TERRITORIAL INEQUALITIES BETWEEN DIGITAL INNOVATION AND THE LABOUR MARKET[1]

Francesca Carta, Ilaria Straccamore

Abstract. Digitalisation has redefined the strategic choices of companies and the skills required by the labour market. In Italy, digital innovation continues to suffer from significant shortcomings, which are accentuated in specific territories. On this basis, the present study aims to contribute by analysing the relationship between the digital innovation of businesses and the digital skills of workers from a complementary perspective, with the ultimate objective of outlining the digital profile of the Italian regions. The analysis begins with the selection of labour market digitalisation indicators on the demand and supply side, processed by ISTAT and Unioncamere's Excelsior Information System. The relationship between the digital innovation of enterprises and the digital skills of workers is analysed through three composite indices to capture the degree of digitalisation of enterprises, the skill level of the workforce and the expected demand for digital skills in the labour market. The synthesis methodology used here is the Mazziotta-Pareto Index (MPI). The findings indicate significant regional differences in the digitalisation paths of firms and the workforce.

1. Introduction

The contemporary economy is undergoing profound transformations driven by digitalisation, globalisation and flexible specialisation (Semenza, 2022). Digitalisation has posed many changes, such as skill composition and increasing demand for advanced digital skills (Lorraine *et al.*, 2022), making digital literacy a prerequisite for employment and economic inclusion. The demand for digital skills is projected to continue rising significantly, underscoring their critical role in enhancing business performance (OECD, 2023). Consequently, organisations are adapting by flattening hierarchies and emphasising broader competencies of human resources to meet the challenges of rapid technological advancement (Semenza, 2022). Overall, these developments highlight the imperative for both individuals and institutions to embrace digital transformation and its implications on economic competitiveness and social progress. Digitalisation has the power to boost both

[1] This article expresses only the opinions of the authors. Although the paper is the result of joint work, the sections are attributed as follows: paragraphs 1, 2 and 3 to Francesca Carta and paragraphs 4, 5 and 6 to Ilaria Straccamore.

efficiency and well-being. However, it could widen inequality if it leaves some individuals or regions behind (OECD, 2023). In Italy, signs of digital territorial inequalities emerged from an analysis that, through the measurement of the European composite indicator Digital Economy and Society Index (Desi) at the regional level (rDesi), highlighted wide regional disparities in the levels of digitalisation throughout Italy—particularly between North and South (Benecchi *et al*., 2021). Although the gap between the northern and southern regions of Italy has not narrowed over the years, there has been a general improvement in digitalisation levels across all regions (Giannini *et al*. 2022). This finding is also confirmed by a specific analysis of the digital divide at the regional level conducted in 2023. The study, using a reduced version of the Desi index, shows a higher degree of digital penetration and technological development in northern regions (Bruno *et al*., 2023).

In recent decades, the process of internal convergence has slowed, and economic crises such as the 2008 financial downturn and the COVID-19 pandemic have further exacerbated existing territorial disparities. Individuals from disadvantaged areas are more likely to have fewer opportunities to acquire the skills needed for the ongoing digital and green transitions (OECD, 2023). Consequently, European policies and Italian strategies, including the National Recovery and Resilience Plan (NRRP), are crucial for promoting digital development and reducing territorial inequalities. Based on the results of the previous literature and context analysis, this contribution aims to examine the degree of digitalisation in the labour market at the local level. It focuses on the relationship between the digital innovation of enterprises and the digital skills of the workforce, identifying common trends and regional specificities. More precisely, we analysed the digitalisation of labour supply and demand to compare the level of business digitalisation, the digital competencies available in different regions, and the digital skills required by companies. To explore these aspects, we have built three composite indices. These integrated analyses will help to identify the effects of digitalisation on the Italian labour market and measure the digital skill mismatch within it.

2. The European approach to a sustainable digital transition

The digitalisation process must be regulated to ensure that individuals without adequate resources are not excluded from its benefits (OECD, 2019). In 2023, recognising the strategic importance of digital technologies, the European Parliament declared 2021–2030 as the 'Digital Decade'[2] and set specific objectives to be achieved by 2030. This initiative aims to empower businesses and individuals

[2] Decision (EU) 2022/2481 of the European Parliament and of the Council

for a human-centred, sustainable digital future, with progress monitored annually through the Desi. With this in mind, national programmes funded by the EU's Next Generation Fund have a minimum 20% share of funding for digital transformation. In Italy, more than a quarter of NRRP resources have been earmarked for this purpose, and the ambitious initiative 'Digital Italy 2026' has been defined. This intervention focuses on two main axes: digitalisation of public administration investment and an ultrafast network. This initiative joins that of the 'Digital Republic', a national strategy that aims to reduce the digital divide and promote education on the emerging technologies. Key goals for 2026 include reaching 80% of the population with at least basic digital skills, doubling the population with advanced digital skills and increasing the number of Small and Medium Enterprises (SMEs) using ICT specialists by 50%. The EU Council recently adopted conclusions on 'The future of Europe's digital policy'[3] that aim to identify the main priorities of EU digital policy, which must be enhanced by attracting and maintaining a digitally skilled workforce and bridging the digital divide.

3. Digital innovation state of the art: enterprises and labour force

In Italy, there is a significant institutional debate on the impact of digitalisation on the labour market and the necessary policy responses. While Italian companies have made progress in adopting digital technologies, challenges persist in both upskilling workers and enhancing companies' capacity for innovation and digitalisation. According to the Excelsior Information System survey (2023), there is a growing discrepancy between the demand for digital skills and their availability in the workforce. In 2023, 58.1% of companies reported difficulties in finding professionals with the required digital competencies, marking a notable increase from previous years (41.8% in 2022 and 37.8% in 2021). Looking ahead, forecast 2024–2028 emphasises that digital skills are expected to be increasingly in demand across various sectors (Excelsior Information System, 2024).

3.1 Enterprises and the state of innovation

The innovation of enterprises has had a strong acceleration with the COVID-19 pandemic crisis. In the first epidemic phase (2020), digitalisation proved to be an essential ally in managing the crisis and mitigating its consequences in economic terms. The monthly surveys of the Excelsior Information System in May/June 2020 on critical issues and the abilities of businesses to respond during the COVID-19 lockdown period highlighted the centrality of digitalisation in riding out the crisis,

[3] Council of the European Union 9957/24 'The Future of EU Digital Policy - Council Conclusions (21 May 2024)'

mitigating its consequences and nurturing positive prospects for emerging from it in the following months. Comparing the firms that had adopted integrated digitalisation plans before the COVID-19 crisis with those that had not yet adopted them, the first group maintained business regimes unchanged from the pre-emergency ones in 36.1% of cases, compared to 28.2% in the second group. Only 8.2% of digitalised companies considered suspending or closing down their activities, compared to 12.1% of non-digitalised enterprises. The Italian government has enacted various measures to face the emergency and facilitate ongoing transformation, such as the establishment of the Digital and Technological Innovation Fund and New Skills Fund in 2020 (Relaunch decree n.34/2020). The COVID-2019 emergency has thus been translated into an innovative push of unexpected proportions that has helped our country to emerge from the bottom of the European and world rankings in terms of digital and innovation. In 2023, according to the second Digital Decade report (2024), most Italian SMEs have a basic level of digital intensity in line with the EU average (60.7% compared to the EU average of 57.7%). Progress has been particularly strong in the use of electronic invoices (97.5% in 2023 compared to the EU27 average of 38.6%) because the Italian government has put very strong regulations in place from 2014, with constant updates (ISTAT, 2023b). Moreover, in 2023, among Italian companies with at least 10 employees, 61.4% confirmed the use of cloud computing (a leading indicator of technological innovation) against 45.2% of EU27 companies. Despite this, in Italy, only 8 out of 100 companies use artificial intelligence tools. In 55.1% of businesses, it is precisely the lack of digital skills that hinders the adoption of these technologies. Notably, the difficulties are most evident for SMEs. For example, activities that require more specialised skills, such as data analysis, are carried out by 25.7% of SMEs, compared to 74.1% of large enterprises (ISTAT, 2023b).

3.2 Labour force and skills for the digital transition

Digital transformation requires specific skills for the labour force and the population as a whole. Italy has major shortcomings in this area: in 2023, only 45.8% of people have at least basic digital skills (below the EU average of 55.6%), with gaps across all age groups and with a limited dynamic in recent years (European Commission, 2024). The second European objective of the Digital Decade in the axis of action relating to human capital is to reach 20 million specialist employees in ICT by 2030 (from approximately 9 million in 2022), with convergence between men and women (the latter currently accounts for less than 20% of the total). As in the rest of Europe, in Italy, the trend of employment in ICT professions has been more favourable than in the overall labour market. However, the growth of this segment in Italy between 2012 and 2022 was 27%, compared to 58% for the EU27 as a whole. In 2023, employees in ICT professions represented 3.9% of the total in

Italy, and 4.6% in the EU27. In 2022, the number of graduates in ICT in Italy remains significantly below the forecasts of the EU Digital Decade (1.5% against 4.2% of the EU average), which has led to a shortage of qualified personnel for Italian companies. Additionally, there is a negative impact on the use of human capital and the availability of skills, especially digital skills, due to an increase in older workers (aged 65–69).

4. The methodological approach

As previously mentioned, the analysis focuses on measuring the degree of digitalisation in the labour market at the local level. From the literature review, we have drawn inspiration from the Desi and its Italian variant, the rDesi, and from the reduced composite indicator for measuring the digital divide at the regional level (Benecchi *et al*., 2021; Bruno *et al*., 2023; Giannini *et al*., 2022). The theoretical framework of these three studies has been partially reproduced; moreover, we have adopted different choices, motivated by the data at our disposal and the purpose of the work. Specifically, unlike the aforementioned works, the present study highlights two main innovations. Unlike previous studies characterised by the construction of a single composite index, our work involves the establishment of three different composite indices aimed at distinctly highlighting three aspects of labour market digitalisation: the transformation of enterprises, the skills of the workforce and the skills needs of businesses. Additionally, we have introduced the dimension of the digital skills needs of businesses as the link between the level of enterprises' digitalisation and that of the workforce's digital skills.

4.1. Conceptual framework: indices, dimensions and selected indicators

Three composite indices have been built: the *Business Digitalisation Index*, the *Labour Force Index* and the *Digital Skills Prediction Index*. Each index reflects different dimensions of analysis, and each dimension is measured by different elementary indicators, as shown in Table 1.

The *Business Digitalisation Index* reflects the state of the digital transformation on the demand side and is structured along three dimensions: digital infrastructure, the integration of digital technology, and business e-commerce. This index is measured by 7 indicators (from 'a' to 'f' in Table 1) of the ISTAT survey "The Use of ICT by Businesses", with reference to enterprises with at least 10 employees (ISTAT, 2023b). The *Labour Force Index* measures the level of digital skills on the

supply side[4] and is structured along three dimensions: households' connectivity, use of internet services, and digital skills. This index is measured by 12 indicators (from 'g' to 'r' in Table 1) of the ISTAT survey 'Aspects of Daily Life', with an ad hoc module on the use of digital technologies by citizens (ISTAT, 2023a), and the ISTAT survey on "The Use of ICT by Businesses" (ISTAT, 2023b). The *Digital Skills Prediction Index* provides another measure on the demand side regarding the companies' forecasting needs for digital skills. This index is structured along the digital requirements for the professions dimension, consisting of indicators 's' to 'u' in Table 1, which originate from the Unioncamere and ANPAL survey 'Demand Analysis of Digital Skills in Enterprises' (Excelsior Information System, 2023).

The first two indices utilise stock data, whereas the third index relies on flow data. Indicators were selected based on their relevance, validity, timeliness and accessibility, aiming to strike a balance between redundancy and information loss.

4.2. Statistical method

Measuring a digital economy and society is a multidimensional phenomenon that requires the aggregation of many indicators. A composite index is formed when individual indicators are compiled into a single index based on an underlying model. It should ideally measure multidimensional concepts that cannot be captured by a single indicator (OECD, 2008).

The synthesis methodology used in this context is the Mazziotta-Pareto Index, in the MPI version (Mazziotta and Pareto, 2020). It is a composite 'non-compensatory' indicator based on the hypothesis of 'non-replaceability' of the value of one elementary indicator with another. It also enables simplicity and transparency of calculation, robustness, and the immediate use and interpretation of results. These characteristics have made it particularly suitable for our purpose.

All indicators are normalised into z-score, with an average of 100 and an average square error of 10. Therefore, the transformed values will be in the range of approximately 70–130. Based on the arithmetic mean of z-scores, the aggregation function is corrected by a penalty coefficient that penalises units with the greatest imbalances between the individual indicators while having the same average.

All selected indicators have been selected with positive polarity; that is, as indicators in accordance with the analysed phenomenon. For the weighting system, we decided to assign the same weight to all indicators.

[4] To measure the digital skills of the workforce, we used indicators related to citizens' digital skills. Since these indicators could also refer to the so-called 'no workforce' (such as inactive or retired people), we will use them as a proxy for the digital skills of the workforce.

Table 1 − *Indices, dimensions and selected indicators.*

Index	Dimension	Indicator
Business digitalisation	Digital infrastructure	a. enterprises connected to internet through fixed broadband
	Integration of digital technology	b. enterprises with a website or a homepage c. enterprises having Enterprise Resource Planning (ERP)[5] software d. enterprises using at least one social media e. enterprises buying cloud computing services
	Business e-commerce	*f.* enterprises active in e-commerce in the previous year in on-line sales, selling at least 1% of total sales
	Households' connectivity	g. households with internet at home
Labour Force	Use of internet services	People aged 14 and over who have used the internet in the last 12 months to access public administration online services to: h. download or print official forms i. make an appointment/make a reservation (e.g. clinics, etc.) j. get information about services, benefits, etc. k. request for certificates/documents (e.g. birth, residence, etc.) l. enrolment in school or university m. application for social security benefits (e.g. pension, etc.) n. persons aged 14 and over who have used the internet in the last 12 months for the use of digital identity (SPID/CIE) o. persons aged 14 and over who have used the internet in the last 12 months to purchase goods/services for private use
	Digital skills	p. persons employed using computers with access to internet at least once a week q. persons aged 16-74 who have used the internet in the last 3 months and have at least basic digital skills *r.* 16-74 year old people who have used the internet in the last 3 months and have digital skills above the basic level
Digital Skills Prediction	Digital requirements for professions	Predicted new entrants by companies for 2023 according to the ability to use: s. mathematical languages and methods t. internet technologies/multimedia communication tools u. Industry 4.0 technologies to innovate processes

5. Results

5.1. Business Digitalisation Index

The *Business Digitalisation Index* shows that all the northern regions, except for Liguria and Valle d'Aosta, and Lazio in the centre, record the highest level of

[5] Software to manage resources by sharing information between different functional areas (e.g. accounting, planning, production, marketing, etc.). It can be a standard, customized or a self-created software.

digitalisation, while the regions of the South lag behind (Table 2). The components of this composite index contribute differently to the results. The *digital infrastructure of companies*, measured by the fixed broadband connection, is highly and uniformly distributed throughout the territory (Italian average of 97.2% and standard deviation of 2.8%). The *integration of digital technology* by enterprises is measured by the number of companies that have a website/home page, ERP software and social media, and by enterprises that purchase cloud computing services. The use of websites is the most widespread technology (average of 69.7%); however, this is characterised by the most heterogeneous distribution between Italian regions (standard deviation of 9.9%). A technology less commonly used is ERP software (average of 37.7% and standard deviation of 7.4%). For all these components, the regions with the highest scores are mainly concentrated in the North, with the exception of Sardinia and Puglia for the use of social media and Trentino Alto Adige for a low percentage of companies using cloud computing services. *E-commerce* remains rare within Italian companies (average of 13.9%). In the regional ranking, Sardinia, Trentino and Valle d'Aosta are at the top, followed by Calabria and Campania, while Molise, Umbria and Liguria are the last three. Therefore, e-commerce partially reduces the disparity between the North and the South of the country. This result is in line with the general evidence suggesting that e-commerce is relatively more widespread among regions with a higher concentration in the service economy.

5.2. Labour Force Index

The *Labour Force Index* shows a large disparity between the Centre-North and the South, with the exception of Sardinia (Table 2). The components of this index contribute differently to the results. *Households' connectivity* has a wide and homogeneous spread in all the regions (average of 83.2% and standard deviation of 3.4%). The *use of internet services* is measured by persons who use digital identity, online government services and websites, and who order or purchase goods or services online. The latter is the most widespread competence (on average 49.3%), while the use of public administration websites for the application of social security benefits, enrolment in school or university, and requests for certificates are the least used (average of 10.0%, 11.9%, 12.3% respectively). These components confirm the North-South gap, with Liguria being the only northern region below the Italian average, while Sardinia is the only southern region above the Italian average. *Digital skills* are measured by the employees of companies using the internet at work, by people who have at least basic digital skills or digital skills above the basic level. The former is the most widespread competence (on average, 51.6% against 23.4% for basic digital skills and 21.4% for digital skills above the basic level). All of these

indicators highlight the North-South gap, with the Lazio region at the top of the ranking for workers' digital skills and citizens' advanced digital skills.

5.3. Digital Skills Prediction Index

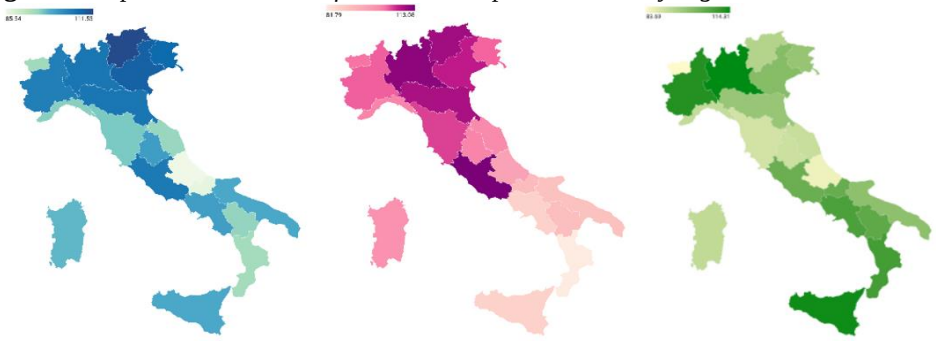
The *Digital Skills Prediction Index* measures companies' predictive demand for digital skills required for the profession. With the other two composite indices, this index allows a better understanding of territorial dynamics, completing the picture of businesses' digitalisation levels and the digital skills available in the territory, with the digital competency needs of companies. The ability to use internet technologies (e.g. desktop PCs, internet browsers, etc.) and manage visual and multimedia communication tools is the most widespread skill required by companies (on average, 63.4% of the predicted new entrants in 2023), while the use of mathematical languages and methods is the second (on average 50.6%). The use of Industry 4.0 technologies (e.g. artificial intelligence, internet of things, data analytics, big data, etc.) is required for 37.1% of the predicted new entrants. The *Digital Skills Prediction Index* displays the highest variance among all three composite indices, showing a heterogeneous distribution across the territory. Lombardy and Piedmont are the regions with the greatest volume of requests for digital competencies, followed by Sicily, Calabria and Campania (Table 2). Valle d'Aosta and Abruzzo are at the bottom of this ranking. In particular, Lombardy and Piedmont, followed by the southern regions, are at the top of the ranking for the search for the ability to use internet technologies, multimedia communication tools, and mathematical languages. Southern regions, particularly Calabria and Sicily, ranked highest in terms of the search for the ability to use Industry 4.0 technologies.

5.4. Regional profiles: an integrated overview

Comparing the three indices used in this study reveals significant territorial divides in the digital skills of the workforce. Both the demand for digital skills by firms (*Digital Skills Prediction Index* results) and the supply of these skills (*Labour Force Index* results) show greater regional variability than the adoption of digital technologies by companies. Moreover, by comparing the blue map with the pink one in Figure 1, we observe that the spread of business digitalisation aligns with the distribution of digital skills available in the territories, indicating clear spatial patterns. Northern regions and Lazio show the most innovative digital systems and higher digital skills, while the rest of the country lags behind. This evidence could highlight a mutual relationship according to which the digital skills in the territory could not only contribute to the construction of a digital industrial system but also be fed by it (e.g. through training programmes being promoted by companies). Another consideration emerges by comparing the green map with the blue and pink

maps in Figure 1, where we can see that the demand for digital skills by enterprises sometimes reflects both business digitalisation and the dissemination of digital skills (e.g. Piedmont and Lombardy), but not always (e.g. Sicily, Calabria and Campania). This result could have several possible explanations.

Figure 1 − *Spatial distribution of the three composite indices by region.*



Source: ISTAT and Excelsior Information System

The first one is that the business demand for digital skills is based on forecasting needs and, therefore, on provisional flow data, which implies that regions with low numbers of new entrants expected in 2023 could have acquired the necessary skills before. Another aspect is the stimulus provided by the European Cohesion Policy and the NRRP, which, with substantial funding, could have encouraged a greater demand for digital skills, especially for companies in the southern regions. In 2023, for example, as part of the National Strategy of Smart Specialisation, funding was allocated to companies in the southern regions. Another explanation may lie in the lower level of professional attractiveness of the South.

6. Conclusions

Digital innovation changes production processes and requires the adaptation of workers' skills. From this perspective, our paper analyses the relationship between enterprises' digital innovation and workers' digital skills by using a complementarity approach. We focus on measuring digitalisation at the regional level, comparing three aspects of the digital economy: the transformation of enterprises, workforce skills and business needs. This integrated analysis reveals regional disparities in the digital innovation paths of companies and the workforce, and highlights the skill mismatch in the labour market, which is pronounced in southern Italy. Moreover, for Italy, which lags far behind other EU countries in the digital transformation, the development of digital skills in human capital continues to be a major challenge.

Table 2 – *Business Digitalisation Index, Labour Force Index and Digital Skills Prediction Index at the regional level. Year 2023, Italy.*

REGIONS	Business's digitalisation Index	Labour Force Index	Digital Skills Prediction Index
Piedmont	104.6	103.8	112.6
Valle D'Aosta/Vallée d'Aoste	94.3	102.7	83.7
Lombardy	105.8	111.6	114.3
Trentino Alto Adige/Sudtirol	111.5	110.1	94.4
Veneto	108.5	107.7	100.6
Friuli Venezia Giulia	107.2	103.5	98.5
Liguria	95.9	101.7	92.0
Emilia Romagna	105.7	109.4	98.2
Tuscany	96.4	105.2	90.0
Umbria	100.6	101.7	90.9
Marche	95.1	100.6	91.5
Lazio	105.4	113.1	104.4
Abruzzo	85.5	96.5	85.8
Molise	86.5	91.0	105.0
Campania	100.3	86.5	108.4
Puglia	99.0	89.6	99.7
Basilicata	95.5	90.4	106.2
Calabria	93.9	81.8	109.4
Sicily	99.0	86.6	113.8
Sardinia	97.9	99.5	92.4

Source: ISTAT and Excelsior Information System

We believe that the methodological framework of this study and its results could be useful to monitor these issues over time and attempt to measure the effectiveness of policies, which will be fully assessed close to the deadlines of the European and national targets.

References

BENECCHI A., BOTTONI C., CIAPANNA E., FRIGO A., MILAN A., SCARINZI E. 2021. Digitalisation in Italy: evidence from a new regional index. *Questioni di Economia e Finanza (Occasional Papers)*, No. 662, Banca d'Italia Eurosistema.

BRUNO G., DIGLIO A., PICCOLO C., PIPICELLI E. 2023. A reduced Composite Indicator for Digital Divide measurement at the regional level: An application to the Digital Economy and Society Index (DESI), *Technological Forecasting and Social Change*, Vol. 190, No.122461, pp. 1-16.

EUROPEAN COMMISSION. 2024. *2030 Digital Decade - Report on the state of the Digital Decade 2023*. Luxembourg: Publications Office of the European Union.

GIANNINI V., IACOBUCCI D., PERUGINI F. 2022. I divari regionali nella digitalizzazione. In CORÒ G., DE CASTRIS M. and SCALERA D. (Eds.) *PNRR Italia - Il difficile equilibrio tra i territori*, Roma: Donzelli Editore.
ISTAT. 2023a. Cittadini e Ict, anno 2023. *Statistica Report*, ISTAT.
ISTAT. 2023b. Imprese e Ict, anno 2023. *Statistica Report*, ISTAT.
LORRAINE C., SHUTING X., COUTTS A.P. 2022. *Digitalization and Employment - A Review*. Geneva: Publications of the ILO.
MAZZIOTTA M., PARETO A. 2020. *Gli indici sintetici*. Torino: Giappichelli.
OECD. 2023. *OECD Skills Outlook 2023: Skills for a Resilient Green and Digital Transition*. Paris: OECD.
OECD. 2019. *OECD Employment Outlook 2019: The Future of Work*. Paris: OECD
OECD. 2008. *Handbook on constructing composite indicators. Methodology and user guide*. Paris: OECD.
SEMENZA R. 2022. *Manuale di Sociologia del lavoro*. Torino: Utet Editore.
SISTEMA INFORMATIVO EXCELSIOR. 2020. *Impatti dell'emergenza COVID-19 sulle imprese e prospettive di ripresa rilevati attraverso il sistema informativo Excelsior*. Roma: Unioncamere e ANPAL.
SISTEMA INFORMATIVO EXCELSIOR. 2024. *Previsioni dei fabbisogni occupazionali e professionali in Italia a medio termine (2024-2028)*. Roma: Unioncamere e ANPAL.
SISTEMA INFORMATIVO EXCELSIOR. 2023. *Le competenze digitali. Analisi della domanda di competenze digitali nelle imprese, indagine 2023*. Roma: Unioncamere e ANPAL.

Francesca CARTA, Istat, francesca.carta@istat.it
Ilaria STRACCAMORE, Istat, straccamore@istat.it