“How can data analytics and employee upskilling foster digital maturity and sustainable practices in SMES?”

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HOW CAN DATA ANALYTICS AND EMPLOYEE UPSKILLING FOSTER DIGITAL MATURITY AND SUSTAINABLE PRACTICES IN SMEs?

Abstract

The accelerating pace of digital and environmental transformation presents both opportunities and challenges for small- and medium-sized enterprises (SMEs) across the European Union. While digital tools like data analytics can significantly boost operational efficiency and sustainability, many SMEs lack the internal capabilities to fully leverage them. This study investigates how upskilling employees in digital competencies can help SMEs enhance their digital maturity and achieve long-term resilience. A descriptive trend analysis was based on Eurostat datasets focusing on enterprise size categories and examining indicators such as data analytics activities, the prevalence of ICT training, and difficulties encountered in recruiting ICT specialists. Visualized through Tableau, the data reveal notable disparities: in 2023, only 14.5% of small and 33.8% of medium-sized enterprises with high digital maturity performed data analytics, compared to 59.4% of large enterprises. Despite clear demand, only 5% of small and 20% of medium enterprises attempted to recruit ICT-skilled personnel, frequently citing a lack of qualified candidates or unaffordable salary expectations. SMEs rely on their own staff for data analytics tasks, yet many still do not offer structured training. While countries like Finland stand out, with 61.7% of medium enterprises providing ICT upskilling, others fall well below the EU average. These results underscore that internal skill development is not just a workaround but a strategic necessity for SMEs striving to keep pace with digital demands, overcome labor market constraints, and build a foundation for sustainable growth.

Keywords sustainability, training, digitalization, strategy, competences

JEL Classification O33, O44, M15

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INTRODUCTION

Companies are trying to maintain and strengthen their competitive advantage, which is essential for increasing their digital maturity, i.e., the level of how well they can utilize digital technologies.

According to the targets of the European Union, several strategies, policies, and initiatives have been prepared, and the development of the digital economy and society is a significant part of it. With the concept of digital transformation, the SME sector became one of the biggest potential users of advanced data analytics. The integration of digital solutions into business strategies has become crucial, and a corporate digital strategy is essential to ensure a smooth information flow, both internally and externally, throughout the value chain. Integrating digital innovation into the digital strategy can also increase business resilience. Due to the numerous operating processes that utilize digitalized data (such as transaction data or the Internet of Things), a large amount of data is readily available for transformation

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into data warehouses and analysis. The analysis of these data helps in identifying inefficient points of the business processes and finding bottlenecks. The quantity and quality of these types of data can also be used in advanced data analytics. These data support many decisions related to the optimization of material, financial, and information resources, increasing cooperation, and forecasting. The directions are clear regarding the performance of the enterprises. To achieve the targeted numbers, enterprises operating in the sector must increase their innovation capacity and adoption of digital technologies, and upskill their current workforce to equip them with the necessary skill sets to enhance innovation levels.

1. LITERATURE REVIEW

Digital transformation encompasses a broader organizational shift toward embracing digital technologies to drive innovation, create new business models, and adapt to changing market dynamics (Samper et al., 2022). By embracing digital transformation and creating digital strategies, SMEs can increase their digital competitiveness and overcome implementation barriers (Ritala et al., 2021).

Digital transformation can create stronger synergies between different business processes, and it can also improve operational efficiency and information flow within the company (Merín-Rodrigáñez et al., 2024). To successfully implement digital transformations, SME leaders need to equip employees with the necessary digital literacy skills (Wu et al., 2024). A successful digital transformation should enable a company to be more agile and responsive to market changes, including the ability to quickly adapt to shifting customer needs, emerging trends, new technologies, and evolving regulations. Improved data management processes can also lead to a successful digital transformation, starting with the implementation of more efficient data collection and analysis methods, enhanced data security, and the use of analytical data to support decision-making (Heubeck, 2023).

Digital transformation is successful if it improves the efficiency of the company's current business processes, which can contribute to better revenue generation. This could manifest in reduced costs, streamlined processes, and increased productivity (Peng & Tao, 2022). As digital maturity is becoming crucial, enterprises are expected to be up-to-date and aware of current digital trends and solutions in each industry, such as data analytics, which, when utilized, organizations will be endowed with the ability to discover their true competitive advantages (Afaishat et al., 2024) and potential weaknesses (Viana et al., 2023).

With the growing level of digitization in supply chains, the adoption of advanced technologies to develop enterprise digital maturity is becoming crucial for SMEs. Thus, enterprises should pay close attention to it (Sakas et al., 2023). Digital innovation is revolutionizing the way businesses operate, with data analytics at the forefront of this transformation (Uršič & Čater, 2024). By leveraging sophisticated data analytics tools, companies can extract valuable business insights that drive decision-making and strategic planning (Cubric & Li, 2024). These insights enable organizations to identify trends, optimize operations, and anticipate market changes, ultimately providing a significant competitive advantage (Saeedikiya et al., 2024). In an increasingly competitive landscape, the ability to harness and interpret data effectively can set a business apart from its rivals, fostering growth and enhancing profitability (Bachmann & Jodlbauer, 2023).

Moreover, the integration of digital innovation extends beyond mere operational efficiencies to embrace broader goals of environmental sustainability (Okolo et al., 2023). The digital transition plays a pivotal role in the green transition as companies seek to minimize their environmental footprint through smarter, technology-driven practices (Martins et al., 2022). Advanced analytics and IoT-enabled monitoring systems allow businesses to track and reduce energy consumption, cut down on waste (Yadav et al., 2024), and manage resources through CRM and ERP systems (Ganahl et al., 2023) more effectively. This convergence of digital and green initiatives not only enhances sustainability efforts but also builds a resilient, future-ready business model (Ma & Wang, 2024) that aligns with global sustainability goals and regulatory requirements (Năstasă et al., 2024).

Numerous studies examine the benefits of digital transformation and data analytics for enterprises (Table A1 in Appendix A). These articles evidently focus on potential challenges and barriers that are preventing companies from carrying out a successful digital transformation. One of the most hindering factors is the lack of relevant knowledge and poor digital skills within the enterprises, which affects many territories. In today's digital landscape, privacy and data protection concerns are increasingly prevalent (Kumar et al., 2024), posing significant challenges to organizations.

Implementing a corporate digital responsibility (CDR) strategy can effectively address these concerns, ensuring that data analytics practices are conducted transparently and ethically (Lobschat et al., 2021). By adopting CDR practices, companies can enhance trust and mitigate risks associated with data misuse, thereby fostering a secure environment for data-driven decision-making that prioritizes social and environmental principles (Rugeviciute, 2023).

CDR policies should focus on how data are collected, managed, analyzed, and then interpreted by decision-makers (Cheng & Zhang, 2023). As ICT-related questions are getting more strategic weight in business-related decisions, it is of utmost importance for SMEs to develop comprehensive CDR practices. SMEs frequently handle sensitive customer information, making data protection critical for maintaining trust and compliance with regulations such as the GDRP (Zafar et al., 2024).

As digital transformation accelerates, ensuring robust data protection measures is essential for SMEs to protect customer privacy (Soori et al., 2024) and ensure business continuity (Kalaitzi & Tsolakis, 2022). Naturally, to develop these practices and policies, SMEs should allocate resources to train and upskill employees or hire new staff with the relevant digital skills (Shaik et al., 2024).

The aim of this study is to examine the current data analysis practices with the help of descriptive statistical visualizations among the EU member states based on secondary datasets in 2022 and 2023. The paper highlights their importance in relation to digital maturity and how they can jointly improve the sustainability of SMEs through the internal skill development of their own employees. Moreover, it is interesting to discover factors hindering the hiring of ICT-skilled employees in SMEs.

2. METHODOLOGY

This paper attempted to discover the current trends in data analytics among small and medium-sized enterprises (SMEs) in the European Union by highlighting similarities and differences in applied ICT and employee hiring trends with the utilization of visualized descriptive statistical figures. It was examined whether tasks related to data analytics are performed mainly internally by employees or they are outsourced to third-party organizations and how much resources they spend on internal skill training.

Additionally, the study focused on understanding how the digital maturity levels of SMEs have evolved from 2021 to 2023, extending to recruitment practices and the difficulties companies face

Table 1. Eurostat indicator set

Source: Own elaborations based on Eurostat (n.d.) datasets.

Year	Indicator code	Label	Missing country	Missing sector
2023	E_DA	Data analytics for the enterprise is performed by the enterprise's own employees or by an external provider	Portugal	50-249
2023	E_DAEXT	Enterprises where data analytics for the enterprise is performed by an external enterprise or organization	Portugal	50-249
2023	E_DAOWN	Enterprises where data analytics for the enterprise is performed by own employees	Portugal	50-249
2022	ISOC_SKE_ITRCRS	Enterprise recruited/tried to recruit personnel for jobs requiring ICT specialist skills in 2022 per country and size class (%)	Portugal	ALL
2023	E_DI3	Enterprises with high digital intensity index analyzing data (v3) (%)	Portugal	50-249
2022	ISOC_SKE_ITTS	Enterprises that provided training to develop/upgrade ICT skills of their personnel (%)	Montenegro	50-249

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when hiring ICT specialists, such as a lack of applicants, excessively high salary expectations, or insufficient education and experience from the candidate side. A secondary data collection was performed based on Eurostat databases, and Tableau was utilized to create comprehensive data visualizations.

It is believed that SMEs should focus on internal training and upskilling their employees to achieve more efficient digital transformations and be more resilient.

Table 1 summarizes the analyzed Eurostat variables from secondary data collection with their brief description. The missing values (where data were not available) were also indicated. The collection was performed by SME size categories (1–49, 50–249, 250+). In the case of Portugal, some of the data values were missing, mainly for the medium sector, due to confidentiality.

3. RESULTS AND DISCUSSION

The Digital Intensity Index (DII-v3) is a composite Eurostat indicator that aims to measure how well companies can integrate digital solutions into their business processes and organizational culture (Leogrande, 2022) per country for comparison. According to Criveanu (2023), a high level of digital intensity can support sustainability practices and boost innovation and efficiency within a company. Performing data analytical activities is one of the twelve key aspects that determine the level of digital intensity of companies.

The changes in the level of DII can be seen in Figure 1, from 2021 to 2023, by size category, where data analytics had the most significant influence on the collected data. The indicator shows a decline in the percentage of companies with very low DII, indicating progress in digital adoption. Additionally, there has been a marked increase in the number of SMEs reaching high and very high DII levels, signifying a positive shift toward greater digital engagement.

Figure 2 delineates the distribution of the Digital Intensity Index (v3) across SME size categories, revealing significant disparities in digital adoption.

Small enterprises predominantly fall into the very low digital intensity category, with 45.4% lagging in digital integration. In contrast, only 3.5% of small enterprises achieve very high digital intensity. Medium enterprises present a more balanced distribution across the spectrum, yet they still gravitate toward the lower end, with 24.0% in the very low category and only 9.6% reaching very high digital intensity. Large enterprises demonstrate a pronounced inclination toward higher digital intensity levels. While only 9.0% of large enterprises are in the very low category, a substantial 26.3% achieve very high digital intensity.

Source: Own elaborations based on Eurostat (n.d.) datasets.

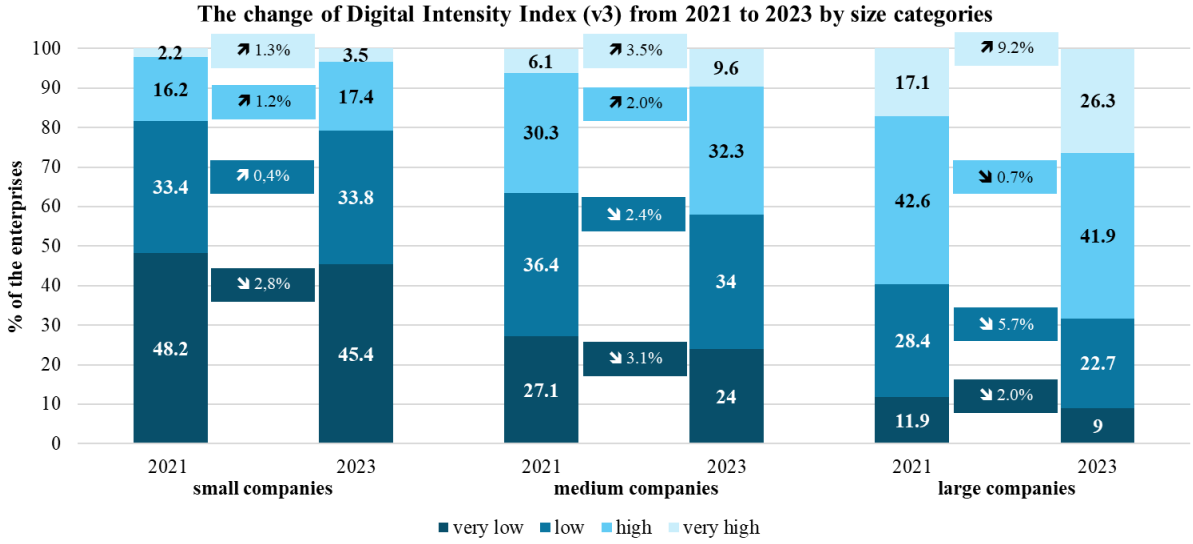

Figure 1. Changes in Digital Intensity Index (v3) from 2021 to 2023 by size categories

Source: Own elaborations based on Eurostat (n.d.) datasets.

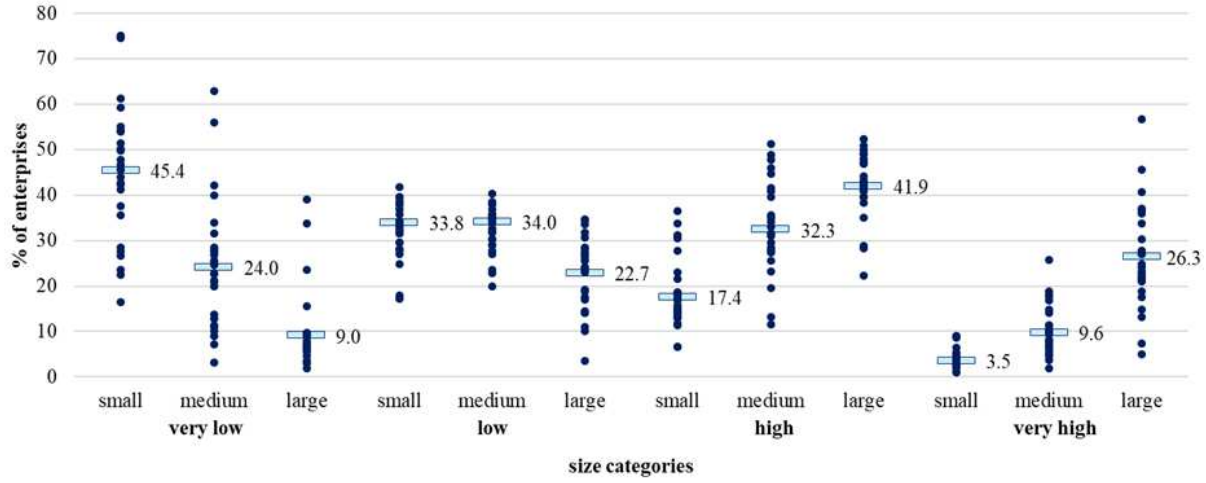

Figure 2. Values of Digital Intensity Index (v3) per enterprise size categories (%)

These findings suggest a clear correlation between enterprise size and digital intensity. Moreover, they underscore the need for targeted strategies and support to help more SMEs overcome barriers to digital adoption and fully harness the benefits of advanced technologies. Addressing these challenges is crucial for fostering a more digitally robust and competitive business landscape.

However, despite these advancements, a significant proportion of SMEs still remain at very low and low DII levels. This persistent issue highlights the ongoing challenges in achieving widespread digital transformation within this sector.

Figure 3 presents an insight into how powerful the effect data analytics can have on DII levels. In 2023, the percentage of enterprises with aggregated high and very high Digital Intensity Index that perform data analytics varied significantly across Europe. Although most of these companies are considered digitally mature, they are not or barely performing such activities. The gradient coloring is from red (performing under the EU-27 average) to green (performing over the EU average). For small companies, the EU average is 14.52%; for mediums, it is 33.84%; and for large ones, it is 59.45%. The highest-performing countries are Finland, Denmark, and the Netherlands. The laggers are Bulgaria and Romania.

Source: Own elaborations based on Eurostat (n.d.) datasets.

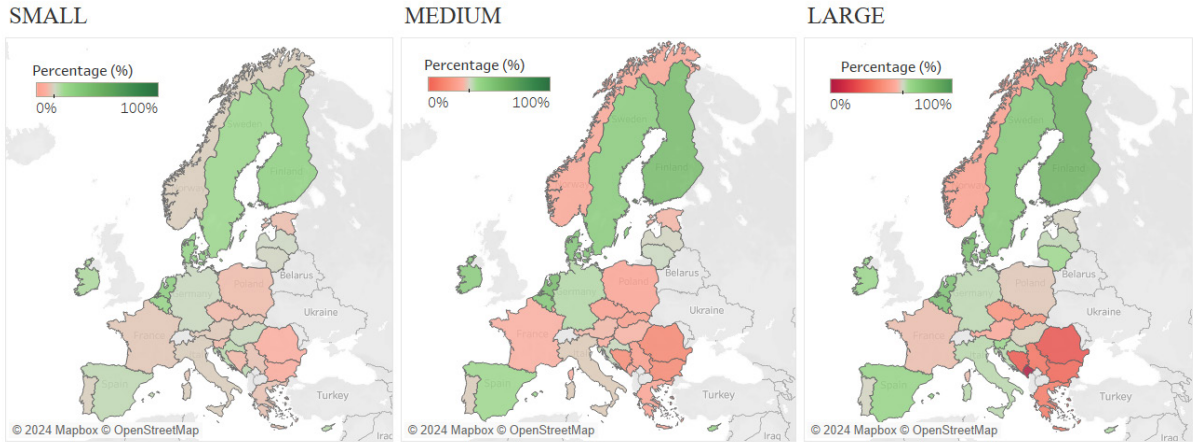

Figure 3. Enterprises with aggregated high and very high Digital Intensity Index, which perform data analytics per country and size category in 2023 (%)

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Small enterprises that perform data analytics in Nordic countries (Sweden, Finland), Ireland, and the Netherlands exhibit high digital intensity, moderate levels in Germany and Denmark, and low levels in Eastern and Southern Europe (Poland, Romania, Spain, and Greece). Medium enterprises follow a similar pattern with high levels in Finland and Sweden, moderate in Germany and the UK, and low in France, Spain, and Bulgaria. Large enterprises show very high digital intensity in Nordic countries, high in Germany, the UK, and the Netherlands, and lower in France, Poland, and Greece.

According to Yang et al. (2021) and Justy et al. (2023), the adoption rate of data analytics in SMEs remains low due to adoption barriers mainly, like lack of funds, lack of expertise in data protection, technical knowledge, and organizational culture.

To further analyze the lack of technological knowledge factor in SMEs, Figure 4 discovers who performs the data analytic activities. The results indicate that, in most cases, the companies' own employees are responsible for creating insights from company data. This means that there is an internal need to develop the ICT skills of employees in SMEs, which most companies acknowledge.

Where the sector of a given country exceeded the EU-27 average, the bar was highlighted in color; the rest was grayed out, performing under the EU-27 average. It is interesting to observe that the Hungarian small enterprises outsource most of the data analytical tasks within the EU, still having low digital intensity levels.

Eurostat collected data in 2022 on companies that attempted to recruit personnel for jobs requiring ICT specialist skills (Figure 5). The terminology was later extended to jobs, too, that required normal ICT skills from the applicants. The gradient went from red (0%), which represented organizations performing under the EU-27 average, to green (100%), performing over the EU-27 average.

For small enterprises, the EU average is 6.4%; for medium-sized ones, it is 19.42%; for large ones, it is 48.82%, indicating significant differences.

Small enterprises, which are often characterized by their limited resources and smaller employed workforce, showed the least engagement in external recruitment for roles requiring ICT skills (5%). This low percentage can be attributed to budget constraints, the preference for multifunctional roles within smaller teams, and potentially the reliance on existing staff to fulfill ICT needs.

Medium-sized enterprises exhibited a more proactive approach toward recruiting ICT specialists. Thus, 20% of them were engaged in external hiring. In most cases, these firms are in a phase of

Source: Own elaborations based on Eurostat (n.d.) datasets.

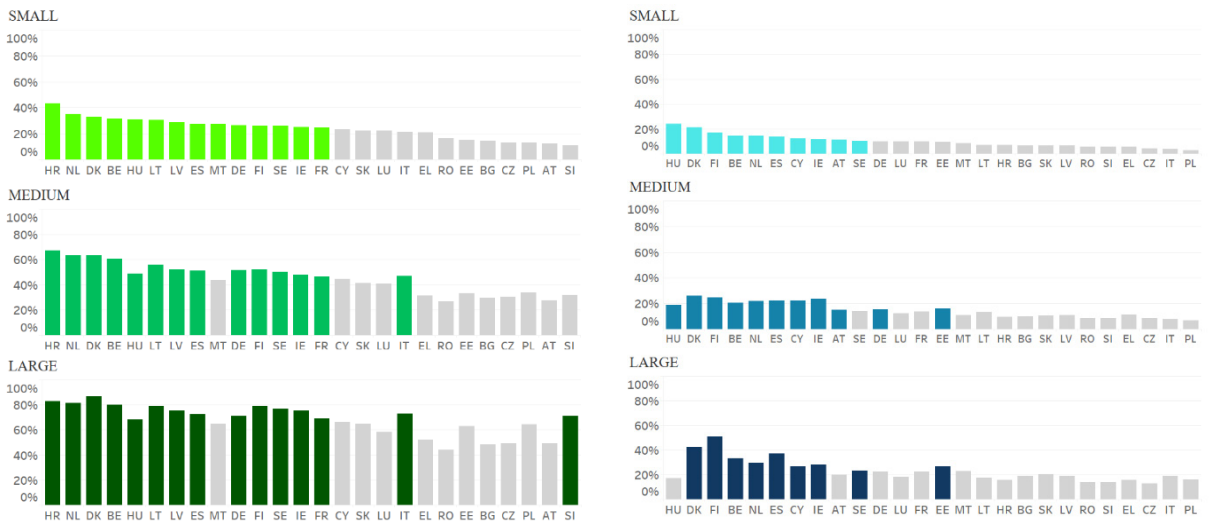

Figure 4. Enterprises where own employees perform data analytic tasks, or they were outsourced to third-party organizations in 2023 (%)

Source: Own elaborations based on Eurostat (n.d.) datasets.

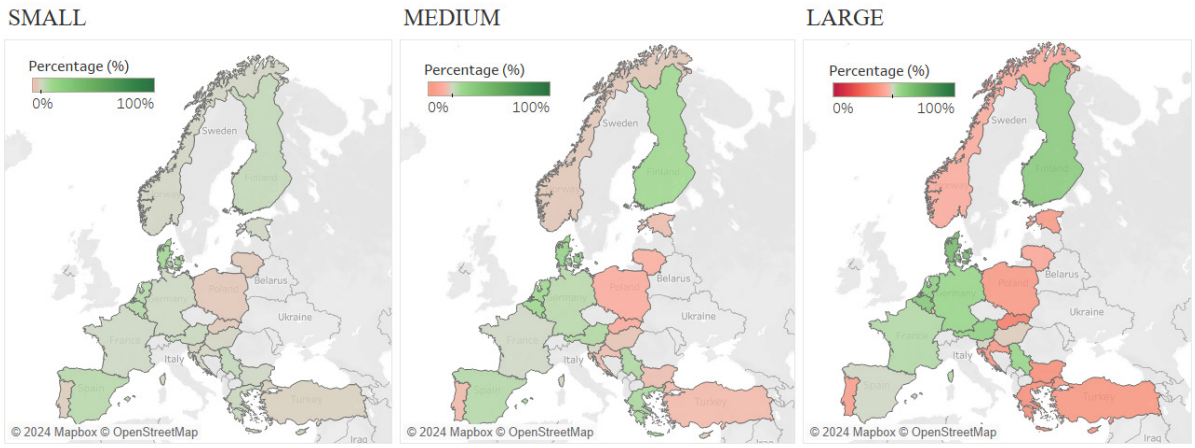

Figure 5. Enterprise that recruited/tried to recruit personnel for jobs requiring ICT specialist skills in 2022 per country and size class (%)

scaling up; they tend to integrate ICT solutions into company processes to support their growth, enhance operational efficiency, and remain competitive. The moderate engagement level suggests a balanced approach, where medium-sized businesses might be combining internal upskilling with selective external recruitment to meet their ICT requirements.

Large enterprises, with their substantial resources and complex operational demands, had the highest percentage of external ICT specialist recruitment (55%). This high engagement level reflects the critical need for advanced ICT expertise to manage sophisticated digital infrastructures, drive innovation, and maintain a competitive edge in the market. Large enterprises often have the financial capacity and strategic imperative to invest heavily in specialized ICT talent.

SMEs can experience difficulties when they opt for external hiring for jobs requiring ICT skills in the EU, which could explain the low engagement levels.

The primary reason for these difficulties appears to be the applicants' lack of relevant ICT-related qualifications from education and/or training (Figure 6), leading to a shortage of candidates with the necessary skills and knowledge in specific ICT fields required by the enterprises. Finding candidates who not only have the necessary ICT skills but also the relevant work experience (Figure 6) that recruiters require is also a hindering factor.

Another reason could be the high salary expectations of applicants (Figure 7), which often exceeds what enterprises are willing or able to offer for

Source: Own elaborations based on Eurostat (n.d.) datasets.

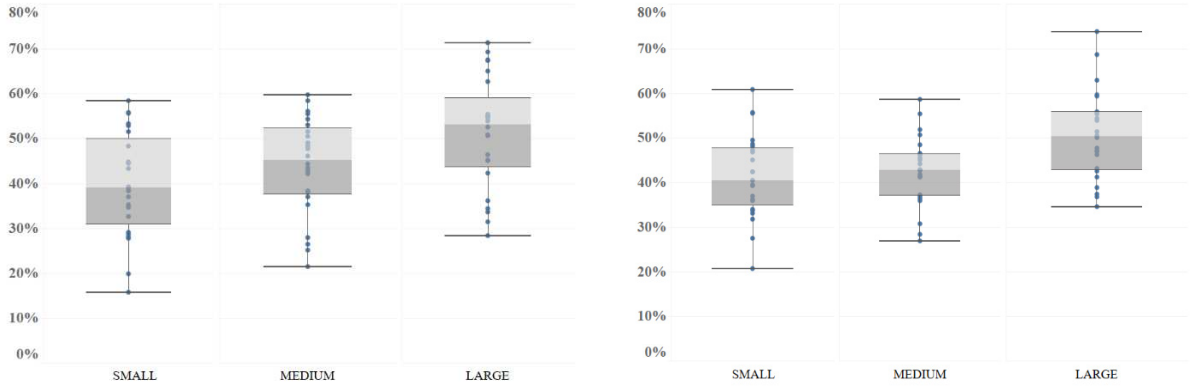

Figure 6. Enterprises encountering difficulties when trying to recruit employees for jobs requiring ICT specialist skills in 2022: Applicant has no relevant education or work experience (%)

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Source: Own elaborations based on Eurostat (n.d.) datasets.

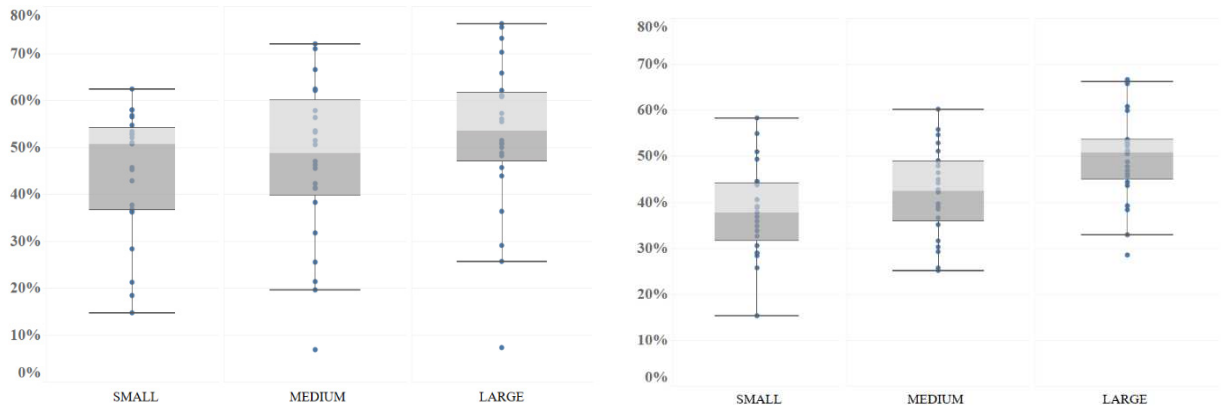

Figure 7. Enterprises encountering difficulties when trying to recruit employees for jobs requiring ICT specialist skills in 2022: Applicant's salary expectations are too high, and no applicants applied for jobs (%)

specific vacant positions, thus deterring the candidates from accepting job offers. Per the last difficulty factor, the number of candidates responding to job postings can be insufficient sometimes (Figure 7), leading to difficulties in finding suitable candidates for positions requiring ICT skills; thus, training employees internally should be in focus more regularly for SME leaders.

Figure 8 presents a comprehensive overview of the proportion of SME enterprises that offer training to employees to develop their ICT skills per size categories. The heatmap provides a clear indication of how each country performs in this activity. The green highlighting represents performance above the EU average, and the red coloring indicates performance below average.

Countries like Finland, Denmark, and the Netherlands exhibit strong performance in this activity across all enterprise sizes, consistently surpassing the EU average. Finland stands out with impressive figures: 34.1% for small, 61.7% for medium, and 87.2% for large enterprises.

On the other hand, countries such as Bosnia and Herzegovina and Bulgaria exhibit significantly lower engagement in providing ICT training, with Bosnia and Herzegovina having only 13.3% of small enterprises and 21.1% of medium enterprises offering such training, which is markedly below the EU average. The large companies in Greece, Romania, and Montenegro also stand out with their low engagement.

These trends highlight crucial areas not only for businesses but for policy intervention and support to ensure a more skilled workforce across the continent, particularly as digital transformation continues to accelerate globally.

Digital transformation can help businesses in several areas and has a high potential to make their social, economic, and environmental processes more effective. According to the goals of the European Union, this transformation is essential to maintain an appropriate level of business maturity level for which a skilled workforce is needed, and in most cases, it means the development of the current workforce. Businesses must include digital solutions in their business models as well, which should be guided by a digital strategy. Therefore, they need to be well equipped with the new digital solutions and provide training to their employees to make the transformation successful, which indicates a clear skill demand in the job market. This does not mean the capability to use these solutions themselves but also an overall knowledge of how they can integrate them into current business functions. The situation with SMEs is not easy when they must decide on investments, as financial constraints are one of the biggest barriers they face. With well-defined strategic goals and a clear vision, they can utilize their available skilled workforce to easily determine optimal solutions or alternatives for scaling up their digital readiness, resulting in a cost-effective investment in digital technology implementation (e.g., Cloud Computing and Storage, Open-Source solutions, Scalable solutions).

Source: Own elaborations based on Eurostat (n.d.) datasets.

	SMALL	MEDIUM	LARGE
Austria	14.7%	42.4%	75.0%
Belgium	26.8%	57.6%	87.1%
Bosnia and Herzegovina	13.3%	21.1%	45.3%
Bulgaria	6.6%	17.1%	41.0%
Croatia	17.2%	33.5%	61.4%
Cyprus	24.4%	47.1%	74.9%
Czechia	15.9%	43.4%	79.9%
Denmark	27.2%	54.8%	80.8%
Estonia	14.5%	33.9%	67.3%
Finland	34.1%	61.7%	87.2%
France	11.2%	30.0%	61.7%
Germany	22.1%	44.8%	72.6%
Greece	10.4%	34.5%	38.3%
Hungary	14.0%	34.2%	70.7%
Ireland	19.2%	36.3%	68.2%
Italy	16.1%	37.4%	65.4%
Latvia	10.9%	30.6%	71.8%
Lithuania	8.8%	24.7%	60.4%
Luxembourg	16.6%	39.4%	65.7%
Malta	23.7%	43.4%	72.7%
Montenegro	23.2%	25.1%	32.3%
Netherlands	22.2%	51.8%	79.1%
North Macedonia	9.1%	18.4%	69.5%
Norway	30.1%	54.9%	80.1%
Poland	18.9%	43.5%	80.3%
Portugal	20.2%	40.0%	70.2%
Romania	6.7%	13.9%	36.4%
Serbia	17.5%	33.9%	60.0%
Slovakia	10.8%	26.3%	60.5%
Slovenia	22.6%	52.3%	81.2%
Spain	16.3%	38.2%	68.9%
Sweden	29.5%	53.9%	80.1%
Türkiye	13.6%	25.7%	53.1%

Figure 8. Enterprises that provided training to develop/upgrade employees ICT skills (%)

As Eurostat plans to release statistics in a comparable way every two years regarding digital intensity levels and hiring tendencies regarding the applications of employees, this study can be a foundation of a future article discussing future trends in more depth.

Table 2 summarizes possible methods for how SMEs can develop their employees to upgrade their ICT skills and widen their knowledge of sustainability practices. A higher level of training can enhance employees' skills and learning abilities in the long term, laying the foundation for a creative and innovative workplace environment (Banmairuroy et al., 2022).

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Table 2. Methods to upskill employees

Source: Own elaborations based on Zerguine et al. (2024), Borms et al. (2023), Pilav-Velic et al. (2024), Puttonen et al. (2022), Raghunath et al. (2023), Pailman and Groot (2022), Khazanchi et al. (2022), Wongsansukcharoen and Thaweepaiboonwong (2023), Gladysz et al. (2023), Jackson et al. (2022), Koilo (2024).

Method	Description
Workshops and Seminars	Structured training sessions focusing on specific skills or topics, such as data analytics tools, ICT best practices, and sustainability issues
Online Courses	Utilizing platforms like Coursera, edX, Udemy, and LinkedIn Learning to provide employees with access to a wide range of courses on ICT, data analytics, and sustainability
Mentorship Programs	Pairing less experienced employees with seasoned mentors who can provide guidance, support, and knowledge transfer on relevant skills
Internal hackathon	Organizing internal competitions where employees work on solving ICT and data analytics challenges, fostering creativity and practical problem-solving skills
Certification Programs	Supporting employees in obtaining professional certifications in areas such as data analytics, ICT, and sustainability from recognized institutions
Guest Lectures	Inviting industry experts to deliver lectures or talks on innovative ICT trends, data analytics advancements, and sustainability strategies
eLearning Modules	Developing or purchasing interactive online modules focused on specific skills, allowing employees to learn at their own pace
Job Rotation	Rotating employees through different roles and departments to expose them to various aspects of the business and develop a broader skill set
Knowledge Sharing Platforms	Implementing internal platforms or forums where employees can share resources, insights, and best practices related to ICT and sustainability
Work-Integrated Learning	Partnering with educational institutions to offer work-integrated learning opportunities, such as internships or co-op programs, focusing on ICT and sustainability

CONCLUSION

The primary objective of this study was to investigate the current trends and challenges related to data analytics and digital transformation within SMEs in the European Union. Specifically, the study examined how these organizations perform data analytical tasks internally or through outsourcing, their involvement in ICT skills development, and the evolving recruitment practices for ICT specialists from 2021 to 2023. The paper leveraged secondary data from Eurostat and utilized visualized descriptive statistics to uncover meaningful insights by enterprise size and geography.

The analysis revealed that while digital intensity levels are generally improving, significant disparities remain, especially among small enterprises that lag in digital adoption. Internal employee involvement in data analytics is prevalent across all SME categories, yet the insufficient digital skills among staff and barriers to hiring qualified ICT professionals pose considerable challenges. Moreover, the study confirmed that digital maturity is closely tied to both enterprise size and national context, with Northern European countries leading in digital intensity and training initiatives while Eastern and Southern regions struggle.

These findings point to several important conclusions. First, internal upskilling remains a critical factor for advancing digital readiness in SMEs. Enterprises that invest in workforce development are more likely to reach higher digital intensity levels and better adapt to technological advancements. Second, reliance on internal staff for data analytics underlines the urgency for targeted, scalable, and cost-effective training methods tailored to SME capabilities. Third, recruitment challenges, ranging from high salary expectations to a lack of qualified applicants, further reinforce the importance of nurturing in-house talent.

The paper suggests exploring the longitudinal impact of specific training programs on SME digital performance, as well as the role of government and policy-level support in addressing regional and sectoral disparities. As Eurostat continues to release updated datasets biennially, this study provides a foundation for more in-depth, predictive analyses of the digital transformation of SMEs and their strategic workforce planning.

AUTHOR CONTRIBUTIONS

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APPENDIX A

Table A1. Collected and reviewed findings on digital transformation and data analytics benefits and challenges

SME description	Digital transformation domains	Drivers/Advantages	Barriers/Challenges	Practical implications	Reference
Country: France Sector: manufacturing and agriculture Survey: semi-structured interviews Sample: 35	Big data, data analytics	Identified exogenous factors: market, competition, and the Covid-19 crisis have positive effects	Identified endogenous factors: lack of strategy, necessary skills, and organizational culture have negative effects	Overview of the importance of data analytics for SMEs, investigating driving and hindering forces of ICT adaption	Justy et al. (2023)
Country: Finland Sector: service and manufacturing Survey: structured survey Sample: 250	Digital business strategy, sustainability, financial performance	A well-defined sustainability strategy has a positive impact on managerial capabilities and financial performance	Sustainability has limiting power on operational capability and financial performance	Sustainability must be integrated into business strategy	Ukko et al. (2019)
Country: Spain Sector: n.d. Survey: semi-structured survey and interview Sample: 26 (micro, very small and small)	Quality and security management systems	The worked-out method has eased implementation in an agile and innovative way, focusing on cost savings	Internal training of employees is critically important	A way to boost industrialization and process improvement in SMEs with lean aspects	Gaitero et al. (2021)
Country: Finland Sector: n.d. Survey: fully structured survey Sample: 280	Digital supply chain and smart technologies	Smart technologies mediate the relationship between digital transformation and relationship performance	Digital transformation and smart technologies can improve relationship performance	Investing in technologies can boost relationships and value creation throughout supply chains	Nasiri et al. (2020)
Country: Spain Sector: agri-food cooperatives Survey: structured survey Sample: 75	Digital maturity model	Enterprise size; position in value chain, sales channels	Economic barriers; challenges on food safety, food waste and sustainability	Size of agri-food cooperatives should be more emphasized in research and business practice	Santos et al. (2024)
Country: Hungary, Slovakia, Czechia, Poland, Serbia, Bulgaria Sector: agri-food sector and manufacturing sectors Survey: semi-structured survey and interviews Sample: 90	Digitalization of business processes (Industry 4.0 and Agri-food 4.0 transition)	General digital implementation factors for agri-food companies apply in the same manner as for other manufacturing sectors	Lack of digital skills and innovative organizational culture	Developing an innovative digital business model can help SMEs become digitally mature in Central and Eastern Europe	Varbanovaa et al. (2023)
Country: Romania Sector: mostly leather goods equipment and machinery manufacturing Survey: structured survey Sample: 27	Digitalized business environment	Digital transformation enhances communication with partners and customers, which results in improved service efficiency and quality	Stubbornness to change, lack of digital skills, financial constraints, employee morale, and innovation culture is poor	Digital transformation can boost information change between business functions, which results in enhanced operational and financial performance and service or product quality improvement	Mihu and Herciu (2024)
Country: Italy Sector: food, fashion, and furniture design industries Survey: semi-structured interviews Sample: 6	The impact of digital transformation on customer value creation Technologies involved: Big Data analytics, applications, QR codes, and chatbots	Usage of digital assets and solutions can boost digital innovation by creating new business models and opening up new sales channels to reach new customers	Unsupportive change management	Digital transformation is important to develop a better digital marketing reputation, which results in competitive advantage in the long run	Matarazzo et al. (2021)

Table A1 (cont.). Collected and reviewed findings on digital transformation and data analytics benefits and challenges

SME description	Digital transformation domains	Drivers/Advantages	Barriers/Challenges	Practical implications	Reference
Country: Latvia Sector: tourism, accommodation and catering, water and air transport, retail Survey: structured Sample: 425	Digital readiness assessment	Size influences the success of DT and how it is carried out	Fear of missing out, SMEs need assistance to carry out digital transformation (financial aids for employee training, mentoring, consultations, and tax relief can ease this fear)	Carrying out digital transformation has uniquely challenging problems varying per SME size, but its importance is acknowledged	Rupeika-Apoga et al. (2021)
Country: Latvia Sector: not specified Survey: structured Sample: 246	Digital orientation and digital capability	Digital transformation influences business strategy and streamlines processes, which usually positively impacts revenue levels	Employee digital skills must be developed in SMEs	The complexity of business models has an effect on the success of digital transformation	Rupeika-Apoga et al. (2022)
Country: Czechia Sector: 14 sectors involved Survey: 2 rounded survey Sample: 154 (74 were involved in a follow-up survey about threats)	Threats and opportunities of management in digital transformation	Sustainability is considered as a strategic opportunity by most companies	Digital transformation is very costly and time-consuming for SMEs. It is necessary to identify in their digital strategies which areas of digital transformation have a priority	SMEs are confused about perceived digital benefits and threats depending on their digital maturity levels	Šimberová et al. (2022)
Country: Germany Sector: 21 sectors involved Survey: structured survey Sample: 1100	Digital diffusion, collaboration with customers and suppliers	Diffusing digital solutions into business processes can positively trigger innovation in SMEs, especially in manufacturing	Company capabilities define the success of product innovations in SMEs	Digital technologies innovate business processes, SMEs with a high focus on R&D, and employee training can develop and innovate products better	Hassan et al. (2023)
Country: Latvia Sector: all Survey: structured Sample: 425 (MSMEs)	Sustainable digital transformation	Twin transitions boost sustainability practices in SMEs	Small firms: issues with lack of manager knowledge, Medium firms: issues with IT security, uncertainty about future digital standards, internal willingness to change, common: shortage of candidates with necessary digital skills, financing options.	Digital transformation barriers vary per SME size classes	Rupeika-Apoga et al. (2021)
Country: Greece Sector: manufacturing Survey: structured survey Sample: 1014	Industry 4.0 technologies, Absorptive capacity (skills, training, HR and R&D activities involved)	Innovation can be more effective if combined with the utilization of digital assets in SMEs	National policies should focus more on innovation support, R&D spending, employee training, communication with market actors	Firms have different capabilities per size categories, which could limit them in the way how they integrate, assimilate, and transfer new solutions and knowledge into business processes	Kastelli et al. (2022)

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