11. Innovation, research and creativity[1]

Throughout the 2010-2019 decade, the indicators of the domain showed a steady and slow improvement. Nevertheless, results generally remained well below the European average and the levels of the main benchmark EU countries, underlining Italy's delay and weaknesses in the transition to a knowledge-based economy.

By the way, almost all Italian measures of the Innovation, research and creativity domain exhibited better results in 2019 than in the baseline year (Table 1).

The pandemic crisis had a strong negative impact on research intensity, innovation in enterprises and cultural and creative employment, and halted the growth of knowledge workers. In 2020-2021, the indicators related to research intensity (as a percent of GDP) and knowledge workers (as a percentage of employment) seemed to grow in Italy, but these changes are entirely due to the reduction of GDP and general employment rate.

Over 2021-2022, in the context of the general employment recovery, the human capital indicators followed different paths. The first and second years of the pandemic hit hard cultural and creative employment; in 2022 the indicator shows an improvement even though without a full recovery. Instead, the weight of knowledge workers on total workers remains broadly stable, as the employment recovery in 2021 and 2022 is more concentrated in other occupations and sectors of activity.

The outward flows of young Italians with a tertiary degree do not stop, but in 2021, for the first time after at least a decade, a reduction of net losses is recorded, as repatriations increase and expatriations decrease.

Table 1. Innovation, research and creativity indicators: value for the latest available year and percentage changes for different periods

Indicators	Starting year	Latest available year	Latest available year value	Percentage changes			
				2019 compared with starting year	2021 compared with 2019	2022 compared with 2021	2022 compared with 2019
R&D intensity (%) (a)	2010	2020	1.5	Better	Better	-	-
Patent propensity (per millions of inhabit.)	2010	2019	80.7	Better	-	-	-
Gross fixed capital formation of intellectual property products (%)	2010	2022	120.0	Better	Better	Better	Better
Innovation rate of the national productive system (%) (a) (b)	2010	2020	50.9	Better	Worse	-	-
Impact of knowledge workers on employment (%)	2018	2022	17.8	Better	Better	Worse	Stable
Cultural employment (% of total employment)	2018	2022	3.5	Stable	Worse	Better	Worse
Brain circulation (Italians, 25-39 years old) (Per 1,000 resident graduates)	2019	2021	-2.7	-	Better	-	-
Regular internet users (%)	2010	2022	75.6	Better	Better	Better	Better
Availability of at least one computer and Internet connection in the household (%)	2010	2022	68.2	Better	Better	Worse	Better
Municipalities with online services for families (%)	2012	2018	25.1	Better	-	-	-
Enterprises with at least 10 persons employed with web sales to end customers (%)	2013	2022	13.3	Better	Better	Worse	Better

Better Worse Stable - Not available

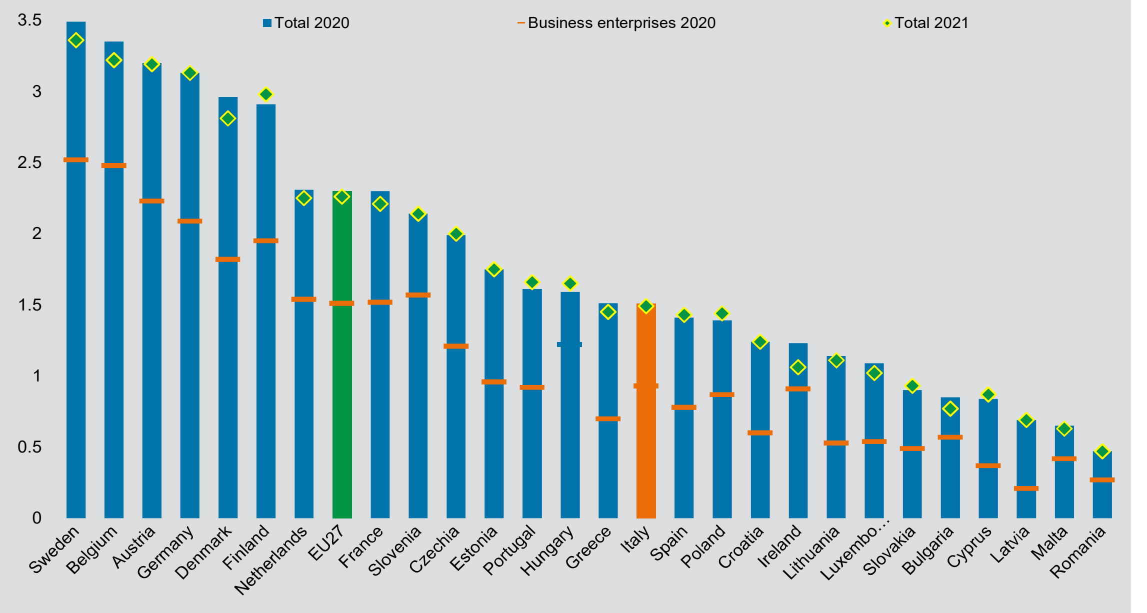
(a) Year 2021 not available. Changes referred to the year 2020.
(b) Year 2019 not available. Changes referred to the year 2018.
Note: If the relative change between the two years exceeds 1% it is considered positive (green), if it is lower than -1% it is considered negative (red). In the range -1 and +1% the change is considered stable (yellow). The polarity of the indicator was taken into account when calculating the changes to consider the improvement or worsening in terms of well-being.

1 This chapter was edited by Stefania Taralli, with contributions from Laura Iannucci, Francesca Licari, Valeria Mastrostefano, Alessandra Nurra and Laura Zannella. Alessandra Nurra, Stefania Taralli and Laura Zannella collaborated in realising the box "Citizens and businesses in the digital transition".

R&D recovery is expected in 2021 after the spending fall in 2020

In 2020, Italy's research intensity (percentage of R&D expenditure on GDP) stands at 1.51% (the EU27 average is equal to 2.3%). Italian research intensity seems to be growing in the first pandemic year (it was 1.46% in 2019) but the change is all due to the fall in GDP that was greater than that in R&D expenditure (-4.7%). The fall in Italian R&D expenditure is mainly due to businesses (-6.8%), which in 2020 contributed 61.8% of total R&D expenditure (65.8% the EU27 figure).
Preliminary data for 2021 indicate an important recovery in R&D spending by Italian companies (+5.2% compared to 2020) (Figure 1).

Figure 1. Total expenditure on research and development in Italy and in the European Union countries. Years 2020 and 2021. Values as a percentage of GDP

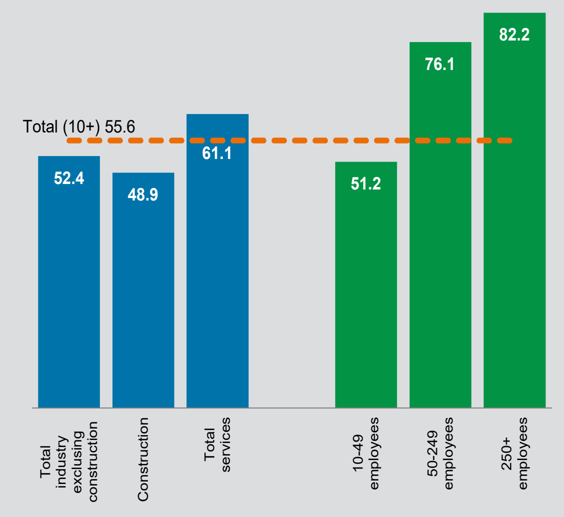


Source: Eurostat

Sharp decline in innovation in business enterprises. Industrial and small businesses the hardest hit

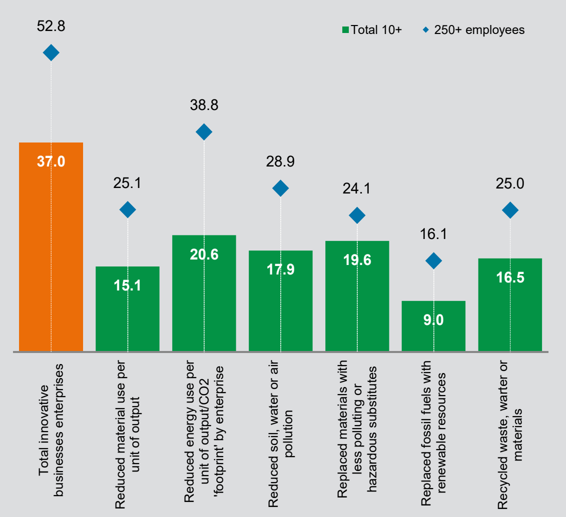
In the three-year period 2018-2020, only 50.9% of industrial and service companies with 10 or more employees carried out innovative activities; this share is in sharp decline compared to 2016-2018 (about -5 percentage points). The fall is largely due to the health emergency, as declared by almost two out of three companies with innovative activities.
In 2020, more than half (55.6%) of companies with innovative activities introduced smart working for the first time; 37.0% of innovative companies chose eco-friendly ways of innovating production processes (Figure 2; Figure 3).

Figure 2. Business enterprises with innovation activities that first introduced smart working by economic activity and size class of persons employed. Year 2020. Percentage on total business enterprises



Source: Istat, Cis (Community Innovation Survey)

Figure 3. Business enterprises that introduced product or process innovations by choosing environmentally sustainable ways in their production processes. Year 2020. Percentage on business enterprises that introduced product or process innovations



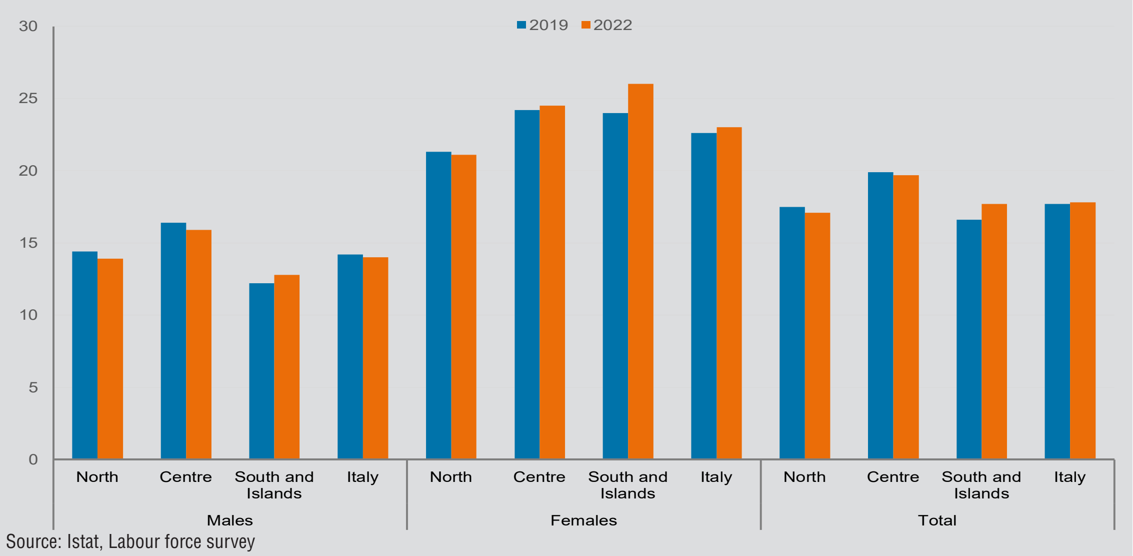
Source: Istat, Cis (Community Innovation Survey)

General employment recovery pulls knowledge workers and cultural employment in Southern Italy

In 2022, the share of knowledge workers comes back at its pre-pandemic level (17.8%), with a slight decrease in the last year (-0.4 percentage points).

In recent years, this indicator has accentuated its strong gender and regional features: it reaches the highest levels ever for women living in Southern Italy (26.0%) and at the national level it marks a 9 percentage points gap in favour of women (23.0% against 14.0% for men) (Figure 4).

Figure 4. Employees with tertiary education (ISCED 6-7-8) in scientific-technological occupations (ISCO 2-3) by sex and geographic area. Years 2019 and 2022. Values per 100 employees with the same characteristics



Source: Istat, Labour force survey

In 2022, cultural and creative employment is 3.5% of total employment.
This result indicates the full recovery for women (3.8%) who double their advantage over men (the gap is 0.5 percentage points; it was 0.2 in 2019).
The plus of the North over the South and Islands remains large (1.2 percentage points), but in southern Italy the cultural and creative employment had a quite lively dynamic in last years (+16.2% compared to 2021 and +4% compared to 2019), with accentuated growth in a picture of lower overall employment growth (+2.9% in the last year; +1.0% from 2019).

Brain circulation of young Italians declines

In 2021, for the first time in the decade, the loss of young Italian graduates (25-39 years old) due to migration flows gets smaller. The net migration rate to foreign countries of young Italians with a tertiary degree is still negative (-2.7 per 1,000) with greater losses in the North-east (-3.1 per thousand) and in the South and Islands (-2.8; -3.2).
Including the intra-Italian transfers of young graduates, the overall balance is positive, indicating a gain for the North and the Centre (+8.7 per thousand; +3.4), where the transfers from the Italian southern regions offset the losses to foreign countries. South an Islands in 2021 record a net loss of over 20 thousand young graduates (18 thousand of which migrated to central and northern Italy) (Figure 5).

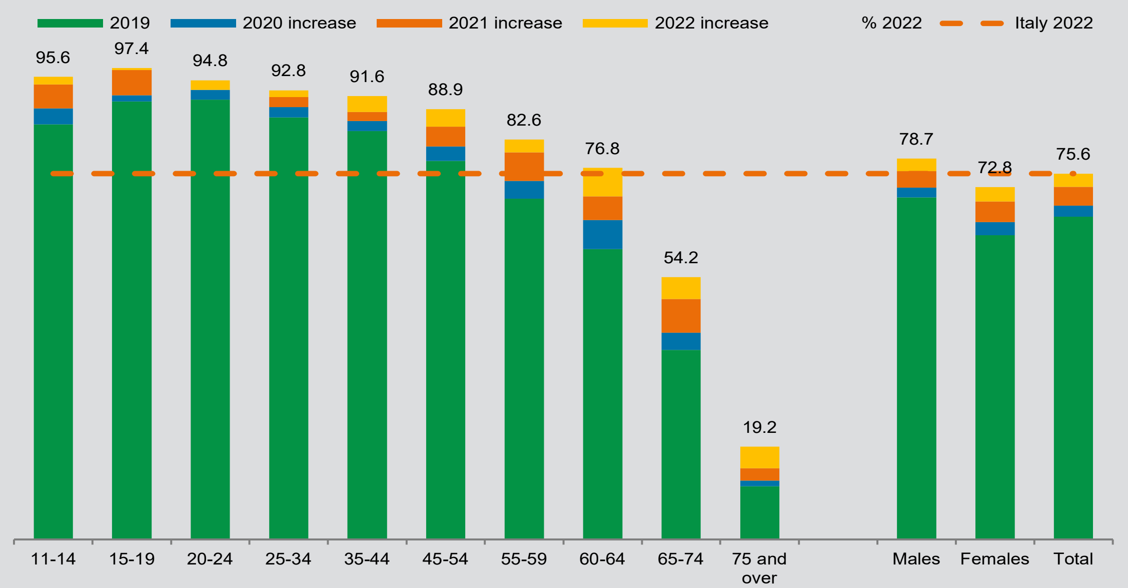
Figure 5. Net migration rate of Italian graduates (aged 25-39 years) by origin/destination and geographic area. Years 2019, 2020, 2021. Values per 1,000 residents with the same characteristics

Source: Istat, Registrations and cancellations from the registry for residence transfer and Permanent census of population.

Age-related digital divides remain wide

Regular Internet use is still growing in Italy (people aged 11 and over), but regional inequalities remain strong.
The Italian figure stands at 75.6% in 2022 (over 40 million people), with the North 8 percentage point higher than the South (78.6%; 70.6%).
The indicator is also increasing for the elderly, but they remain behind; regular Internet use is at 54.2% among people aged 65-74 and at 19.2% among people aged 75 and over. The gender gap is unchanged (on average men are 6 percentage points higher than women), but it's all concentrated in the over 60s age-group (Figure 6).

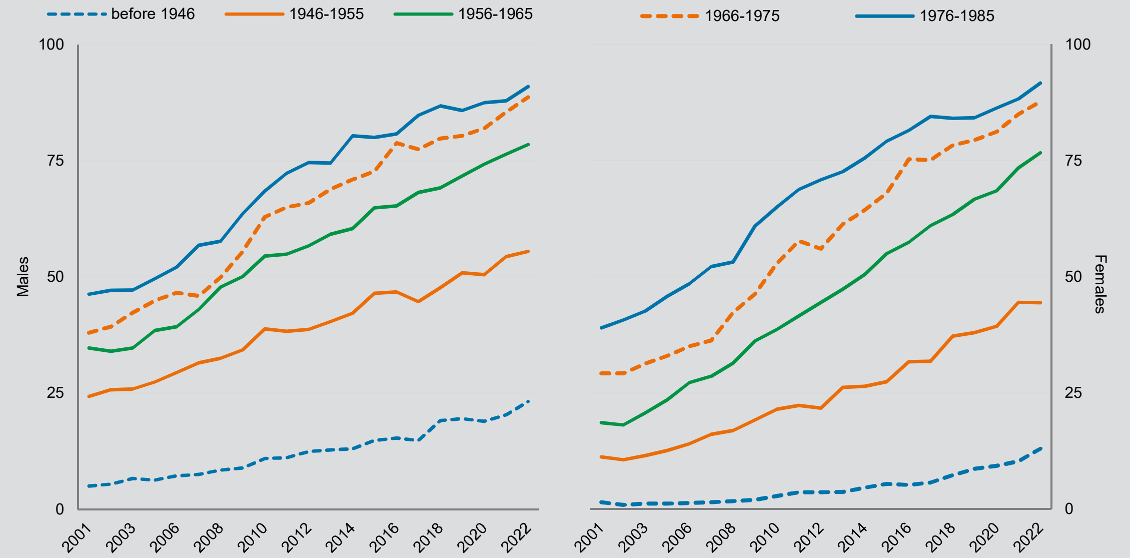
Figure 6. People aged 11 and over who used the Internet at least once a week in the 3 months prior to the interview. Years 2019-2022. Percentages



Source: Istat, Survey on the use of ICT in the Households and by individuals

Broadening the time series analysis to the last 21 years, a convergence on high levels of Internet use is clearly seen among the younger generations of digital immigrants (those born after 1955) and a growing gap with the two older age-groups, who remain even further behind. Both trends are more accentuated for women (Figure 7).

Figure 7. People aged 11 and over who used the Internet at least once a week in the 3 months prior to the interview by sex and cohort of birth (non-digital natives). Years 2001-2022. Percentages

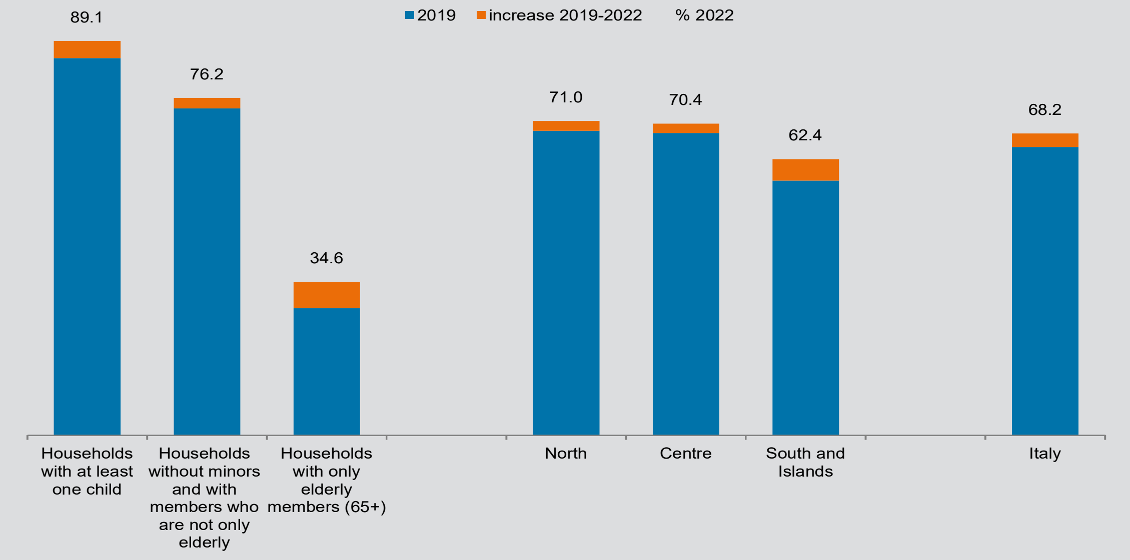


Source: Istat, Survey on the use of ICT in the Households and by individuals

Regional gap in households' access to the Internet narrows but is still wide

In 2022, 68.2% of Italian households have a PC and Internet connection at home (+3.1 percentage points compared to 2019).
When breaking down by household type or geographic area digital divides are wide: the indicator drops to 34.6% among elderly-only households; in southern Italy, one family in three remains excluded (62.4% have both PC and connection), and the figure is 8.6 percentage points lower than the North (Figure 8).

Figure 8. Households with Internet connection and at least one personal computer by family type and geographic area. Years 2019 and 2022

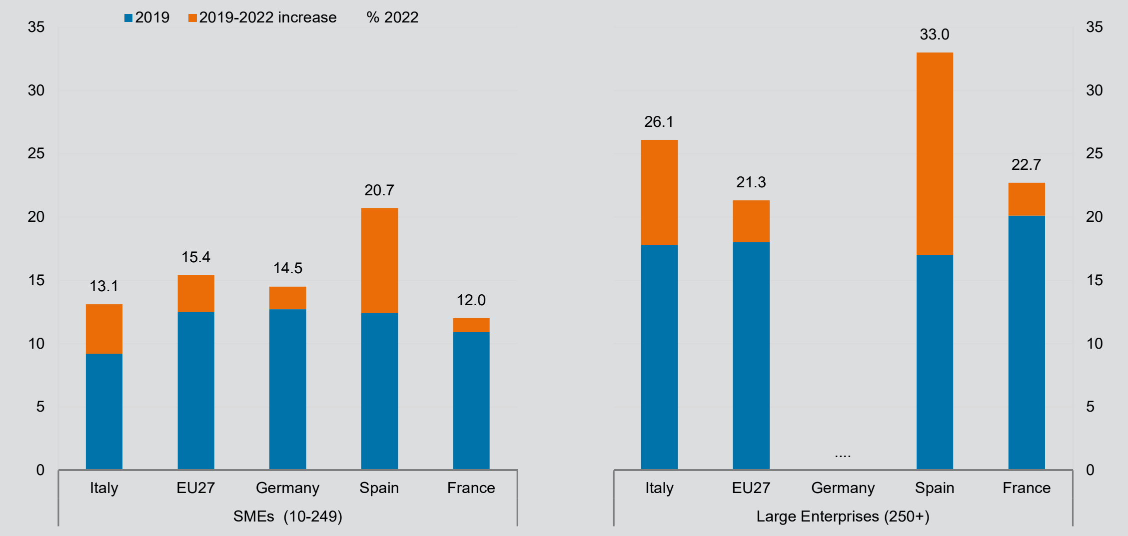


Source: Istat, Survey on the use of ICT in the Households and by individuals

E-commerce share of total sales grows in 2022

In 2022 (sales year 2021), 13.3% of Italian companies with at least 10 employees sold their goods and services to end consumers via the web. The Italian figure is about 2 percentage points lower than the European one (15.6%).
The indicator is increasing (+3.9 percentage points from 2019) but the growth is weaker for Italian SMEs (10-249 employees), which lag behind the EU27 average (13.1% and 15.4% respectively).
Conversely, in 2022 larger Italian companies (250 employees and over) surpassed their European counterparts by rising to 26.1% (the European figure is 21.3%) (Figure 9).

Figure 9. Enterprises with 10 or more persons employed that during the previous year sold via web to end customers (B2C) by size classes of persons employed. Italy and European countries. Years 2019 and 2022. Percentages

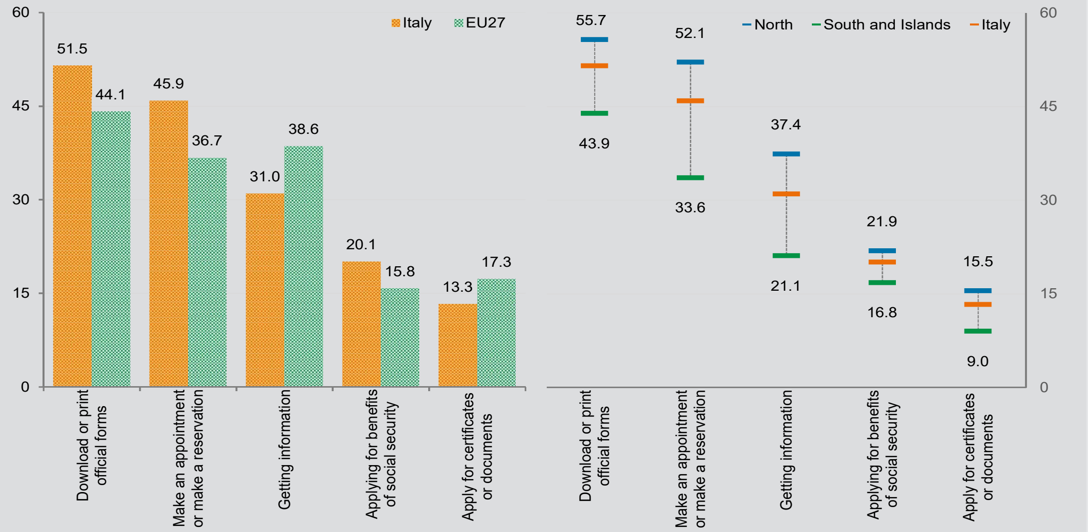


Source: Eurostat - Survey on information and communication technology in enterprises

CITIZENS AND BUSINESSES IN THE DIGITAL TRANSITION

Indicators related to the use of e-government services, show that Italy is rapidly approaching the EU27 average, and in many cases has exceeded it.
In 2022, 31,0 percent of Italian Internet users (16-74 years old) acquired information through the websites or the apps of Italian public administrations or public services providers (the EU27 average is 38.6 percent). A 51.5 percent of Internet users downloaded or printed official forms (44.1 percent the EU27 average); 45.9 percent scheduled on Internet an appointment or reservation to some public office (36.7 percent the EU27 average); 20.1 percent applied online for social security benefits (15.8 percent the EU27 average) (Figure A).

Figure A. People (16-74 years) who used government websites or apps in the past 12 months in Italy and the EU27 by type of online activity. Year 2022. Percentage values

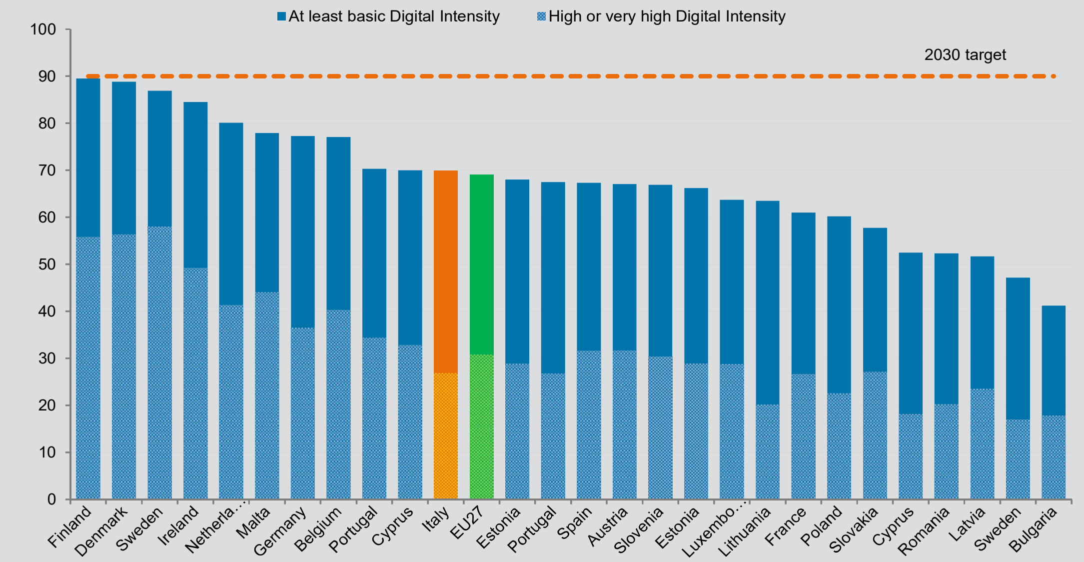


Source: Istat, Survey on the use of ICT in the Households and by individuals

Concerning the digital transition of enterprises with 10 employees and over, Italian indicators report contrasting results.
The growth rate of online sales is rather slow, but other measures show a greater push for digital transition. Examples include the availability of connectivity at speeds of at least 30 Mbit/s fixed broadband (from 37.4 percent in 2018 to 82.8 percent in 2022), the use of cloud services (from 22.5 percent to 60.5 percent), and electronic invoicing (from 41.6 percent to 94.9 percent).
Growth rates are much lower for online sales (18.3% in 2022; +4 percentage points from 2018) and web sales (15.5% in 2022; +3.4 percentage points).
One target of the Digital Compass is to achieve by 2023 the 90 percent of European small and medium-sized enterprises (SMEs) with at least a “basic level of digital intensity” (at least 4 out of the 12 items of the Digital Intensity Index - DII). From 2018 to 2022, the growth of the Digital Intensity Index took Italian SMEs from 20th to 11th position in the European ranking, bringing Italy (69.9 percent) just above the European average.

This good result, however, in 2022 is offset by the retreat from the EU27 average of the Italian SMEs at “high or very high digital intensity” (at least 7 out of 12 DII items). The Italian figure in 2022 (26.8 percent) is 4 percentage points lower than the EU27 one (30.8

Figure B. Small and medium-sized enterprises (10-249 employees) with at least basic digital intensity in Italy and European countries. Year 2022. Percentage values



Source: Eurostat

percent) (Figure B).

Indicators

1. **R&D intensity:** Percentage of expenditure for intramural research and development activities performed by business enterprise, government, higher education (public and private) and non-profit sector on GDP. Expenditure and GDP are considered in current prices, million euro.
   Source: Istat - R&D survey in companies; R&D survey in non-profit organizations; Survey on R&D in public bodies
2. **Patent propensity:** Number of patent applications filed to the European Patent Office (EPO) per million of inhabitants.
   Source: OCSE, Database Regpat
3. **Gross fixed capital formation of intellectual property products:** Research and development; mineral exploration and evaluation; entertaiment literary or artistic originals; computer software and database. Chained values, Indexed 2015 = 100.
   Source: Istat - National Accounts
4. **Innovation rate of the national productive system:** Percentage of firms that have introduced product or process innovation in a three-year period on total number of firms with at least 10 persons employed.
   Source: Istat, Cis (Community Innovation Survey)
5. **Impact of knowledge workers on employment:** Percentage of employees with tertiary education (ISCED 6-7-8) in scientific-technological occupations (ISCO 2-3) on total employees.
   Source: Istat - Labour force survey
6. **Cultural employment (% of total employment):** Percentage of employees in cultural and creative professions or sectors of activity (ISCO-08, Nace rev.2) out of the total number of employees (15 years and over).
   Source: Istat - Labour force survey
7. **Brain circulation (Italians, 25-39 years old):** Net migration rate of holders of a tertiary degree: (immigrants-emigrants) / total resident population * 1,000. Both numerator and denominator refer to Italian holders of a tertiary degree, 25-39 years old.
   Source: Istat - Registrations and cancellations from the registry for residence transfer and Permanent census of population
8. **Regular Internet users:** Percentage of individuals aged 11 and over who used the Internet at least once a week in the 3 months prior to the interview.
   Source: Istat - Survey on the use of ICT in the Households and by individuals
9. **Availability of at least one computer and Internet connection in the household:** Percentage of households with Internet connection and at least one personal computer (including desktop computers, laptops, notebooks, tablets; excluding smartphones, PDAs with phone functions, e-book readers and game consoles).
   Source: Istat - Survey on the use of ICT in the Households and by individuals
10. **Municipalities with online services for families:** Percentage of Municipalities that provide on line at least one service for families or individuals at a level that allows the electronic start and conclusion of the entire process (including any on line payment).
    Source: Istat - Survey on information and communication technology in public administrations
11. **Enterprises with at least 10 persons employed with web sales to end customers:** Percentage of enterprises with 10 or more persons employed that during the previous year sold via web to end customers (B2C). From the survey year 2021 economic activities from division 10 to 82 are included according to Ateco 2007 nomenclature (excluding section K - Financial and insurance activities). From the same survey year, estimates refer to the unit of analysis “enterprise”, i.e. a statistical unit that may consist of one or more legal units.
    Source: Istat - Survey on information and communication technology in enterprises

Indicators by region and geographic area

REGIONS GEOGRAPHIC AREAS	R&D intensity (a) 2020	Patent propensity (b) 2019	Intellectual property products (e) 2022	Innovation rate of the national productive system (d) 2020	Impact of knowledge workers on employment (c) 2022
Piemonte	2.33	112.6	....	58.3	16.4
Valle d'Aosta/Vallée d'Aoste	0.58	31.8	....	35.3	14.0
Liguria	1.56	50.5	....	54.8	18.4
Lombardia	1.36	142.7	....	46.5	17.8
Trentino-Alto Adige/Südtirol	1.21	114.9	....	46.7	14.8
Bolzano/Bozen	*0.90*	*124.5*	....	*45.3*	*13.5*
Trento	*1.58*	*105.6*	....	*48.6*	*16.2*
Veneto	1.38	134.5	....	52.3	15.6
Friuli-Venezia Giulia	1.74	114.4	....	52.2	15.8
Emilia-Romagna	2.11	197.0	....	52.0	18.3
Toscana	1.66	87.0	....	43.6	16.7
Umbria	1.06	38.9	....	51.6	16.8
Marche	1.03	73.4	....	59.0	16.4
Lazio	1.98	35.9	....	46.6	23.2
Abruzzo	1.03	41.9	....	51.9	17.9
Molise	1.04	28.3	....	34.2	18.9
Campania	1.34	18.2	....	48.3	19.2
Puglia	0.85	14.4	....	48.2	16.4
Basilicata	0.68	6.3	....	44.8	16.3
Calabria	0.61	12.0	....	47.8	17.1
Sicilia	0.90	12.5	....	40.0	17.7
Sardegna	0.91	10.6	....	40.1	16.8
North	1.63	137.4	....	53.5	17.1
North-west	1.59	124.9	....	55.0	17.5
North-east	1.68	154.6	....	51.6	16.6
Centre	1.72	56.9	....	47.9	19.7
South and Islands	1.00	16.2	....	46.1	17.7
South	1.04	12.0	....	48.2	17.8
Islands	0.90	18.2	....	40.0	17.4
Italy	**1.51**	**80.7**	**120.0**	**50.9**	**17.8**

(a) Percentage of R&D expenditure on GDP;
(b) Per million of inhabitants;
(c) Per 100 in employment;
(d) Per 100 enterprises with at least 10 employees;
(e) Chain-linked values with reference year 2015;
(f) Per 1,000 inhabitants aged 25-39 with tertiary education (bachelor's degrees, AFAM, PhD);
(g) Per 100 persons aged 11 and over;
(h) Per 100 households;
(i) Per 100 Municipalities.

Cultural employment (c)	Brain circulation (Italians, 25-39 years old) (f)	Regular internet users (g)	Availability of at least one computer and Internet connection in the household (h)	Municipalities with online services for families (i)	Enterprises with web sales to end customers (c)
2022	2021	2022	2022	2018	2022
3.5	0.4	75.4	67.9	15.0	11.7
2.9	-9.2	75.3	67.5	21.6	19.7
2.9	0.7	76.4	66.2	13.2	6.2
4.1	14.6	80.1	72.9	41.3	12.4
3.7	3.1	81.5	77.5	17.1	20.8
3.6	*1.9*	*80.7*	*76.2*	*22.5*	*24.8*
3.9	*3.9*	*82.2*	*78.8*	*13.6*	*15.0*
4.0	-0.5	78.7	73.3	43.4	11.2
2.9	-0.6	78.5	71.6	20.0	12.8
2.9	17.8	78.7	68.0	45.6	11.4
4.6	3.9	76.4	68.9	39.1	11.8
3.8	-7.0	75.4	66.9	28.3	15.8
3.5	-7.4	76.0	71.4	17.5	9.1
4.8	7.3	77.9	71.7	20.9	16.7
2.3	-12.9	73.4	67.2	12.5	13.8
1.9	-30.0	73.7	64.7	5.9	12.5
2.8	-22.2	71.8	65.3	18.5	18.6
2.5	-21.8	70.3	60.3	25.2	11.1
2.4	-37.0	70.3	58.3	15.3	13.9
2.0	-32.9	64.5	56.9	8.7	11.0
2.5	-23.5	70.6	60.6	12.3	20.1
2.3	-11.8	72.1	67.3	21.8	18.2
3.7	8.7	78.6	71.0	30.4	12.1
3.8	13.7	78.4	70.8	28.2	11.9
3.4	5.1	78.9	71.4	34.9	12.4
4.5	3.4	77	70.4	25.9	13.7
2.5	-22.7	70.6	62.4	15.6	16.1
2.5	-57.0	70.5	62.5	15.0	14.8
2.4	-8.6	71	62.3	16.9	19.6
3.5	**-2.7**	**75.6**	**68.2**	**25.1**	**13.3**