filtered depending on the country, evolutionary stage, technologies, services provided, focus TRL and sectors. It also shows the 185 DIHs that are involved in H2020 projects.

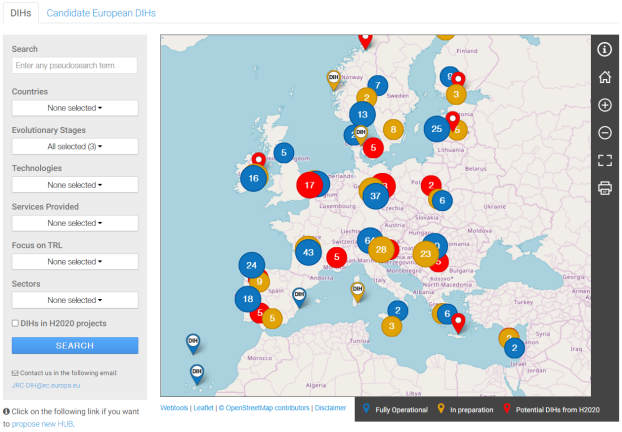

Fig. 3: Landscape of DIHs across Europe. Source: Digital Innovation Hubs - Smart Specialisation Platform.

3.2 Analysis of actors in AI network

By the same tool and filtering the technologies and sectors it is possible to find AI actors and future AI DIHs participants. But the main objection that have been observed in this report is the 30 selected DIHs[33], see Annex 2 and Annex 4, that received mentoring and coaching on business development, financing and innovation management in March, 2019. The selection has been made by an expert Steering Committee on both DIHs and AI-related

[32] https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool

[33] Here you can find the full list of the 30 AI DIHs contacts: https://digital-strategy.ec.europa.eu/en/news/30-digital-innovation-hubs-focused-artificial-intelligence-selected-training-programme

technologies, under the supervision of representatives of the European Commission.

The total number of 150 applications are from 27 different Member States (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and United Kingdom) and three Horizon 2020 associated countries (Serbia, Switzerland and Norway) has been submitted.

These Digital Innovation Hubs focused on Artificial Intelligence have been searched and explored at their platforms. This process ensures what capabilities are being provided by the different hubs and if they are able to coordinate and be part of the AI DIH network.

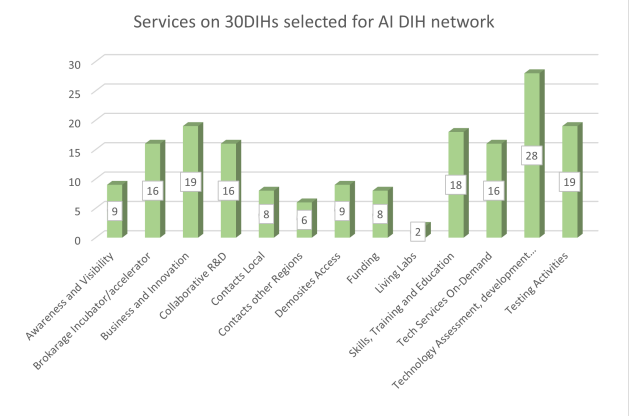

Fig. 5: Services on 30 DIHs selected for AI DIH network. Source: Own production.

3.3 Definition of key experts and services

After revising the aptitudes and competences of the 30 DIHs selected to start the AI DIH network initiative, an important approach in this report was to elaborate the mapping of these and select and compare their abilities, expertness and services to provide qualitative results about the cohesion of the network. It can be divided in three different consults about each DIH. The first was the expertise orientation of the organisation (see Figure 4). Then, the different services

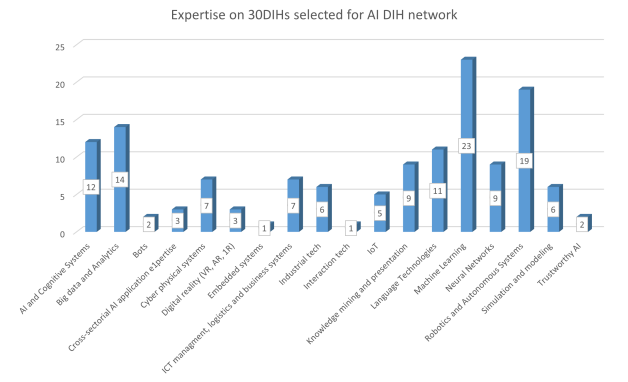

Fig. 4: Expertise on 30 DIHs selected for AI DIH network. Source: Own production.

that each hub could offer to SMEs and midgap enterprises in order to support and digitalize them (see Figure 5).

Also, the specialized sectors of each hub was analyzed to determine which range of implementation and on what stage were the different sectors around Europe and its cohesion to the network and the rest of DIHs.

3.4 Analysis of Living Labs judgment

In order to integrate and develop the paper that Living Labs could accomplish in the AI DIH network is necessary to analyse their own points of view. To determine the role that Living Labs are playing in this Digital Transformation and AI Impact, a survey has been launched to members of ENoLL, specially to effective members that can highly contribute to the results of this paper (see Annex 3). The questions are AI-related, both objective part, such as what services, domains and co-working plans do they have, and a perceiving part, asking about the link between Living Labs and DIH. This will support the paper with firm evidence from the Living Labs exposure.

4 Results

With the previously considerations presented in the methodology, various results have been obtained, further object of discussion. Firstly, in the process of identifying the DIHs that are present in the Digital Innovation Hubs tool, it is considered that not all DIHs in this platform may have implemented all the characteristics and methodologies that a DIH should have. Anyway most of these are filtered as ”in preparation” and could lead to a proper development of DIH, in a closer future, adapting and mentoring these centres. At the same time, it is visible the collaboration approach and values that these organisations are showing to being part of the network. Also, it is seen the broad distribution of sectors and the specialization strategy that is focusing those centres to their main objectives and problems.

Focusing in the Artificial Intelligence sector in the mapping, it is observed that not all 30 AI DIHs are mapped as candidates for European Digital Innovation Hubs, but all seem to appear in the DIHs map, as individual organisations or as clusters of organisations. Through the analysis, the different features were compared and there are different grades of innovation across Europe, and classified as it follows:

- **Leader**: performing best among EU regions in terms of research systems and business innovation. There are two subgroups Leaders + (FCAI, Munich Innovation Hub for Applied AI and Smart Industry Hub South (Data Value Center)) and Leader - (DFKI Human Centric AI Innovation Hub).

- **Strong**: powerful research methodologies and business innovation. There are three subgroups, Strong + (Know-Center GmbH, IMEC, Super IoT, DIGIHALL, Teralab, CeADAR - National Centre for Applied Data and Analytics and Artificial Intelligence), Strong (Danish Technological Institute, SINTEF) and Strong - (Czech Institute of Informatics, Robotics and Cybernetics, DIGIWEST, VDTC of

the Fraunhofer IFF, Area Science Park IP4FVGand PRODUTECH Digital Innovation Hub National Platform).

- **Moderate**: Great efforts on research centres and innovation models. Classified as Moderate + (nZEB Smart Home, HPC4Poland, Digital Innovation Hub Slovenia (4P DIH) and Spanish Digital Innovation Hub for HPC), Moderate (Smart Industry Centre (SmartIC), DIH Lombardia, RIF (Robotics Innovation Facility) BioRobotics Institute, Latvian IT Cluster DIH, Lithuanian robotic DIH (LTroboticsDIH), AIR4S and ITI Data Cycle Hub) and Moderate - (CROBOHUB Croatian Robotics Digital Innovation Hub).

- **Modest**: as the least innovative regions in Europe. The only one in this group is PIAP HUB from Warsaw, Poland.

The features of these regions differ significantly (Hollanders et al., 2019), hence its classification. A part of the innovation performance of each DIH, there were others characteristics analyzed to determine the grade of cohesion between the hubs and potential collaborative initiatives:

1. Services offered.
2. Specialization of the hub.
3. Experience of sectors involved in the hub.
4. Collaboration with Living Labs.

4.1 Services offered

The 30 AI DIHs showed to offer 13 distinctive services, such as Business and innovation, Technology assessment, development and prototyping, Technology services on-demand, Skills, training and mentoring, Awareness, Testing activities, Demosites access, Collaborative R&D, Funding, Network of contacts and Brokerage. In the analysis, it is observable that there are some DIHs that are offering more services than others. For example there are 15 DIHs that offer 6 or more services (IMEC and CeADAR at the top of the list with 10 services). The 15 DIHs remaining are offering less than 6 services (Teralab and Czech Institute of Informatics, Robotics and Cybernetics with only 2 and 3 services). Also, it is observed that the value of the service offered may change in function of the hubs' experience.

Focusing in the services that are offered, the most common service is Technology assessment, development and prototyping, where 28 DIHs of the 30 AI DIHs could give proper assessment to the SMEs and organizations interested. The following common services are Business and innovation with 19 DIHs, Testing activities with 19 DIHs and Skills, training and mentoring with 18 DIHs. The least common and/or more specific ones are direct Funding with 8 DIHs, Demosites access with 9 DIHs and Awareness and visibily with 9 DIHs. In total, there are 174 services offered by the 30 AI DIHs, that could be same services with other sectors' expertise or other vision. These services could increase by the collaborative connections and networking with other hubs.

Some examples of ecosystem and business services from some of the 30 AI DIHs are presented. SuperIoT and the Finnish Center for Artificial Intelligence have developed an AI maturity assessment tool[34], available for all industrial organizations, that shows a basic visualization of AI maturity in six dimensions: Strategy and Management, Products and Services, Competence and Cooperation, Processes, Data and Technology. IP4FVG launched a campaing to assess the digital readiness of 89 manufacturing companies and then select the "Manufacturing lighthouses"[35] (10 most digitally advanced companies) to play a model role for the others. Smart Industries organised a one-day training course on data collection and cybersecurity issues to tackle the fact that the vast majority of data is not digital available or not cleaned/complete; using open source software (OPC), open source hardware (Raspberry Pi) and open source tools (Python programming). AIR4S, supported by the promising start-up Geoblink[36] is running an UPM entrepreneurship program, "actúaupm"; providing consulting services in business ideas validation, promotional services and advanced education and skill development to the staff in innovation and entrepreneurship. The DIH of nZEB Smart Home supported Pragma-IoT[37] (a spin-off of CERTH/ITI) and a brewery in order to improve its logistics procedures; where the solutions offered included a complete and legal automation of the malt transportation within the brewery, with a deployment of an IoT infrastructure and platform to handle all logs and remotely the brewery assets.

4.2 Specialization of the hub

In this section, there are 18 expertise domains: AI and cognitive systems, Robotics and autonomous systems, IoT, Machine and deep learning, Language technologies, Cross-sectorial AI application expertise, Cyber-physical systems, Simulation and modeling, ICT management, Trustworthy AI, Neural networks, Big data and analytics, Digital reality, Industrial technology and Knowledge mining and presentation. Considering that there are similar and contributing technologies between them, it is important to remark that the next section "Experience of sectors involved in the hub" will detail specific sectors of the different expertise, knowing that a singular technology can be very extensive which can exceed the specialization of a specific DIH.

Going into detail through the different expertise, the most common expertise domain is Machine and Deep Learning which 23 DIHs have shown themselves as experts in this domain. Following is Robotics and autonomous systems with 19 DIHs and Big data and analytics with 14 DIHs. The least common expertise domains are Trustworthy AI with only 2 expertise DIHs, Digital reality as virtual reality, augmented reality and digital twins models with 3 DIHs and IoT systems with 5 DIHs. The total expertise domains managed by the 30 AI DIHs are 142, counting that domains can be repeated in different DIHs. These expertise could share data and connect with similar experts to collaborate

[34] https://ai.digimaturity.vtt.fi/?lang=en
[35] https://www.ip4fvg.it/premiazione-fari-manifatturieri-fvg/
[36] https://www.geoblink.com/
[37] https://pragma-iot.com/

on furthers projects, supporting those organisations that may need help to overcome digital gaps. Also, it is perceived that these DIHs that are carring with less expert domains on their organisation does not mean that are less important, instead these DIHs could have more experience and investigation on their main expertise domains than those that cover more expertise domains; so, they may lead in their technologies to support the rest of the network.

Some examples of how ML have been used to support the DIHs themselves and SMEs. Know-center GmbH had supported Reval Austria[38] to improve its system with AI-functionalities using a two-step approach, where a validated data was introduced into the system to generate and evaluate data-driven AI use cases; developing suitable ML models that are consequently implemented in each release of Reval's software product. DIGIHALL found an unassisted SMEs, through a broker in a different region, that wanted to introduce an AI quality control in their automotive factory; after the DIH defined a proof-of-concept demonstrator using a testbed the SMEs contacted an independent star-up to define an industrial solution. Other examples coming from the application of languages technologies and video recognition are following. Munich Innovation Hub for applied AI contacted Fortiss within the DIH that helped Ubotica Technologies Limited[39], an Irish SMEs, that needed to integrate technology to validate AI components in their development of an AI solution for detecting Diabetic Retinopathy (DR) indicators in retinal images taken by specialist Fundus cameras. DFKI Human Centric AI Innovation Hub assisted a small enterprise working in the wooding craft sector in managing and valuating their knowledge, with the support of AI driven solutions, that build an interactive knowledge database to be used current and future employees. In the robotics specialization, CROBOHUB, jointly with ENDORSE, helped Enikon Aerospace Ltd.[40] on their road to automation, offering solutions for compliant motion of the whole robotic manipulator which will allow the Enikon to increase the amount of surface of the products that can be treated with the robotic manipulator, as well increasing the performance, efficiency and the safety of workers. And the last example, aiming digital reality technologies, where CIIRC DIH cooperates with Pocket Virtuality[41] (who developed Fata Morgana to create environmental models available at any location) on connecting industrial systems, such as robots, into the AR/VR environment to expound use cases suitable for industrial application.

4.3 Experience of sectors involved in the hub

As it is explained previously, the European Commission is aiming to a Specialisation Strategy. The 30 AI DIHs have been working in 14 different sectors where they obtained experience from the past obstacles and problems. The sectors that are implicated in the AI DIH network are: Industry 4.0, Transport, mobility and logistics, Robotics, Health, Finances, Energy and environment, Industrial production and automation, Software and communication, Agricultural and food technologies, Digital reality, eGovernment, Education and Materials. Compared to the previous section "Specialization of the hub", where the focus is in the technology as a method or tool, in this section the objective is to aim these sectors that the DIHs are exploring. Also, highlight the similarities and possible cross-sections of the different sectors, that may lead to future connections.

Inspecting the roles and sectors of the different 30 AI DIHs, it is seen that there are 11 DIHs that are exploring unique sectors in their centres. The rest of the 19 hubs are into 2 or more sectors. The most common sector across the 30 AI DIHs is the Software and ICT with 17 DIHs working on this sector. Then, there are 14 DIHs working in the sector of Health and 13 DIHs in the Industry sector. The least common are Education with only 1 hub making progress and Materials with 2 hubs behind, Agricultural and food technology and eGovernment sectors have 5 DIHs specialized each. Also, it was valued the previous experience in the AI sector to determine the capabilities that these hubs may developed (see Figure 6).

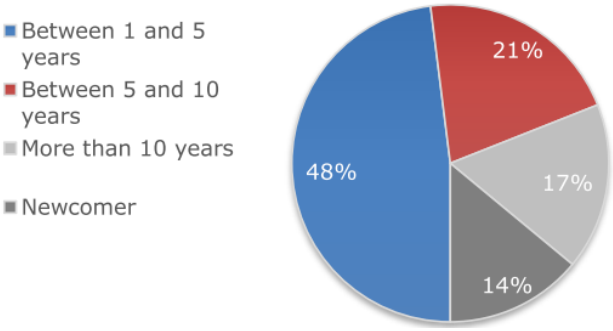

Fig. 6: Experience in the AI field of participating DIHs. Source: Digitising European Industry Initiative.

As in the other sections of results, the meaning of focusing in less sectors does not mean less importance in the network, as if it is more centered in one specific sector, it may give more specific solution in the same camp.

The Digital Europe Programme denotes the implication of EDIH in Public Sector among their potential customers. This implication from the DIHs can come in three different ways, explained with an example each:

- **Preparing for the implementation of AI solutions.** Where organisations would need some previous requirements to adopt AI technologies, such us supporting the improvement of data governance. For example, AIR4S assisted the Spanish National Library[42] providing specific technical services provision, assessment on software licensing procedures and customized training to the client in order to create qualified professionals. The on-demand technological service integrate all the data coming from heterogeneous sources and connect the Spanish library with other relevant data coming from international libraries.

- **Develop or design AI solutions.** Where the DIHs are direct provider of the public sector, having the

[38] https://www.reval.com/
[39] https://ubotica.com/
[40] https://enikonaerospace.com/
[41] https://www.pocketvirtuality.com/
[42] https://datos.bne.es/

necessary skills. For example, DIGIHALL helped the French government[43] to develop a platform for collecting and analysing structured and unstructured data, giving access to public agents to company data and to consumer feedback in an easier manner.

- **Assist companies providing services.** Where DIHs acts as indirect supplier for the public sector, working with SMEs that are liaising the public organisation. For example, AIR4S supported Graffter[44] in its way to develop a social network for the smart city. AIR4S provided consulting services in computer vision, hosting service at the UPM business incubator, partnering on public competitive funding calls, and advanced education and skill development on AI.

Similar implications of DIHs with SMEs or associations are also seen on previous projects examples. These types of implications usually occur in organizations that already have brokerage or financing. Financing and brokerage are more focused on SMEs and small companies that are in the digital gap.

4.4 Collaboration with Living Labs

The 14 Living Labs (LL), effective members from ENoLL, who have answered the survey have shown their perspective about AI and DIHs (in Annex 3 there are the questions of the survey). According to the interests of the participants, 22% (10/14) of all topics related to AI indicate that are related with the Social Impact of AI, 17% (8/14) related with AI development and technology transfer, another 17% with Inclusion / Reducing the digital gap for AI, a 15% (7/14) for Education and Ethics 13% (6/14) on AI, a 9% (4/14) on AI research, and the 7% (3/14) are not interested/related in AI (see Figure 7). In these terms, the 64% (9/14) are currently implementing AI-related projects, but the 100% of participants show interest to implement AI projects in the future and 93% (13/14) to collaborate with other Living Labs.

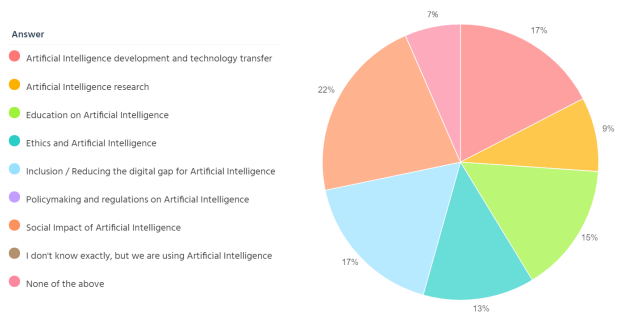

Fig. 7: Living Labs interested in the different dimensions indicated in the survey. Source: Own production through SurveyLegend.

The participants answered about their AI production, where 7 of them, at least, marked that they produce data and services, 5 produce software, 4 write reports, 4 create multimedia contents / web and others, and 1 Mobile Apps (see Figure 8). Noticing that there is not any LL developing Devices. Referring to the domains that their Living Labs are using AI, 8 participants marked Smart Cities & Regions, 7 Health & Wellbeing, 5 Mobility, 5 Culture & (co-)creativity, 4 Industries & manufacturing, 3 Social Inclusion, Innovation and Education, 2 for Agriculture & Agri-food, Media, Rural areas, Environment and e-Government/eParticipation. Noticing that Energy was not market by any participant. Asking about who developed the AI within their projects, 36% (8/14) answered with Companies, 18% (4/14) Academic institutions and their own Living Lab, 14% (3/14) others, 9% (2/14) do not know it, and 5% (1/14) their own Living Lab with other Living Labs. The LL also answered to which TRL levels are implementing in their AI-related projects, and the 28% (7/14) do not know it, 16% (4/14) do TRL 7 and 6, 12% (3/14) do TRL 5, 8% (2/14) do TRL 4 and 3, 4% (1/14) do TRL 2, 1 and 8. There is not a LL that implement TRL 9 for the moment. The 36% (5/14) of participants ensure be involved in AI-related DIHs / EDIH, with examples of projects such as waste management system, Industry 4.0, Cobotics or Smart manufacturing.

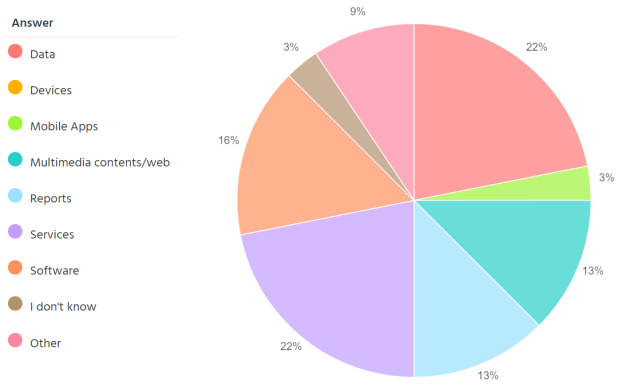

Fig. 8: Living Labs production related to AI. Source: Own production through SurveyLegend.

About the perception questions between the link of DIHs and Living Labs, most of the participants think that are complementary ideas, where EDIH is an opportunity to develop the quattro helix model, Living Labs can act as an excellent tool to support the digital transformation and can be used as infrastructure in "test before invest" functionalities of DIHs. Participants also believe that Living Labs can connect DIHs to real-life environments and to other companies and SMEs, that may lack in the existing link; and DIHs can provide the resources to complete the innovative products, complementing the innovation process of Living Labs. About the role of citizens (as final users) and the public administration in the context of DIH, it is seen that most of the answers received are giving importance to both roles, and can be complementary as well. Where citizens can bring feedback, ethical considerations and take part in the innovation process; acting as testers, co-creating and validating the deployment of new technologies such as AI. One participant remarked that citizens are not key stakeholder for the moment. In the public administration question, most of the answers point to the PA's role as providing facilities, finance and policy-makers; enabling and facilitating the capabilities of local

[43] https://www.modernisation.gouv.fr/action-publique-2022/
[44] http://www.thegraffter.com/

eco-systems.

5 Discussion

After the interpretation of the data used in the methodology and the analysis in the results there are some themes that will be discussed in this section. It is clear the initiative that DIHs are deploying in the different regions across Europe. The role of collaboration and innovation of these centres is the key to achieve the objective of the Digital European Programme. It is seen how the bottom-up approach can lead to major projects and roles, where starting to support SMEs and those organisations behind the digital gap will lead to different specialisations and potential breakthrough around Europe and worldwide. A clear example is the AI DIH network that is being developed around the Artificial Intelligence field, as a new technology that can bring new business solutions and innovation in SMEs, research centers, public administration and enterprises.

Despite the fact that the DIH network initiative has been implemented recently, and even more so the AI DIH network, in this period it has been possible to observe certain implementation keys and principles that indicate how the initiative is developing. It is recognised the clear and added value that collaboration is giving in this initiative, accomplishing the task of facilitate and increment the opportunities, as a fast solution solvers for many organisations, across regions and Member States. In this approach, Living Labs could act as experienced agents, leaders in collaboration and networking, guiding and sharing previous learned knowledge, methods and best practices to speed up an optimum deployment of the network. The management of pilot projects is being robust and effective, consolidating the infrastructure and the services of DIHs. Also, it is visible the involvement of DIHs with expertise and experience in AI digital assessment, where larger companies could ensure continuous involvement in the project thanks to a more agile allocation of resources. At the same time, there are some obstacles that do not allow the correct implementation of DIH, such as some DIHs lacked resources to be allocated to the initiative. To develop a great collaboration and cooperation between DIHs, it is needed a strong leadership from the involved Hubs to elaborate on participants inputs and advanced proposals, as well as the need for continuous commitment by the DIHs involved. Lastly, there is a lack of experience in cross border-collaborations outside the context of externally funded projects which raised legal challenges in regulating the collaboration; this would need to be further addressed to make cooperation possible on a business as usual basis.

5.1 Improving the collaboration and networking

The collaboration between organisations and Hubs is crucial to ensure the objectives of the project. Some clear examples of collaboration have been shown, highlighting the importance of it and teaching good practices of this great method of innovation. But to ensure a progressive framework of collaboration it is important to encourage the definition of additional cooperation scenarios, promoting other collaboration use cases different from AI. Also, the promotion of the projects under H2020 and its cooperation between the different initiatives would test and refine their basis in the DEP. To promote collaboration between initiatives, first is important to define potential schemes for collaboration between EDIHs and DIHs and assess benefits and costs of the parties involved, as identifying measures to overcome obstacles for collaboration, such as legal regulations. DIHs spend time and resources in cooperation scenarios, having costs and producing benefits. In this terms, assess in detail the financial needs of DIHs involved and analyse the costs that should be sustained by the DIH, as identifying the most suitable support that can be offered, the amount of aid and the mechanism for its distribution.

In order to promote focus on specific aspects, such as Artificial Intelligence, it is considered to create thematic communities, where DIHs can have a criteria and assign tasks or projects. Identifying the knowledge, skills and competences from different organisations will boost collaboration approaches and integration of EDIHs, developing a framework that could be used by EDIHs and stakeholders to rapidly access and distribute the qualities of each Hub. Defining a set of indicators to assess the quality and quantity of services, as a common European criteria for assessing DIH capabilities and introducing regular inspections to evaluate the different DIH mechanisms, would lead to independent and precise feedback on areas for improvement and a more confident framework where the DIH community would perceive lower risks in collaborating with them. Living Labs can bring connection to real-life environments to foster and improve this criteria, and aspire to a better solid base of collaboration. Evaluators will need diverse methods to evaluate the all framework, as there is no unique procedure to answer the questions, that may include interviews, surveys for ”softer issues” and control groups and social network analysis from business registers and statistical offices for those ”harder economic results” (Kalpaka et al., 2020). Analysing the activities currently performed by DIHs, could be established a set of common services on DIHs (more deeply specialized in their technological domains); and exploring where the less common, but useful, services are being needed and developed, to map all these activities, common and not common. Gathering data from European initiatives and projects involving DIHs and analysing the existing platforms functionalities and suggestions is important to develop a unique platform for supporting DIHs collaboration, avoiding the fragmentation of information on various platforms, defining the financing and operating model of the platform and engaging the users to give constructive feedback.

This approach to generate an AI-on-demand platform can be use as reference of the AI DIH network. Bringing together AI resources and stakeholders, accelerating AI-based innovation (solutions, research, products), thus overcoming fragmentation (European Commission, 2021a). It would lead to a critical mass of resources, community co-working effect and rapid development and growth. It could bring more people, from the non-tech sector, only giving them the opportunity to explore by themselves the coming AI-related innovation. The ability of Living Labs

to interact, join and work with many stakeholders would enhance the approach between stakeholders and DIHs, uniting the Living Labs stakeholder experience with the DIHs resources. The EDIHs network will work closely to the platform, acting as an European marketplace for AI resources providing access to AI tools and expertise. The DIHs would need to adapt and consolidate the on-demand projects and innovation opportunities in order to enhance their connections with the SMEs and organisations. In light of SMEs are who can have specific problems and the DIHs may not noticed about it. The different Hubs need to be able to respond and derive solutions to these new problems or obstacles that may surge. These new on-demand needs or services will be added to the AI-on-demand platform, making bigger the specialization network and improving response capacity and effectiveness.

5.2 Impact of AI

The Artificial Intelligence is growing and developing fast. It can be a powerful tool in many domains and sectors, making a huge change in business and innovation models. This potent instrument can facilitate and support decision making for humans, but it also can harm society if not applied correctly.

To continue a good and prosperous development of this technology is important to support those who are working and developing the technology. AI DIH network will give an impulse to this technology. Financing the AI start-ups and developing skills will create opportunities to ensure AI in the region. The network will strengthen the research and innovation community, creating a framework of services and needs around AI-related themes. Promoting the knowledge transfer and expertise for SMEs, as supporting partnerships between SMEs and stakeholders, will enhance the production and use of this potent instrument of Artificial Intelligence. The DIHs will be in charge of this task, and they will be the ones who will make a bigger impact of AI in our society. They will concentrate the talent and benefits across Europe to maximize the clustering effects and the specialization on AI. If this task is not done, it is possible that AI would not succeed in Europe, draining other parts of the world their qualified and talented people, which will negatively affect their economy. Creating this AI DIH network will give the chance to welcome many researchers, instead of the capacity of a single center, and at the same time it will able to create multiple centres with diverse set of expertise from different parts of the network, as seen in the Canada example of the establishment of Mila, Vector Institute and Alberta Machine Intelligence institute (Gupta and Lanteigne, 2020). In order to tackle the SMEs gap, it seems that the developing AI expertise and establishing partnerships with stakeholders are struggling the SMEs in the AI approach. So, the DIHs that previously have implemented these solutions in other fields, will support SMEs bridging the gap between SMEs and the large companies in terms of AI expertise. DIHs as the perfect coordination and competence to disseminate standards and guidance on how to operationalize theoretical approaches in responsible AI to something that practitioners can implement into their everyday work.

On the other hand, the rapid development of AI does not help with AI legislation. The current legislation may have some gaps (not exclusively in the EU, but around the world), as it is ill-prepared to deal with security threats that stem from AI. There are some activities that are very new and different from their predecessors such as automated cyberattacks or weapons, and AI-generated propaganda. In order to minimise the risks to implementation resulting from lack of knowledge and expertise in the market as well as to facilitate compliance of providers and notified bodies, the EDIH, Testing and Experimentation Facilities (TEFs), AI-on-demand platform and the Regulation should contribute to the implementation of a correct Regulation, and may provide in particular technical and scientific support to providers and notified bodies. Also, it is seen that the classification of AI services according to high-risk, medium-risk or low-risk, maybe is not as explicit as it can be. The European Commission states that for development of high-risk AI systems it is important to guarantee access and use high quality datasets within their respective fields of activities (European Commission, 2021c). But, the indication of AI high-risk is confusing because there are some AI systems that does not seem particularly risky at first glance. Beyond, it can have consequences, as it happened with ML labelling a Black man and woman as being of ”gorillas”. It will not lead on jobs rejection or conviction of a person, but it can have serious societal impacts that can affect to mental health, besides is not covered by any ethic. Even it can go further if these labelling that seem not risky are used to train more risky technologies without the users’ consent. AI that may appear inoffensive can easily become a ”high-risk” system. So, compulsory requirements not only should apply for ”high-risk” applications of AI, but also ”medium-risk” and ”low-risk” should be subject to similar compulsory requirements.

In addition, there is a need to establish minimal requirements to allow people to make informed choices or withdraw from a given situation. In terms of transparency, explicability and lawfulness, the AI must follow ethic lines to develop a trustfully, sustainable and non-discriminatory application, avoiding the segregation and distrust of people towards AI. This should be done by a combination of an ex-ante compliance and ex-post enforcement mechanisms. The EU Regulation will encourage the use of regulatory sandboxes establishing a controlled environment to test innovative technologies for a limited time, where DIHs will facilitate access to testing and experimentation (European Commission, 2021b). It is important to guarantee an ethical framework to develop AI systems without bias, that may be unintentional, to guide the developers and young talented people on the deployment of AI systems. The DIH network should help to monitor and implement these parameters and regulation across Europe to ensure a fair ecosystem.

5.3 Services and Specialization

As seen, the AI DIHs cover the vast majority of sectors, specially robotics, industry and health, supporting SMEs that may need any help in terms of services or expertise. The different sectors analysed may be extensive when applying different AI solutions, as we know AI has many applications on many fields. The crucial function of DIHs is the distribution of knowledge and services. It is possible

that a enterprise have a problem already solved in a DIH, so it is easy to implement a solution plan. The challenge comes when this problem may be similar to other problems solved, or not at all, but there are some changes. DIHs and Competence Centers need to understand and know the technology that are using in order to implement it in new problems, adapting the knowledge and functionalities they already now with research and exploring the problem in question. Each SME may have differences with the rest, so here the importance of not *"Copy & Paste"* the solution or service, but modify and readjust to each need. The EDIHs network will use relevant AI TEFs helping companies to innovate their new products and services and make them market ready, facilitating equal access to SMEs. It is essential to ensure the environment dimension, creating a data space for climate-neutral and smart communities and specific assess in this dimension. Sharing results between DIH is vital on the network, and not only in the environment dimension. EDIHs network, also, will take place in the robotics and health sector, in order to help health systems and industry, as supporting the European robotics sector, but not only in an individual vision. The *cross-sector* exchange of information may be as important as the *cross-border* exchange, and in this point, Living Labs may be useful hooking up sectors and borders, given its familiarity on crossing and sharing ideas, projects and services. This could offer new services and techniques that mix knowledge between sectors and DIHs, leading to innovative solutions, such as mixing robotics with health technologies to implement active and assisted living technologies. So, a robust and strategic structure of the network is needed to achieve a wide range of research and solutions.

At the same time, it is seen in the results a broad range of services and expertise in the AI DIHs. Some of them offer more than others, but this not mean that are better. The strategy of specialization focus on most popular challenges and preoccupations about regions by each research centre. This means that dominating an specific technology will lead to more specific problems and better solving of the same, regardless the different sectors are adopting the DIH. Specializing on a singular sector will lead to specific approaches on researches and possible fragmentation of problems, giving place to more specific centres and investigations to enhance the growth and development of knowledge. On the other hand, having different sectors in the same center can facilitate cross-sector exchange of information. So, AI DIHs have different functions that should reach the goal of act like an unique network of expertise and services, where an individual DIH may achieve some goals, but acting as a whole will increase the effectiveness, resolution, quantity and quality of major solutions. The importance of contacts is playing an important role here. A coordinated and cohesive network with many participants will increase the range of services and expertise. So, a DIH may not have the necessary equipment to support a SME, but other organisation that have been helped or participates on the network has it and is ready to share it, enabling a massive production of solutions for many SMEs.

The DIHs should not only wait for SMEs to come to need services or education. It is crucial that DIHs are proactive and advantaged over the problems of the region. They must explore all possible fields in which they can help before being asked over the area they are working, so they anticipate current and future problems in society and organisations, getting better results and more sophisticated solutions (as they dedicated more research time). Analysing the customer base will allow the DIHs to make a qualitative analysis and identify the behaviour, expectations and needs, defining the customers' requirements. This could lead to patterns and defining relevant segments of customers.

Also, the Hubs should be supported by citizens, as they are who will be helped. The society have the answers about what problems are in their cities and industries, they will be the final target and users, the growth and development of society. In these terms, DIHs need to contact society to know problems around the region and defining the acting framework; and Living Labs would offer this citizen/customer orientation to DIHs that are more focused on SMEs mainly. Society, as innovation agents, is who will be the one that responds to the actions of the network and who will use the services it offers, that is why their contribution and feedback is important, as they would contribute to generate better services and products showing the user experience results that would bring ethical considerations, in AI cases, or important contributions that may not be noticed by DIHs. Exclude the society, would lead to wrong objectives and implementations that would not impact on growth and development, it means giving less points of view of the problem and not sharing valuable information to affront it. The involvement of innovation agents will indicate what the real problems are and improve the focus of research and development. All agents from the *Quadruple Helix Model* (government, industry, academia and society) must work together to ensure an open innovation framework where collaborative and co-created shared value respond to any interesting objective in our large community, unleashing exponential technologies, and extraordinarily rapid adoptions.

5.4 AI and the public sector

In a quick view, the public sector consists of governments and all publicly controlled or publicly funded agencies, enterprises, and other entities that deliver public programs, goods, or services (Dube and Danescu, 2011). So, all the activities and organisations that are controlled publicly such as mobility, government paperwork, health care... depend of the public sector. Notice that not every region has the same public sector than the rest, as it may change the law, and the different activities controlled by public organisations. In terms of Europe, there are robust principles that regulates some terms covering all Members States, such as the General Data Protection Regulation (GDPR). This regulation protect the citizen rights about their data and private affairs from the rest of the population, applying on webs, surveys, online activities... but it does not apply to the newest technologies. Where technologies as AI develop faster than its own definition and regulation, due its complicated technical and social concepts. AI technical concepts as "black box" may be difficult to explain, but also the social concepts such as "fairness" or "discrimination", that may vary depending on the person. So, in terms of

governance, it is important to consider who are driving AI on public sector and what they stand to gain. To define who and how is developing the AI it is crucial to answer these three questions. First, who sets the agenda for AI governance? Second, what cultural logic is instantiated by that agenda and, third, who benefits from it? Answering these questions is important because it highlights the risks of letting industry drive the agenda and reveals blind spots in current research efforts (Cath, 2018).

Most of the AI models and innovations are led by American companies, and the same companies are at the forefront of regulatory frameworks. But, when it comes to Europe, it is important to ensure that we are not guided by the same regulatory initiatives as America, as it may not fit with the rest of the regulations and initiatives that ensure our rights. It is true that if AI can make greats improvements on diverse sectors it may help public sector, but it will have to be prove of ethical and lawful from a holistic look on the reality of technology and business models. The European Commission is aiming to make the public sector a trailblazer for using AI (European Commission, 2021b). It can contribute to better public services and bring benefits across public-sector activities, but it must adopt a secure, trustworthy and sustainable AI. As has been said, public sector can involve many activities where private and vulnerable data of many people is treated. EDIHs should be used to promote dialogue among industry actors through Europe, and ensure a proper framework to develop AI in public sector, before its deployment. In the context of DIHs, the link should be stronger to allow more real-life environments and platforms to increase the options and visualization of how AI would impact on society. The public administration could play a good role by implementing public-private procurement instruments, providing finance, supporting policy making to enable use of products developed through DIH or being users within DIH, promoting the use and contact with them.

Promoting the adoption of AI by the public sector could lead to some benefits for the society, but it must develop a robust ethical and secure framework to avoid future social problems. AI is a new technology that is growing rapidly, but it may not be ready for the public sector. Focusing the efforts on research and innovation community and partnering the private sector would point the way to the public sector. Right now, there are not outstanding actions that would make real benefits of deploy AI in the public sector. The AI hype should not guide our policy makers to get ahead of the power of this technology. It is crucial to ensure that there are no negative effects before implement any AI application that can harm the society, as there are some examples of ML security emergent field where new vulnerabilities are left unprotected by traditional cybersecurity measures.

6 Conclusion

The innovative and collaborative methods are magnificent to spread knowledge and services. But, they must have solid bases and robust structures to guarantee its correct operation, organizing the information and redistributing it in an orderly manner. This organization can be guided by Living Labs that have years of experience in co-operative and collaborative methods. In terms of growth, digitalization should be implemented in the organisations from the different regions to guarantee an economic and research development, ensuring a digital framework where data and services can be easily achievable and allowing society to progress. DIH are seen as one of the key instruments of the European Commission initiative to boost the digitalization across Europe. Following the Specialization Strategy will focus the researchers on their talent and speciality, usually associated to their region, centralizing the problems and enhancing the effectiveness.

- To improve collaborative practices, the obstacles should be identified first, such as legal regulations. Then it is needed to define indicators to assess the quality of each service to achieve a proper distribution of the capacities of each DIH. Also, establishing a common European criterion for these evaluations. The **AI-on-demand platform** could act as organism that evaluates the different activities, making the unity of the AI DIH network where resources and stakeholders meet and AI-related innovations are accelerated. Taking the collaboration and stakeholders' experience of **Living Labs** will lead to the rapid and best functioning of the network. This would contribute to give a **holistic vision**, making easier the distribution of the critical mass of resources and co-working.

- The network of Hubs should offer **high-quality education** to centres and organisation that are interested, as well as the one that the DIHs themselves should receive by the program mentors (*training the trainer*), as well as Living Labs can also offer knowledge and best practices. This will create a framework where all organisations can exchange information and knowledge easily in similar formats, regarding that they have similar principles. Ensuring robust guidelines, according to ethics, explainable and lawful AI systems, approaching to the **trustworthy** of AI. At the same time, it will facilitate the detection of incoherent regulations that do not support collaborative and innovative models in the European framework. Concerning to the hard, medium and low AI risks that is pointing the European Commission, it is remarkable the subjective methods that sustain this approach, as a low-risk AI system can quickly become a high-risk system or take part of it. For this reason all risks should dispose of compulsory requirements, instead of only point the "high-risk applications".

- AI DIH network will have to adapt to diverse problems that SMEs and organisations may have, as each business model can vary from pasts or similar ones. To ensure a wide range of help, the DIHs should co-operate with the TEFs, in order to offer specialised facilities to those who may need it, according that the specialization of the organisations will lead to overcome more difficult challenges. To make a good cohesion inside the network, an **office-support** should manage and connect the different specializations. While DIHs inform and analyze the characteristics that exist in society, anticipating to possible problems in the regions. For this reason, the feedback and

suggestions from **citizens and customers** are specially important as products and services are developed for these innovation agents, and they would give to the experts an approach of their needs. In this case, Living Labs should extrapolate its link with citizens and the public administration to DIHs, maximizing the stakeholders, opportunities and results of the network.

- In aspects of **public sector**, it is the organ that should regulate and consolidate a robust and legal framework approach to AI, and thank to the experience and research of DIHs, this task could be executed more correctly and precisely. The main problem is that technology grows faster than regulation, and for this reason, it cannot be applied in public spaces and matters as it could have negative effects on society if they are not consulted by experts on both camps, AI and public sector. Living Labs can take part in this approach, given its knowledge and relationship with the public administration and project management, strengthening the collaboration in private-public initiatives. Testing AI systems in DIHs, TEFs, SMEs, diverse organisations and the private sector in general, it is a perfect approach to check the functionalities and outcomes of AI applications in the real world, before trying to implement AI in public sector that operates with data from millions of people that could be exposed to cyberattacks. But as C. Cath said, *"because the real test for good governance of AI systems comes when the rubber hits the road, or rather, the robot"*.

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Annex

A.1 Similar Initiatives

The following list indicate some ongoing European initiatives, platforms, projects and networks that involve DIHs, which may represent a good starting point for DIHs interested in identifying potential partners and explore AI-related collaborations:

- The AI DIH Network is a preparatory action of the EC bringing together 30 DIHs from across Europe to explore opportunities and models for cross-border collaboration in the field of AI.

- AI4EU established with the support of the EC, the project aims to build a European Artificial Intelligence On-Demand Platform and Ecosystem.
- DIHNET, an European project supporting collaboration and fostering connection between existing networks of Digital Innovation Hubs.
- MIDIH supports the digital transformation of manufacturing SMEs and is currently composed by 3 Pan European DIHs, 2 DIHs, 9 Competence Centre and 2 Teaching Factories.
- I4MS is a European Commission project that supports the digital transformation of manufacturing SMEs through a network of Digital Innovation Hubs.
- Rodin is an H2020 project coordinating the activities of different DIHs European Networks working in the field of robotics. Networks coordinated by Rodin include: DIH-HERO, DIH2, TRINITY, RIMA, AgROBOfood.
- The European AI Alliance is a forum established by the EC to collect feedback on AI policy issues and to provide inputs for the High Level Expert Group on Artificial Intelligence (AI HLEG).
- CLAIRE is a research network bringing together experts and research institutions working on Artificial Intelligence across Europe.
- Data Pitch is a EU-funded open innovation programme dedicated to open data. It works with start-ups and SMEs to connect them with the right corporate and public-sector organisations that could provide them with the needed data.
- ROBOTT-NET is an European project led by four national RTOs that support European companies in the uptake and development of solutions in the field of robotics.
- The Big Data Value Association (BDVA) is an industry-driven international not–for-profit organisation whose mission is to develop an Innovation Ecosystem that will enable the data and AI-driven digital transformation in Europe.
- Smart Anything Everywhere (SAE) is a H2020 funded project offering funding and support to SMEs in their digital transformation and to establish fully functional ecosystems of DIHs that can also provide services beyond technical advice (e.g. business consulting and training).

A.2 AI DIH map

To make a clear view of the 30 DIH that form the AI DIH network, the distribution of the hubs is presented in the following picture (see Figure 9):

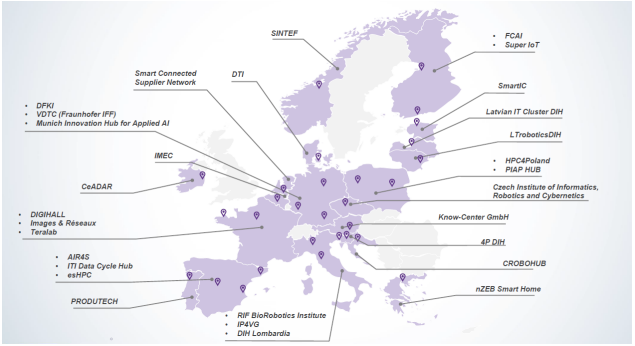

Fig. 9: Location of the 30 AI DIHs in Europe. Source: AI DIH Network report.

A.3 Survey

Effective ENoLL members have answered a survey related with AI and DIHs to determine which function could have Living Labs in the network and what compatibles could benefit from this merge. The questions are the following:

1. Contact details: Full name and E-mail
2. Is your Living Lab related to -or is interested in- any of the following dimensions of AI?
   (a) Artificial Intelligence research
   (b) Artificial Intelligence development and technology transfer
   (c) Social Impact of Artificial Intelligence
   (d) Ethics and Artificial Intelligence
   (e) Policy making and regulations on Artificial Intelligence
   (f) Education on Artificial Intelligence
   (g) Inclusion / Reducing the digital gap for Artificial Intelligence
   (h) None of the above
3. Have you implemented or are you currently implementing an AI-related project within your LL? *(With this question we want to know if you have previous experience in AI or anything related to its Social Impact.)*
   (a) Yes
   (b) No
4. Are you interested in implementing AI in projects within your LL in the future?
   (a) Yes
   (b) No
5. Are you interested to collaborate with other living labs in some AI projects? *(With this question we are interested in knowing which ENoLL Living Labs will be ready to participate in joint actions related to AI.)*
   (a) Yes
   (b) No
6. What does your LL produce related to AI?

(a) Data
(b) Devices
(c) Mobile Apps
(d) Multimedia contents/web
(e) Reports
(f) Services
(g) Software
(h) I don't know
(i) Other, namely:

7. Do you think that your LL has AI-related outcomes that could be of interest to the ENoLL community?
   (a) Yes
   (b) No
8. In which domains are you using AI?
   (a) Agriculture & Agri-food
   (b) Culture & (co-)creativity
   (c) Education
   (d) e-Government/eParticipation
   (e) Energy
   (f) Environment
   (g) Health & Wellbeing
   (h) Industries & manufacturing
   (i) Media
   (j) Mobility
   (k) Rural areas
   (l) Smart Cities & Regions
   (m) Social Inclusion
   (n) Social Innovation
   (o) Other, namely:
9. Who developed the AI which is used in your living lab project(s)?
   (a) Academic Institutions
   (b) Companies
   (c) Our living lab
   (d) Our living lab with other living lab(s)
   (e) Other living lab
   (f) I don't know
   (g) Other, namely:
10. Which TRL levels did you already implement in your AI-related projects? *(To answer this question we use the Technology Readiness Level, (TRL) indicating the maturity of a given technology.)*
    (a) TRL 1 – basic principles observed
    (b) TRL 2 – technology concept formulated
    (c) TRL 3 – experimental proof of concept
    (d) TRL 4 – technology validated in lab
    (e) TRL 5 – technology validated in relevant environment
    (f) TRL 6 – technology demonstrated in relevant environment
    (g) TRL 7 – system prototype demonstration in operational environment
    (h) TRL 8 – system complete and qualified
    (i) TRL 9 – actual system proven in operational environment
    (j) I don't know
    (k) Other, namely:
11. Is your organisation/Living lab involved in AI-related Digital Innovation Hubs (DIH or eDIH)?
    (a) Yes
    (b) No
    (c) I don't know
12. Do you have any example of AI-related innovation within the context of DIH? Name it if you do:
13. How do you perceive the link between DIHs and Living Labs (you can develop your answer here as you wish)?
14. How do you see the role of the citizens(final users, not companies) in the context of DIH?
15. How do you see the role of public administrations in the context of DIH?

A.4 List of 30 AI DIHs

In the last two pages you can find attached the AI DIH list of participants, announced in this European Commission article, where there are the 30 hubs that are involved in the AI DIH network and its respective information (DIH name, country, city, coordinator and website). This document has been very useful in order to reach and analyse the 30 AI DIHs that take part in this initiative.

DIH Name	Country	City	Coordinator	Website
Know-Center GmbH	Austria	Graz	Independent legal entity	http://www.know-center.tugraz.at/
IMEC	Belgium	Leuven	IMEC	https://www.imec-int.com/en/home
CROBOHUB Croatian Robotics Digital Innovation Hub	Croatia	Zagreb	Innovation Centre Nikola Tesla	http://www.icent.hr/en/crobohub/
Czech Institute of Informatics, Robotics and Cybernetics	Czech Republic	Praha	Czech Institute of Informatics, Robotics and Cybernetics (CIIRC), Czech Technical University (CTU) in Prague	https://www.ciirc.cvut.cz/
Danish Technological Institute	Denmark	Odense	Danish Technological Institute	https://www.dti.dk/robot
Smart Industry Centre (SmartIC)	Estonia	Tallinn	Tallinn University of Technology	http://www.smartic.ee
FCAI	Finland	Espoo	Aalto-korkeakoulusäätiö	https://fcai.fi/
Super IoT	Finland	Oulu	University of Oulu	http://www.superiot.fi
DIGIHALL	France	Palaiseau	CEA LIST	http://www.digihall.fr
DIGIWEST	France	Lannion	Images et réseaux	http://www.images-et-reseaux.com/fr
Teralab	France	Paris	Institut Mines Telecom IMT	https://www.teralab-datascience.fr/
DFKI Human Centric AI Innovation Hub	Germany	Kaiserslautern	German Research Center for Artificial Intelligence GmbH	https://www.dfki.de/en/web/
VDTC of the Fraunhofer IFF	Germany	Magdeburg	Fraunhofer Institute for Factory Operation and Automation IFF	https://www.produktion.fraunhofer.de/de/forschung-im-verbund/forschungskooperationen/digitalinnovationhubs.html
Munich Innovation Hub for Applied AI	Germany	Munich	fortiss GmbH	https://innohubai.fortiss.org
nZEB Smart Home	Greece	Thessaloniki	Center for Research and Technology Hellas / Information Technologies Institute (CERTH/ITI)	https://smarthome.iti.gr

DIH Name	Country	City	Coordinator	Website
CeADAR - National Centre for Applied Data Analytics and Artificial Intelligence	Ireland	Dublin	University College Dublin	https://www.ceadar.ie/
RIF (Robotics Innovation Facility) BioRobotics Institute	Italy	Pontedera	Scuola Superiore Sant'Anna	http://www.pecciolirif.com/
Area Science Park IP4FVG	Italy	Trieste	Area Science Park	http://www.ip4fvg.it/
DIH Lombardia	Italy	Milano	Confindustria Lombardia	http://www.dihlombardia.com
Latvian IT Cluster DIH	Latvia	Riga	Lavian IT Cluster	http://www.itbaltic.com
Lithuanian robotic DIH (LTroboticsDIH)	Lithuania	Vilnius	Lithuanian Robotics Association (LRA)	http://www.ltrobotics.eu/en/digital-innovation-hub/
SINTEF	Norway	Trondheim	SINTEF	https://www.sintef.no/en/
HPC4Poland	Poland	Poznan	Poznan Supercomputing and Networking Center, PSNC	http://www.hpc4poland.pl
PIAP HUB	Poland	Warsaw	Industrial Research Institute for Automation and Measurements PIAP	http://www.hub.piap.pl/
PRODUTECH Digital Innovation Hub National Platform	Portugal	Porto	PRODUTECH - Pólo das Tecnologias de Produção	http://www.produtech.org
Digital Innovation Hub Slovenia	Slovenia	Ljubljana	Digital Innovation Hub Slovenia	http://dihslovenia.si/
AIR4S	Spain	Madrid	Universidad Politécnica de Madrid	http://www.upm.es/dih-air4s
ITI Data Cycle Hub	Spain	Valencia	Instituto Tecnológico de Informática	https://www.iti.es/data-cycle-hub/
Spanish Digital Innovation Hub for HPC	Spain	Barcelona	Barcelona Supercomputing Center-Centro Nacional de Supercomputación (BSC-CNS	https://www.res.es/es
Smart Industry Hub South	The Netherlands	Eindhoven	Brabant Development Fund (BOM)	https://www.smartindustry.nl/smart-industry-zuid/