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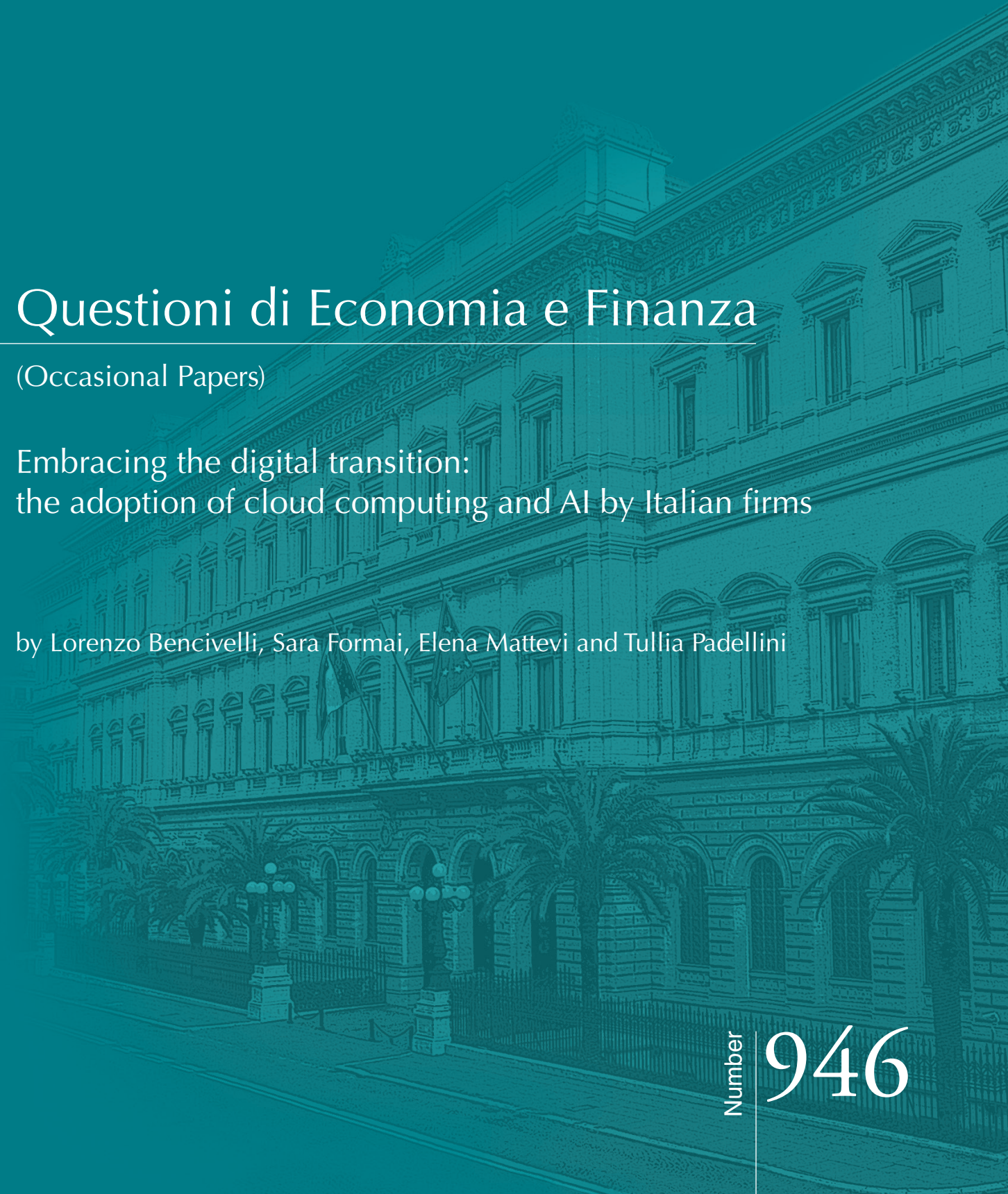

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EMBRACING THE DIGITAL TRANSITION: THE ADOPTION OF CLOUD COMPUTING AND AI BY ITALIAN FIRMS

by Lorenzo Bencivelli*, Sara Formai*, Elena Mattevi* and Tullia Padellini*

Abstract

The diffusion of advanced digital technologies is reshaping the organization and performance of firms, yet comprehensive evidence on their adoption remains scarce. This paper draws on data from Banca d'Italia's business surveys to assess the uptake of cloud computing and artificial intelligence (AI) among Italian firms. As of early 2024, over 50 per cent of firms with at least 20 employees had adopted cloud services, showing minimal variation across sectors and suggesting that this technology is becoming standard infrastructure. AI adoption remains more limited – rising from 4 per cent in 2020 to 13 per cent in 2024 – and tends to be experimental or task-specific. Adoption rates are strongly associated with firm size, export activity, group affiliation, and innovation capacity. Managerial quality and prior digital investments also influence AI uptake. Expectations about generative AI point to job transformation rather than displacement. Accordingly, the analysis reveals that digital technology adoption is positively correlated with realized and expected employment growth.

JEL Classification: O33, D22, L86, J21.

Keywords: digital technologies, cloud computing, artificial intelligence, generative AI, firm performance, business surveys.

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* Banca d'Italia.

1. Introduction and main results

The rapid advancement of digital technologies, such as cloud computing and artificial intelligence (AI), is expected to drive profound transformations in the operations of manufacturing and services firms worldwide. AI most likely meets the criteria for classification as a General Purpose Technology (GPT), as defined in the foundational work of Bresnahan and Trajtenberg (1995), which is characterized by three defining features: (i) they are widely used across diverse sectors, (ii) they are capable of ongoing technical improvement, and (iii) they enable innovation in application sectors (Bresnahan, 2010). As such, AI is expected to change the production paradigm in the 21st century (Agrawal et al., 2019; Cockburn et al., 2019; Brynjolfsson et al., 2021). The literature presents a wide range of predictions of the potential long-run impacts of these technologies in terms of aggregate productivity, depending on the different assumptions made on (i) the micro-economic cost saving effect from AI; (ii) the share of economic activities that are going to be impacted; (iii) the speed of adoption; and (iv) the effect that AI is assumed to have on the rate of innovation and future productivity growth.[1]

Labour market outcomes could turn out to be different across sectors and skill levels. There is a general consensus that, unlike previous waves of automation, the most exposed professions are those that primarily require cognitive skills.[2] At the same time, among these occupations, both those at higher risk of substitution and those that are complementary to AI appear at the top end of the income distribution; the effects on inequality are therefore uncertain.[3] All in all, while the potential productivity gains from advanced digital technologies might be significant, they might differ substantially across countries. According to Filippucci et al. (2024), the expected TFP gains from AI over the next decade are the highest in Germany and in the US (in a range between 0.25 and 0.6 percentage points per year for both countries), while in France and Italy the gains would be about half of that (roughly between 0.1 and 0.3), largely mirroring adoption rate differences. The cross-country variation in the 10-year horizon adoption rates estimated in the paper ranges from less than 20 in in Italy to 40 per cent in Germany and reflects differences in digital infrastructure, human capital and other structural features that can be spurred by policy initiatives.

To collect information on the adoption of digital technologies by Italian firms, the 2020 and 2024 waves of the Bank of Italy's business surveys[4] have included questions investigating the extent and the reasons for the use of advanced technologies, such as AI and cloud computing.[5] In this analysis we use these data to study the current state of adoption of cloud computing, AI and *generative* AI (henceforth "GenAI") by Italian firms, its growth since 2020, the characteristics of firms adopting AI

[1] These estimates range from a merely 1 per cent increase in TFP in 10 years according to Acemoglu (2024), to up to 28 percent increase in labor productivity over the same horizon according to Baily, Brynjolfsson and Korniek (2023).
[2] According to Frey and Osborne (2017), up to 47 per cent of current US jobs could become obsolete and be replaced by AI.
[3] If, for example, we look at previous technology waves, we observe lower employment rates for medium-skilled workers following digitalization, in the early 2000s (Goos et al., 2009) and growing rates with the advent of machine learning and big data in the 2010s (Albanesi et al., 2023). See also Cazzaniga et al. (2024), Dalla Zuanna et al. (2024).
[4] Results for the 2025 wave will be published in July 2025. For some preliminary evidence see Annual Report for 2024, Bank of Italy.
[5] In addition to the digital technologies investigated here, the module also investigates the adoption of robotics. Results for this technology are presented in Appendix B.

or cloud computing (taken to be a necessary requirement for the use of AI)[6] and the business perceptions of the effects these technologies will have on the labour market in the next couple of years. In particular, the 2024 waves of the annual surveys allow to also qualify the diffusion of GenAI defined as the set of AI techniques for generating personalized responses to a user's requests (such as in the form of text, images or audio). Its ability to produce content that is original and following instructions provided by the user makes GenAI a tool with diverse and relevant applications in different industries and business functions. Although it is based on technologies that have been known for decades, a number of products have been commercialized only since 2022 and since then they have been rapidly making it possible for individuals and businesses to become aware of and use it.

While still limited at the moment, the adoption of AI technologies is growing fast; Acemoglu et al. (2022), using data from the US Census Annual Business Survey, found that among US firms with at least one employee, 3 per cent (representing 13 per cent of total employment) used AI technologies in 2018. Using the US Census Business Trends and Outlook Survey on US firms, Bonney et al. (2024) found that at the beginning of 2024 this share was up to 6 per cent, with firms expecting to increase AI adoption to 9 per cent by the end of the year. Interestingly, they also found that the increase was particularly strong among smaller firms. The sudden diffusion of GenAI algorithms to the general markets might have allowed smaller firms to overcome the hurdles to adoption provided by sunk costs of implementation, data availability, proper assessment and treatment of risks related to privacy concerns and cybersecurity and scarcity of skilled labor force. Among large global firms surveyed by McKinsey (2024), the employment weighted adoption rate of AI technologies has gone from 20 per cent in 2017 to 55 in 2023 and 72 at in 2024,[7] with a major contribution from GenAI following the breakthrough on the market of ChatGPT. For this reason, McKinsey (2024) considers 2022 a tipping point in the diffusion of AI technologies.

As for European countries, in 2024 the adoption of digital technologies firms was still well below the Digital Decade targets (European Commission 2021), in particular those related to AI[8]. According to the latest EU survey on 'ICT usage and e-commerce in enterprises'[9] the share of firms with at least 10 employees adopting AI technologies was 13.5 per cent for the EU, 19.8 for Germany, 11.3 for Spain, 9.9 for France and only 8.2 for Italy (European Commission, 2024). Italy ranks much higher for cloud technologies, where the adoption rate is 55 per cent against an EU average of 39 (the latest data refer to 2023).

Results from the Bank of Italy business survey on the adoption rates are broadly in line with those from the EU commission. We show that the diffusion of these digital technologies among Italian firms above 20 employees is widening, although at a different pace. In line with existing evidence, cloud computing is progressively becoming the state of the art, with a rate of adoption that ranges between 40 and 60 per cent across sectors. On the other side, the diffusion of AI is at a much earlier

[6] As cloud platforms simplify the deployment of AI applications by offering developers preconfigured templates and settings, they make advanced AI tools more accessible to a wider range of users.

[7] This private sector surveys are not representative of the US firm population as they tend to be biased towards larger corporations and do not reproduce the distribution of employment across different sectors.

[8] Under current trends, the targets will not be met by 2030: the projected baseline trajectory indicates that only 64 per cent of businesses in the EU will use cloud and 17 per cent AI, far from the 75 per cent objective. The digitalization of SMEs is also progressing too slowly and unevenly across the EU.

[9] Statistics were obtained from the surveys conducted by National Statistical Authorities in the first months of 2024.

stage, with most of the sectors displaying adoption rates around 10 percent or below (13 per cent on average); only in the professional, scientific, and technical services the adoption rate is close to 30 per cent. These numbers are aligned with those from the ISTAT's ICT survey, that for firms with more than 10 employees finds an average adoption rate in 2024 of 8.5 per cent (up from 5 in 2023). [10] When we differentiate by type of use, only a small fraction of adopters (13 per cent) employ them intensively, the rest is still in a phase of either testing or limited use.

Looking at firm's characteristics, we find that adoption is more frequent among larger firms and, controlling for size, among young firm that have just left the startup phase. With respect to cloud technologies, firms headquartered in Italy's South and islands are lagging. For AI, we also find a higher rate of adoption among those firms who displayed more structured managerial practices and high R&D spending well before 2024, suggesting that the choice to equip with this technology hinges on entrepreneurial culture and propensity to innovate.

The main reasons behind firms' decision to adopt AI are the upgrading of already automated production processes and the improvement of business support processes.[11] The use of AI for the automation of tasks performed by employees is less relevant and we do not find evidence of substitution effects between the use of AI and employment, both realized and predicted, hinting that the adopters did not make their decision with the aim of replacing labor, at least in the near term. According to firms' answers, this result also holds for GenAI: users see GenAI as a technology yielding new job opportunities and requiring a reorganization of labor tasks, but not necessarily replacing employment. These findings are in line with Handa et al. (2025) who find that AI is mostly used for augmentation of human capabilities (e.g. reading and programming) in support activities rather than for full automation (fulfilling task with minimal human involvement).

This paper is structured as follows: in Section 2 we describe the data sources and provide some descriptive statistics. In Section 3 we investigate the characteristics of firms adopting digital technologies; Section 4 will discuss firms' use and perception of AI, with a special focus on GenAI, while in Section 5 we study the association between the use of these technologies and firms' performances, exploiting data on realized and expected employment and turnover.

2. Data and descriptive statistics

Our data come from the Bank of Italy's Survey of Industrial and Service Firms (INVIND) and Business Outlook Survey of Industrial and Service Firms (Sondtel), which are carried out every year on a sample of around 4000 enterprises with at least 20 employees, operating in industry[12] and non-financial private services.[13] More specifically we analyze data from two waves of INVIND, which

[10] According to the ITC survey, in 2024 one third of firms with more than 250 employees adopted AI technologies. For a comparable sample of firms, the adoption rate for INVIND firms is equal to 30 per cent.

[11] The survey questions on the reason for adoption are limited to AI technologies.

[12] The section on advanced technologies was not included in the questionnaire addressed to construction firms, thus construction firms are excluded from the analysis.

[13] More details can be found in Appendix A and in INVIND's methodological note https://www.bancaditalia.it/pubblicazioni/metodi-e-fonti-note/metodi-note-2017/en_survey_methodology_invind.pdf. INVIND interviews are conducted between February and May of each year; Sondtel interviews are conducted every year between September and October.

contained a module on the use of advanced technologies in 2020 and 2024, including AI and cloud computing, and the 2024 wave of Sondtel, which contained questions specifically on the adoption and use of GenAI; the relevant questions can be found in the Appendix.[14]

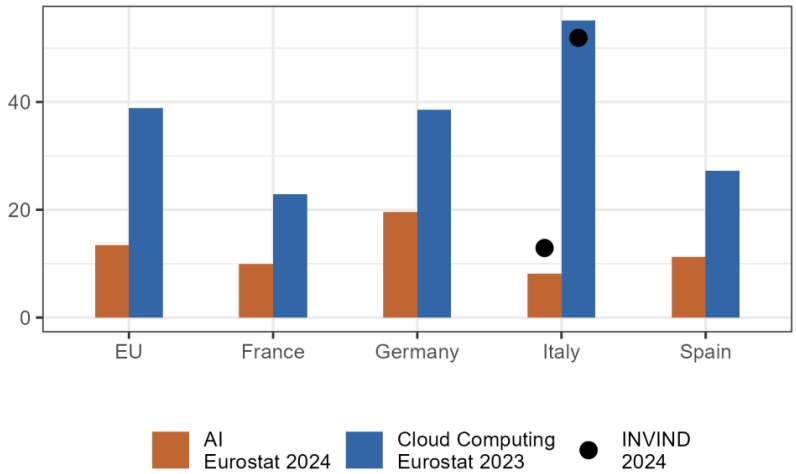
Between 2020 and 2024 the adoption of cloud computing and AI by Italian firms increased substantially (Table 1), although starting from different initial levels. Cloud technologies are more widely adopted, with 28 per cent of the firms using it already in 2020 and more than half in 2024. AI experienced a much faster growth, however the diffusion of this technology in production processes is lower, equal to 13 percent in 2024 (from about 4 in 2020). Employment-weighted use rates show a similar increasing trend but higher overall levels, especially for AI, indicating that bigger firms are more prone to exploit digital technologies. While the estimated adoption of cloud technologies is broadly in line with the European Commission's data, we estimate a higher rate of adoption of AI (see Figure 1).

Table 1. Adoption rates of digital technologies

	Firms		Employment	
	2020	2024	2020	2024
Cloud computing	28	52	46	66
Artificial Intelligence	4	13	16	29

Notes: own elaboration on INVIND data. Share of firms adopting cloud computing and artificial intelligence. Statistics in columns are weighted by the number of firms in the population and are estimates of the share of firms adopting the technologies; statistics in columns 3 and 4 are weighted by the number of employees and provide estimates of the share of workers interested by the adoption of these technologies.

Figure 1: Adoption of AI and cloud computing in major EU countries.



Source: European Commission Cloud and Artificial Intelligence DESI indicators (https://ec.europa.eu/eurostat/statisticsexplained/) on firms with 10 employees or more in 2023 and 2024 respectively and Bank of Italy INVIND on firms with 20+ employees in 2024.

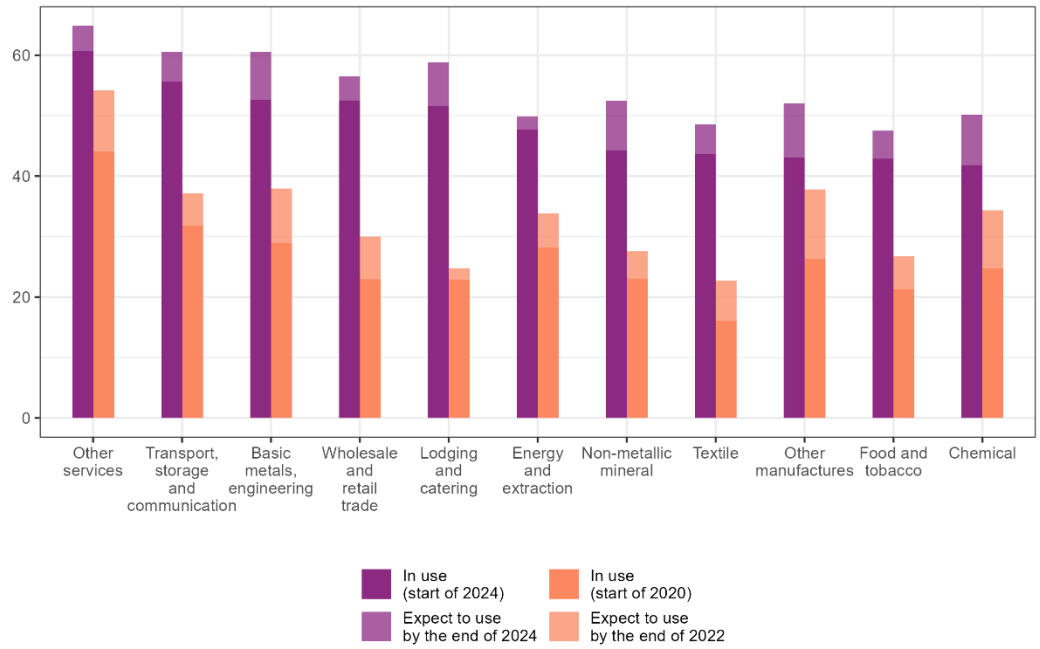
[14] In order to ease cross country comparisons, the questions included in 2023 INVIND on AI were also included in the Deutsche Bundesbank business survey held in the second quarter of 2024. Results were published in the December 2024 Monthly Report (Bundesbank 2024).

The actual and expected (shaded bars) adoption rates of cloud computing and AI in 2020 and at the beginning of 2024, broken down by sector, are shown in Figure 2 and display a significant growth in the period considered. The diffusion of the two technologies is clearly at a different stage: cloud computing (panel a) in 2024 exhibited a much higher and more homogenous rate of adoption across sectors, within the range 40-60 per cent. In all sectors more firms were planning to adopt this technology by the end of the year, with the share of non-adopters (firms not using it and not planning to do so) being higher than 50 per cent only in the textile and food industries.

AI diffusion is clearly less mature: the adoption is more frequent in services, especially in the "Other services group" including professional, scientific, and technical services,[15] which have the highest rates of AI use in both years, increasing from about 7 per cent in 2020 to 29 in 2024. The food, the chemicals, and the transport, storage and communication services sectors have also experienced a strong increase in the adoption of AI techniques. On the other side, the textile and clothing sector has the lowest rate of adoption, 3 percent. Comparing the 2-years-ahead expectations at the beginning of 2020 with the actual adoption rate at the beginning of 2024, it is clear that awareness on the use of the new technology was still very limited in 2020: in sectors like basic metals, chemicals, energy, trade and textile, the expectations for 2022 were well above the adoption 2 years later, on the contrary tourism and other services were underestimating or unaware of the potential usefulness of the new tool. As for expectation at the beginning of 2024, firms were expecting to increase adoption rates by the end of the year overall by 8 percentage points, to 21 per cent.

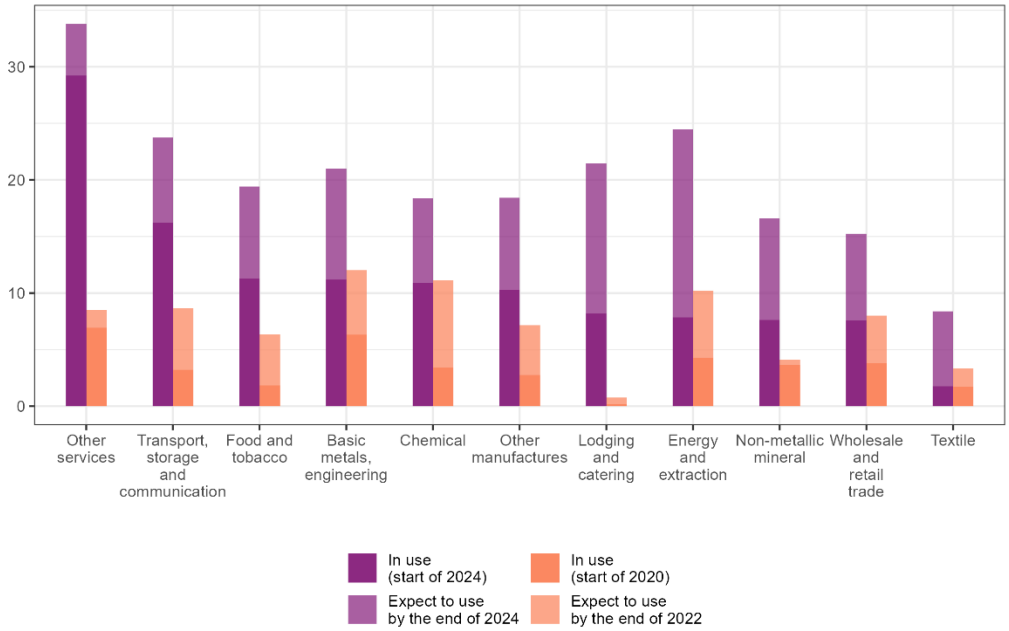
Figure 2. Adoption rates of cloud computing and artificial intelligence by sector, 2020 and 2024

(a) Cloud Computing



[15] Firms categorized with NACE M and N; for a full description of NACE codes corresponding to INVIND's sectors see Table A2 in the Appendix.

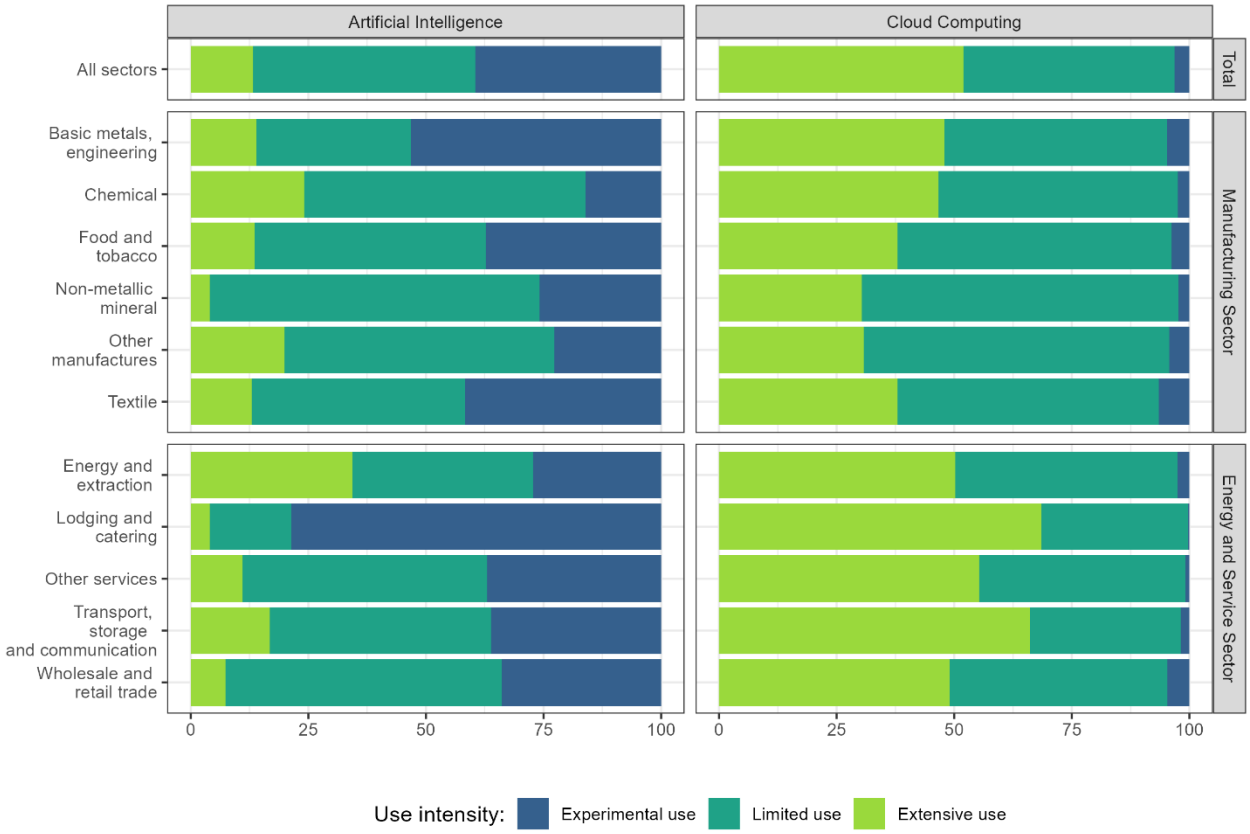
(b) Artificial Intelligence



Notes: own elaboration on INVIND data. Share of firms adopting artificial intelligence by sector of activity. "Other services" includes the NACE sections L (real-estate activities), M (Professional, scientific and technical activities) and N (renting, travel agencies, support services to enterprises). Expected use refers to the following 2 years in the 2020 wave and the following year (by the end of 2024) in the 2024 wave. Statistics weighted by the number of firms in the population.

When focusing on the 2024 INVIND wave, which provides more details on the intensity of adoption and distinguishes between extensive, limited and experimental use of the technologies, we can see that AI adoption is driven by the experimental use, which represents around 40 per cent of total adoption (Figure 3). Experimental adoption is particularly common among firms in lodging and catering services and in the manufacturing of basic metals and engineering products, which are among the sectors that also expected a higher increase in the use of the technology. On the other hand, on average only 13 per cent of the adoption is given by an extensive use. Coherently with its wider diffusion, cloud technology is instead characterized by a low experimental use (just 3 per cent of the adopters) and a high intense use (more than 50 on average).

Figure 3. Adoption intensity by sector, 2024

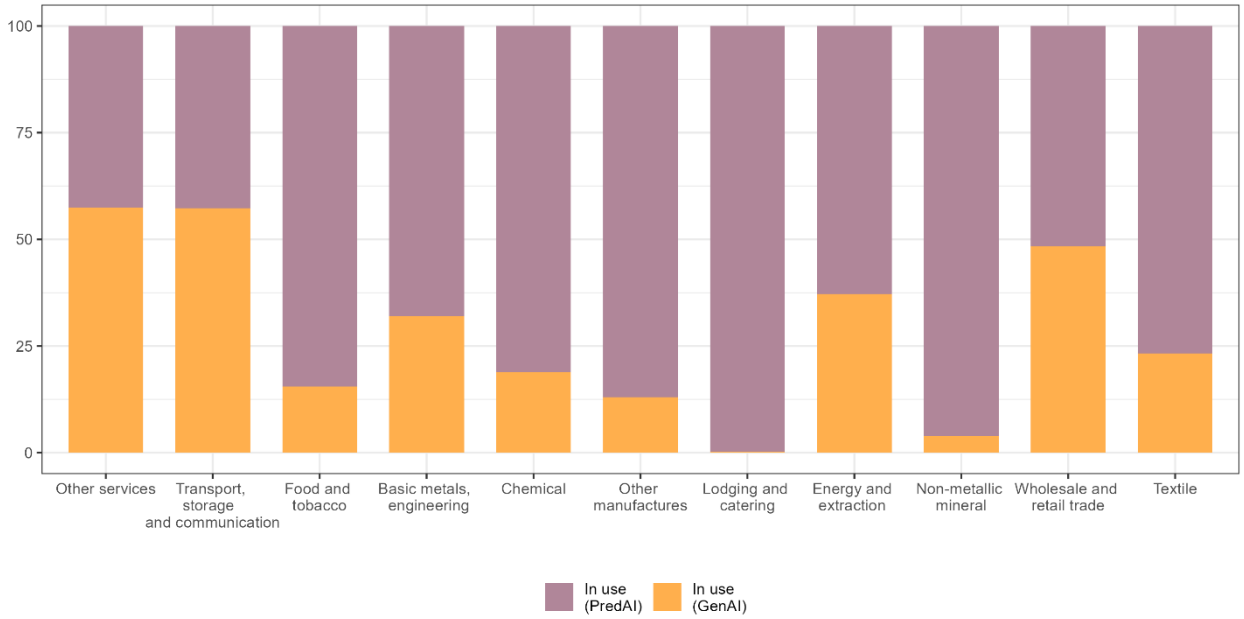


Notes: own elaboration on INVIND data. Use intensity of digital technologies across firms that are currently adopting, by sector. Statistics weighted by the number of firms in the population.

Finally, when focusing on GenAI, the INVIND 2024 wave finds that the adoption is still very low, with only 5 per cent of firms already exploiting it. Most firms using AI do not use generative tools, with the notable exceptions of the professional services, logistics and communication and wholesale and retail trade (Figure 4). According to the Sondtel survey conducted 6 months later, firms mostly use GenAI in the production process, in the management of human resources and of commercial relationships (see Figure A2 in the Appendix) and expect an increased use in the coming months.[16]

[16] For more details, see Sondtel 2024, https://www.bancaditalia.it/pubblicazioni/sondaggio-imprese/2024-sondaggio-imprese/statistiche_SIS_2024.pdf.

Figure 4. Adoption of generative tools among firms using AI



Notes: own elaboration on INVIND data. Share of firms using some generative tools and firms using only predictive tools among firms that are currently adopting AI, by sector. Statistics weighted by the number of firms in the population.

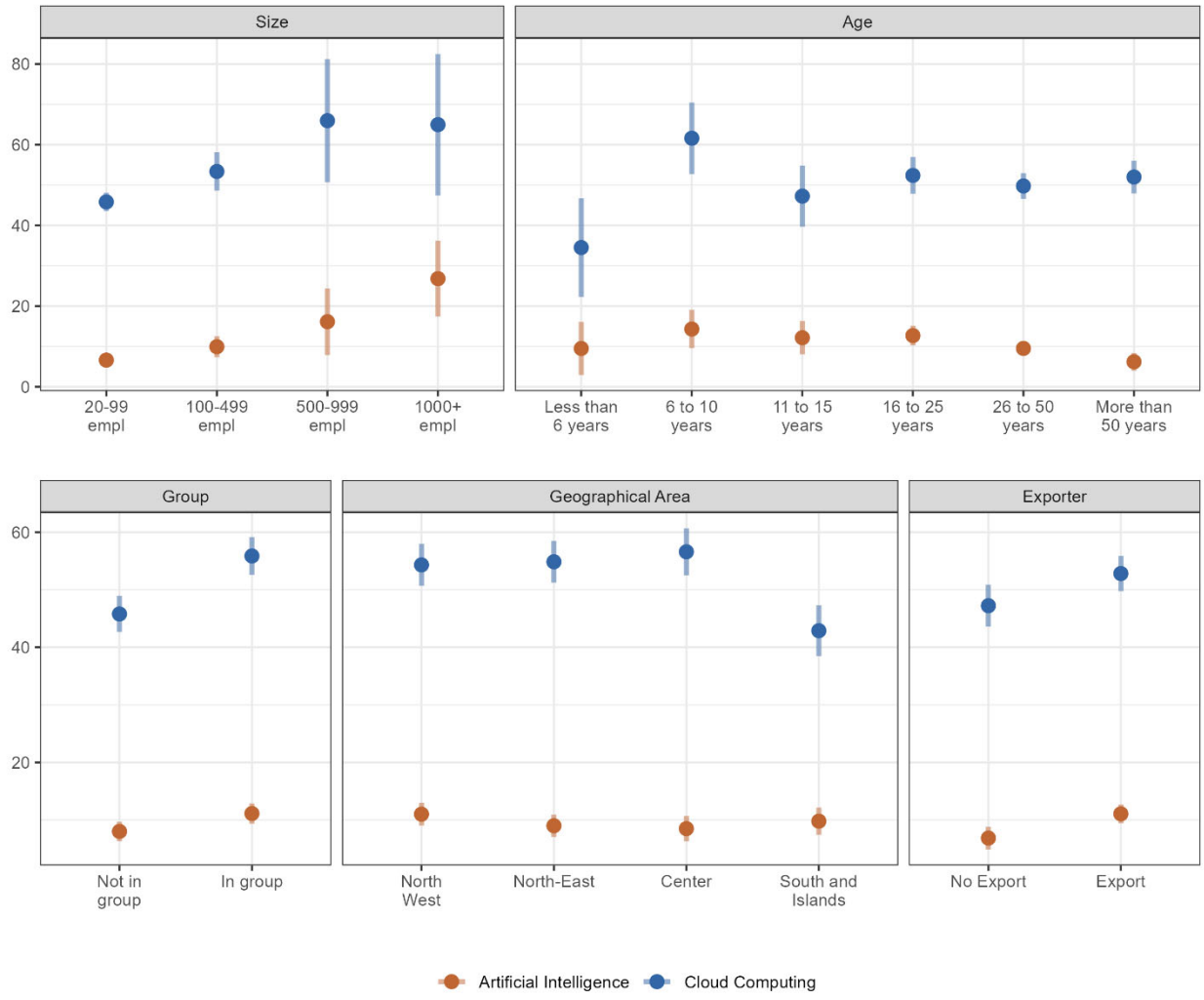
3. Adoption of digital technologies by firm characteristics

We investigated which individual firms' characteristics are more strongly associated with the adoption of digital technologies through a linear probability model (LPM), where the dependent variable takes value 1 if the firm has adopted the technology, 0 otherwise, and the explanatory variables are dummies for size classes, geographic locations, export status, sector, age class and membership to a group.[17] As shown in Figure 5, firms' size is the main source of heterogeneity, with larger firms significantly more likely to adopt digital technologies than smaller ones, even when controlling for other characteristics. While AI adoption increases monotonically with size, cloud adoption plateaus for firms with more than 500 employees. Firms headquartered in the South of Italy seem less prone to equip with cloud compared to those located in other areas while; when it comes to the decision of adopting AI, firm's location is not a relevant factor. The use of the two technologies is the highest for firms that have just exited the startup phase (age 6-10) and, for AI, is then decreasing with age (inverted "U-shaped"), while cloud adoption is rather constant among older firms.[18] Both exporters and firms belonging to a group are more likely to be involved in the digital transformation, even when controlling for size and sector.

[17] It is to be noted that the low rate of adoption of AI makes the LPM parameters' estimate less precise.

[18] The adoption by sector, conditional on the other demographic characteristics, is basically unchanged with respect to what we showed in the previous section (see Figure A3 in the appendix for details).

Figure 5. Adoption rates by firm characteristics, conditional means 2024



Notes: own elaboration on INVIND 2024 data. Marginal means of a linear probability model with response variable equal to 1 if the firm makes an extensive or limited use of the digital technology and 0 otherwise, adjusted for dimension, sector of activity, geographical area, age, exporter status and grouping structure of the firm. Outcomes by industry can be found in Figure A2 of the Appendix. Statistics weighted by the number of firms in the population.

Then, we test whether the use of structured managerial practices is associated with the decision to adopt new technologies. To this end, we leverage on Baltruinaite et al. (2022) that computed the Management and Organizational Practices Survey (MOPS) indicator based on evidence from INVIND 2020 wave.[19] We also investigate the correlation with the propensity to innovate, measured by the share of research and development (R&D) expenditure on total investments. MOPS were a relevant factor underlying the adoption of artificial intelligence and cloud computing in 2020, but having more structured practices does not seem to affect cloud adoption in 2024 (Table 2). A possible explanation for this difference is that cloud is already considered standard endowment required by the state of the art technology, and more sophisticated managerial practices might be relevant only in the first phases of adoption. Data on which MOPS are estimated were collected in 2020, well ahead

[19] The 2020 wave of INVIND included specific variables aiming at defining managerial practices according to Bloom et al. (2019). The MOPS indicator ranges from 0 to 1, where the higher score indicates better managerial practices.

of the AI diffusion tipping point. This consideration reinforces our argument that firms adopting AI were already those more prone to the adoption of new technologies. Another factor resulting positively associated with the adoption of AI is the share of resources invested in R&D over investment expenditure. Although this variable might be expected to be correlated with higher MOPS, when both included in the same equation, they keep displaying positive, significant, and basically unchanged coefficients. Moreover, the fact that the coefficient for turnover per employee is never significantly different from zero, reassures that higher MOPS and R&D expenditure are not simply capturing higher productivity firms.[20]

Table 2. Impact of firms practices on adoption

	Dependent variable:					
	Artificial Intelligence (2020)			**Artificial Intelligence (2024)**		
	(1)	(2)	(3)	(4)	(5)	(6)
MOPS score	8.2***		7.6***	23.6***		22.3***
	(2.7)		(2.7)	(3.8)		(3.8)
Share of R&D expend.		11.1***	10.8***		12.9***	10.6***
		(2.0)	(2.0)		(3.6)	(3.5)
Turnover per employee	−0.0001	−0.0001	−0.0001	−0.0002	−0.0002	−0.0001
	(0.0004)	(0.0004)	(0.0004)	(0.0005)	(0.0005)	(0.0005)
Observations	1,499	1,499	1,499	1,170	1,170	1,170
R^2	0.08	0.09	0.10	0.08	0.06	0.09
Adjusted R^2	0.07	0.08	0.08	0.06	0.04	0.06
	Cloud Computing (2020)			**Cloud Computing (2024)**		
	(1)	(2)	(3)	(4)	(5)	(6)
MOPS score	38.5***		37.3***	10.1		9.8
	(6.2)		(6.1)	(7.9)		(7.9)
Share of R&D expend.		21.8***	20.5***		3.1	2.1
		(4.7)	(4.6)		(7.3)	(7.4)
Turnover per employee	−0.001	−0.001	−0.0004	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	1,501	1,501	1,501	1,171	1,171	1,171
R^2	0.15	0.14	0.16	0.06	0.06	0.06
Adjusted R^2	0.14	0.13	0.15	0.04	0.04	0.04

*p<0.1; **p<0.05; ***p<0.01

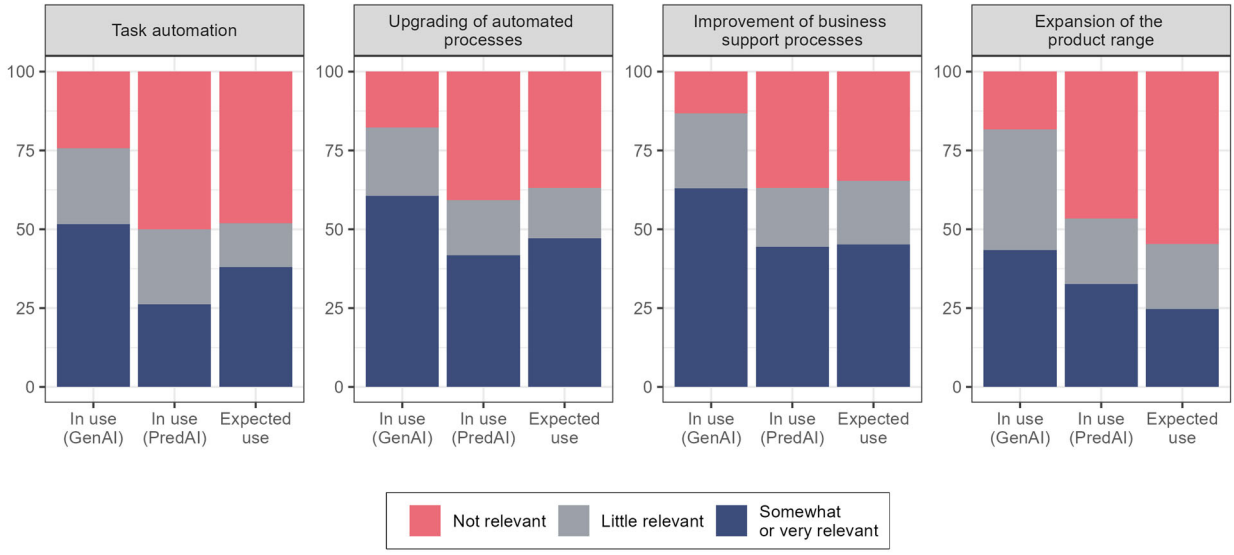
Notes: own elaboration on INVIND data. Regression coefficients of a linear probability model with response variable equal to 1 if the firm makes an extensive or limited use of the advanced technology and 0 otherwise, controlling for dimension, sector of activity, geographical area, export status, grouping and age of the firm. Turnover by employee and share of R&D over total investments are averaged over the years 2021-2023; firms that did not participate to at least two waves are removed from the analysis. The analysis for 2024 is limited to firms answering both INVIND 2020 MOPS section and INVIND 2024 advance tecnology adoption, hence the smaller number of observations. Statistics weighted by the number of firms in the population.

[20] Results are robust when including as additional controls the firm's leverage and investment ratio based on balance sheet data.

4. Firms' use and perception of Artificial Intelligence

Firms using AI in 2024 or planning to do so by the end of the year were asked to state the primary goal of the adoption of this technology by evaluating the relevance of each of the four categories: (i) automation of tasks previously done by workers, (ii) improvement of methods and/or production processes among those already automated, (iii) enhancement of quality and reliability of work support process and (iv) broadening the range of the goods and/or the services produced. Figure 6 shows the distribution of the outcomes conditional on having either adopted some GenAI technology (*In use GenAI*), or only predictive AI (*In use PredAI*) or planning to adopt AI in the following months (*Expected use*). In general, firms adopting generative tools perceive the AI technologies as more relevant to the enhancement of business activities than those who are not adopting it (shorter red bars). On the contrary, there is no relevant difference in the distribution of answers between firms adopting only predictive AI and those planning to do so in the near future. For the three groups of firms, the main reasons behind AI adoption are the upgrading of already automated production processes and the improvement of their business support processes. The fact that the main reason for adoption is to perform support activities and that expanding the product range is instead the least relevant might suggest that the potential of AI tools may still not be explored to a full extent. Interestingly, automation of tasks performed by employees is significantly more important for firm using GenAI tools.

Figure 6. Relevance of objectives for AI adoption

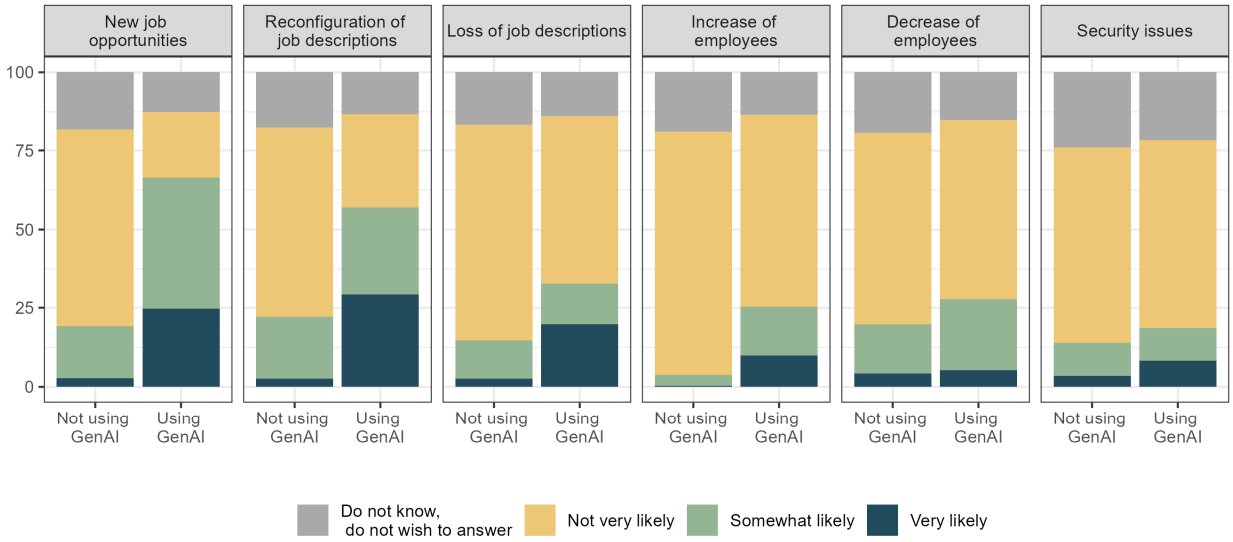


Notes: own elaboration on INVIND 2024 data. Relevance of objectives in the decision to adopt artificial intelligence among the firms that declared that they use these technologies or plan to do so by December 2024. Firms using GenAI may also be using predictive modelling (PredAI); firms defined as "In use (PredAI)" have not adopted any generative tools. Statistics weighted by the number of firms in the population.

Evidence from Sondtel, which included a section on the use and perception specifically of GenAI, shows that firms that are not already adopting AI are less likely to believe that this technology might have relevant effects on their activity (the sum of the gray and orange bars in Figure 7 is higher than for adopters). Almost a fifth of firms do not yet have an opinion about the implications that GenAI might have in the next two years on the organization of work; roughly two thirds believe it is unlikely that these tools will lead to a change in employment in their company or a

reduction in the overall tasks performed by their staff. Over a quarter of firms, on the other hand, anticipate that these technologies will likely bring new job opportunities or a reorganization of business tasks, with the same number of employees; the share rises to about 60 percent for firms already using GenAI.[21] Among firms currently using GenAI, the share of firms believing that it will very likely lead to an increase in employment is larger than firms not using it, while the opposite can be observed with respect to expectations of a reduction in employment, which is judged as very likely by an equally small share of firms in the two groups. Fear of breaches and data loss do not seem factors holding back firms from adopting GenAI: on average, less than one in seven firms rate it very or fairly likely that the tool will put confidential corporate data at risk; early adopters seem slightly more concerned of the risks embedded in the use of this technology.

Figure 7. Firms' perceptions of GenAI



Notes: own elaboration on Sondtel 2024 data. Probability assigned to the occurrence of each event in the next 2 years and associated to the introduction of GenAI. Firms are defined as "Using GenAI" if they are using it for any of the following: (i) production, (ii) business accounting, (iii) financial management, (iv) staff management or (v) business relations. Statistics weighted by the number of firms in the population.

5. Digital technologies and firm performance

In this section we leverage questions regarding realized and expected business outcomes, to look at the relationship between the adoption of digital technologies and firm performance. As a first exercise, we look at the performance of firms that used cloud computing and AI technologies already in 2020. According to the results presented in Table 3, the few firms using AI or cloud computing already in 2020 experienced significantly higher growth rate of employment between 2020 and 2023 when controlling for the growth in revenues in the same years and in the previous two (columns 1 and 2). At the same time, firms who were adopting these technologies already in 2020 are more likely to use AI in 2024 (columns 3 and 4) and to be among the early adopters of GenAI technologies

[21] Cfr also the box *The use of generative artificial intelligence* in the Sondtel 2024 Report, Bank of Italy. As opposed to INVIND, where only firms already adopting or planning to adopt AI were asked about its relevance, in the latest wave of Sondtel, all firms were asked their opinion about the impact of generative AI on the activity and employment. Moreover, elaborations in the Sondtel 2024 Report are based on statistics weighted by the number of employees in the population.

(columns 5 and 6). In particular, these results support the idea of cloud computing being an enabling technology to subsequent digital transformation.

Table 3. Early adoption and performance

	Dependent variable:					
	Av. empl. growth '20-'23		AI adoption in '24		GenAI adoption in '24	
	(1)	(2)	(3)	(4)	(5)	(6)
AI '20: in use	2.0**		0.5***		0.4***	
	(0.9)		(0.05)		(0.03)	
Cloud Computing '20: in use		0.6*		0.1***		0.1***
		(0.3)		(0.02)		(0.01)
Av. turnover growth '20-'23	0.1***	0.1***	0.001	0.001	0.000	0.000
	(0.01)	(0.01)	(0.001)	(0.001)	(0.000)	(0.000)
Av. empl. growth '17-'19	0.1***	0.1***	0.001	−0.000	0.001	0.000
	(0.02)	(0.02)	(0.001)	(0.001)	(0.001)	(0.001)
Av. turnover growth '17-'19	0.04***	0.04***	−0.000	−0.000	−0.000	−0.000
	(0.01)	(0.01)	(0.001)	(0.001)	(0.000)	(0.001)
Constant	2.2*	2.1*	0.001	−0.01	−0.03	−0.03
	(1.2)	(1.2)	(0.1)	(0.1)	(0.05)	(0.05)
Controls	yes	yes	yes	yes	yes	yes
Observations	1,476	1,478	1,360	1,360	1,356	1,356
R^2	0.3	0.3	0.1	0.1	0.1	0.1
Adjusted R^2	0.3	0.3	0.1	0.1	0.1	0.1
						*p<0.1; **p<0.05; ***p<0.01

Notes: own elaboration on INVIND data. Columns (1) and (2), (3) and (4) refer to a linear regression with response variables equal to yearly realized growth of the number of empoyees averaged across the years between 2020 and 2023. The remaining columns correspond to a linear probability model with response variable equal to 1 if the firm made an extensive or limited use of AI in 2024 (columns 3 and 4) or any use of GenAI (columns 5 and 6) and 0 otherwise. All models adjust for dimension, geographical area, age, exporter status and grouping structure of the firm. Weighted statistics by the number of firms.

For firms using digital technologies by the beginning of 2024, we do not yet have data on future performance; hence, we analyze the relation between adoption and past realized growth or expectations one-year-ahead.

The dependent variables in Table 4 are expressed, for both revenues and employment, in terms of: average realized yearly growth between 2021 and 2023 (columns 1 and 4); average one year ahead expected growth predicted for 2022 –2024 (columns 2 and 5) and the expected growth for 2024 (columns 3 and 6).

Table 4. Use of advanced technologies (AI and cloud) and employment growth

	Employment growth					
	Av. real. '21-'23	Av. pred. '22-'24	Pred. '24	Av. real. '21-'23	Av. pred. '22-'24	Pred. '24
	(1)	(2)	(3)	(4)	(5)	(6)
AI '24: in use	2.1***	−0.2	1.2*			
	(0.8)	(0.5)	(0.7)			
AI '24: experimental use	−1.4	1.3**	2.8***			
	(0.8)	(0.5)	(0.8)			
Generative AI '24	3.3***	1.0	−0.8			
	(1.0)	(0.6)	(0.9)			
Cloud Comp. '24: in use				1.9***	0.3	1.0***
				(0.3)	(0.2)	(0.3)
Cloud Comp. '24: exp. use				−1.5	−0.04	0.8
				(1.3)	(0.8)	(1.2)
Av. real turn. growth '21-'23	0.05***	0.02***	0.02***	0.05***	0.02***	0.02***
	(0.01)	(0.003)	(0.005)	(0.01)	(0.003)	(0.005)
Av. real empl. growth '21-'23		0.2***	0.02		0.2***	0.01
		(0.01)	(0.02)		(0.01)	(0.02)
Constant	−2.3	1.8*	4.8***	−2.2	1.7*	4.7***
	(1.6)	(1.0)	(1.5)	(1.6)	(1.0)	(1.5)
Observations	3,000	3,000	3,000	3,025	3,025	3,025
R^2	0.2	0.1	0.1	0.2	0.1	0.1
Adjusted R^2	0.2	0.1	0.1	0.2	0.1	0.1

*p<0.1; **p<0.05; ***p<0.01

Notes: own elaboration on INVIND data. Coefficient of a linear regression model, with percentage variation as response variable and digital technlogy adoption as main variable of interest, adjusted for dimension, sector of activity, geographical area, export status, grouping and age of the firm. Models (3) and (6) additionally adjust also for the average predicted employment growth in 2022-2023. Reference category is firms with less than 100 employees, northwest, not using the technology. Statistics weighted by the number of firms in the population.

The use of AI and of GenAI is positively correlated with past and expected employment growth. This positive association suggests that firms adopting AI are on average performing well and foreseeing an expansion of their activity, without replacing labor with AI or planning to do so in the medium term, in line with the evidence described in the previous section based on firms' perception of the effects of the technology. Analogously, the current use of cloud computing is positively associated with employment growth, both realized and expected.[22] These findings overall are consistent with those found by Acemoglu et al. (2022) and Bonney et al (2024) for US firms using US Census data.

[22] The evidence on turnover growth also points in favor of a positive association between adoption of digital technologies and firm performance, although the relation appears less strong. Results are available upon requests.

6. Conclusions

The results presented are preliminary evidence about the attitude of the Italian firms toward the adoption of digital technologies, in particular cloud computing and artificial intelligence. While the former has been around for some time already, the latter has had a clear tipping point in 2022 when the generative artificial intelligence algorithms hit the market, giving display of the potential of this technology. We find that the majority of Italian firms adopted cloud computing and mostly considers it as a standard technology, whereas AI, and even more so generative AI, are still at their inception phase.

The adoption of digital technologies is happening at an uneven pace across regions and sectors. Firms located in the South and smaller firms have adopted both technologies less frequently. Variation across sectors is much higher for AI, with firms in the services sector displaying higher adoption rates, especially in professional services and in telecommunications.

Structured management practices and R&D expenditure, both characteristics reflecting a positive attitude toward innovation and new technologies, are positively correlated with the use of AI. Early adoption of both could computing and AI is associated with the use of AI in the following years and, in particular, with the introduction of new GenAI technologies.

Finally, findings do not seem to indicate that, at least for the moment, a capital-labor replacement effect is in play. Firms expect, in the medium term, the creation of new and different jobs as well as a re-composition of the tasks performed, while the concerns about a reduction of the headcount seem limited. Moreover, we find that the adoption of these technologies is positively associated with a better firm performance, in terms of higher realized and expected employment growth. Whether these patterns will change as the diffusion of AI progresses remains to be seen.

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Appendix A

Figure A1. Questionnaire

INVIND 2020

Now consider the advanced technologies listed below:	Is the technology currently used in your firm?	**If not**, do you intend to adopt it over the next two years?
Cloud computing ..... (Yes/No)	TEC2BNA	TEC2BNB
Big data ..... (Yes/No)	TEC5BNA	TEC5BNB
Artificial intelligence ..... (Yes/No)	TEC5ANA	TEC5ANB
Advanced robotics ..... (Yes/No)	TEC11NA	TEC11NB
3D printing ..... (Yes/No)	TEC14NA	TEC14NB

INVIND 2024

Looking at the advanced technology listed below: how much is it used at your firm in the production process and/or in support activities?	
A Cloud computing (set of hardware and software resources for processing and storing network data)	TEC2N
B Predictive (such as text mining, voice and image recognition or machine learning) **and/or generative artificial intelligence** (such as chatbots, virtual assistants and tools for the autonomous production of original texts, codes, images, and audio and video clips)	TEC5N
C Robotics (machines that are automatically controlled, reprogrammable and multipurpose)	TEC11N
D Interconnection in the production process (e.g. the Internet of Things and radio frequency identification)	TEC8N
Legend: *1 = extensive use; 2 = limited use; 3 = only experimental uses; 4 = not currently used but expected to be introduced by December 2024; 5 = not currently used and not expected to be introduced by December 2024.*	
If you use Artificial Intelligence (1, 2 or 3 for question B):	
Does your firm use generative tools as part of its artificial intelligence technology?	TEC22

1 Yes, more than it uses predictive tools
2 Yes, to the same extent that it uses predictive tools
3 Yes, less than it uses predictive tools
4 No

*If your answers to the previous **B** or **C** questions are from 1 to 4:*

How important are the following objectives when choosing to use Artificial Intelligence and/or robotics?	Artificial Intelligence	Robotics
Automation of tasks previously done by workers	TEC23AA	TEC23AB
Improvement of methods and/or production processes among those previously automated	TEC23BA	TEC23BB
Enhancement of the qualities and reliability of work support processes	TEC23CA	TEC23CB
Broadening the range of goods and/or services produced	TEC23DA	TEC23DB
Legend: *1 = not important; 2 = not very important; 3 = somewhat important; 4 = very important.*		

Artificial intelligence

22 What is the likelihood that your firm will integrate generative artificial intelligence tools *('GenAI')* **into the following work processes over the next 12 months?** *(GenAI uses information provided by the user, such as text, images, audio or other, to generate customized replies to incoming prompts. Examples of GenAI include ChatGPT, Google Bard/Gemini, Dall-E, Claude, Synthesia, and Dream Machine)***.**

A production	**P202A**
B business accounting	**P202B**
C financial management	**P202C**
D staff management	**P202D**
E business relations (interactions with customers and suppliers)	**P202E**

***Answers**: 1 = unlikely; 2 = not very likely; 3 = somewhat likely; 4 = very likely; 5 = we already use GenAI in this process; 9 = do not know, do not wish to answer.*

23 What is the likelihood that the following events will occur in a firm similar to yours (by size and business sector) over the next 2 years?

A the use of GenAI will result in new job opportunities (e.g. internationalization of some activities or creation of new professional profiles)	**P203A**
B the use of GenAI will result in a reconfiguration of job descriptions within the company, with the number of employees remaining unchanged	**P203B**
C some tasks will be handled with GenAI and will no longer be assigned to dedicated staff	**P203C**
D the use of GenAI will result in more jobs	**P203D**
E the use of GenAI will result in fewer jobs	**P203E**
F the use of GenAI will pose a risk to the firm's confidential data	**P203F**

***Answers**: 1 = unlikely; 2 = not very likely; 3 = somewhat likely; 4 = very likely; 9 = do not know, do not wish to answer.*

Table A1. Data coverage

	Number of surveyed firms	Number of respondents (share)
Invind 2020[23]	3183	2070 (65%)
Invind 2024	4131	3356 (81%)
Sondtel 2024	4085	3068 (75%)

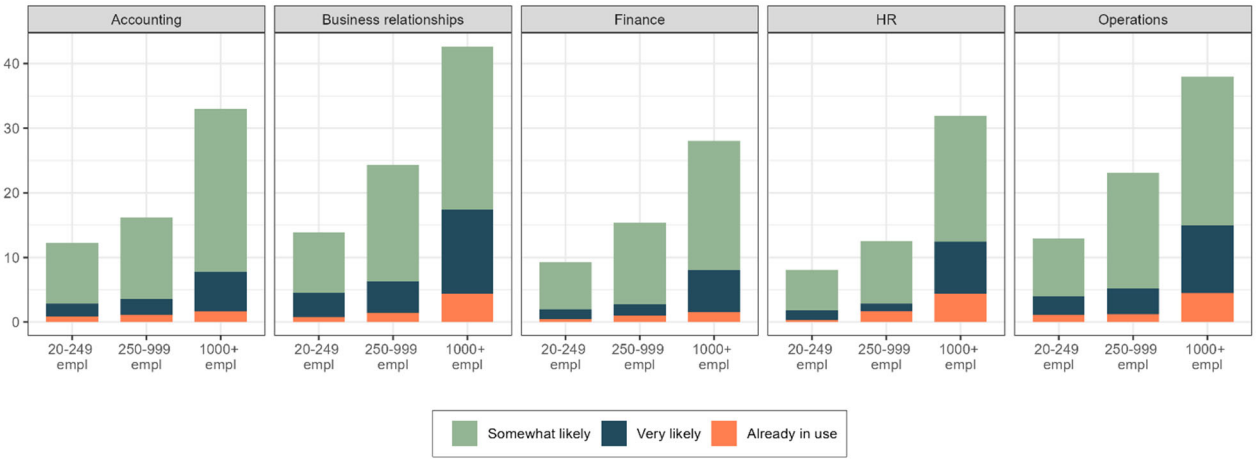
Table A2. Sector grouping

Branches of economic activity

	NACE 2007 section	NACE 2007 divisions	Sectors of economic activity	Sector aggregations used in the tables
Industry excluding construction	C	10–12	Food products, beverages and tobacco	Other manufactures
		13–15	Textiles, clothing, leather and footwear	Textiles, clothing, leather and footwear
		19–22	Chemical, rubber and plastic products	Chemical, rubber and plastic products
		23	Non-metallic minerals	Other manufactures
		24–30; 33	Basic metals and engineering	Basic metals and engineering
		16–18; 31–32	Other manufactures (wood, pulp and other)	Other manufactures
	B	05–09	Mining and Quarrying	Energy and extractive industries
	D	35	Electricity supply	Energy and extractive industries
	E	36–39	Water supply	Energy and extractive industries
Construction	F	41–43	Construction	Construction
Private non-financial services	G	45–47	Wholesale and retail trade, repair services	Distribution, lodging and catering
	I	55–56	Lodging and catering	
	H	49–53	Transport and storage	Transport, storage and communication
	J	58–63	Information and communication services	
	L, M, N (a)	68–75; 77–82	Other services provided to enterprises and households	Other services provided to enterprises and households

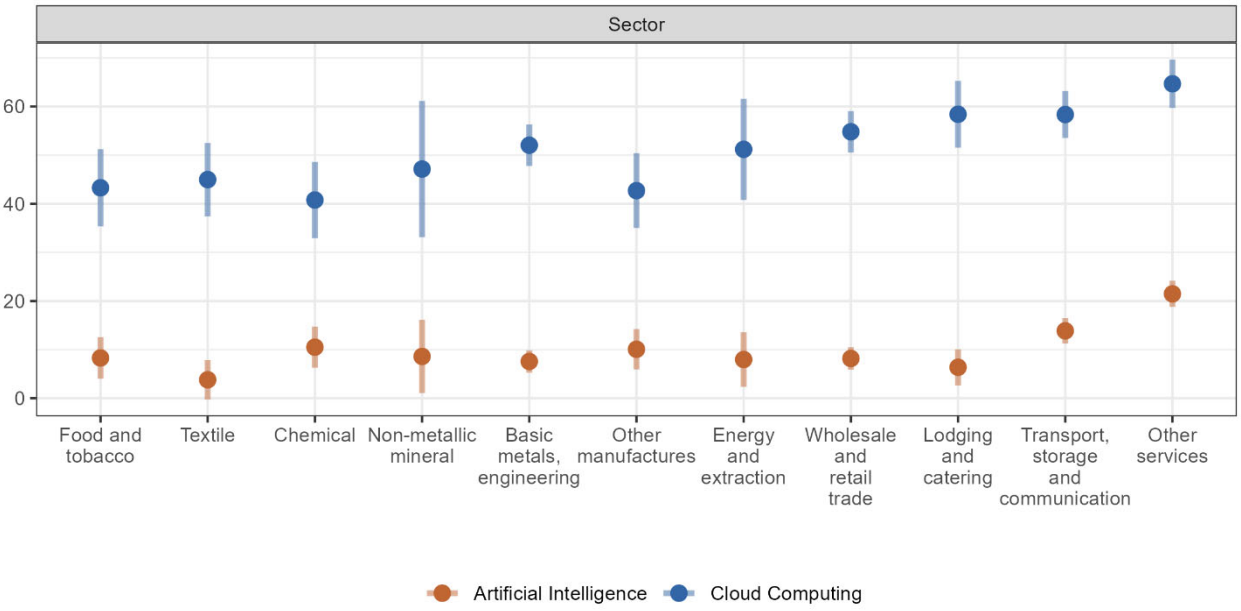
(a) Includes: L = real-estate activities; M = Professional, scientific and technical activities; N = renting, travel agencies, support services to enterprises.

Figure A2. Use of GenAI in corporate functions by probability assigned to adoption in the next 12 months



Notes: own elaboration on Sondtel data. Share of firms expecting to use GenAI over the next 12 months, by size group and corporate function. Weighted statistics by the number of firms.

Figure A3. Adoption rates by firm sectors, conditional means 2024



Notes: own elaboration on INVIND 2024 data. Marginal means of a linear probability model with response variable equal to 1 if the firm makes an extensive or limited use of the digital technology and 0 otherwise, adjusted for dimension, geographical area, age, exporter status and grouping structure of the firm. Weighted statistics by the number of firms.

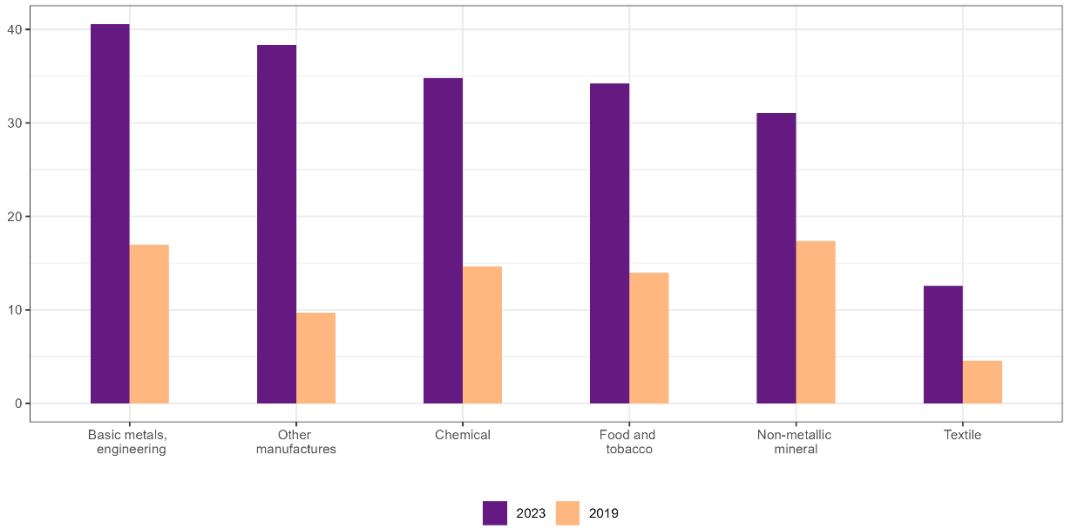
Appendix B – Robotics

Table B1. Adoption rates of robots

	Firm weighted		Employment weighted	
	2020	2024	2020	2024
All sectors	7.0	19.4	18.2	34.1
Manufacturing only	13.1	31.0	30.1	53.9

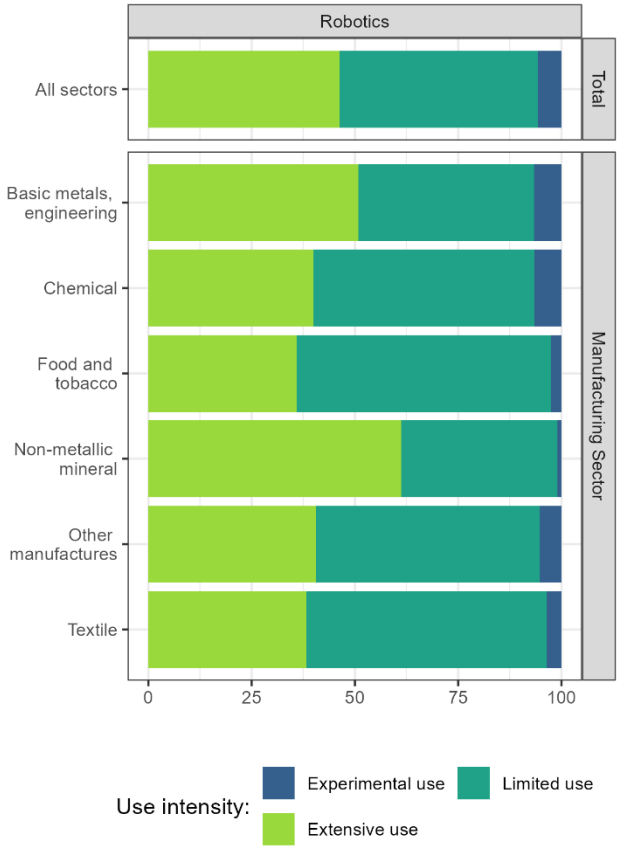
Notes: own elaboration on INVIND 2020 and 2024 data. Share of firms adopting robotics. Weighted statistics.

Figure B1. Adoption rates of robotics by sector, 2020 and 2024



Notes: own elaboration on INVIND 2020 and 2024 data. Share of firms adopting robotics by sector of activity. Only firms in the manufacturing are considered. Weighted statistics by the number of firms.

Figure B2. Adoption intensity by sector, 2024



Notes: own elaboration on INVIND 2024 data. Use intensity of robotics across firms that are currently adopting them, by sector. "Total" refers to the whole manufacturing sector. Weighted statistics by the number of firms.