

Methodological Appendix

Marco Di Gregorio, Gianmaria Pessina
and Lia Tirabeni

A Digitalisation indices

To ensure transparency and replicability, this methodological note describes the data sources used and procedures used to construct the digitalisation indices employed in this volume. The appendix is organised by index.

Calculation of the Digital Intensity Index at the regional level

The *Digital Intensity Index*¹ (DII) is computed at the regional level following the Eurostat methodology and applied to microdata from the Italian National Institute of Statistics (ISTAT) *Survey on Information and Communication Technologies in Enterprises* (2020). We adopt the Eurostat 2020 methodology (Version II).² The index has an additive structure and is based on the 12 indicators listed in [Table A.1](#).

In the Italian context, indicator 12 (sending electronic invoices suitable for automated processing) shows limited variation following the legal obligation introduced on 1 January 2019 (Law No. 205/2017). The indicator is nevertheless retained to ensure temporal and international comparability and to preserve

Table A.1 Indicators of the Digital Intensity Index (2020 – Version II).

N. Indicator

- | | |
|----|---|
| 1 | Enterprises in which more than 50% of employees have access to the Internet for work purposes |
| 2 | Maximum contracted speed of the fastest fixed Internet connection ≥ 30 Mb/s |
| 3 | Enterprises with e-commerce sales accounting for at least 1% of turnover |
| 4 | Big data analysis from any data source |
| 5 | Provision of mobile devices with Internet access to more than 20% of employees |
| 6 | Website with advanced functionalities |
| 7 | Enterprises with a website |
| 8 | Use of 3D printing technologies |
| 9 | Presence of ICT specialists |
| 10 | Use of industrial or service robots |
| 11 | Use of medium-to-high level cloud computing services |
| 12 | Sending electronic invoices suitable for automated processing |

Eurostat's categorical classification: very low (0–3), low (4–6), high (7–9) and very high (10–12) digital intensity.

Estimates are obtained by applying the final weights provided by ISTAT, which indicate the number of enterprises in the population represented by each responding unit. These weights are based on sampling probabilities and response rates, and are calibrated using auxiliary variables on the number of enterprises and employees drawn from the ASIA archive (Statistical Register of Active Enterprises). Calibrated sampling weights are used in analytic form to account for differential representativeness of observations and to improve the statistical reliability of aggregated estimates.

Industry 4.0 Production Technologies Index

The *Industry 4.0 Production Technologies Index* is an additive index constructed by the authors. Using the ISTAT Survey on *Information and Communication Technologies in Enterprises* (2020), we identify three indicators referring to the core set of Industry 4.0 production technologies. Each adopted technology is assigned a unitary value. The technologies considered are listed in [Table A.2](#).

Digital Potential Index

The *Digital Potential Index* is based on the OECD (Organisation for Economic Co-operation and Development) taxonomy proposed by [Calvino et al. \(2018\)](#), which classifies sectors by degree of digital intensity ([Table A.3](#)). This multidimensional approach relies on indicators capturing: (i) tangible and intangible Information and Communication Technologies (ICT) investments; (ii) purchases of intermediate ICT goods and services; (iii) industrial robots per employee; (iv) the share of ICT specialists in total employment; and (v) the share of turnover generated through online sales. The classification is built on a sample of advanced OECD countries and on sectoral data harmonised according to the ISIC Rev.4 (International Standard Industrial Classification of All Economic Activities, Revision 4) classification for the period 2001–2015. The correspondence between ISIC Rev.4 and NACE Rev.2 (The Statistical Classification of Economic Activities in the European Community, Revision 2) allows application of this taxonomy to ASIA archive, using employees in local units as the reference unit and aggregating sectors at the regional level in full consistency with the OECD classification.

Table A.2 Industry 4.0 production technologies considered.

<i>Technology</i>	<i>Description</i>
Internet of Things (IoT) for production	Use of sensors or RFID (radio-frequency identification) to monitor and automate production processes
Advanced robotics	Use of industrial and service robots
3D printing	Use of 3D (three-dimensional) printing technologies, either owned or acquired as a service

Table A.3 Sectoral classification by quartile of digital intensity.

<i>Sector denomination</i>	<i>ISIC Rev.4</i>	<i>Digital intensity</i>	<i>Manufacturing</i>
Telecommunications	61	High	
Scientific research and development	72	High	
Transport equipment	29–30	High	Yes
Information Technology (IT) and other information services	62–63	High	
Finance and insurance	64–66	High	
Legal and accounting activities, etc.	69–71	High	
Advertising and market research; other business services	73–75	High	
Administrative and support service activities	77–82	High	
Other service activities	94–96	High	
Computer, electronic and optical products	26	Medium-high	Yes
Electrical equipment	27	Medium-high	Yes
Machinery and equipment nec (not elsewhere classified)	28	Medium-high	Yes
Public administration and defence	84	Medium-high	
Wood and paper products and printing	16–18	Medium-high	Yes
Furniture; other manufacturing	31–33	Medium-high	Yes
Wholesale and retail trade, repair	45–47	Medium-high	
Publishing, audiovisual and broadcasting	58–60	Medium-high	
Arts, entertainment and recreation	90–93	Medium-high	
Coke and refined petroleum products	19	Medium-low	Yes
Chemicals and chemical products	20	Medium-low	Yes
Pharmaceutical products	21	Medium-low	Yes
Education	85	Medium-low	
Human health activities	86	Medium-low	
Textiles, wearing apparel, leather	13–15	Medium-low	Yes
Rubber and plastic products	22–23	Medium-low	Yes
Basic metals and fabricated metal products	24–25	Medium-low	Yes
Residential care and social work activities	87–88	Medium-low	
Electricity, gas, steam and air conditioning	35	Low	
Real estate	68	Low	
Agriculture, forestry, fishing	01–03	Low	
Mining and quarrying	05–07	Low	
Food products, beverages and tobacco	10–12	Low	Yes
Water supply; sewerage, waste management	36–39	Low	
Construction	41–43	Low	
Transportation and storage	49–53	Low	
Accommodation and food service activities	55–56	Low	

In the Italian context, employment-based measures are preferred to firm counts, given the strong presence of micro- and small firms and their uneven sectoral and territorial distribution. Firm counts would introduce potential distortions, overestimating highly fragmented sectors ([Bartelsman, Haltiwanger, and Scarpetta 2009](#); [Bugamelli et al. 2012](#)).

Definition of Knowledge Intensive Business Services (KIBS)

The literature distinguishes between technology-based Knowledge Intensive Business Services (T-KIBS) and Professional Knowledge Intensive Business Services (P-KIBS). In line with the Eurostat classification based on NACE Rev.2, the ICT sector includes specific manufacturing activities related to electronic products as well as information and communication services. The detailed classification is reported in [Table A.4](#).

In this study, code 95.1 (*Repair of computers and communication equipment*) is excluded due to the high prevalence of sole proprietorships in the Italian context.

Definition of STEM and ICT enrolments

Enrolments in STEM (Science, Technology, Engineering and Mathematics) and ICT fields are classified according to the ISTAT classification, consistent with

Table A.4 Sectoral classification of KIBS and ICT.

<i>Technical KIBS (T-KIBS)</i>		<i>Professional KIBS (P-KIBS)</i>		<i>ICT sectors</i>	
<i>Code</i>	<i>Description</i>	<i>Code</i>	<i>Description</i>	<i>Code</i>	<i>Description</i>
58.2	Software publishing	69.2	Accounting, bookkeeping and auditing activities; tax consultancy	26.1	Manufacture of electronic components and boards
62	Computer programming, consultancy and related activities	70.2	Management consultancy activities	26.2	Manufacture of computers and peripheral equipment
63.1	Data processing, hosting and related activities; web portals	71.1	Architectural and engineering activities and related technical consultancy	26.3	Manufacture of communication equipment
72.1	Research and experimental development on natural sciences and engineering	72.2	Research and experimental development on social sciences and humanities	26.4	Manufacture of consumer electronics
		73.1	Advertising	26.8	Manufacture of magnetic and optical media
		74	Other professional, scientific and technical activities	58.2	Software publishing
				61	Telecommunications
				62	Computer programming, consultancy and related activities
				63.1	Data processing, hosting and related activities; web portals

Table A.5 Classification of STEM and ICT fields of study (ISCED/ISTAT).

<i>Category</i>		<i>Code</i>	<i>Description</i>
STEM		9	Science
STEM	ICT	10	Computer science and ICT technologies
STEM		11	Architecture and civil engineering
STEM		12	Industrial and information engineering

ISCED (International Classification of Education) and Eurostat standards. This enables the construction of an index following the Digital Economy and Society Index (DESI) Eurostat 2021 methodology, with results expressed as a percentage of the relevant European policy targets: 40 per cent for STEM fields and 10 per cent for ICT fields. The categories considered are listed in [Table A.5](#).

B Interviews

Complementing the quantitative analysis and the social network analysis applied to regional networks, the research included a qualitative in-depth phase. The qualitative design operates at two levels: the analysis of the institutional field and the organisational analysis of small and medium-sized enterprises (SMEs).

Institutional field

The analysis of the institutional field was based on 123 semi-structured interviews with key informants (Bogner et al. 2009; [Dexter 1970](#)), distributed across the regions under study, as reported in [Table A.6](#).

Interviewees were selected to ensure interregional comparability while capturing territorial specificities. First, a positional criterion was adopted, targeting individuals holding strategic roles within key organisations of regional digitalisation systems (RDSs), particularly in the Industry 4.0 field (policy actors and employers’ organisations). This ensured a consistent information base across regions. Second, a reputational criterion enabled local research units to involve additional informants recognised for their expertise or influence, facilitating the identification of context-specific dynamics and configurations.

Data collection followed the tradition of semi-structured expert interviews ([Bichi 2007](#)) and adopted a responsive interviewing approach (Rubin and Rubin 2011), aimed at eliciting interviewees’ expert knowledge ([Meuser and Nagel 2009](#)). The design supported interregional comparison while allowing flexibility to explore emerging themes.

Interviews were conducted after presentation of the project, obtaining informed consent for audio recording, and assuring confidentiality and anonymity. The

Table A.6 Interviewees by region, organisation and role.

<i>ID</i>	<i>Organisation</i>	<i>Organisation type</i>	<i>Role</i>
<i>Piedmont</i>			
I1	Regione Piemonte	Public administration	Executive
I2	DIH Confindustria Piemonte	DIH	Consultant
I3	Piemonte Innova	Innovation cluster/ hub	Consultant
I4	Camera di Commercio Torino	PID	Officer
I5	Polo innovazione MESAP	Innovation cluster/ hub	Manager
I6	CIM 4.0	Competence centre	Executive
I7	Camera di Commercio Cuneo	PID	Officer
I8	CNA Torino	Employers' association	Head of innovation/ digitalisation
I9	I3P	Incubator/ accelerator	Executive
I10	ITS Mobilità sostenibile, Meccatronica, Aerospazio	ITS (Higher Technical Institute)	Executive
I11	Polo Po.in.tex Biella	Innovation cluster/ hub	Executive
I12	Comune di Torino	Public administration	Head of innovation/ digitalisation
I13	Confindustria Cuneo	Employers' association	Head of External Relations
I14	CSI Piemonte	Public agency/ in-house	Executive
I15	DIH Confartigianato Cuneo	DIH	Executive
I16	ICxT	Research laboratory	Executive
I17	Fondazione Links	Technology transfer centre	Executive
I18	Novara Sviluppo	Innovation cluster/ hub	Executive
I19	Piccola Industria Torino	Employers' association	Executive
I20	Politecnico di Torino	University	Department Director (Automation and Computer Science)
I21	Unione Industriali Asti	Employers' association	Head of innovation/ digitalisation
I22	Unione Industriali Torino	Employers' association	Executive
I23	Unioncamere Piemonte	PID	Officer

(Continued)

Table A.6 (Continued)

<i>ID</i>	<i>Organisation</i>	<i>Organisation type</i>	<i>Role</i>
<i>Lombardy</i>			
I24	AFIL – Associazione Fabbrica Intelligente Lombardia	Innovation cluster/hub	Head of innovation/digitalisation
I25	Camera di Commercio Bergamo – Bergamo Sviluppo	PID	Executive
I26	Confindustria Lombardia	Employers' association	Union representative
I27	DIH Lombardia	DIH	Executive
I28	MADE – Competence Center	Competence centre	Manager
I29	Politecnico di Milano	University	University lecturer
I30	Direzione Generale Università, Ricerca, Innovazione di Regione Lombardia	Public administration	Officer
I31	CGIL Lombardia	Trade union	Union representative
I32	Camera di Commercio di Brescia	PID	Officer
I33	Camera di Commercio di Como-Lecco	PID	Officer
I34	Assolombarda	Employers' association	Head of innovation/digitalisation
I35	Direzione Generale Sviluppo Economico Regione Lombardia	Public administration	Executive
I36	Camera di Commercio di Varese	PID	Officer
I37	CISL Lombardia	Trade union	Union representative
I38	ITS Rizzoli	ITS (Higher Technical Institute)	Executive
<i>Veneto</i>			
I39	Camera di Commercio Treviso-Belluno	PID	Officer
I40	DIH Confartigianato VI	DIH	Executive
I41	Competence Center Smact	Competence centre	Executive
I42	Speedhub Confindustria VR	DIH	Executive
I43	T2I	DIH	Manager
I44	ITS Academy Meccatronico Veneto	ITS (Higher Technical Institute)	Executive
I45	Confindustria Veneto area Est	Employers' association	Head of innovation/digitalisation
I46	PID Verona	PID	Officer
I47	PID Venezia-Rovigo	PID	Officer
I48	DIH Belluno Dolomiti	DIH	Executive
I49	Unismart	Technology transfer centre	Executive

(Continued)

Table A.6 (Continued)

<i>ID</i>	<i>Organisation</i>	<i>Organisation type</i>	<i>Role</i>
<i>Veneto</i>			
I50	Unioncamere Veneto	PID	Officer
I51	Veneto Innovazione Spa	Innovation cluster/ hub	Executive
I52	DIH Confindustria Siav	DIH	Executive
I53	Veneto Innovazione Spa	Innovation cluster/ hub	Executive
<i>Emilia-Romagna</i>			
I54	Unindustria Reggio Emilia	Employers' association	Head of innovation/ digitalisation
I55	CNA Bologna	Employers' association	Head of innovation/ digitalisation
I56	Confindustria Emilia Area Centro	Employers' association	Head of innovation/ digitalisation
I57	BI-REX	Competence centre	Manager
I58	Camera di Commercio Bologna	PID	Officer
I59	ART-ER	Public agency/ in-house	Head of innovation/ digitalisation
I60	Camera di Commercio Reggio Emilia	PID	Officer
I61	Fondazione Aldini Valeriani	Training organisation	Manager
I62	Regione Emilia-Romagna	Public administration	Head of innovation/ digitalisation
I63	FIOM-CGIL Bologna	Trade union	Union representative
I64	DIH Confindustria ER	DIH	Head of innovation/ digitalisation
I65	Tecnopolo Reggio Emilia	Technology transfer centre	Executive
I66	Clust-ER Innovate	Innovation cluster/ hub	Manager
I67	CNA Innovazione	Employers' association	Head of innovation/ digitalisation
I68	Tecnopolo CNR Bologna	Technology transfer centre	Head of innovation/ digitalisation
I69	CINECA	Interuniversity consortium	Head of innovation/ digitalisation
I70	Clust-ER Mech	Innovation cluster/ hub	Manager
I71	Confartigianato-Lapam Reggio Emilia-Modena	Employers' association	Head of innovation/ digitalisation
<i>Tuscany</i>			
I72	CGIL Firenze	Trade union	Union representative
I73	CISL Toscana	Trade union	Union representative
I74	Fondazione Cassa di Risparmio Firenze	Banking Foundation	Head of innovation/ digitalisation
I75	Università di Firenze	University	Professor

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Table A.6 (Continued)

<i>ID</i>	<i>Organisation</i>	<i>Organisation type</i>	<i>Role</i>
<i>Tuscany</i>			
I76	Università di Firenze	University	Professor
I77	CGIL Toscana	Trade union	Union representative
I78	KTO – placement e imprenditorialità Università di Firenze	University	Officer
I79	Università di Firenze	University	Professor
I80	Startup MAMACrowd	Company	Head of innovation/ digitalisation
I81	Startup Vino.com	Company	Chief Executive Officer
I82	Enegan	Company	Head of innovation/ digitalisation
I83	Laviosa	Company	Head of innovation/ digitalisation
I84	Agrobit	Company	Head of innovation/ digitalisation
I85	INEOS	Company	Head of innovation/ digitalisation
I86	MB Elettronica	Company	Head of innovation/ digitalisation
I87	Fondazione Intesa San Paolo	Innovation centre	Executive
I88	Consiglio Comunale Firenze (Firenze Democratica)	Public administration	Politician
I89	Nana Bianca	Incubator/ accelerator	Executive
I90	Fasep	Company	Chief Executive Officer
I91	SSE	Company	Manager
I92	Proxima Robotics	Company	Chief Executive Officer
I93	Irpet	Research organisation	Researcher
I94	Confindustria Toscana	Employers' association/DIH	Head of innovation/ digitalisation
I95	Confartigianato Toscana	Employers' association	Union representative
I96	Competence Center Artes 4.0	Competence centre	Executive
I97	PID Camera di Commercio di Firenze	PID	Officer
I98	Nana Bianca – Confindustria	Incubator / accelerator	Executive
I99	Murate Idea Park	Incubator / accelerator	Manager
I100	Fondazione Intesa San Paolo innovation center	Innovation centre	Manager
<i>Marche</i>			
I101	PID Marche	PID	Officer
I102	CGIL Marche	Trade union	Union representative

(Continued)

Table A.6 (Continued)

<i>ID</i>	<i>Organisation</i>	<i>Organisation type</i>	<i>Role</i>
<i>Marche</i>			
I103	CISL	Trade union	Head of regional structural funds
I104	UIL	Trade union	Union representative
I105	BP CUBE	Innovation cluster/ hub	Chief Executive Officer
I106	DIH Confindustria Marche	DIH	Manager
I107	Marche innovation hub	Innovation cluster/ hub	Head of internationalisation
I108	CNA Fermo	Employers' association	Executive
I109	Confindustria Ancona	Employers' association	Head of training
I110	Camera di Commercio di Caserta	PID	Executive
<i>Campania</i>			
I111	Camera di Commercio di Napoli	PID	Executive
I112	Campania Digital Innovation Hub	Innovation cluster/ hub	Scientific manager
I113	CeSMA – Centro Servizi Metrologici e Tecnologici Avanzati	Research organisation	Executive
I114	Cgil Campania e Napoli	Trade union	Union representative
I115	Cisl Campania	Trade union	Union representative
I116	Cisl Fim Campania	Trade union	Union representative
I117	Cisl FIM Nazionale	Trade union	Union representative
I118	RSA Leonardo s.p.a.	Trade union	Union representative
I119	Materias srl	Company	Chief Executive Officer
I120	Medaarch	Company	Chief Executive Officer
I121	PID Med	PID	Scientific manager
I122	Regione Campania	Public administration	Executive
I123	SRM – Studi e Ricerche per il Mezzogiorno	Research organisation	Head of Business & Territory Service

interview guide covered: (i) background information on the organisation and the interviewee's role; (ii) perceptions of regional digitalisation (strengths and weaknesses, opportunities for SMEs, infrastructure, skills, key actors and relevant experiences); (iii) the role and initiatives of the organisation and its collaborations; (iv) the perceived impact of national policies, particularly the Industry 4.0 policy package; and (v) skills-related issues, including risks of occupational obsolescence and training and reskilling initiatives. Each interview concluded with an open section and the possibility of follow-up contact for clarification or comments on the study's progress and results.

Organisational analysis of SMEs

The organisational analysis of SMEs was conducted on a sample of 60 manufacturing SMEs located in the seven regions examined (Piedmont, Lombardy, Veneto, Emilia-Romagna, Tuscany, Marche and Campania), with the aim of reconstructing how digitalisation processes unfold within firms.

Given the complex and processual nature of the phenomenon, involving multiple organisational actors over time, the study adopted a case study strategy (Eisenhardt 1989; Yin 2018). This method is particularly suited to the in-depth investigation of organisational phenomena (Fiss 2009), as it enables reconstruction of processes while fostering sustained engagement with organisational members.

Case studies are particularly appropriate when the objective is to identify holistic organisational patterns (Numagami 1998) and when the unit of analysis is the organisation as a whole (Larsson 1993). As noted by Yin (2018), this strategy is especially effective for addressing “*how* questions”, grounded in a processual perspective. It is therefore consistent with the aim of understanding how digitalisation takes shape within SMEs.

A multiple case study design was adopted to enhance analytical rigour through systematic cross-case comparison (Eisenhardt 1989). Case selection, structured on a regional basis, initially relied on a reputational criterion. Firms were first identified through interviews with key informants; selection was then complemented by referrals from company representatives, trade union organisations and other intermediary actors. Finally, dedicated platforms and websites disseminating smart manufacturing best practices (e.g. DIHs and Competence Centres) were consulted.

Sectorally, the sample prioritised manufacturing firms operating – where possible – in industries with high or medium-high digitalisation propensity, according to the OECD classification (Table A.7) (Calvino et al. 2018).

For each case study, data collection combined in-depth interviews, participant observation and document analysis. Fieldwork was conducted between January 2024 and March 2025. Interviews involved executives and managers at different hierarchical levels and functions, depending on firms’ characteristics.

The semi-structured interview guide drew on organisational literature (Catino and Tirabeni 2023) and its digital dimension (Plesner and Husted 2020). The analysis was structured around three levels of observation: micro, meso and macro (Alison and Zelikow 1999; Catino 2013; Scott and Davis 2007). Each macro-theme was articulated into analytical sub-themes, to examine core issues more closely. Figure A.1 presents the interview logic, main thematic areas and examples of guiding questions, adapted as necessary to context and interviewee.

Interviews focused on coordination and control of work processes; organisational structure; job quality and autonomy; changes in job content; and decisions concerning the adoption and use of digital technologies.

On-site visits were conducted at the firms studied, allowing direct observation of operational processes and the collection of field notes on situated work practices. These observations were complemented by analysis of internal documentation

Table A.7 Case studies by region, core business and number of employees.

<i>Firm ID</i>	<i>Region</i>	<i>Core business</i>	<i>No. of employees</i>
F1	Piedmont	Machinery and equipment	1–49
F2	Campania	Software	1–49
F3	Lombardy	Plastics	50–99
F4	Piedmont	Machinery and equipment	1–49
F5	Piedmont	Electronics	1–49
F6	Marche	Plastics	1–49
F7	Emilia-Romagna	Mechanical processing	1–49
F8	Emilia-Romagna	Electronics	1–49
F9	Lombardy	Machinery and equipment	1–49
F10	Veneto	Machinery and equipment	50–99
F11	Piedmont	Machinery and equipment	100–149
F12	Emilia-Romagna	Mechanical processing	1–49
F13	Emilia-Romagna	Automotive	1–49
F14	Marche	Furniture	1–49
F15	Veneto	Machinery and equipment	1–49
F16	Campania	Paper Products	1–49
F17	Lombardy	Machinery and equipment	150–199
F18	Emilia-Romagna	Food Industry	100–149
F19	Lombardy	Machinery and equipment	50–99
F20	Piedmont	Machinery and equipment	50–99
F21	Tuscany	Plastics	150–199
F22	Campania	Packaging	50–99
F23	Emilia-Romagna	Electronics	1–49
F24	Piedmont	Mechanical processing	1–49
F25	Piedmont	Machinery and equipment	1–49
F26	Emilia-Romagna	Electronics	100–149
F27	Emilia-Romagna	Plastics	200–249
F28	Veneto	Machinery and equipment	100–149
F29	Veneto	Machinery and equipment	100–149
F30	Lombardy	Metalworking	50–99
F31	Campania	Machinery and equipment	1–49
F32	Lombardy	Eyewear	50–99
F33	Piedmont	Plastics	1–49
F34	Campania	Machinery and equipment	1–49
F35	Veneto	Machinery and equipment	50–99
F36	Lombardy	Automotive	150–199
F37	Emilia-Romagna	Automotive	1–49
F38	Tuscany	Machinery and equipment	1–49
F39	Marche	Apparel	1–49
F40	Marche	Furniture	1–49
F41	Campania	Software and machinery	200–249
F42	Lombardy	Chemicals	50–99
F43	Tuscany	Chemicals	150–199
F44	Veneto	Machinery and equipment	1–49
F45	Veneto	Printing and graphic arts	1–49
F46	Campania	Paper products	100–149
F47	Marche	Mechanical processing	1–49
F48	Campania	Machinery and equipment	1–49
F49	Tuscany	Machinery and equipment	1–49

(Continued)

Table A.7 (Continued)

<i>Firm ID</i>	<i>Region</i>	<i>Core business</i>	<i>No. of employees</i>
F50	Veneto	Machinery and equipment	50–99
F51	Tuscany	Machinery and equipment	200–249
F52	Veneto	Machinery and equipment	1–49
F53	Campania	Food industry	50–99
F54	Tuscany	Food industry	1–49
F55	Tuscany	Finance	1–49
F56	Veneto	Machinery and equipment	50–99
F57	Lombardy	Plastics	50–99
F58	Campania	Machinery and equipment	50–99
F59	Tuscany	Software	1–49
F60	Lombardy	Machinery and equipment	50–99

(where available) and external materials accessed through firms’ official communication channels.

Data were organised, coded and analysed using a thematic analysis approach (Lochmiller 2021), aimed at identifying and interpreting recurring patterns across different types of empirical materials. Themes were defined as unifying principles capturing aspects relevant to the research question and emerging across multiple sources. The process proceeded through systematic coding and categorisation, leading to the construction of themes that describe and interpret significant patterns in the material.

Finally, data triangulation (Flick 2017) enables an in-depth analysis of work processes and of the challenges and opportunities associated with the adoption and use of digital technologies in the organisations examined.

C Networks construction

This section describes the procedures used to construct and analyse the network graphs for the seven Regional Digitalisation Systems (RDSs) examined. The study offers a comparative analysis of the relational architectures supporting territorial digitalisation. The unit of analysis is the regional network, formalised as a graph $G = (V, E)$, where vertices V represent the actors (organisations, institutions and agencies) constituting the RDS, and edges E represent co-participation in initiatives promoting digital transformation at the local economy. In line with Social Network Analysis (SNA), these ties are interpreted as proxies for the channels through which information, resources and coordination circulate.

Data collection

To ensure comparability across RDSs while capturing local specificities, network boundaries were defined through a two-step procedure.

In the first phase, a nominalist approach was adopted (Laumann et al. 1983), identifying actors on a positional basis. These actors were selected according to

Level of analysis	Macro theme	Sub-theme	Questions (examples)
<i>Macro</i> (interorganisational)	Digital technologies and the reconfiguration of organisational structure	Technologies and coordination mechanisms; new decision-making models and managerial strategies; the relationship between technology and organisational structure (e.g. the opening/closing of organisational boundaries; project-based/temporary organisational forms and their integration into more stable forms)	Which digital technology/technologies have you introduced? For which processes? And with what objectives? What reasons led to the decision to digitalise (e.g. regulations, funding, etc.)? Was there any particularly influential actor? (e.g. a trade association, an internal manager, the owner; etc.) Did the adoption of the new technology require the introduction of new rules and/or forms of formalisation? Could you provide some examples? How is it changing your strategies and decision-making processes? Could you give some examples? Is it also changing the way you interact with other firms? If so, how? Could you provide some examples?
<i>Meso</i> (intraorganisational)			
<i>Micro</i> (situated practices)	Models and Practices of Human–Machine Interaction	Technology and quality of work; new models of labour regulation; the relationship between autonomy and discretion; technologies and changes in job content; situated practices of technology use (technology-in-practice).	Do you think that the quality of work has changed following the introduction of the new technology? If so, in what ways? Could you provide some examples? Do you think new work practices (including informal ones) have developed following the introduction of the new technology? If so, which ones? Have you observed any experimentation in use and/or creative uses of the newly introduced technology by workers?

Figure A.1 Dimensions of the analysis: macro, meso and micro.

Source: Authors' elaboration.

their institutional role in supporting the digital transition within the Industry 4.0 framework, thereby establishing an initial analytical boundary defined a priori.

For each region, reference actors included those listed in the Industry 4.0 Atlas – digital enterprise points (PIDs), Digital Innovation Hubs (DIH) and Competence Centres (CC) – together with the main employers’ associations and business organisations operating at the provincial or supra-provincial level. The list was defined through a harmonisation process involving regional research teams and a central coordination unit to ensure consistent inclusion criteria.

Once this boundary was set, all initiatives attributable to the reference actors between January 2020 and March 2023 were systematically mapped. This period captures network consolidation following the implementation of the Industry 4.0 policy and provides a uniform temporal reference prior to fieldwork. Data were collected through document analysis and manually coded into structured databases to ensure the consistency of variables and the traceability of sources. Sources included institutional websites and official social media pages, covering event announcements, invitations, training catalogues, promotional activities and business support initiatives.

The mapped initiatives constituted the empirical basis for reconstructing ties among the initial actors and identifying additional organisations involved as co-promoters or partners. In this second phase, the nominalist approach was complemented by a relational criterion: new nodes were included based on actual participation in initiatives. This allowed the network to extend beyond formal institutional boundaries, thereby reducing boundary bias and capturing the effective structure of each RDS, including operationally relevant actors not initially identified.

Data quality was ensured through ongoing monitoring and a peer review by regional research teams and the central coordination unit. The database underwent validation, cleaning and standardisation of actor information.

Network modelling and projection

The consolidated data were structured as two-mode affiliation matrices, where each cell indicates an actor’s participation in a given initiative. For the analysis presented, these matrices were projected into one-mode adjacent matrices through actor-by-actor projection (Borgatti and Halgin 2011; Wasserman and Faust 1994).

Each regional network was modelled as an undirected weighted graph: an edge indicates co-participation in at least one initiative, and edge weight corresponds to the number of joint initiatives.

Network measures: Definitions and normalisation

Chapter 6 employs four indicators to describe network structure and actor positioning. Consistent with the theoretical framework, these are interpreted as proxies for structural relevance rather than direct measures of power.

Betweenness centrality (BC) is calculated following the standard definition (Wasserman and Faust 1994), as the sum, across all pairs of distinct nodes, of the proportion of shortest paths passing through a given node. Two derived measures are used. The first is each actor's share of total BC, expressed as a percentage of overall network BC. This captures the concentration of brokerage and indicates whether intermediation is centralised or distributed. The second is normalised BC, obtained by dividing raw BC by the theoretical maximum for an undirected network of size n (i.e. $(n - 1)(n - 2)/2$). This reduces distortions due to differences in network size across regions. Finally, normalised degree centrality is calculated as the proportion of observed ties relative to the maximum possible ($k/n - 1$). Degree is computed on the unweighted network to capture the breadth of each actor's relational portfolio while avoiding overestimation of actors characterised by highly intense but concentrated collaborations.

Notes

- 1 For definitions, see the DII Glossary: [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Digital_Intensity_Index_\(DII\)](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Digital_Intensity_Index_(DII))
- 2 For a comparison across the different versions of the index, see: <https://ec.europa.eu/eurostat/documents/341889/725524/DII+v1+v2+v3+v4+2015-2023.pdf/2d0e55ee-8306-54db-a6e2-29a86583c1fe?t=1703234324067>