DIGITAL INNOVATION HUBS

Insights from European Experience in Supporting Business Digitalization

Rene Wintjes • Fernando Vargas

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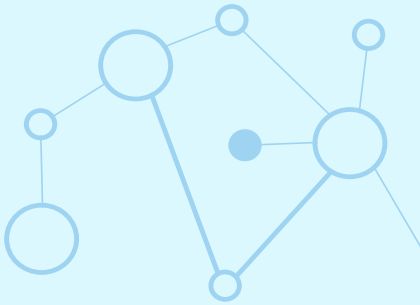

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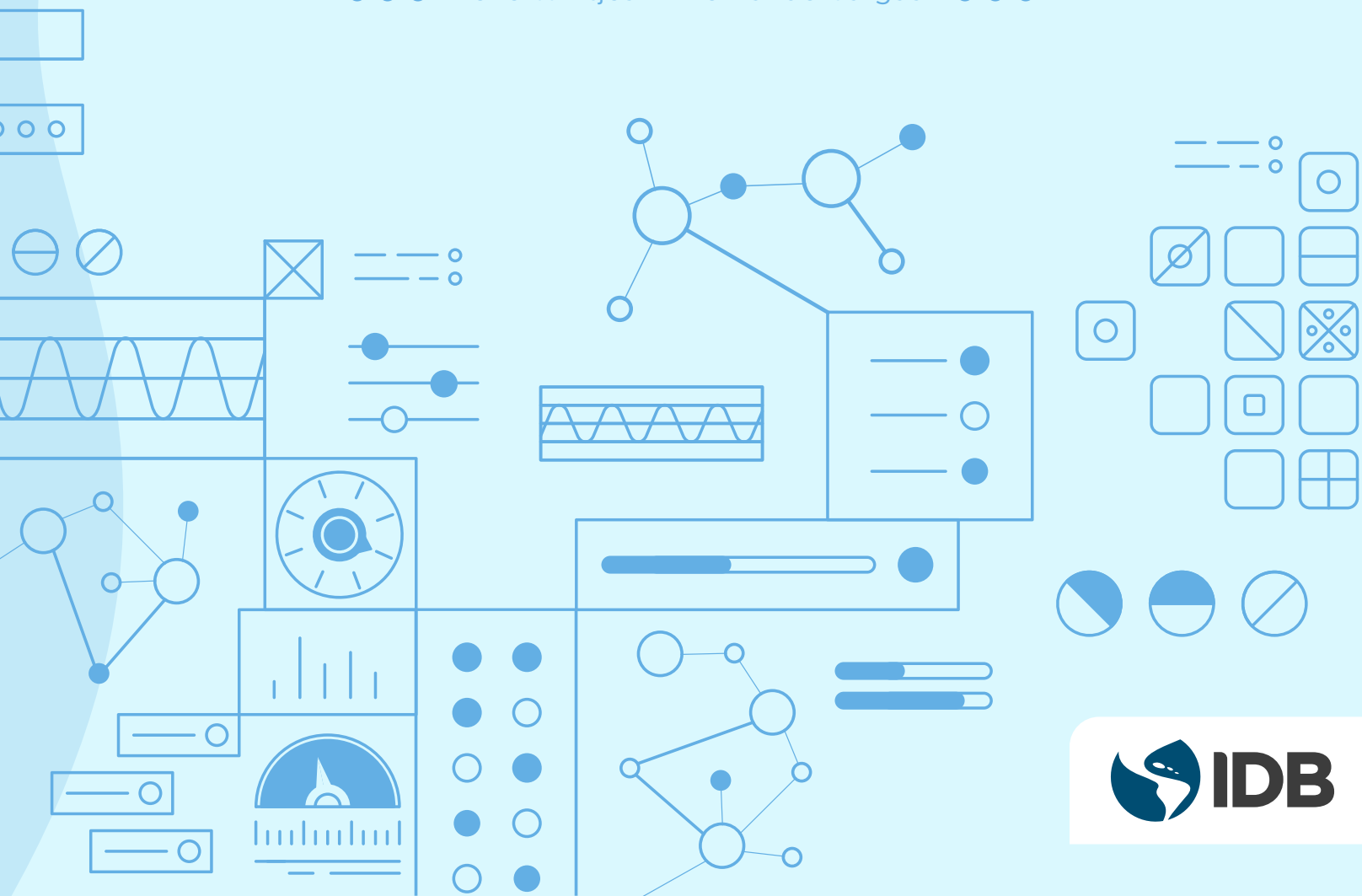

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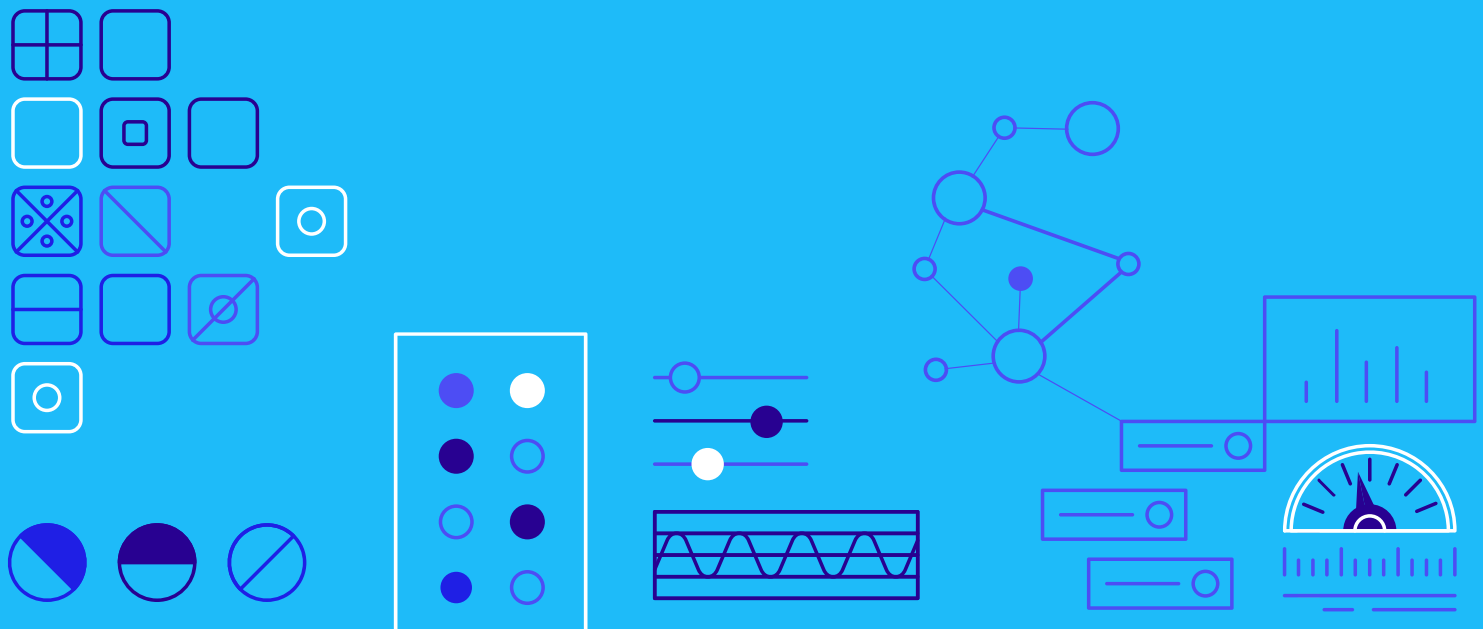
CONTENT

1. INTRODUCTION



1. Introduction

This paper presents a series of insights from digital innovation hubs (DIHs), an initiative developed by the European Commission (EC) to support digitization from a regional development perspective, and which could guide policymaking in Latin America and the Caribbean (LAC). DIHs are highly heterogeneous, not just in terms of technological competence but also in terms of the sort of demand served, highlighting the need for compatibility between local technology supply and demand. In the three DIHs analyzed herein (in Andalucía, Spain; Maribor, Slovenia; and Vicenza, Italy), the set of services supplied to the community emerges from a process of self-discovery, which, to be carried out successfully, requires not only solid internal skills but also public funding.

Opportunities for digitalization are abundant and complex due to many kinds of inter-linkages and inter-dependencies that characterize information and communication technologies (ICTs). Linkages among technologies, industries, territories, and policy areas give rise to dynamics of convergence and integration as well as the emergence of new and possibly disrupting situations. The opportunity and need for digitalization have further increased due to COVID-19. Digital technologies are relevant for all actors, sectors, national economies, and levels of society (regional, national, or global) for achieving diverse developmental goals. However, the level of diffusion and adoption of digital technologies varies. The concept of DIHs emerged in 2016 in European Union (EU) policy, notably within the framework of the Digitising European Industry initiative (DEI), to promote the wider diffusion and uptake of digital technologies.

The EU policy concept has been developed further by the Directorate-General for Communications Networks, Content and Technology (DG Connect), and its practices have been monitored by the Institute for Prospective Technology Studies (IPTS) of the Joint Research Center (JRC). From the original emphasis on competence centres for manufacturing industries, the concept has widened and deepened, and the implementation practices have extended in scale and scope.[1] DIHs have been funded by several policy domains, and at several policy levels. The goals embodied within the Digital Europe Program 2021–2027, concern scaling-up and linking those DIHs embedded in regional ecosystems into a European network.

What can others learn from the experiences with this EU concept that has been adopted by many regions in Europe, notably in their Smart Specialization Strategies (S3)? How could it serve to promote the wider diffusion and uptake of digitalization elsewhere? This paper aims to answer these questions and provide new information that can help LAC policymakers design their own business digitalization public policies.

In this paper, Section 2 discusses the rationale and key design features of the DIH concept. Section 3 delves into the description and categorization of over 300 fully operational DIHs, examining their main characteristics and the regional context. Section 4 presents insights from the analysis of three distinct DIH case studies. Lastly, Section 5 offers conclusions and policy recommendations based on the main findings of the study.

[1] "Competence Centers are investments by (EU) Member States made to encourage greater efficiency in the interaction between researchers, industry, and the public sector, in research topics that promote economic growth by their direct relevance to industry agendas. They can be considered as public-private partnerships, aimed at enabling research which might not otherwise take place, and facilitate better interaction with industry towards producing tangible economic benefits" (CREST, 2008: 7).

2. RATIONALE AND KEY DESIGN FEATURES OF THE DIH AS A PUBLIC POLICY TOOL

2. Rationale and Key Design Features of the DIH as a Public Policy Tool

A DIH is not a one-size-fits-all model or a ready-to-use tool for public policy, rather, a framework for enabling a network of actors to discover suitable sets of technologies and services that can spur digital uptake and innovation in a certain region. DIHs differ widely in their design features as does the rationale of the various policymakers at the various funding levels involved (EU, national, regional). Moreover, neither rationale nor design features are written in stone and have changed over time. The concept was born from the notion of a competence center and developed into a network of hubs, and subsequently broadened out into a complex pan-European landscape, where the DIH functions as an umbrella concept for a network or system of public and private policy initiatives. This section describes the policy background of the DIH concept and how it has developed over time.

2.1. Why a Focus on Digital Technologies

Digital technology and digitalization have an enabling and a general-purpose characteristic; its use is not limited to one purpose or use in one sector. Teece (2018) points out the value-capture problem for innovators in the digital economy. Because enabling technologies have numerous downstream application fields, the traditional appropriation through ownership is hampering and value-capture therefore requires an understanding of the dynamics of platforms and ecosystems.

The enabling and general-purpose characteristic of digital technology also changes the traditional rationale for innovation policy which is also based on the appropriation of the (social and private) returns on innovation investments (Trajtenberg, 2011). In the case of enabling and, especially, general-purpose technologies, the rationale for policy intervention is stronger because the social returns are high. This provides an argument for public intervention to promote the wide diffusion and uptake of digitization by small- and medium-sized enterprises (SMEs) across all sectors.

Besides the traditional policy rationale for promoting capacity to generate new ICTs from scientific research, ICT-uptake has become more prominent in the rationale for digitization policy interventions. The inherent uncertainties of producer-user interactions and the diffusion of scientific inventions, call for policy intervention. The different actors and factors involved constitute the ecosystems and platforms the policy documents on DIHs refer to. This (eco)system concept is based on the innovation systems literature, e.g., the concept of interactive learning between producers and users of knowledge (Lundvall, 1992; Wintjes, 2016). While traditionally separated (as independent policy siloes) science policy has for a long time merely aimed at global scientific excellence (disrupting science), but for the sake of place-based development it is important to consider the interplay with regional (economic, industrial, societal) relevance and the breakthrough in use.

2.2. Why it Needs to be Place-Based and Collaborative

Adopting ICT and developing new innovative digital solutions does not make the world flat: location and regional embeddedness still matter. Many aspects of knowledge and innovation remain tacit and are mainly exchanged in face-to-face interactions. Furthermore, regional needs and regional specific assets differ among territories, and the institutions and governance of these systems also differ. Therefore, successful policy needs to be designed as organizational, institutional, governance structures where new combinations give rise to innovation dynamics in the conditions of the local framework. In this respect, Asheim, Boschma, and Cooke (2011) refer to a Schumpeter perspective on innovation and label the corresponding innovation policy as a platform policy that aims to promote synergetic combinations, also between policies. In a place-based setting, such strategies are more recently referred to as S3.

Beyond the innovation systems literature and concept of interactive learning, it is important to promote interactive learning between policymakers and policy users. Meso-level structures and regional initiatives become vehicles and dynamic platforms where different public and private policies interact and jointly develop new specific structures and strategies. This implies that DIHs should not be, nor evolve into, a one-size-fits all rationale or model with common features. Answers to policy questions such as kinds of skills to be promoted, kinds of investments to be subsidized, services to be provided, best business models, the level of technological readiness to be aimed for, and which technologies deserve priority, cannot be copied from "best practices" of others, but should be based on a joint, collaborative learning process. This process is an entrepreneurial discovery process through learning by doing, by using and by interacting, rather than a prescribed recipe.

2.3. The DIH Concept: From Competence Centres to a Complex Transnational Landscape

The EC launched the Digitising European Industry (DEI) initiative in April 2016, and included DIHs as one of the pillars of the strategy. The background to DIHs is therefore industrial, steered by national policymakers who had already developed agendas and strategies to digitize industry, for example, with the German Industry 4.0 initiative,[2] and the EU level of policy providing coherence and coordination.

Originally, the background was also more on the scientific, technology supply-side, evidenced by the original emphasis on R&D projects through HORIZON.[3] The previous policy rationale and focus on the pre-competitive (R&D) part of value-chains and innovation chains (with lower levels of technological readiness) to avoid market distortions, has more recently been broadened by integrating the closer-to-market and competitive elements. The emphasis is now on the wider uptake of technology and innovations. State-aid regulation in Europe has been 'modernised' to allow for the promotion of experimenting, testing, and demonstrating the use of technology.[4]

A DIH is, thus, "a support facility that helps companies become more competitive by improving their business/production processes, products and services through digital technologies." (European Comission, 2017, p. 8) DIHs act as a one-stop-shop, providing customers with access to technology-testing, and financing support, market intelligence and networking opportunities. They can focus on key technologies such as robotics, photonics, high performance computing (HPC), and cyber-physical systems. They can also concentrate on specific sectors such as agriculture, construction, manufacturing, and others.

As mentioned, the DIH concept has evolved towards a platform approach where different actors are involved. The DIH is formed by a group of coordinated organizations with complementary expertise and a non-profit objective, offering a set of services to companies—especially SMEs (including start-ups) and mid-caps—to support their digital transformation through a one-stop-shop. **The services revolve around four kinds of services (Kalpaka, Sörvik, and Tasigiorgou, 2020):**

- **Test before invest:** before making the actual investment decisions and to get even better ideas on what could be a good way to digitalise, testing, demonstrating, experimenting, and learning-by-doing serves to lower inherent uncertainty related to adoption of new technologies and innovation.

- **Skills and training:** to increase the local supply of the talent needed for digital transformation, training trainers, reskilling, and regularly updating on curricula and training materials.

- **Support to find investments:** to decrease asymmetries of information between companies and financial capital, providing access to finance, access to incubation and

[2] See also: https://ec.europa.eu/futurium/en/system/files/ged/national_initiatives_for_digitising_industry_across_the_eu.pdf.

[3] The research and innovation funding programme of the EU.

[4] https://ec.europa.eu/competition/state_aid/modernisation/index_en.html.

acceleration programs, supporting proposals for grants, and bring results of testing the next phase.

- **Innovation ecosystem and networking:** to improve coordination and cooperation between actors in the local system, engaging in brokerage and innovation-promoting activities.

Thus, instruments and programs (with different design features) **are provided to support digital transformation at three levels:**

1. **Company level** (or more recently, the organizational level, since digitization in the public sector is also provided by many DIHs); typical support provided to organizations include experimentation, business plan development, access to finance, and skills/training.

2. **Innovation ecosystems,** such as organizing and transforming the ecosystem behind the digitalization of manufacturing industries or that of a regional cluster.

3. **Coordination at EU level** and internationalization of the involved actors and new value chains.

The EU's support for DIHs includes a range of policy interventions. Depending on the level of support (e.g., regional, national, EU) and the policy domain to have developed and funded each intervention, the rationale and design features differ. Sometimes they are aligned to specific digital technological areas, and others they are tailored to target SMEs in national priority sectors or cross-border cooperation between DIHs.[5]

Over time, DIHs develop a specialization in applications and sectors that benefit greatly from the key digital technologies supported by Digital Europe: HPC, AI, and cybersecurity. DIHs normally focus on a portfolio of services related to more than one application, sector, and technology. However, the specialization of each DIH must correspond to the needs of the region and its S3 (Rissola and Sörvik, 2018). Networking allows specialized hubs to offer their competencies, expertise, and resources to other DIHs and vice versa.

[5] The Digital Innovation Hub Enhanced Learning Program (DIHELP) was a nine-month program for DIHs, offering coaching and mentoring to further develop their activities. Similar support was provided in earlier programs, such as to study the feasibility within the ICT Innovation for Manufacturing SMEs (I4MS) mentoring program and the Smart Factories project.

3. GENERAL DESCRIPTION AND CATEGORIZATION OF DIHS

3. General Description and Categorization of DIHs

3.1. Objective, Data, and Methodology of Categorization

This section provides a description and categorization of DIHs in Europe that can help extract applicable lessons for forming digitization policy in LAC. As such, the purpose is to gain an understanding of the diversity of DIHs in Europe, their primary characteristics, and the variation of these in relation to the operating environment. The goal is not a hub that could be labelled "best practice", or "most excellent" nor is it the most technologically advanced, most disruptive, largest, or fastest growing hub.

Important in this regard is the type of client the DIH supports. **DIHs reflect both the needs and assets for digitalization** (as the demand-side and supply-side of digitalization) **within the territorial** (regional, national, European) **ecosystem in which they are immersed.** Merely supporting excellence on the supply-side of digitalization could in this respect create "cathedrals in the desert" or "white elephants" that hamper interactive learning between producers and users of digital technology and the resulting embeddedness of the territorial entity involved (at regional, national, European, or other international level).

Through the JRC IPTS, the authors had access to the database of the existing on-line catalogue available at the S3 Platform.[6] In Spring 2020, there were 636 DIHs listed in the catalogue, 346 of which were fully operational. The data includes characteristics of the DIH (such as location, region, various size indicators, type of organization, main services provided, and number of clients) and of the type of clients they support.

DIHs differ in terms of scale and scope of their activities (see Section 3.2) as well as the technological readiness level (TRL) of their activities. A few other characteristics relate to and create these differences, such as the kind of region in which they operate (see Section 3.3), organizational form, and type of clients, markets, and sectors they serve (see Section 3.4). A typology of DIHs is based on these sections (see Section 3.5).

3.2. Scale and Scope of DIH

Three indicators help to typify the scale of activities of a DIH: turnover of the hub, employment at the hub, and the number of customers served. All are related, especially turnover and employment, and have been used to calculate a scale index (Scale Summary 3 Index).

Five variables can be used to characterize the DIHs in terms of scope:

1. Number of different activities carried out by the DIH.[7]
2. Quantity of digital technology areas in which the DIH is focused.
3. Number of industries served.
4. Number of sources of funding for the DIH.
5. Readiness level of the digital technologies involved (TRL).

The first three are highly interrelated and are therefore summarized in a single index (Scope Summary Index_A). On average, DIHs provide about nine different services. The five services most commonly provided by DIHs are ecosystem building/networking, collaborative research, awareness creation, education and training, and concept validation and prototyping (Figure 1). The five most

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

[7] The higher the number of services, the larger the scope or broader the portfolio of services.

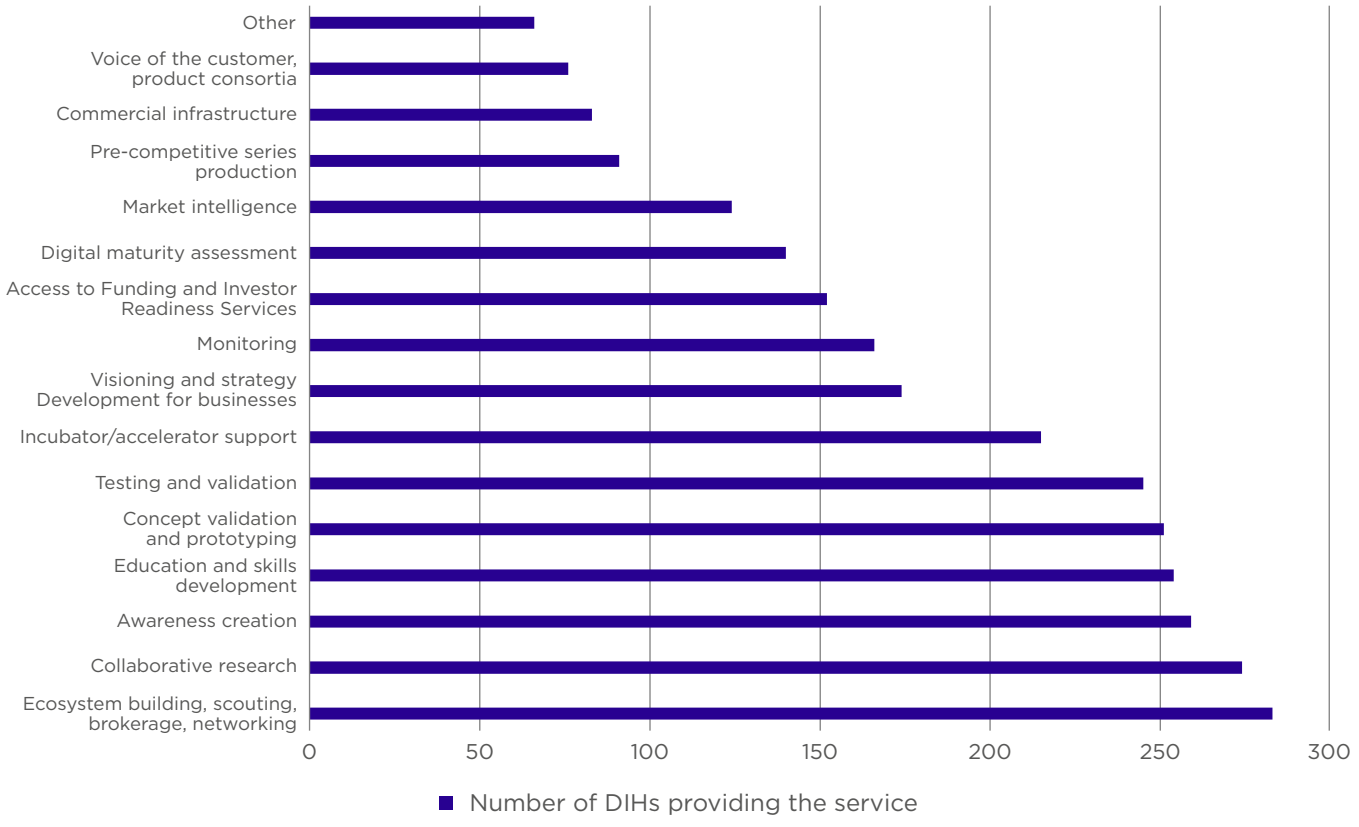
common digital technology areas are internet of things (IoT), AI, robotics, big data, and simulation/modelling (Figure 2).[8]

Regional funding is the most common source of funding for DIHs, in that it leads in the ranking of type of sources of funding for DIHs (Table 1). On average a DIH receives financing from four to five of the mentioned sources. Although the importance of each of these sources in the total budget is not specified, it nevertheless indicates the extent to which the business models of the DIHs are based on a diversified portfolio of public and private funding sources. It also shows that DIHs indeed function as policy platforms, since they depend on a set of different public and private funding sources.

Figure 2 shows that TRL 6 (technology demonstrated in relevant environment) is the most common level of technological readiness among DIHs, as it applies to 270 DIHs in the database. The range of levels addressed typically is around level 4–7, with an average level of 5. This average shows that DIHs focus neither solely on basic R&D nor solely on commercial market transactions.

Scale and scope, one of the main dimensions that distinguish DIHs from one other, is determined by the summary index for the three scale indicators (Scale Summary 3 Index), the summary indicator for the three highly interrelated scope indicators (Scope Summary Index_A), and two less interrelated scope indicators, TRL and funding sources. Hence, larger DIHs not only serve more clients and

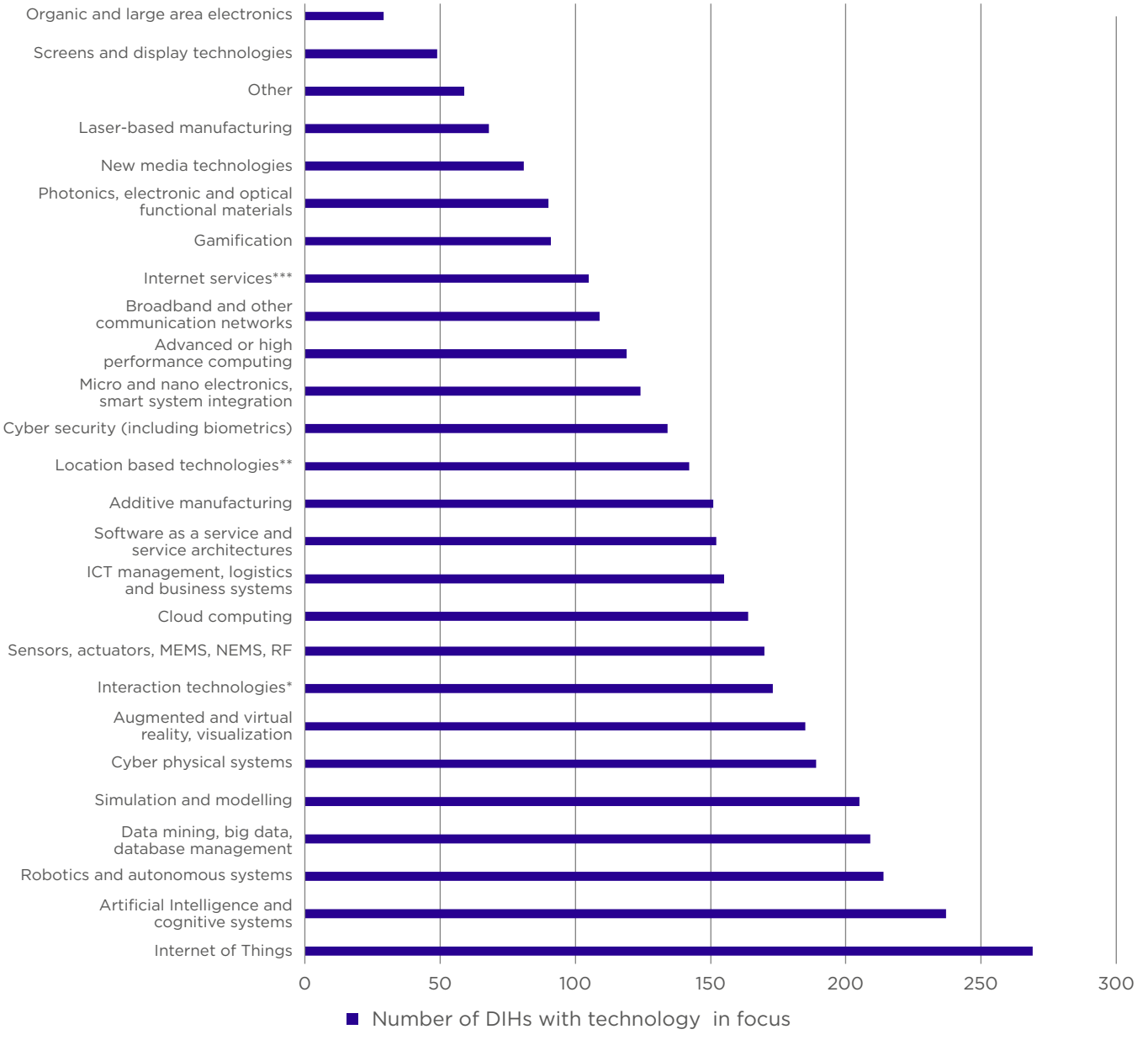
FIGURE 1. Type of Services Provided by Digital Information Hubs



[8] On average, a DIH serves a portfolio of eleven digital technological areas.

employ more people but also have more sources of funding, cover broader technological spectrums, and offer a higher variety of services. Another dimension refers to technology for the manufacturing sector. The weight of manufacturing industries among all the industries served by a single DIH explains, for instance, the average TRL addressed by the DIH. This suggests that independently of scope and scale, service to manufacturing industries relies on, or leads to, the involvement of DIHs at higher-than-average levels of technological readiness.[9]

FIGURE 2. Digital Technology Focus Areas and Number of DIHs



Source: Authors' elaboration based on DIHs catalogue.
Notes: * For example, human-machine Interaction, motion recognition, and language technologies.
** For example, GPS, GIS, and in-house localization.
*** For example, web development, web production, design, networking, and e-commerce.

[9] Annex 1 presents the full results of the principal components analysis.

TABLE 1: Frequency of Funding Sources Used by DIHs

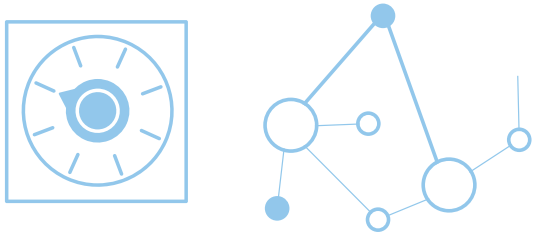
Type of funding source	Number of DIHs by funding source
Regional funding	206
National specific innovation funding	192
Horizon 2020	187
Private funding	179
Partner resources	168
European Regional Development Fund	147
National basic research funding	127
Memberships	105
Other	62
European Social Fund	52
COSME	44

Source: Authors' elaboration based on DIHs catalogue.

TABLE 2: Frequency of TRL Addressed by DIHs

	Levels of technological readiness	Number of DIH by TRL
TRL 1	Basic principles observed	125
TRL 2	Technology concept formulated	163
TRL 3	Experimental proof of concept	197
TRL 4	Technology validated in lab	222
TRL 5	Technology validated in relevant environment (e.g. industrial)	247
TRL 6	Technology demonstrated in relevant environment	270
TRL 7	System prototype demonstration in operational environment	255
TRL 8	System complete and qualified	194
TRL 9	Actual system proven in operational environment	142

Source: Authors' elaboration based on DIHs catalogue and European Commission (2014).



3.3. DIHs and the Regional Context

As in Miörner, *et al.* (2019), regional characteristics are considered when categorizing and selecting DIHs for a case study. Regional data has therefore been added to the database, notably benchmarking data from the S3 platform[10] concerning urbanization and the share of manufacturing industries, and data from the Regional Innovation Index.[11] Additional data from the Digital Economy and Society Index,[12] is available at the national level, together with regional data on internet use from Eurostat.[13]

Using factor analysis the regional context of 199 regions in Europe was categorized into five types of regions according to urbanization, industry structure, digitalization and innovation. The five groups, or types of regions, are characterized in Table A2. Type 1 and Type 2 regions are both highly digitalized and highly innovative. Types 3, 4, and 5 EU regions are arguably closer to the regional context of LAC and therefore have greater relevance as a reference. Type 3 regions are classed as "medium innovative manufacturing," since the regions in this group have a medium level of digitalization and innovation and a high share of employment in manufacturing industries. Type 4 regions are referred to as "medium, urban, service region," being characterized by a high share of the population living in urban areas and low share of employment in manufacturing industries. Type 5 regions are simply termed "rural," since on average only percent of the population in these regions live in urban areas.

Most DIHs (approximately two thirds) can be found in Type 2 regions—that is, urban regions in Europe with a high level of digitalization and innovation. A smaller group of DIHs can be found in medium innovative manufacturing regions. Since the regional market potential in these regions consists to a relatively large extent on manufacturing industries, it is unsurprising that DIHs in these regions have on average a relatively high share of manufacturing industries among their clients (57 percent). In contrast, for DIHs located in medium, urban, services regions, the manufacturing industries represent on average only 28 percent of the industries they serve. DIHs in less urban regions (Type 1, and Type 5) tend to be larger in scale than DIHs in urban regions. There are only four DIHs located in Type 5 rural regions, but their scale and scope is relatively large. Finally, the average TRL does not differ among the DIHs located in different type of regions.

In highly digitalized regions, DIHs have a more specific, specialized characteristic, while in regions that score low on the digitalization index, DIHs have a broader scope. **DIHs operating in less-digitalized regions appear to be offering a broader set of technologies, perhaps to compensate for the lack of other knowledge suppliers in the region.** This mechanism could also help explain the even larger scope of DIHs operating in rural regions, which in this case is also related to an increase in size. On the other hand, DIHs in the more innovative regions are also larger, indicating the need to meet higher demand from a more digitalized private sector (see Table A5).

3.4. DIH Clients and Organizational Form

Since the EU only requires DIHs to be non-profit, the hubs are highly diverse in terms of organizational form. Most DIHs are part of a public organization, frequently research and technology organizations (RTOs) or public universities, followed by those that are part of private organizations (see Table A6). Still, a sizeable proportion of DIHs are organized as public–private partnerships (PPPs), informal networks, foundations, and even just single projects.

[10] https://s3platform.jrc.ec.europa.eu/regional-benchmarking.

[11] https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/regional-innovation-scoreboard_en.

[12] https://digital-agenda-data.eu/datasets/desi.

[13] The national DESI summary index has been multiplied with the regional nuts2 level indicator on internet use to arrive at a regional specific indicator regarding the digitization context.

DIHs work with an extensive range of partners. The most common partners are universities (213), and there is often more than one collaborating in a single DIH. RTOs are partners for 162 DIHs. SMEs, large enterprises, and industry associations are other types of frequently ocurring partners. Interestingly, the number of partners is significantly related to its scope but not its scale. Hence, it appears that having more partners is a common way to increase the scope of activities of a DIH without affecting its size.

The policy rationale to support DIHs is highly oriented to promoting the digitization of SMEs, though many DIHs also support the digitization of other types of customers, such as large enterprises or research organizations (Table 3). While the concept of DIHs was originally to support digitalization of the manufacturing industry, it has been broadened to include service industries and, more recently, support for digitalization of the public sector.

DIHs that serve both large enterprises and research organizations are significantly larger than the rest in scale and scope. They also receive funding from many more different public funding sources (see Table A8). Still, their target TRL is no different from the rest. In terms of industry served, DIHs which do not serve any manufacturing industry markets are significantly smaller in scale and scope then DIHs which do serve one or more manufacturing markets (see Table A12). Again, in terms of the average TRL level, the difference is not significant. Table 3 shows the frequency of markets/industries.

To summarize, high-tech manufacturing activities are the two most significant industries requiring DIH services, followed by education, logistics, health, and agriculture, sectors which stand to gain significantly from the effective incorporation of digital technologies (Figure 3). DIHs that include universities and RTOs have the scale, and thus the equipment and infrastructure, as well as the technological expertise, to meet the needs of large enterprises and multinationals without neglecting work with SMEs. In contrast, private-led DIHs are smaller, directed more at the service sector, and working in activities closer to the market.

TABLE 3: Frequency of Customer Type

	Number of DIHs serving customer Type
SMEs (<250 employees)	222
Large companies, multinationals	145
Research organizations	115
Start-up companies	186
Mid-Caps (between €2–10 billion turnover)	172
Large companies and research organizations	89

Source: Authors' elaboration based on DIHs catalogue.

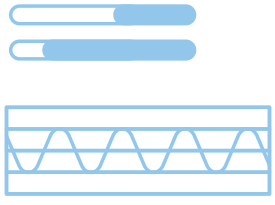
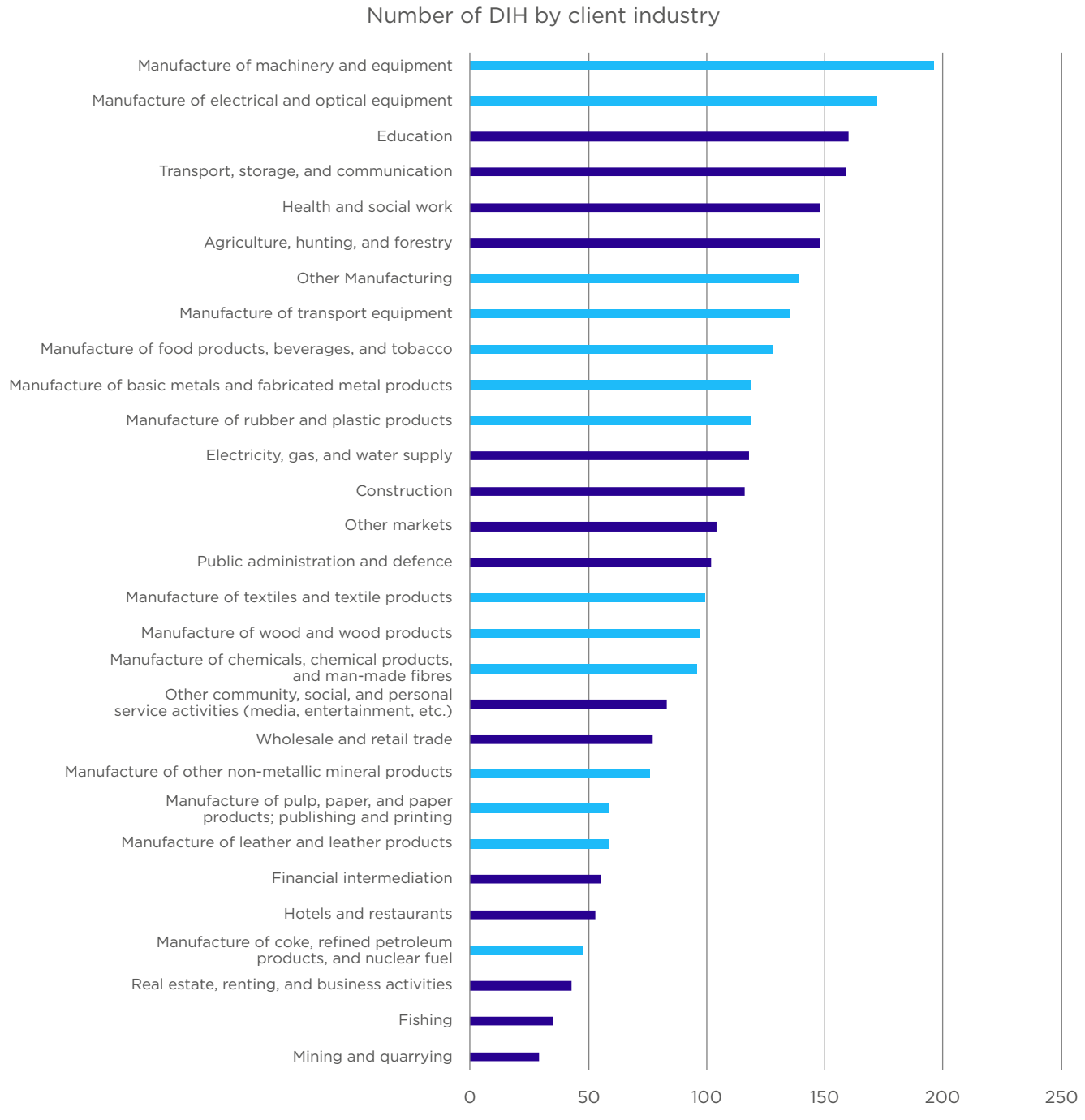


FIGURE 3. Market Sector/Industries Served by DIH



Source: Authors' elaboration based on DIHs catalogue.

3.5. A Typology: Four Types of DIHs

As mentioned, capturing diversity among DIHs is not easy. Nonetheless, a synthesising typology of DIHs can help to extract main regularities, based on two distinctions concerning organizational form and sectors served, namely: those DIHs that are part of a university or other public Research Technology Organization versus those which are not (labelled as Private); and DIHs that serve primarily manufacturing sector clients (over 50 percent) versus those that are more, or fully, oriented to the service sector.

This results in four types of DIHs:

1. Private for services.
2. Private for manufacturing.
3. University for services.
4. University for manufacturing.

Table 4 presents some characteristics that differ significantly per type of DIH. University DIHs are significantly larger in scale (in terms of turnover, employment, and number of customers). These DIHs are also located in regions with a higher regional innovation score. The two university types of DIHs address lower TRLs than private ones, and those for services address lower TRL than those for manufacturing. All manufacturing DIHs can be found in regions with a higher share of manufacturing employment.

The university DIHs (Types 3 and 4) more often have multinational companies among their clients, compared to the other hubs. Serving SMEs is especially common among private manufacturing DIHs. There is a high relevance of the agricultural sector as clients of DIHs oriented to services, considering the importance of the sector in LAC (Table 5). Concerning funding sources, private DIHs (Types 1 and 2) are more likely to procure funding from memberships, though public funding is critical. At least 47 percent obtained EU research funding from the Horizon 2020 program or national research programs. The importance of public funding is even more evident for DIHs Types 3 and 4.

TABLE 4: How the Four Types of DIH Differ in Scale, Average TRL Addressed, and Regional Context

Type of DIH	Summary scale index average per type of DIH**	Average TRL addressed, average per type of DIH*	Regional manufacturing employment share in %, average per type of DIH**	Regional innovation score, average per type of DIH*
Private for services (N=95)	53	5.1	15	90
Private for manufacturing (N=119)	52	5.4	18	90
University for services (N=63)	65	4.6	16	98
University for manufacturing (N=45)	67	5.0	18	100

Source: Authors' calculations based on DIHs catalogue.
Note: Significance in ANOVA: *p<0.05; **p<0.01.

The sectoral demand is more relevant for defining the type of technology offered than the organization characteristics of the DIHs (Table 6). Hence, those DIHs focused on services (Types 1 and 3) tend to specialize in software as a service, cybersecurity, and high-performance computing, while those oriented toward manufacturing specialize in robotics and cyber physical systems.

Despite the significant demand for the technological specialization of DIHs, the characteristics of the knowledge provider have a greater bearing on the services they provide. It is possible that the prevalence of collaborative research and testing and validating services at university-led DIHs (Types 3 and 4) reflects the availability of researchers, specialized equipment, and facilities. In contrast, Types 1 and 2 DIHs are typically more intensive providers of mentoring, digital maturity assessment, and ecosystem building services, backed by business and management expertise (Table 7).

TABLE 5: Customers Served and Funding Source, % of Hubs per Type of DIH

Type of DIH (number of hubs)	Serving large companies, multinationals	DIH's Serving SMEs, share per type	Serving agriculture**	Membership funding**	EU Research funding Horizon2020**
Private for services (95)	40%	63%	57%	46%	47%
Private for manufacturing (119)	39%	74%	36%	34%	54%
University for services (63)	57%	68%	57%	13%	73%
University for manufacturing (45)	53%	69%	33%	27%	71%

Source: Authors' calculations based on DIHs catalogue.
Notes: *Chi-square significant at p<0.05; **Chi-square significant at p<0.01.

TABLE 6: Digital Technology Focus Areas, Percent of Hubs per Type of DIH

Type of DIH	Software as a service	Broadband, 5G	Robotics	Cyber physical systems	Cyber security	High-performance computing
Private for services	61%	44%	60%	47%	49%	39%
Private for manufacturing	41%	33%	76%	67%	38%	38%
University for services	46%	29%	52%	54%	48%	41%
University for manufacturing	36%	22%	76%	67%	27%	24%

Source: Authors' calculations based on DIHs catalogue.

TABLE 7: Services Provided, Percent of DIHs per Type

Type of DIH	Collaborative research	Mentoring	Digital maturity assessment	Ecosystem building	Testing and validating
Private for services	76%	61%	36%	93%	73%
Private for manufacturing	87%	48%	50%	88%	72%
University for services	92%	51%	44%	89%	81%
University for manufacturing	91%	42%	40%	76%	87%

Source: Authors' calculations based on DIHs catalogue.

Despite the significant demand for the technological specialization of DIHs, the characteristics of the knowledge provider have a greater bearing on the services they provide. It is possible that the prevalence of collaborative research and testing and validating services at university-led DIHs (Types 3 and 4) reflects the availability of researchers, specialized equipment, and facilities. In contrast, Types 1 and 2 DIHs are typically more intensive providers of mentoring, digital maturity assessment, and ecosystem building services, backed by business and management expertise (Table 7).

In summary, **university-led DIHs are typically larger than their private counterparts, rendering them more capable of offering services that need specialized equipment and facilities, such as collaborative innovation and testing services.** Conversely, private-led DIHs operate at TRLs closer to the market, primarily within the services and manufacturing sectors. These hubs excel in providing services that demand robust networks and managerial expertise, such as mentoring, assessments, and ecosystem development. While all the DIHs examined are geared toward serving SMEs, this is particularly true for private manufacturing-focused DIHs. Correspondingly, university-led DIHs seem better equipped to collaborate with larger corporations and multinational enterprises (MNEs). Independently of their organizational structure, service-oriented DIHs frequently engage with the agribusiness sector. Demand-side factors significantly influence the technological specializations of DIHs, with service and manufacturing-oriented hubs concentrating on different sets of digital technologies. Finally, while all DIHs are heavily dependent on public funding, private hubs have the added advantage of raising funds through memberships.

4. INSIGHTS FROM THREE DIH CASE STUDIES

4. Insights from Three DIH Case Studies

4.1. Design and Implementation Process: How DIHs Develop

Previous studies have looked at DIH practices; JRC-IPTS has carried out three studies and produced a handbook (Kalpaka, Sörvik, and Tasigiorgou 2020) with a step-by-step approach to inform policymakers, as well as DIH managers, on how to start or develop a DIH (Figure 4). The approach starts with an analysis of regional needs and assets, looking at what SMEs in the region need for their digital objectives, what is lacking in the regional innovation systems, and which regional assets can be used to develop a DIH. Relevant analyses have often been performed during the development of S3 regional innovation strategies. Also, Industry 4.0 analyses and Digital Agendas have served the existing DIHs. The subsequent steps described in the handbook focus on (i) preparation phase: pre-study and pilot, (ii) vision and business proposal, (iii) service definition, (iv) organizational form, (v) business model and funding, and (vi) national and international partnerships, and (vii) monitoring and impact assessment.

The above steps can all be relevant to improving DIHs. The order of the steps is more complex in practise and less linear. Several of the changes and decisions concerned may run in parallel and may not necessarily involve the entire DIH, but only one specific project, activity, policy instrument or new service. Whether as a support platform, as an umbrella of policy instruments, or as a digital innovation ecosystem, their development is complex. The COVID-19 pandemic has also brought changes, not only in terms of regional needs for digitization, but also in physical, on-site provided services, with implications for the other steps.

The overall impression is that most hubs are still in the phase of defining their services and developing a wider set of services. The organizational form is often not fully formalised, and the business/funding model is often not settled as a long-term, sustainable model. The DIHs are interested in all kinds of funding opportunities, including those for establishing national and international partnerships, but most hubs seem to see their regional role and the addressing of regional needs as the most important for their level of governance. Miörner *et al.* (2019) report a desire among DIHs for expanded collaboration both within and beyond their regions.

Miörner, *et al.* (2019) conclude from the JRC-Seville survey among DIHs that overall, the hubs were strong in terms of bringing people together, but that there was as yet less evidence of tangible project activities. Providing access to technologies and stakeholder networks was one of the DIH's foremost strengths, while prototyping and testbed activities seemed less well developed. In regions that are at the technological frontier, DIHs may serve and specialise in such an innovation-supply-side role, but hubs in the more moderate innovative and digitalized regions seem more oriented to strengthening the demand-side for digital innovation by providing access to a broad and integrating set of digital technologies. In this respect, they seem to have further increased their portfolio of services as they mature.

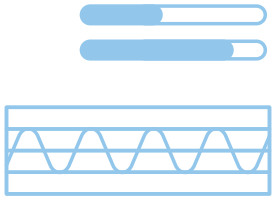


FIGURE 4. Step-by-Step Approach on How to Set Up/Reinforce a DIH

Source: Kalpaka, Sörvik, and Tasigiorgou (2020).

4.2. Selection of Cases

Three cases were identified and selected for their relevance as a potential reference case for LAC. The cases were chosen from DIHs that receive regional government funding and have a client/sector base relevant to the region. They correspond to three of the four types of DIH in the European region of types 3–5 (i.e., the mid to laggard innovators) (see the regional typology in Annex 1).

DIHs located in EU type regions (1 & 2), characterized by both a high level of innovation performance and high score on the digital economy and society index (the national index combined with regional indicator for internet use), were not selected, since DIH policy practices in those highly innovative and digitalized regions are likely to be less relevant as a reference for LAC, because regional needs and assets call for different policy interventions.

DIH Andalucía Agrotech is located in Sevilla, in the Andalucian region of Spain. It is specialized in agri-food and classified as a Type 1 DIH, since it is neither part of a university nor specialized in serving manufacturing industries. In line with this case study's regional typology, Andalucía is in Group 4—characterized as "medium urban services regions"—and scores as moderate in the innovation and digitalization index, with a relatively high level of urbanization and a low share of manufacturing employment. The other two DIHs are in Type 3 regions—classified as "medium innovative manufacturing regions"—with a below average score in innovation and digitization and a relatively high share of manufacturing employment (see Box 1).

DIH Vicenza, established and coordinated by the industry association Confartigianato Vicenza and located in the Veneto region of Northeastern Italy, is focused on manufacturing industries, specifically textiles. This hub is therefore a Type 2 "private for manufacturing" DIH. This region also scores as moderate in the innovation and digital index but is characterized by a relatively high share of manufacturing employment, mostly within SMEs (see Box 2).

DIH University Maribor (UM) in East Slovenia is one of the relatively few that serves the construction industry, a sector particularly lagging in terms of productivity in the LAC region. As a hub that also supports service industries, it is a Type 3 "university for service" DIH. The East Slovenia region has a moderate level of innovation and digitization compared to the EU regional average. The share of manufacturing industries is relatively high (see Box 3).

4.3. Insights from the Three Cases

Motivation for starting a DIH and launching initiatives: addressing regional needs

In the case of DIH Vicenza the national 4.0 plan was a major motivation for promoting (identifying, set-up, support, and development) regional hubs and competence centers to support the digitization of the manufacturing industry as a tool to transform industries during the 4th industrial revolution. The DIH did not receive any public grants directly, but member companies are able to apply for national and regional 4.0 support for digitalization. For DIH Vicenza, participation in (and funding from) EU projects did not play a role. According to Matteo Pisanu, Manager of DIH Vincenza, "the DIH could not have been born without the impulse from Confartigianato Imprese Vicenza, which financed the entire design from the outset. DIH Vicenza is indeed the result of a private initiative with no public grants. It was possible because we work in a large organization." As a large industry association, they have a long history and ample experience in serving the needs of industrial companies in the region, which are mostly SMEs.

In the case of DIH Andalucía Agrotech the main raison d'être was the demand from many farmers and food industries in Andalucía. According to Judit Anda Ugarte, Technical Advisor of the Junta de Andalucía, "it was the agri-food sector that demanded a sort of catalyst for digital innovation." The process to find sources of funding was initiated through project calls and other instruments. In the early stages, the European S3P Agrifood Thematic Partnership on Traceability and Big Data

emerged and fuelled the activities of this DIH in Seville. Given the economic, social, and cultural importance of agri-food in the region, "it was logical to take a sectoral approach and then dig deeper into its particular strengths and weaknesses." This strategy provided a way to both analyse and address the specific needs of the agri-food sector in Andalucía, and on the other hand, develop custom-built solutions based on digital technologies to respond to those needs, for example, through living labs and other experiences which could be applied at a local level.

In the case of the DIH UM, the national plan for digitalizing the economy was a major inspiration, the government voucher program being the trigger. This voucher system subsidized part (60 percent of investments) of the digital transformation costs of companies. Maja Sušec, Coordinator of the DIH UM, explained that there are different vouchers for different digitalization activities (e.g., one for digital activities such as implementing a website and another for developing a whole strategic digitalization plan). To take advantage of the scheme, increasing the involvement of universities, technology infrastructures and competence centers was key. However, at that time there was only one DIH in Slovenia, located in the capital city, Ljubljana. For many national innovation strategies and structures (e.g., the SRIP partnerships) Ljubljana is considered the technological core of the country, but the specific regional demand for digitalization support in the Eastern region and the benefit of physical proximity, called for initiating the DIH UM.

In brief, **local demand for support in digitization was, in all three cases, the main motive for initiating the hub.** From best practices described by Kalpaka, Sörvik, and Tasigiorgou (2020), **this situation is different for high-tech and highly digitalized regions where there are examples of DIHs specialized in supplying digital technology in a narrow field of research and innovation.** Also, the analysis in Section 3 has pointed out this difference, in the sense that in highly digitalized regions the DIHs often have a more specific characteristic with a digital technology niche in focus.

Implementing a DIH based on previous structures and local capabilities

The launch of the DIH is not always the beginning of collaboration, as there are always underlying collaborative structures that facilitate its formation. In the case of DIH Vicenza, the industry association dates back decades. In other instances, the infrastructures were established as a result of more recent policy initiatives. For DIH Vicenza, the technological capability is the result of partnerships among universities, competence centers, and tech companies. According to Pisanu, these companies are not only members of the association; a strong network with other, different kind of partners at the local level is one of our strengths." About 50 percent of the DIH Vicenza team is composed of members of the Confartigianato association and the other half were hired from several universities in northern Italy. At the time of the interview, there were 15 people on the team, and DIH Vincenza did not have its own legal entity but was a business department of Confartigianato. In recent years, DIH Vicenza has worked to better understand the needs of its clients, made up mainly of SMEs. In terms of exports, Vicenza province ranks third in Italy, thanks to the type of small manufacturing companies, which includes many artisan and crafts businesses. In these firms, non-serial production is a distinctive characteristic, which also shapes their digitalization process.

In the case of the DIH UM, the existing structures or platforms included the Technology Transfer Office (TTO) and the Enterprise Europe Network (EEN) activities at the university. The original full-time members of DIH UM started out working at the TTO and EEN units at the UM. One of the main competences and activities concerns the preparation of applications for public funding. University experts in certain fields may be involved in implementation. When launching a DIH it is important to know that it can develop out of existing activities and pre-existing structures, such as the voucher system and TTO-activities. Sušec explained that while implementing and growing the DIH, some match-making platforms like Demola, or the

involvement of UM in the Smart City SRIP, have decreased in importance, while the importance of other platforms has increased. The VZHODNA. SI agreement between the UM and 22 municipalities has, for instance, increased in importance as a platform for the DIH. Concerning construction and Smart City initiatives in these municipalities, students and university experts, such as architects and engineers, are involved in designing and developing new retirement homes, applying the latest digital technologies. Because of similar socio-economic characteristcs there is cross-border cooperation with Croatia.

The reason for the public administration's leading role in the Andalucía Agrotech DIH is simply the consequence of being the main facilitator of previous joint, collaborative efforts within the region. However, according to Anda Ugarte, members will likely take on leading roles as the Andalucía Agrotech DIH matures. In the meantime, the hub has significantly increased in technological know-how during its development, especially in competence areas which have more impact on the agri-food sector, for example, earth observation, AI, and IoT. Anda Ugarte also highlighted the hub's strong focus on education and training, as well as on promoting a digital culture within the agri-food sector. Andalucía Agrotech DIH has a multi-actor approach, enabling it to tackle the whole range of TRL levels, since some members can focus on lower TRL levels while others do so on higher levels. In terms of technological capability, the hub originally focused on big data and traceability. Big Data was initially considered a starting point in usage and exploitation of data to bring added value to the agri-food chain. Traceability of products/processes along the agri-food chain was also included as a fundamental pillar of the initial path, as it is of great importance to ensure quality and safety standards. Nonetheless, Anda Ugarte clarifies: "both areas of interest have been expanded as Andalucía Agrotech DIH has increased its knowledge and competences. The integration of new digital technologies (AI, blockchain, remote sensing, IoT, etc.) that bring innovative solutions to the agri-food sector, has emerged as a natural consequence."

Implementation of the DIH concept has remained a local/regional specific development path, based on regional demand characteristics. Also, specialization is a localized path based on the original demand characteristics. Overall, the three cases represent the strong local demand-side orientation that one expects in regions that are in a "catching-up" situation, or at least in a position further away from the technological frontier. In terms of technological capabilities and services, the portfolio or scope of the DIHs has become broader, as new technologies and services have been integrated. The DIHs are still more oriented toward supporting local industries in their digitalization than in supporting the exploitation and export of digital technology to other regions.

Recent developments

Miörner, *et al.* (2019b) conclude that many DIHs do not prioritize investing in test and demonstration infrastructures and that it may be worthwhile to investigate further how testbed environments can be networked. The three DIHs discussed herein are doing exactly this. DIH Vicenza, for instance, has made an agreement with FabLabs in the region and with Faberlab Varese in the neighbouring region. For test, demonstration, and training activities, the hub also increased collaboration with the Italian Institute of Technology in Genoa. In addition, it is initiating training projects focused on digital skills for small entrepreneurs in different fields such as robots, wearables, big data, and ecommerce. DIH Vicenza develops digital 4.0 capabilities by working with partners who can provide their expertise, for example, by setting up the Comau Learning Center at the DIH Vicenza with the Italian IT multinational, Comau. Maurizio Cremonini, Head of Marketing at Comau, stated: "We want it to play a key role in building the 'factory of the future,' offering participants a first-hand glimpse of how technology and innovation can facilitate the development of skills while at the same time improving company processes and managerial practices." The ambitions of the DIH and Comau are served by Comau's educational "e.DO robots and HUMANufacturing vision."

During the COVID-19 crisis, the demand for physical spaces at DIH Vicenza decreased, as many courses and training activities were suspended. In the aftermath, many of these are being moved online, along with consultancies and other events.

Andalucía Agrotech DIH launched a technology marketplace where agri-food companies can meet the local technological suppliers and start-ups. Concerning test and demonstration activities, Andalucía Agrotech DIH has been collaborating with other entities (e.g., competence centers and universities) to test digital technologies and bring innovative solutions to the agri-food sector. For example, the hub implemented a living lab in collaboration with FIWARE ZONE (another public–private initiative promoted by the Regional Ministry of Economy, Knowledge, Businesses, and Universities) to introduce IoT for the monitoring of livestock. Moreover, and again in partnership with the Regional Ministry of Economy, Andalucía Agrotech DIH launched a 5G-focused challenge to find efficient and sustainable solutions using drones to detect pests/diseases in crops and create treatments in real time. The Andalucía Agrotech DIH has been designated as a European Digital Innovation Hub (EDIH) by the EC.[14]

Box 1: DIH Andalucía Agrotech (1 of 2)

The Andalucía Agrotech Digital Innovation Hub, coordinated by the Regional Ministry of Agriculture, Fisheries, and Rural Development of Andalucia,[a] was established in Sevilla in 2017 to help companies in the agri-food sector navigate the digitization prosess. To do so, the hub centralizes technological services, innovation capacity, and public programs. An ecosystem for innovation in agriculture was already established with the support of innovation policy in 2007. In 2016, Andalucía entered the S3P Agrifood Thematic Partnership on traceability and big data with other European regions that had also prioritized agri-food-related innovation. The DIH was designed to speed up the implementation of digitization in the agri-food value chain and provide necessary training. The hub serves the entire region of Andalucía and the organizational form is a network organization without a formal structure. By March 2018, 111 partners were involved. The hub's annual turnover, as of 2020, was in the range of EUR250.000–500.000 and it had between 10 and 25 employees. Partner companies include both SMEs and large companies, many from the ICT sector, as well as several associations and cooperatives.

MISSION

As stated in the DIH Catalogue,[b] the mission of the Andalucía Agrotech DIH is as follows:

- Be an ecosystem: the hub is a connector and facilitator for all actors involved in agro-technology.
- Be a one-stop shop: the hub pools people, resources, and tools related to the agri-food sector.

[a] https://www.traceabilityandbigdata.eu/best-practices/andalucia-agrotech-dih.

[b] https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/1020/view.

[14] https://www.andaluciaagrotech.com/edih.

Box 1: DIH Andalucía Agrotech (2 of 2)

- Be based on competence centers: these centers provide support to their customers through technological infrastructures as well as access to the latest knowledge, experiences, and technologies.
- Provide financial or business support to implement innovations.
- Offer a physical and digital platform to enable effective collaboration.
- Be the first regional point of contact: proximity is key to strengthening the innovation ecosystem.
- Be a regional and international benchmark hub in the field of agrotech.

POLICY SUPPORT

The funding structure includes both private (membership) and public sources, the latter from various policy levels (e.g., EU, national, and regional). Funding from Horizon 2020 financed programs such as SmartAgriHubs, ICT-BioChain, and POWER4BIO. Previously, the Partnership on Traceability and Big Data[c] involved collaboration with other regions and their S3. This partnership gave Andalucía the opportunity to prepare for the subsequent creation of the DIH Andalucía Agrotech, which is also supported by the Digitising European Industry Initiative, national innovation and research policies, and digital policy, such as Connected Industry 4.0.

SERVICES PROVIDED

The hub provides services to all industries in the agri-food value chain, including farmers, food manufacturers, distributers, and wholesalers. Services cover all nine levels of technological readiness. An example of a service for business development was the need of several companies and organizations belonging to the hub to improve the traceability of products and empower farmers and consumers at the final stages of the agri-food value chain. They also needed to develop algorithms with machine learning and big data to improve decision-making processes. A direct communication platform between producers and consumers in the agri-food sector solved this problem by providing real-time access to a wide range of detailed information on agri-food products for consumers and distribution companies, which included origin, production process, traceability, promotional information, videos, and any information the producer wished to share with customers. Producers can also use the platform to develop new services, carry out studies on consumer trends, and develop big data tools and applications. Another intervention supported an ICT company in collaboration with a university to monitor and manage livestock through devices adapted to different types of extensive farming, especially in remote areas with difficult access. The company has developed a monitoring system using "FIWARE-Ready IoT device" collars, with multiple sensors and low power wide area (LPWA) and other low-cost and short-range devices that communicate with the collars. This solution will be integrated with the Geographic Information System for the Identification of Agricultural Plots (SIGPAC) by the Junta de Andalucía. In addition, it uses information from the Sentinel satellites and big data algorithms to detect anomalies, such as births and predator attacks.

[c] https://s3platform.jrc.ec.europa.eu/agri-food.

Box 2: DIH University Maribor (1 of 2)

DIH University of Maribor is described in the on-line catalogue as "a regional non-profit network hub of research, industry and business support organizations, utilizing state of the art infrastructure to bring the digital revolution to Slovenia by offering cutting-edge digital technology innovations and services." It also acts as a one-stop shop for the East Cohesion Region of Slovenia, directing industry players towards partners who can help them along the digital transformation process.

MISSION

The mission of DIH UM is to bridge the gap between the digitalization needs of industries and viable solutions. Their vision is to create a collaborative community focused on digital technologies and new business models that can improve the competitiveness of companies. The majority of Slovenian public knowledge institutes are located in the capital city of Ljubljana, in the western region of the country. However, many of the institutions, networks, and policy structures and strategies (clusters, S4, and other DIHs) are quite well integrated into a coherent national system, thus DIH UM aims to bring knowledge from the rest of the nation to the eastern region. The DIH's coordinator is the University of Maribor (UM), the second largest university in Slovenia and the largest knowledge provider in East Slovenia. It has around 13,000 students and 17 faculties, covering the full range of scientific education and research areas. UM has developed strong partnerships with businesses, governmental and non-governmental organizations, and other domestic and international institutions to initiate concrete projects that contribute to economic development and address societal issues, including promotion of sustainable development and provision of public goods and services.

POLICY SUPPORT

As a policy platform, DIH UM links to national or regional policy initiatives related to digitizing industry. The DIH UM is a partner in several S3 pillars and Strategic Research and Innovation Partnerships (SRIPs), such as the SRIP on Smart Cities and Communities and on Smart Buildings and Homes.[a] One of the main goals of DIH UM is to use the available mechanisms—such as SRIPs, clusters, value chains and others—as a vehicle to identify future challenges and determine appropriate solutions, thereby accelerating innovation and digital transformation. In addition to this, UM has secured € 16 million in funding (+4 million in national funding) to build a supercomputer center in Maribor and boost national high-performance computing capacities for research, innovation and business. The project will ensure integration with existing infrastructures, such as the Slovenian State Cloud. HPC-RIVR is a reference project of the Digital Slovenia 2020 (Information Society Development Strategy to 2020).

[a] http://www.svrk.gov.si/en/areas_of_work/slovenian_smart_specialisation_strategy_s4/.

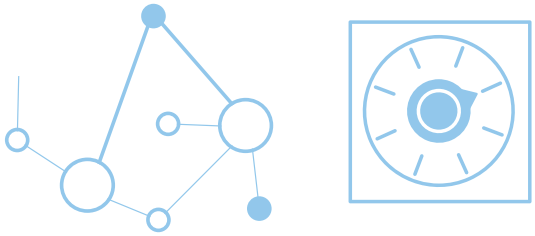
Box 2: DIH University Maribor (2 of 2)

SERVICES PROVIDED

DIH UM is oriented toward sectors prioritized in Slovenia's S3, which encompasses a wide range of service and manufacturing industries that can be grouped into three main pillars:

- **Produce and share knowledge:** including workshops, courses in digitalization, access to R&D infrastructures, support in applying for funding, and search for international partners.
- **Co-develop, test, and launch new products and services:** including strategic research and development projects, experimentation/prototyping, support for scaling-up, and support in testing and product demonstration for companies.
- **Nourish the digital innovation ecosystem:** through community building via different networks, and strategy development.

DIH UM is involved in several networks that provide services; "Demola" facilitates multidisciplinary co-creation projects, bringing together industry experts from leading companies and university students from participating universities in Slovenia (and other countries where Demola operates). This scheme links the DIH UM to education and links students and university staff to specific digitalization challenges in industry and the public sector. The University of Maribor has established an online development center in the Eastern Cohesion Region which enables and encourages partnerships between individuals, companies and institutions with the development and innovative potential to transfer development application knowledge into the surrounding area and procure European funds for the framework of the Eastern Cohesion region. As a result of this initiative UM has signed partnership agreements with 22 Slovenian municipalities. A concrete example of a service provided was the creation of a route optimization for waste collection in the urban area of Maribor. The client was Snaga Maribor, a public company and one of the largest organizations in Slovenia for managing municipal waste. The company collaborated with UM in the development of an algorithm that improved the efficiency of waste collection, saving around 20 percent in time, and 10 to 15 percent in distance travelled.



Box 3: Digital Innovation Hub Vicenza (1 of 2)

The DIH Vicenza,[a] established in 2017 and coordinated by the industry association Confartigianato Vicenza, is an integral part of the National Industry 4.0 Network of relevant competence centers and hubs backed by the Italian Ministry of Economic Development. In 2020, there were 43 fully operational DIHs in Italy registered in the catalogue. According to this information,[b] Confartigianato Vicenza is a non-profit organization founded in 1945. With 16,000 member companies, 500 employees and a network of offices spread throughout the Vicenza province of the Veneto region, it is the largest association of SMEs in Italy. The DIH Vicenza is now a center for the digital transformation of North-East Italy. It relates to and is embedded in the regional innovation ecosystem, as well as with national and international partners in ICT and other high-tech sectors.

MISSION

The DIH Vicenza has the following objectives:

- Guide small and medium-sized manufacturing companies toward an effective digital transformation, making them adaptive and resilient to the disruptive effects that come with adopting digital technologies.
- Meet the demands of local SMEs with digital products, services, and training provided by competence centers and high-profile experts.
- Develop advanced projects and training programs that leverage on accelerating technological developments, such as collaborative robotics and AI, putting human creativity at the center, promoting product customization, and reducing the physical exertion currently required of operators on production lines.
- Provide companies with analysis, support, and fundraising services, and help them connect with suppliers and research partners.

POLICY SUPPORT

The Vicenza Digital Innovation Hub's main link to policy initiatives for digitising industry is the national program and network "Industria 4.0".[c] In the frame of this National Industry 4.0 Plan, around 300 appraisals and consultations were to formalize the R&D activities carried out by companies and obtain tax offsets. Moreover, around 200 companies addressed DIH Vicenza asking to draft digitization projects and complete the necessary procedures to obtain the ministerial vouchers on digitization.

[a] https://digitalinnovationhubvicenza.it.

[b] https://s3platform.jrc.ec.europa.eu/digital-innovation-hubs-tool/-/dih/2667/view.

[c] https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industria4.0_IT%20v2wm.pdf.

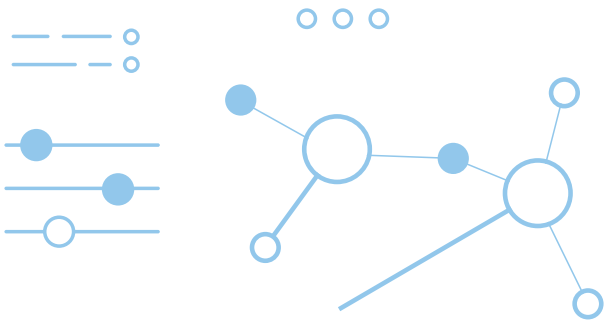
Box 3: Digital Innovation Hub Vicenza (2 of 2)

SERVICES PROVIDED

DIH Vicenza covers levels 1–7 in technological readiness. Their clients are active across a broad range of manufacturing industries. **Many consultations, experiential training, and support activities have been provided in the following areas:**

- Strategic orientation (consultancy on business model design, neuromarketing, soft skills, and customer experience).
- e-Invoicing support: consultancy and access to software developed by Confartigianato DIH Vicenza.
- Support and consultancy in the rapid prototyping field (collaboration experts in the additive manufacturing, 3D scanning, and modelling sectors).
- Orientation meetings on Industry 4.0 in collaboration with large industry players.
- Meetings on smart products, AI, and predictive maintenance.
- Organization of open Innovation initiatives in the ICT field.

An example of a service provided by the DIH was a clothing manufacturing company which needed to invest in six programmable logic controllers (PLC) for the production of yarn fabric (total value €450,000). To secure the investment, analysis was needed to determine the technical specifications of the machinery and interoperability requirements. The hub offered the firm support through providing consulting services.



5. CONCLUSIONS

5. Conclusions

DIHs are innovation ecosystems and policy platforms that take form from a variety of coordinated organizations that actively promote matchmaking on the digital innovation supply and demand side. The general purpose characteristic of digital technologies makes digitization relevant for any organization, sector, region, and country. However, not all have the capacity to make full use of the opportunities that these technologies provide. DIH initiatives must address these disparities. Furthermore, given the importance of tacit knowledge and interactive nature of learning in general and digital innovation in particular, DIHs should be deployed in different regions to tackle idiosyncratic demand, ease knowledge diffusion, and assist with digital uptake.

The analysis of over 300 DIHs in Section 3 gives an indication of the large variety of DIHs in Europe. On average, DIHs provide about nine different services, the three most common being ecosystem building/networking, collaborative research, and awareness creation. On the supply-side, the DIH serves an average of eleven digital technological areas, the three most common being IoT, AI, and robotics. On average the DIHs cover 5 TRLs, of which TRL 6 (technology demonstrated in relevant environment) is the most common. In highly digitalized European regions, the DIHs have more specific specialized characteristics, while in regions scoring low on the digitalization index, the DIHs are more generalized.

When DIHs are classified based on their organizational structure and the industries they serve, new patterns emerge. DIHs affiliated with universities are larger, located in more innovative regions, reliant on public funding rather than membership fees, and serve multinationals more frequently. In addition, these DIHs provide more sophisticated services, such as collaborative research and testing, based on their access to researchers and specialized equipment. The type of digital specialization depends on what industry the DIH is serving; manufacturing-oriented DIHs tend to place a greater digital emphasis on robotics, while service-sector-focused DIHs emphasize software as a service and cyber security.

The three case studies show that **there is more to establishing a DIH than just the first step of identifying a region's needs and assets for digital innovation;** rather, **it involves a process of self-discovery where the organization learns by interacting with its region of influence,** and by continuously refining its activities and technological focus. In all three instances, the original vision has been refined in light of specific regional needs, but this has not resulted in specialization in a digital technological niche, rather, in the expansion of services and incorporation of newly emerging digital technologies. The DIHs have grown and extended their services and competencies, particularly in education, prototyping/testbeds, and services involving student participation, despite the fact that COVID 19 has decreased the use of physical infrastructures.

The following are primary considerations when adopting a DIH-based model to promote digitization of SMEs in LAC:

- As a policy, this is a process of self-discovery and learning on a regional level and requires technological and organizational capabilities.
- The concept of DIHs allows for the development of the digital supply to be compatible with the technological development level of the location. Indeed, DIHs in lagging regions differ from those in regions that are highly digitized and innovative.
- An in-depth assessment of the time and resources is needed to promote collaboration and coordination among main actors in a specific region. Even though the European experience of DIHs has been developed through years of regional (technological) development policies, it has taken a considerable amount of time for a significant proportion of the DIHs to find a more mature organizational form. Without reliable funding, the maturation process could be cut short. Therefore, public funding for DIHs in their infancy is essential for identifying a set of services suitable for a particular region.

The example of DIH UM shows that voucher programs for promoting the digitalization of SMEs can prove an important source of indirect financing for early-stage DIH activities. Similarly, the DIH in Andalucía illustrates how regional policies for productive development, such as S3, can enhance the identification of technological needs while fostering collaboration and creation of networks. Some LAC countries have experimented with these types of initiatives, which can be starting points for DIH-type initiatives to close the gap in digital adoption and innovation.

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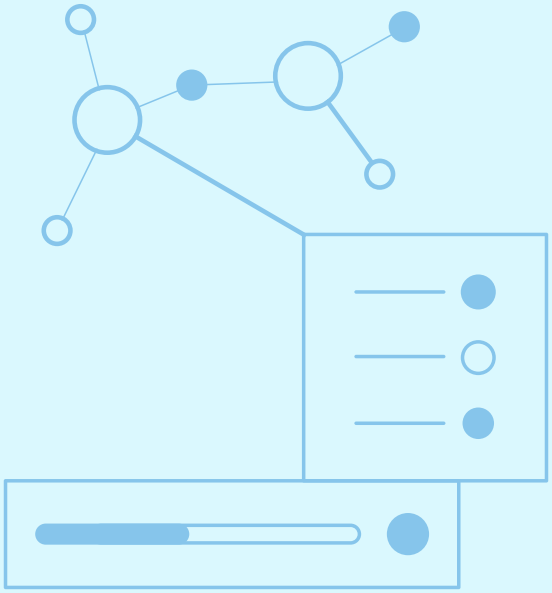


ANNEXES

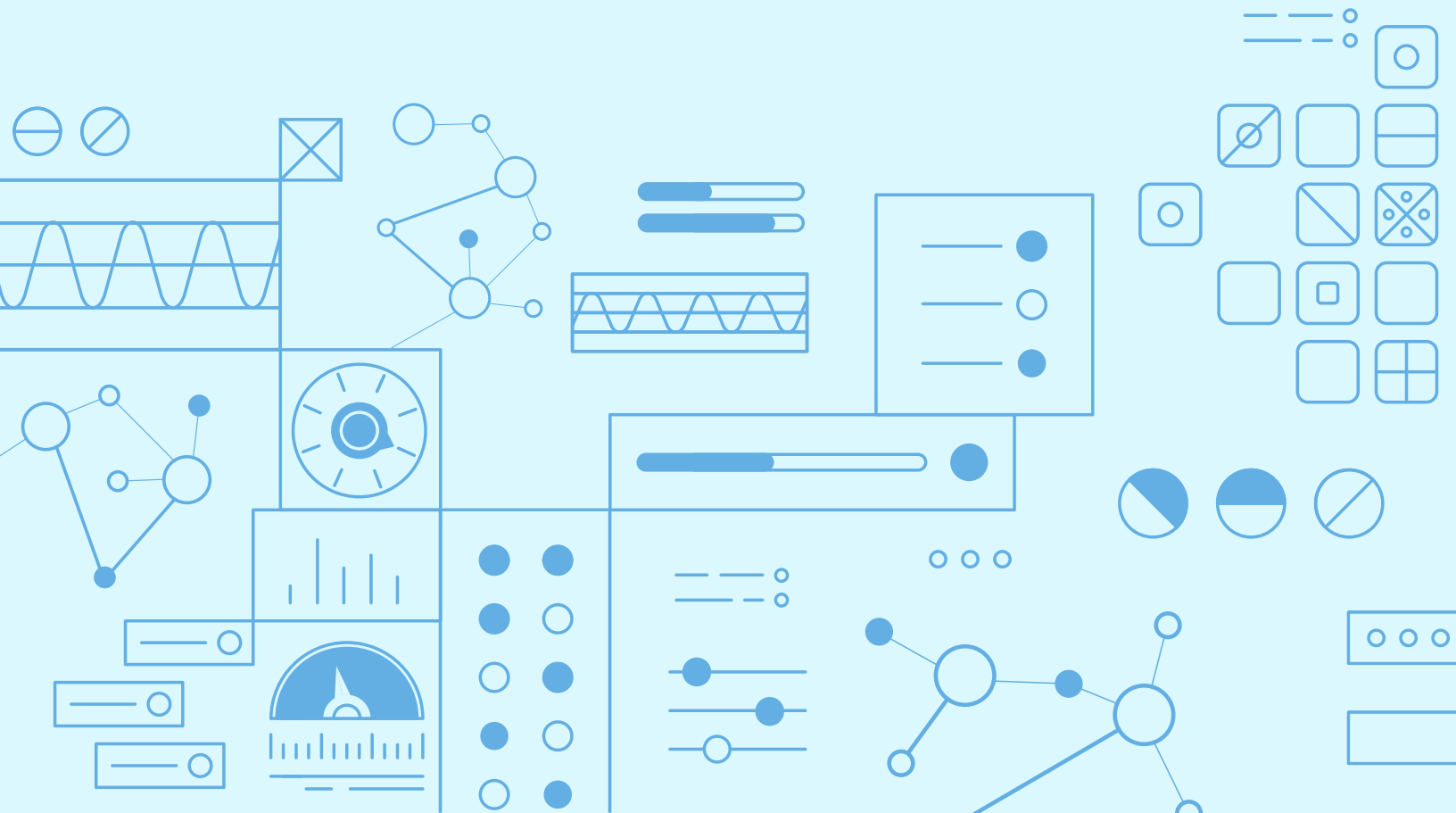


TABLE A1: Two Dimensions Differentiating DIH

	1 Scope and scale dimension	2 Technology dimension
Scope Summary Index_A	.85	
Scope TRL	.81	
Scope Funding Sources	.62	
Scale Summary 3 Index	.57	
Manufacturing industries as % of total industries served		.76
Average of TRL addressed		.74

Source: Rotated Component Matrix. Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 3 iterations.

TABLE A2: EU Regional Typology, Mean Regional Indicator for Urbanization, Industry, Digitalization and Innovation for 5 Groups of European Regions

Groups/ types of regions		Share population in urban area	Employment share manufacturing industry	Digital socio-economic index, including regional indicator for use of internet	Regional Innovation index 2019 (EU=100)
1 High digital and innovative regions (n=16)	Mean	27.8%	15.1%	12.4	102
2 (n=93) High digital and innovative, urban regions	Mean	72.6%	15.2%	10.4	105
3 (n=55) Medium Innovative Manufacturing regions	Mean	49.3%	25.4%	6.5	54
4 (n=24) Medium, urban, services regions	Mean	62.3%	10.7%	7.0	65
5 (n=11) Rural regions	Mean	7.8%	13.6%	5.8	62
Total (N=199)	**Mean**	**57.7%**	**17.4%**	**8.8**	**83**

TABLE A3: Five Correlated Scope Indicators

	Scope digital focus	Scope funding sources	Scope market sectors	Scope services	Scope TRL
Scope digital focus	1	.271**	.342**	.491**	.299**
Scope funding sources	.271**	1	.224**	.317**	.261**
Scope market sectors	.342**	.224**	1	.353**	.138**
Scope services	.491**	.317**	.353**	1	.354**
Scope TRL	.299**	.261**	.138**	.354**	1

Note: N=322; ** Pearson Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

TABLE A4: DIHs Serving Large Enterprises by Size of DIH in Employees

	Clients include large companies, multinationals		Total
Employees At DIH	No	Yes	
1–9	65.9%	34.1%	100.0% (n=126)
10–25	53.7%	46.3%	100.0% (n=67)
25–50	59.0%	41.0%	100.0% (n=39)
50–100	40.9%	59.1%	100.0% (n=22)
>100	37.3%	62.7%	100.0% (n=67)

Note: Chi-square **.

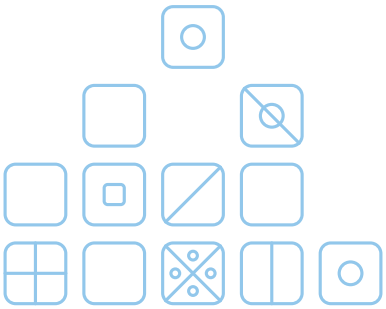


TABLE A5: Mean DIH Characteristics per Type of EU Region

Type of region, number of DIH		scope summary Index B*	Averaged TRL	Percent of manufacturing industries of total industries served**	Scale Summary 3 Index
1 High digital and innovative, rural	N=18	43.6	4.9	46.4	64.8
2 High digital and innovative, urban	N=191	44.6	5.1	46.8	59.1
3 Medium Innovative Manufacturing	N=46	46.8	5.0	57.4	52.7
4 Medium, urban, services	N=38	44.3	5.3	28.4	54.8
5 Rural regions	N=4	64.7	5.4	36.7	69.0
Total	**N=297**	**45.1**	**5.1**	**46.0**	**58.0**

Note: ScopeSummary Index B*: significant difference between types of regions at p=0.035; % Manufacturing industries served *: significant difference between types of regions at p=0.002.

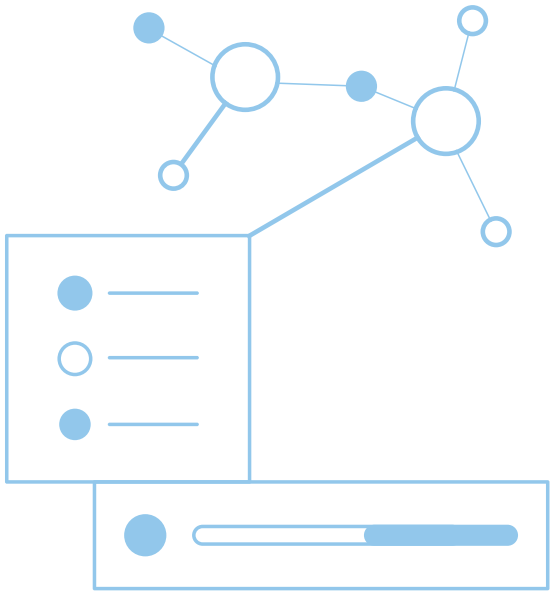


TABLE A6: Mean Scope, Average TRL, Markets Served and Scale by Organizational Form of DIH

Organizational form of DIH		scope summary Index B	Average TRL addressed	Percent of manufacturing industries of total industries served	Scale Summary 3 Index**
1 (part of) Public organization (part of RTO, or university)	N=108	45.2	4.80	41.3	66.1
2 (Part of) Private organization	N=54	41.3	5.45	49.0	49.0
3 Networked organization, without formal structure	N=63	47.6	5.05	48.4	51.6
4 Public Private Partnership	N=37	47.3	5.25	45.5	60.8
5 Foundation, Joint Venture	N=48	45.5	5.53	42.9	50.9
6 Project (formalized end time)	N=11	39.0	5.01	53.7	51.5
Total	**N=321**	**45.1**	**5.12**	**45.1**	**57.1**

Note: ** significant difference between types of organizational form.

TABLE A7: DIH Partners, Type, and Number of Partners

Type of partner	DIH with partners	Sum of partners
Chamber of commerce	66	81
Economic development agency	64	103
Educational institute	44	85
Incubator/accelerator	60	82
Industry association	107	249
Large enterprise	124	482
MidCap	59	120
National government	54	80
Networked, cluster organization	116	270
Regional government	93	139
Research & Technology organization	162	408
SME	126	584
University	213	514
Total	**293**	**3197**

TABLE A8: DIH with both Large Enterprises and Research Organizations as Customer

		Scale Summary 3 Index**	Number of public funding sources**	Average TRL addressed	Scope Summary Index_A**
DIH not serving both large enterprises and Research Organizations	Mean N=108	52.88	2.70	5.132	44.108
DIH that serve BOTH large enterprises and Research Organizations	Mean N=54	67.96	3.67	5.134	50.599
Total	**Mean N=321**	**57.05**	**2.97**	**5.133**	**45.902**

TABLE A9: DIH that Serve Large Enterprises and Multinationals by Organizational Form

		Serving large companies, multi-nationals		
Organizational form DIH		**No**	**Yes**	**Total**
1 (part of) public organization	Count	48	60	108
		44.4%	55.6%	100.0%
2 (Part of) private organization	Count	36	18	54
		66.7%	33.3%	100.0%
3 Networked organization, no formal	Count	35	28	63
		55.6%	44.4%	100.0%
4 PP partnership	Count	17	20	37
		45.9%	54.1%	100.0%
5 Foundation, agency, other	Count	33	15	48
		68.8%	31.3%	100.0%
6 Project (formalized end time)	Count	7	4	11
		63.6%	36.4%	100.0%
Total	**Count**	**176**	**145**	**321**
		54.8%	**45.2%**	**100.0%**

TABLE A10: DIHs Serving Large Companies and Multinationals

Serving Large companies, multi-nationals		Scale Summary 3 Index**	Regional Digitalization indicator (DESI)**	Public funding sources**	Scope funding Sources**
No	Mean	51	9.2	2.6	38
	N	177	160	177	177
Yes	Mean	64	9.9	3.4	45
	N	145	137	145	145
Total	**Mean**	**57**	**9.5**	**2.97**	**41**
	N	**322**	**297**	**322**	**322**

Note: ** p<0.01.

TABLE A11: SME Customer Base for DIHs with or without University as Partner

University as partner?		Customer base includes SMEs (<250 employees)		
		No	Yes	Total
No	Count	42	67	109
		38.5%	61.5%	100.0%
Yes	Count	58	155	213
		27.2%	72.8%	100.0%
Total	**Count**	**100**	**222**	**322**
		31.1%	**68.9%**	**100.0%**

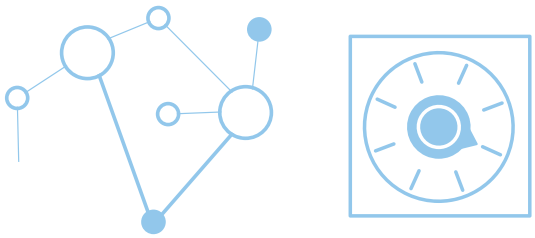


TABLE A12: Mean Characteristics of DIHs with no Manufacturing Markets versus DIHs Serving Manufacturing Industries

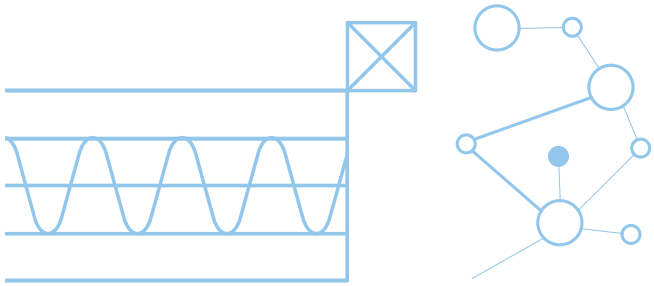
		Mean Scope Summary Index B**	Mean of average TRL addressed	Mean percent of manufacturing industries among total number of industries served**	Mean Scale Summary 3 Index*
No manufacturing industry as market	N=71	40	4.9	0	50
Manufacturing industry served	N=251	46	5.2	58	58
Total	**N=322**	**45**	**5.1**	**45**	**57**

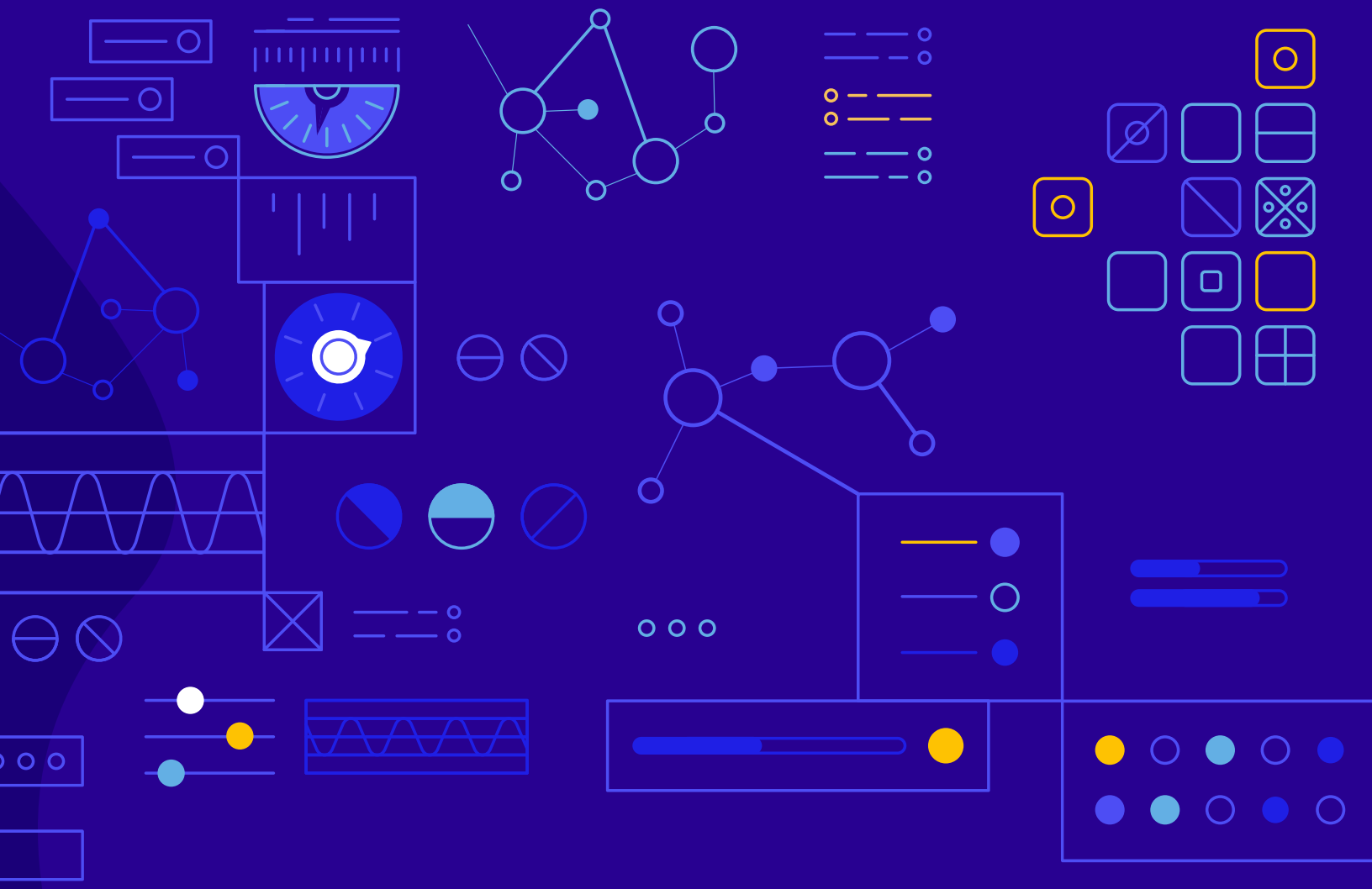
Note: * ANOVA significant at the 0.05 level; ** significant at the 0.01 level.

TABLE A13: SME Client Base for DIH with or without Manufacturing Industries as their Market

			Customer base includes SMEs (<250 employees)		
			No	Yes	Total
Serving manufacturing industries	No	Count	32	39	71
			45.1%	54.9%	100.0%
	Yes (at least 1 industry)	Count	68	183	251
			27.1%	72.9%	100.0%
Total		**Count**	**100**	**222**	**322**
			31.1%	**68.9%**	**100.0%**

Note: Chi-square 0.004 **.





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