Adoption of Advanced Digital Technologies and Platforms: Insights from a UK national survey

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Abstract

Based on a national bespoke survey, this study provides an analysis of the adoption and impact of advanced digital technologies (ADTs), including AI, Big Data, Cloud Computing, 3D Printing, Internet of Things (IoT), and Robotics, as well as digital platforms in the UK. Through sectoral, regional, and organisational comparisons, this report sheds light on the widespread but varied adoption of these technologies, offering valuable insights into firms' outcomes related to productivity, skills development, and business processes.

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Executive summary

Based on a national bespoke survey, this study provides an analysis of the adoption and impact of advanced digital technologies (ADTs), including AI, Big Data, Cloud Computing, 3D Printing, Internet of Things (IoT), and Robotics, as well as digital platforms in the UK. Through sectoral, regional, and organizational comparisons, this report sheds light on the widespread but varied adoption of these technologies, offering valuable insights into firms' outcomes related to productivity, skills development, and business processes.

Key Findings:

The study reveals that ADTs are extensively adopted across the UK, with Cloud Computing being the most widely used technology (with up to 80% adoption in all sectors and regions). However, AI adoption remains moderate, with usage intensity being low. More specialized technologies such as Robotics and 3D Printing are adopted less frequently, mainly in the manufacturing and extractive sectors. Companies are increasingly using multiple technologies together, with Cloud Computing most frequently paired with AI and Big Data, underscoring a trend towards data-driven business processes.

The adoption rate is notably higher in regions with established business hubs, such as London, the North West, and the West Midlands. The study highlights significant regional disparities in the adoption and usage intensity of ADTs, with London showing higher adoption rates and greater integration of technologies such as AI and Robotics. Smaller businesses, however, face greater challenges in adoption, although Cloud Computing is an exception where SMEs show similar adoption levels as larger firms.

The main drivers for adopting ADTs include process improvement, quality enhancement, and automation. Instead, barriers to adoption vary by technology, but common challenges include high costs, skill shortages, and concerns over security, reflecting the challenges of integration and adaptation during initial adoption.

ADTs increase the need for STEM capabilities and digital skills among employees, which are necessary for operating advanced technologies. Digital skills are more critical for ADT adopters, who report a pronounced need for skills like digital information literacy and cybersecurity, reflecting the increasing reliance on data and the necessity for secure information handling. But non-digital skills—particularly in resource management and social skills—are also highly relevant.

Platform adoption is increasing, with larger firms leading the way, particularly in operations-centred platforms. However, many smaller firms struggle, especially with distribution-centred platforms, due to resource constraints and misalignment with their needs. Adoption is concentrated in the service sector, particularly in London and the South East, highlighting a regional digital divide.

Platform adoption shows strong results, with operations-centred platforms improving internal efficiency, and distribution-centred platforms driving innovation, especially in customer engagement and product development. These platforms complement each other, enhancing both internal processes and external responsiveness, leading to better overall performance.

Significant barriers remain, with many firms perceiving platforms as irrelevant to their operations. High costs, the need for structural changes, and resource limitations, especially among smaller firms, continue to hinder broader adoption, emphasizing the need for better alignment, communication, and support to overcome these obstacles.

1. Introduction

Advanced digital technologies (ADT) – AI, Big Data, Cloud Computing, 3D printing, IoT, Robotics – have the potential to transform entire economies, firms, and business models, including labour markets and skills. While the adoption of these new technologies is understood to bring productivity gains, historically, a "productivity paradox" has been observed. For example, the adoption of information and communication technology (ICT) in the 1990s did not result in significant productivity gains (Brynjolfsson, 1993). More recently, analysing the case of AI, Brynjolfsson et al. (2019) conclude that although this technology holds great potential, there is little evidence of aggregate productivity gains for the time being (the "modern productivity paradox").

At the same time, such technologies are enabling platformisation to take place, even in manufacturing firms. This is achieved via transaction and innovation platforms (Gawer, 2021), which are used to improve back-end production processes and front-end customer-facing processes (Tian et al., 2022). Although these platforms can enhance the efficiency and effectiveness of firms and, in turn, affect their productivity, corresponding business model changes are required. Many industrial digital platforms incorporate digital modules that provide new functionalities, such as monitoring and visualisation services (Jovanovic et al., 2022). In this case, complementary assets related to ADT are needed, such as advanced sensors, data analytics, applications, or cloud-based data storage, among others, to enable the automation of processes through both internal and external partners.

Whilst digitalisation and platformisation require companies to rethink their activities, we know very little regarding the relationship between ADTs and platforms, as well as the changes in skillset composition required. We also know very little about how they impact firms' productivity. There are four main reasons for this gap in the literature. First, most studies normally analyse the relationship between ADTs and productivity at an aggregate level using nationwide or industry-level measures. Second, although platformisation is becoming more common across firms, it is still in its infancy (Lerch and Heimberger, 2022). Third, there is a lack of data on the adoption of both ADTs and platforms. The lack of firm-level data has been cited as a critical impediment to understanding how ADTs impact workers and firms (Zolas et al., 2020). Lastly, we have limited knowledge regarding firms' decisions to adopt these ADTs and platforms.

This report is one of the first attempts in the UK to assess firms' adoption rates of ADTs and platforms, by company size, sector and region, as well as their relationship with firms' skill requirements and outcomes.

To investigate this issue, we conducted a national survey on the Adoption of Digital Technologies and Skills (N-ADiTS) in the UK. The survey includes questions about motivations and barriers to adopting the six aforementioned ADTs (AI, Big Data, Cloud Computing, 3D printing, IoT, Robotics), as well as two types of platforms (operations-centred and distribution-centred). It also includes questions about firms' outcomes, including those related to productivity, (hereafter called productivity-related and other outcomes). The study identifies what skills are associated with specific ADTs and whether companies are facing digital and other skills shortages.

2. Literature review

2.1 Advanced Digital Technologies (ADTs)

The rapid proliferation of ADTs is driving a profound transformation across industries. These technologies, part of Industry 4.0 (also known as the Fourth Industrial Revolution -4IR-) (Schwab, 2017), are reshaping product and process development, production, and delivery. The integration of these technologies and tools into business processes promises significant benefits, including enhanced flexibility (Baldwin & Clark, 2000), automation, cost reduction (Brynjolfsson & McAfee, 2014), improved productivity, and faster time-to-market (Graetz & Michaels, 2018). The widespread adoption of ADTs is also influencing labour markets, reshaping skills requirements, and transforming how firms compete in a globalized economy (Evangelista et al., 2014; Oduro et al., 2023).

The diffusion of these ADTs and their transformative effects on businesses and economies has been extensively covered in the literature, especially regarding automation (e.g., Autor et al., 2003; Van Roy et al., 2018; Acemoglu and Restrepo, 2020; Klenert et al., 2020). Researchers have explored the effect of ADT adoption on firms' performance (Oduro et al., 2023; Martínez-Caro et al., 2020; Rialti et al., 2019), including innovation (Usai et al., 2021; Blichfeldt and Faullant, 2021) and productivity (OECD, 2023; Benassi et al., 2022; Ballestar et al., 2020).

While the literature identifies numerous technologies within 4IR due to their broad applicability (Bailey and De Propris, 2019), this study focuses on the adoption of six ADTs: AI, Big Data, Cloud Computing, 3D Printing/Additive Manufacturing, Internet of Things (IoT), and Robotics. Martinelli et al. (2021) investigate key Industry 4.0 technologies and found significant heterogeneity among them. They argue that only Big Data and, to some extent, AI present the key characteristics of generality and originality and can be classified as general-purpose technologies, whereas other Industry 4.0 technologies (Cloud, IoT, 3D Printing, and Robotics) function as enabling technologies, despite strong longevity performance recorded across the board (especially for 3D Printing). This suggests that ADTs are heterogeneous, which may require different sets of skills and capabilities to facilitate their adoption. Moreover, different ADTs are at different stages of diffusion, with Cloud Computing being the most widespread, characterised by high levels of joint adoption (Massini et al., 2022).

The spatial patterns and diffusion processes of ADTs are also non-uniform. In a recent study using European patent data, Corradini et al. (2023) conclude that while robots and 3D Printing, which are more commonly used in high-tech manufacturing, are highly localised, Big Data and IoT appear to be more widespread across regions and sectors due to the lower capital-intensive nature of innovation, as well as their broader versatility and applicability across industries and processes. The UK, the context of our study, lags behind leaders in technology adoption (Roper, 2021) and presents large gaps in the adoption of numerous technologies, including AI (EY, 2021). Although the adoption of a range of basic technologies is associated with productivity gains of up to 25% (ONS, 2018), adoption rates vary by firm size, firm age, region, and sector (ERC, 2018; MSA, 2023), which could explain the modern productivity paradox at more aggregate levels. Internationally, younger, smaller firms and older, larger firms are more likely to adopt AI (OECD, 2022). Regional sector specialisation also affects the adoption of certain ADTs. For example, in the case of Greater Manchester, the adoption of ADTs is driven mainly by firms in knowledge-intensive service and high-tech manufacturing sectors (Massini et al., 2022).

Different motivations and challenges have been identified in the literature for ADT adoption. Traditionally, barriers have been classified according to tangible attributes (e.g., cost-related barriers) and intangible attributes (e.g., human, social, strategic, technological) (Sambasivarao and Deshmukh, 1995). A recent report by the OECD (2021) categorises the barriers to technology diffusion into three key groups: a) firm capabilities, b) market incentives, and c) institutional support. Similarly, Massini et al. (2022) conclude that skills have become a remarkably important intangible asset for firms and, indeed, the lack of access to the required human capital is one of the main barriers to adopting ADTs (in addition to their cost). Scholars have pointed out that skills shortages and skills imbalances are key barriers to regional economic performance and productivity growth (Berlingieri, 2019). Finding the right balance of skills supply that matches the evolution of local demand becomes essential to support productivity, innovation, and competitiveness at the local level (Morris et al., 2019; Corradini et al., 2023). Moreover, since industries tend to show region-specific configurations and specialisation, the development and adoption of ADTs are likely to be correlated with the geographical distribution of skills endowments. This is of particular importance for the UK, where skills gaps have been identified as a key element of regional disparities and inequalities (Green et al., 2016) and regions' growth potential (Sevinc et al., 2020).

SMEs are particularly vulnerable to the risks associated with technology adoption and exhibit some extra challenges. For example, Martinsuo and Luomaranta (2018) compile a list of disadvantages of SMEs in adopting 3D Printers, including a short planning horizon, lack of awareness of the technology's benefits, lack of financial and human resources, limited bargaining power, inadequate inter-organisational information systems, and a strong dependency on existing supply chain partners.

On the other hand, firms that invest in complementary intangible assets, such as management and digital skills, leadership mindsets, and overcome technical and financial constraints, tend to adopt more productivity-enhancing innovations. Firms equipped with the necessary skill sets are more likely to successfully adopt new ADTs and maximise the opportunities presented by Industry 4.0 (Ciarli et al., 2021; Coro et al., 2021) and are crucial for maximising the benefits of these technologies for regional development (De Propris and Bellandi, 2021). In the UK, specific programs have been designed to accelerate digital technology adoption, as in the case of Made Smarter which, according to a recent report (MSA, 2023), concludes that around 90% of the firms that have participated in a specific service line of Made Smarter Adoption have adopted ADTs. Automation and data management solutions were among the most popular digital applications adopted by participant firms.

2.2 Digital Platforms

The concept of platforms emerged from organisational and economic theories as a sophisticated mechanism for coordinating complex stakeholder interactions. Velu (2015) characterises platforms as essential tools for enhancing organisational processes and facilitating market transactions. Gawer (2014) critically examines the divergent interpretations of platforms within economic and engineering disciplines, shedding light on their multifaceted nature. This scholarly discourse has revealed platforms to be more than mere technological infrastructures; they are dynamic ecosystems capable of transforming organisational interactions.

The advent of digital technologies marked a significant turning point in the evolution of platforms. Täuscher and Laudien (2018), along with Fu et al. (2023), introduced the term "platformisation" to describe the systematic transformation of organisational interactions through digital technologies. Early examples such as eBay (founded in 1995) and Amazon

Marketplace (launched in 2000) showcased the potential for multi-sided market interactions, establishing critical paradigms that have shaped subsequent platform evolution.

Gawer and Cusumano (2014) provided pivotal insights into network effects, demonstrating how platform value grows with increased user participation. This phenomenon has been especially evident in consumer-focused digital platforms like Apple's App Store and Google Play Store, which have fundamentally reshaped the dynamics of digital ecosystems. Scholarly research has since developed more nuanced platform typologies. Cusumano et al. (2019) distinguish between innovation platforms and transaction platforms, while Butollo et al. (2022) refine this framework further, classifying platforms as either distribution-centred or production-centred.

Production-Centred Platforms: These platforms focus on process optimisation through the collection and analysis of manufacturing data. Prominent examples include Siemens Mindsphere and Bosch IoT Suite, which integrate software applications to enhance productivity via tools like predictive maintenance and digital twins (Butollo et al., 2022). These platforms act as innovation hubs, enabling modular application development and fostering ecosystems of complementors that supply specialised software. The implications of production-centred platforms extend beyond process efficiencies; they are instrumental in enabling firms to adopt Industry 4.0 practices, although challenges like data sharing and interoperability remain significant (Butollo et al., 2022; Feng et al. 2023).

Distribution-Centred Platforms**:** These platforms facilitate efficient matchmaking between industrial buyers and suppliers by reducing transaction costs and providing standardised processes for order handling. For example, platforms in the mechanical components industry connect diverse manufacturing partners with customers, automating processes like pricing and supplier evaluation (Butollo et al., 2022). The value proposition lies in their ability to offer flexible sourcing options and rapid order fulfilment. However, they also centralise control over transactions, potentially weakening direct supplier-customer relationships and shifting value capture towards the platforms themselves (Hein et al., 2020).

The distinction between production-centred and distribution-centred platforms underscores the evolving role of platforms in global value chains. Production-centred platforms focus on internal process efficiencies and innovation, while distribution-centred platforms address external transactional efficiencies. In the UK context, these platforms could significantly impact sectors like aerospace and precision engineering by enabling productivity gains and streamlined supply chains. However, the risk of dependency on platform ecosystems and potential market concentration highlights the need for strategic engagement with platform technologies (Culotta et al., 2024).

Advanced digital technologies, including the interconnected realms of AI, big data, cloud computing, and machine learning, have collectively transformed platform capabilities by enabling seamless data access, processing, and management. Big data serves as the foundation, providing the vast quantities of information that fuel both production-centred and distribution-centred platforms. Machine learning, a critical component of AI, leverages this data to uncover patterns and drive decision-making, while cloud computing ensures scalable, real-time processing and accessibility. For production-centred platforms, these technologies enable predictive maintenance, adaptive production systems, and customisation, fostering business model innovation and operational efficiency (Qu et al., 2016; Salvador et al., 2020). In distribution-centred platforms, they optimise data-driven matchmaking, refine pricing mechanisms, and enhance supplier evaluations, creating efficient and cost-effective supply chains (Khadem et al., 2023). Bharadwaj et al. (2013) and Akbar and Tracogna (2022) highlight how this integrated technological ecosystem supports robust data management, enabling the distinct efficiencies of both platform types.

While production-centred platforms are most prominent in manufacturing, their underlying principles and technologies are increasingly being applied across non-manufacturing sectors to enhance operational efficiency. To reflect the broader applicability of platform technologies beyond manufacturing, we propose the term 'operations-centred platforms,' encompassing platforms that enhance operational efficiencies across diverse industries. For instance, the Tesco Clubcard demonstrates how operations-centred platforms leverage data to drive efficiencies in the retail sector, underscoring their relevance beyond manufacturing.

3. Methods

The data were collected through a bespoke survey on the Adoption of Digital Technologies and Skills in the UK (N-ADITS)[1]. The questionnaire was designed by the authors, and the data were collected by YouGov using a sample from a UK research panel. The survey sample was selected from the contact database using a random selection method based on the following eligibility criteria: business leaders (i.e., board-level management) in organisations with two or more employees across the private sector.

Our survey aimed to collect responses from approximately 3,000 senior decision-makers employed in the non-agricultural private sectors in the UK, located across the 12 International Territorial Levels (ITL) at Level 1 (regions). We targeted a minimum of 300 responses per region, except for the North East (150), Wales (100), and Northern Ireland (100). A total of 3,175 valid responses were obtained by the end of the fieldwork, conducted between 19 March and 20 May 2024.

All results presented in this report are based on the weighted sample, representative (see Annex I) of the eligible population in terms of size (number of employees), sector (manufacturing, construction, services, and others), and region (the 12 Government Office regions for the UK). The weighting is based on the accredited official statistics from the 2023 Business Population Estimates for the UK and Regions (number of employees).

The questionnaire consists of the following four sections:

Section A. Digital Technologies: This section covers six ADTs (AI, Big Data, Cloud Computing, 3D Printing, IoT, and Robotics). It explores their usage and intensity of use (low, moderate or high), development, firms' motivations for adoption, and barriers to adoption. Additionally, it examines their effects on firms' skills and outcomes. This section was adapted from the technology module of the 2019 United States Annual Business Survey (ABS).

Section B. Digital Platforms: This section focuses on two types of platforms: operations-centred and distribution-centred. It assesses adoption rates, intensity of use (low, moderate or high) impacts on key performance metrics (e.g., efficiency, innovation, customer satisfaction, and market competitiveness), and the primary drivers and barriers to adoption.

Section C. Skills and Training: The Skills and Training section addresses the importance of digital skills and non-digital skills. It also examines whether organisations offer on-the-job or off-the-job training for adopting the six aforementioned ADTs. Digital skills are defined based on the European Digital Competence Framework for Citizens (DigComp). Non-digital skills are integrated from multiple sources, including the US Occupational Information Network (O*NET) and the UK Employer Skills Survey (ESS).

Section D. General Business Information: This section collects information about the company, including ownership, industrial sector, age, turnover, number of employees, and education levels of employees. It also asks about the introduction of innovations, as well as the respondent's gender and location in terms of ITL Level 1 regions of the UK.[2]

Full details of the questions and items included in the survey and utilised for the measurement of the variables are presented in Annex II.

[1] The survey was piloted in Greater Manchester (UK) in 2022 and the results are available here.

[2] Both gender and location refer to participant data available in the YouGov database. Region is calculated based on the postcode reported by respondents and represent where they live, not necessarily where they work.

4. Results

4.1 Business characteristics

The majority of participant companies primarily operate in the service sector[3] (81%), while a smaller percentage are in manufacturing. The sample covers both small and large firms (>=250 employees) with the latter accounting for nearly half of the sample[4]. Many of the companies are well-established, as at least 58% have been operating for over 20 years. 38% are subsidiaries within corporate groups, of which 60% are owned by foreign entities.

Table 1. Business demographics

Demographic variable		% respondents (weighted)
Ownership	Subsidiary	38%
	Owned by foreign companies	*60%*
	Not owned by foreign companies	*38%*
	Foreign ownership unknown	*2%*
	Non-subsidiary	55%
	Unknown	7%
NO. of employees	2-9 employees	18%
	10-49 employees	19%
	50-249 employees	14%
	>=250 employees	49%
Turnover	< £500,000	15%
	££500,000- £1.9 m	10%
	£2m - £9.9 m	12%
	£10m -£49.9m	10%
	£50m - £499.9m	12%
	£500m - £999.9m	5%
	>= £1b	17%
	Unknown	20%
Firm age	age <= 2 years	2%
	2 years < age <= 5 years	5%
	5 years < age <= 10 years	11%
	10 years < age <= 20 years	20%
	20 years < age <= 50 years	31%
	50 years < age <= 100 years	12%
	age > 100 years	15%
	Unknown	4%
Industrial sector	Utilities and Extractive	1%
	Manufacturing	10%
	Construction	8%
	Services	81%
Region	North East	3%
	North West	10%
	Yorkshire and the Humber	8%
	East Midlands	7%
	West Midlands	8%
	East of England	11%
	London	21%
	South East	14%
	South West	8%
	Wales	3%
	Scotland	6%
	Northern Ireland	2%
Total (n=3,175)		100%

[3] See Annex IV for a detailed distribution of the manufacturing and service sector.

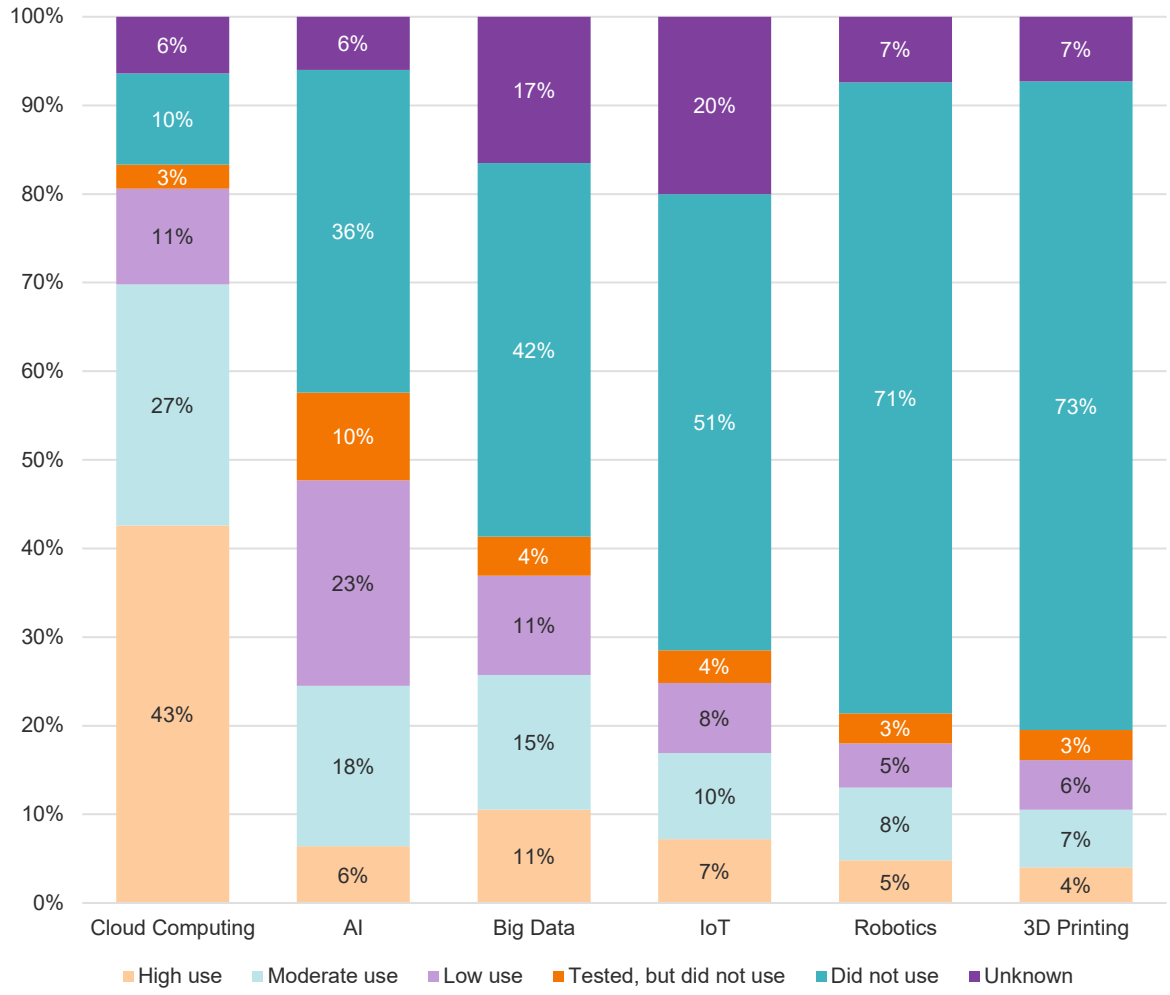
[4] Note that although large firms (>=250 employees) represent almost 50% of the companies in this study, the sample is representative when weighted by the number of employees (see Annex I).

4.2 Advanced digital technologies (ADTs)

4.2.1 Adoption of ADTs

Figure 1 illustrates the adoption rates of ADTs in the UK. Among the six ADTs of interest, cloud computing is the most widely adopted, with four out of five companies using it at a high or moderate intensity Following this, AI ranks second in usage, with nearly half of the companies adopting it. Notably, AI also has the highest rate of "tested, but did not use" (10%), which is more than twice that of any other ADT. Big Data ranks third, with a 37% adoption rate. Similar patterns of usage are observed for IoT and Robotics, though their overall adoption rates are lower. 3D Printing has a usage rate comparable to Robotics. Importantly, joint adoption of ADTs is common. One in four adopters reported using two ADTs, while nearly one in five use three ADTs. The most frequent combinations are Cloud Computing and AI, and Cloud Computing and Big Data when two technologies are adopted. For three technologies, the most common combination is AI, Big Data, and Cloud Computing.

Figure 1. Adoption of ADTs per type of technology

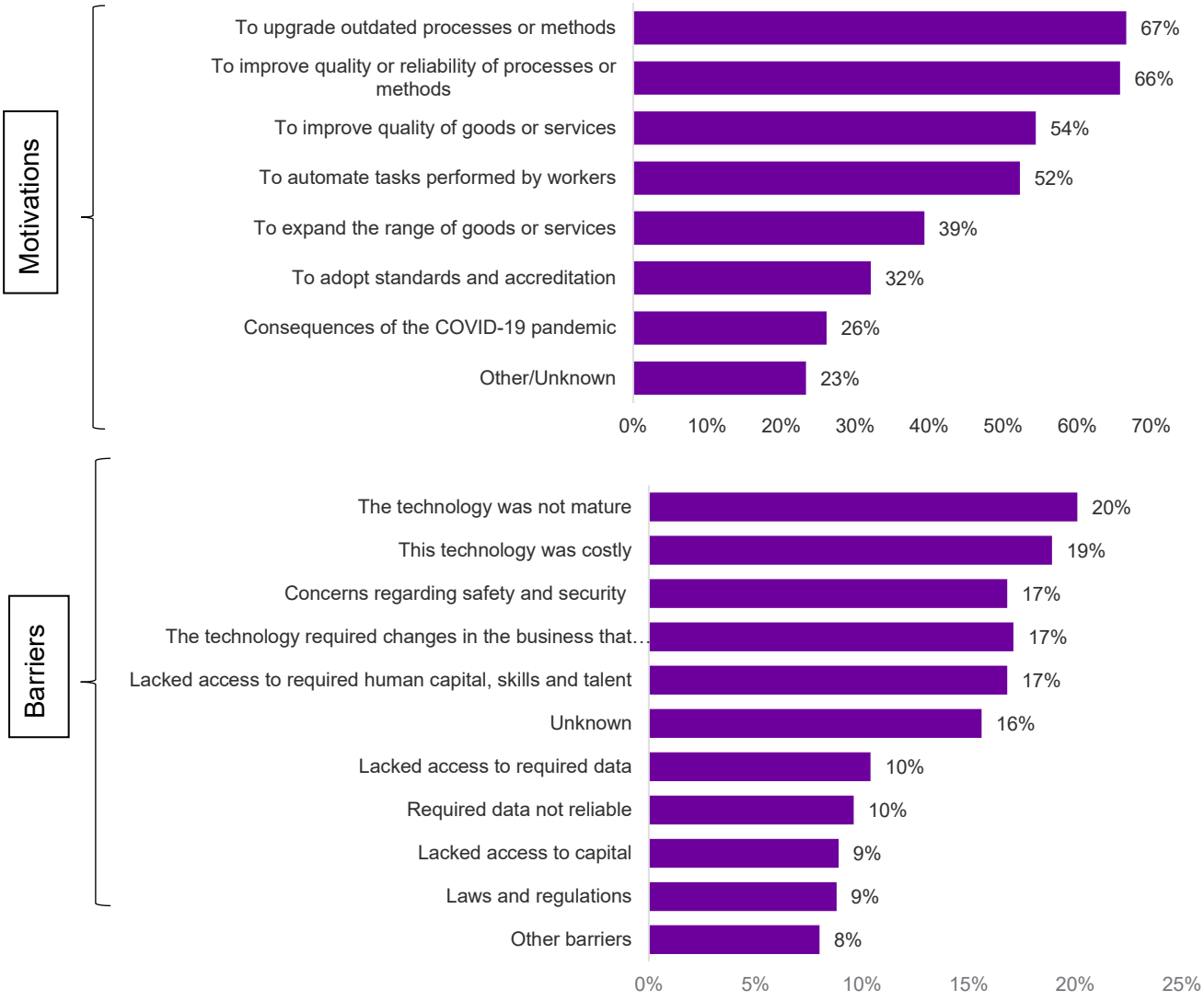


Note: Weighted sample (n = 3,175).

4.2.2 Motivations and barriers to adopt ADTs

Figure 2 highlights the motivations and barriers associated with ADT adoption. Motivations are calculated as the weighted percentage of companies reporting a specific motivation among ADT adopters, while barriers are computed as the weighted percentage of companies citing a specific barrier among non-adopters. The primary motivations for adopting ADTs include upgrading outdated processes, improving the quality of processes, methods, goods, or services, and automation. Conversely, the main barriers to adoption include concerns over the maturity and cost of the technology, issues with safety and security, the need for significant business changes, and a lack of human capital and skills.

Figure 2. Motivations to and barriers for ADT adoption

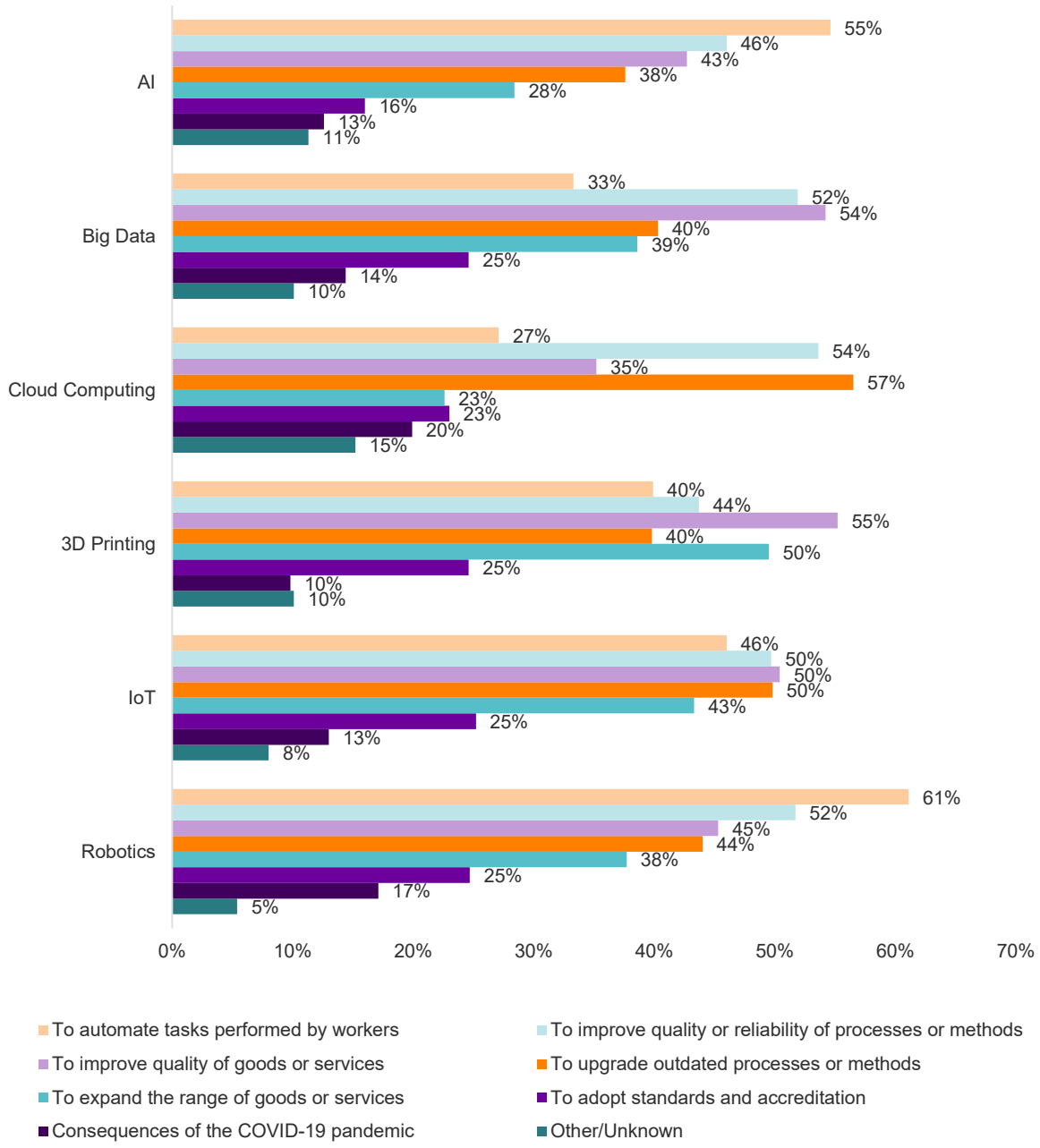


Note: Weighted sample (motivations: n = 2,858; barriers: n = 2,773)

Figures 3 and 4 further break down motivations and barriers by ADT type. For AI and Robotics, automation is the primary motivation. For Big Data and 3D Printing, the main driver is improving the quality of goods and services. In the case of Cloud Computing, the motivation primarily relates to upgrading outdated processes or methods. Regarding barriers in Figure 4, despite widespread Cloud Computing adoption, some businesses refrain from adopting it due to safety and security concerns. For AI, adoption is hindered primarily by perceptions of

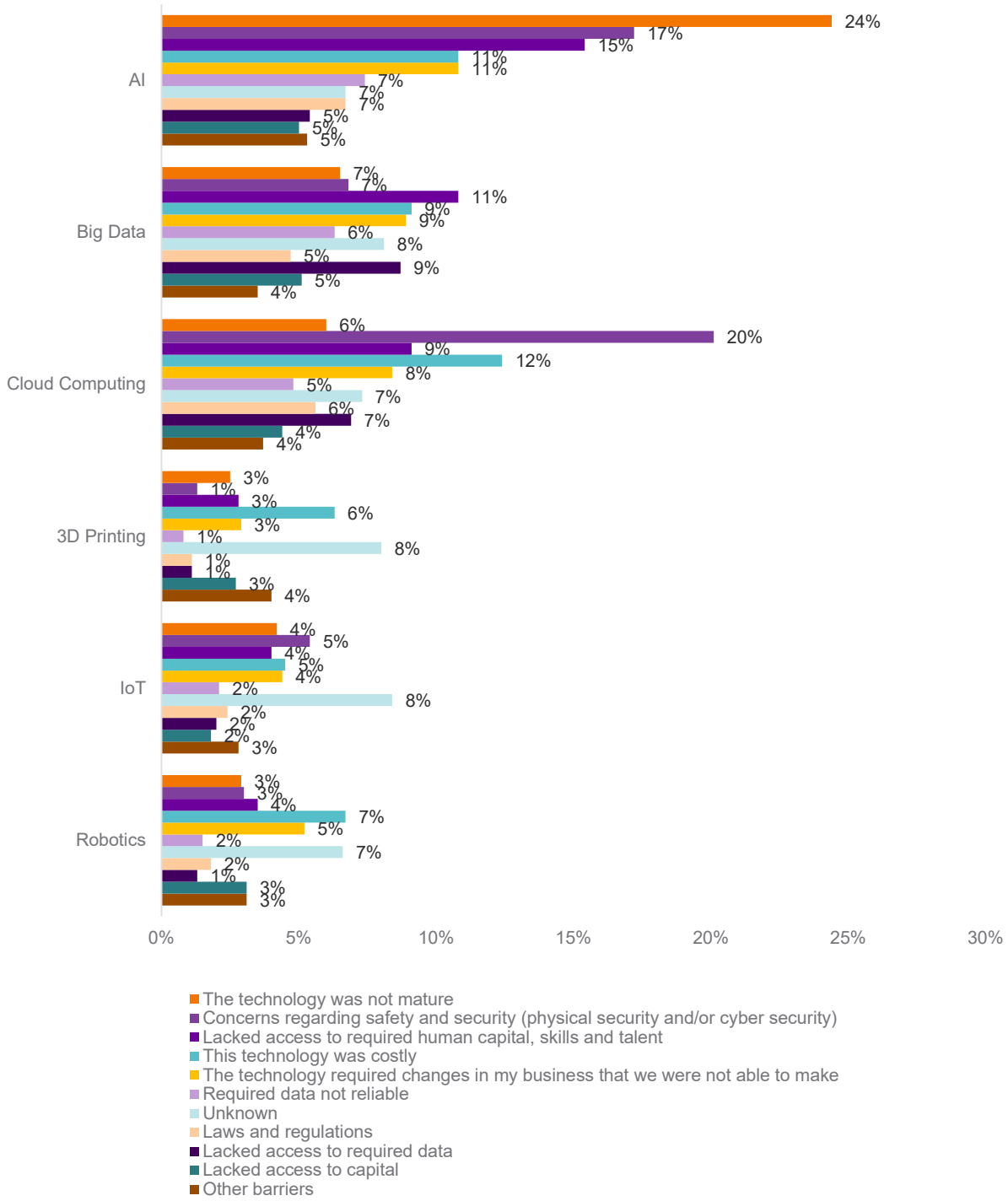
insufficient maturity, followed by safety and security concerns, and a lack of human capital or skills. For Big Data, the main barrier is a lack of human capital. For other technologies, no single barrier stands out, and percentages remain relatively small.

Figure 3. Motivations to adopt each type of ADTs



Note: Weighted sample (AI: n = 1,516; Big Data: n = 1,174; Cloud Computing: n = 2,559; 3D printing: n = 513; IoT: n = 788; Robotics: n = 570).

Figure 4. Barriers to adopt each type of ADTs



Note: Weighted sample (AI: n = 1,468; Big Data: n = 1,476; Cloud Computing: n = 413; 3D printing: n = 2,429; IoT: n = 1,752; Robotics: n = 2,370).

4.2.3 Impact of ADTs

Table 2 presents the impacts of ADT adoption on firms' employment and productivity-related and other outcomes. ADT adoption has generally had a positive impact on employment, particularly by increasing employee skill levels and the proportion of STEM-skilled employees. This trend is consistent across different ADTs, with the highest impact reported by companies adopting Big Data, 3D Printing, and Robotics. In terms of productivity-related and other

outcomes, the primary impact of ADT adoption is on the quality of products and services. Interestingly, the effects on delivery time and production costs are polarised, with roughly 26–28% of adopters reporting positive impacts and 21–23% reporting negative impacts.

When examining differences by technology type, companies adopting AI report significant improvements in the quality of both services and products. However, AI adoption is associated with increased production or process costs and longer delivery times. Technologies related to data like Big Data, Cloud Computing, and IoT similarly influence product and service quality positively but also lead to increased costs and delivery times. These technologies further support diversification of products, services, and customer bases. For technologies more related to manufacturing, such as 3D Printing and Robotics, the difference in the impact lies in reported increases in production volumes, although over 40% of robotics adopters report longer delivery times and higher production costs.

Table 2. Impact of ADTs among adopters

	Any ADT		AI		Big Data		Cloud Computing		3D Printing		IoT		Robotics	
	▲	▼	▲	▼	▲	▼	▲	▼	▲	▼	▲	▼	▲	▼
Employment														
Number of employees	17%	11%	26%	12%	37%	9%	23%	6%	48%	8%	40%	8%	36%	27%
Skill level of employees	38%	3%	54%	4%	62%	3%	49%	2%	65%	5%	59%	4%	61%	5%
STEM skilled employees	33%	3%	51%	3%	61%	4%	39%	2%	68%	5%	58%	2%	63%	4%
Productivity														
Production costs/cost of processes	21%	26%	32%	23%	37%	19%	28%	20%	52%	17%	42%	16%	41%	25%
Selling price of goods and/or service	22%	6%	35%	4%	44%	5%	27%	4%	57%	6%	51%	5%	46%	6%
Volume of production	31%	3%	48%	2%	50%	3%	38%	2%	62%	4%	53%	3%	66%	3%
Product diversification	27%	3%	44%	2%	51%	3%	32%	2%	67%	4%	54%	3%	52%	2%
Quality of product	36%	2%	53%	3%	63%	2%	43%	2%	69%	5%	58%	2%	59%	4%
Time to deliver product	21%	27%	35%	23%	36%	22%	25%	22%	53%	18%	39%	22%	43%	26%
Service diversification	27%	3%	45%	3%	52%	2%	34%	1%	64%	5%	57%	2%	54%	2%
Quality of service	46%	3%	58%	3%	67%	2%	57%	2%	69%	4%	64%	2%	65%	3%
Time to deliver services	23%	28%	41%	25%	37%	22%	28%	25%	53%	15%	44%	17%	46%	23%
Number of customers	28%	3%	42%	3%	52%	3%	34%	2%	60%	4%	51%	3%	49%	3%
Types of customers	21%	2%	34%	2%	47%	2%	27%	2%	59%	3%	51%	2%	48%	3%
n (weighted)	2,858		1,516		1,174		2,559		513		7,88		570	

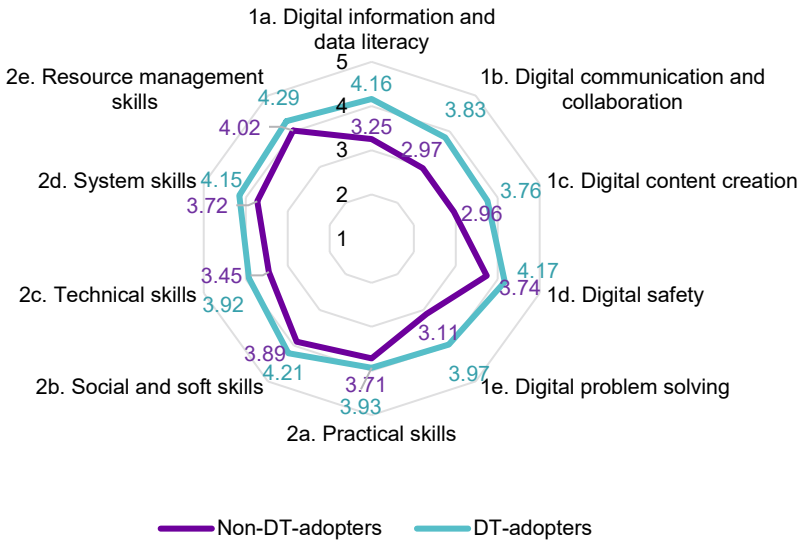
Note: This table presents the percentages of firms that declared increases or decreases in the factors in employment and productivity-related and other outcomes. Firms could select from five categories to describe the impact of adoption of ADTs: 5 – "increased considerably", 4 – "increased", 3 – "did not change", 2 – "decreased" and 1 – "decreased considerably", for each particular statement. To present the effect of adopting a specific type of ADTs we classify 1 and 2 as "decrease" (▼), and 4 and 5 as "increase" (▲). The percentages for "any ADT" are based on the average impact of all the technologies adopted by a respondent: a factor of employment or productivity-related and other outcomes is considered "decreased" for the adopter if the average impact is between 1 and 3, and is considered "increased" if the average is between 4 and 5. Those that selected "did not change" are not reported in the table. Weighted sample (Any DT: n = 2,858; AI: n = 1,516; Big Data: n = 1,174; Cloud Computing: n = 2,559; 3D printing: n = 513; IoT: n = 788; Robotics: n = 570).

4.2.4 Digital skills and non-digital skills

Figure 5 illustrates skill requirements for ADT adopters and non-adopters using mean values (on a scale of 1 to 5) to assess the importance of both digital and non-digital skills. Digital skills (values 1x in the figure) are notably more critical for adopters, who also report larger gaps in digital skills compared to non-digital skills (values 2x in the figure). T-test comparisons confirm significant differences in skill importance between adopters and non-adopters, with adopters consistently ranking skills as more critical. Among digital skills, "digital information and data literacy" and "digital safety" are the most important for adopters, while "resource management

skills" and "social and soft skills" are considered most essential among non-digital skills. For non-adopters, "digital safety" and "management skills" are the most relevant within each category. These patterns remain consistent when comparing adopters and non-adopters by ADT type in Figure 6, with the exception of Big Data, 3D Printing, IoT, and Robotics, where "system skills" are prioritized over "social and soft skills" by technology adopters.

Figure 5. Comparison of skills importance between adopters and non-adopters of ADT



Note: Mean comparison using t-test suggests significant differences for all skills between adopters and non-adopters. Weighted sample (n = 3,175).

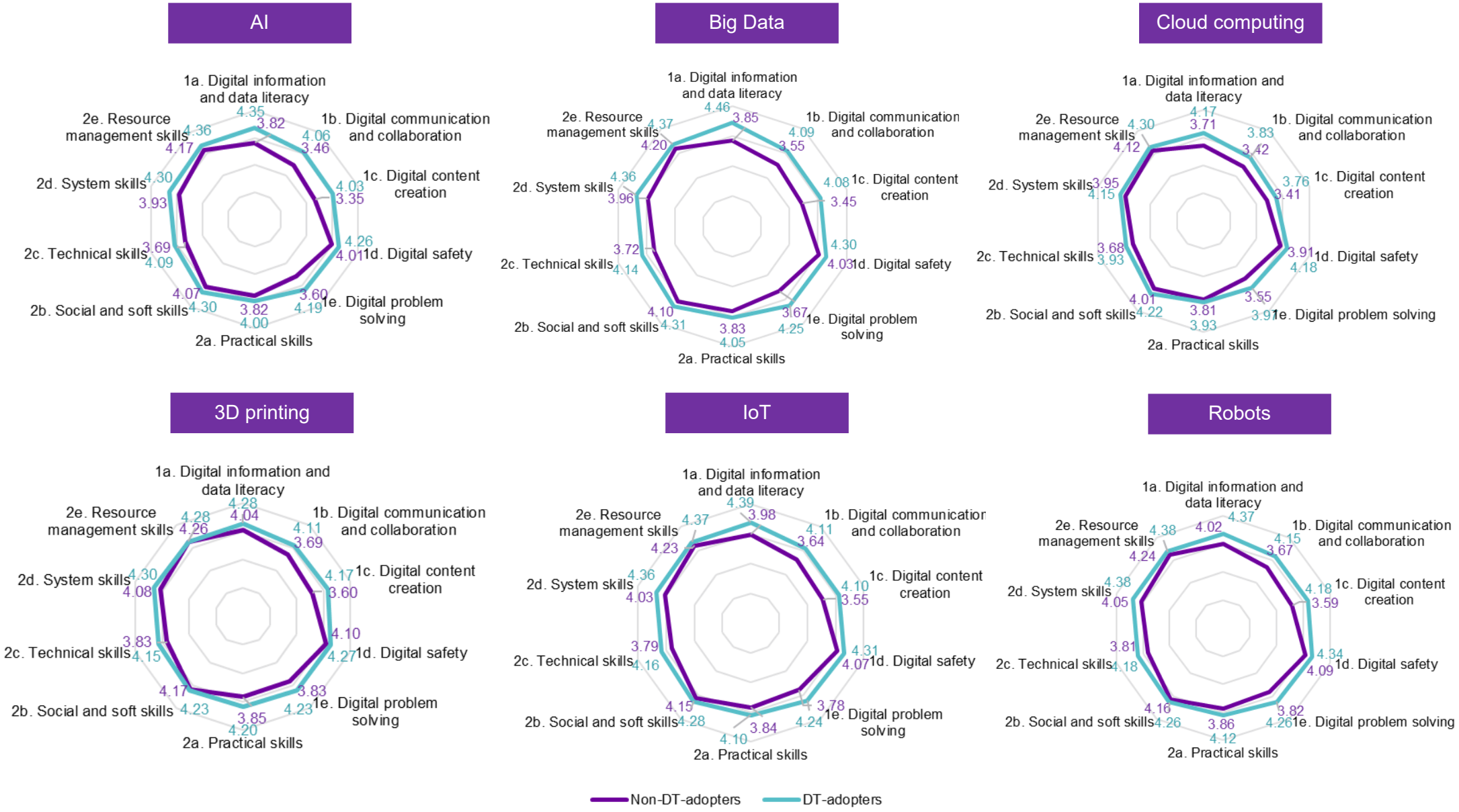
Table 3 reports the number of companies that have provided training for various ADTs. In general, nearly two-thirds of companies have organized training related to ADT adoption, although figures vary by technology. More than half of companies report training on Cloud Computing, and at a smaller scale in AI and on Big Data. For all other technologies, training rates are lower, with fewer than 1 in 4 companies providing training. Training tends to be conducted on the job or through a combination of on- and off-the-job formats, with off-the-job training figures being lower across all technology types.

Table 3. Training

	Any ADT	AI	Big Data	Cloud Computing	3D Printing	IoT	Robotics
Organised	64%	39%	34%	55%	18%	24%	21%
On the job	-	*15%*	*14%*	*28%*	*7%*	*10%*	*8%*
Off the job	-	*5%*	*3%*	*5%*	*3%*	*2%*	*3%*
Both off and on the job		*19%*	*17%*	*22%*	*8%*	*12%*	*10%*
Not organised	27%	51%	51%	34%	67%	61%	65%
Unknown	9%	10%	14%	11%	15%	15%	14%
Total (n=3,175)	100%	100%	100%	100%	100%	100%	100%

Note: Weighted sample (n = 3,175).

Figure 6. Comparison of skills importance between adopters and non- adopters by type of technology

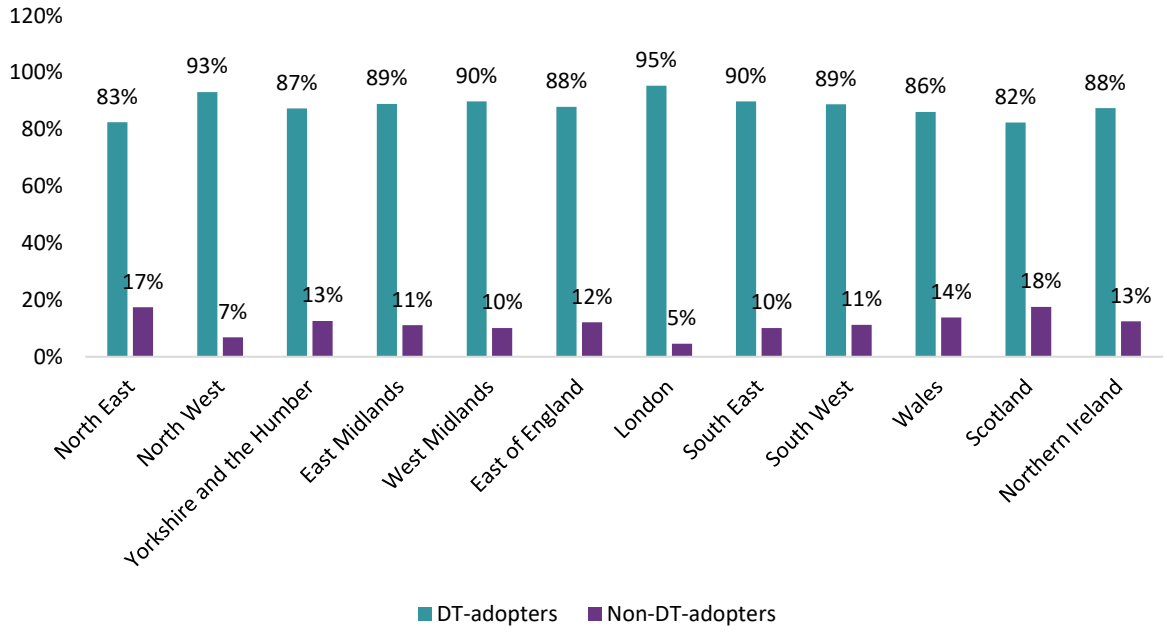


Note: Mean comparisons using t-tests suggest significant differences between adopters and non-adopters with the exception of social and soft skills and resources management skills for 3D-printers where there are not significant differences. Weighted sample (n = 3,175).

4.2.5 Adoption of ADTs by region, sector and size

In general, ADT adoption rates vary only slightly across regions in the UK (Figure 7), with more than four out of five businesses in each region adopting at least one of the listed ADTs. London, the North West, the West Midlands, and the South East have the highest adoption rates. However, differences emerge when considering specific types of technology, as shown in Figure 8.

Figure 7. Adoption of at least one ADT by region

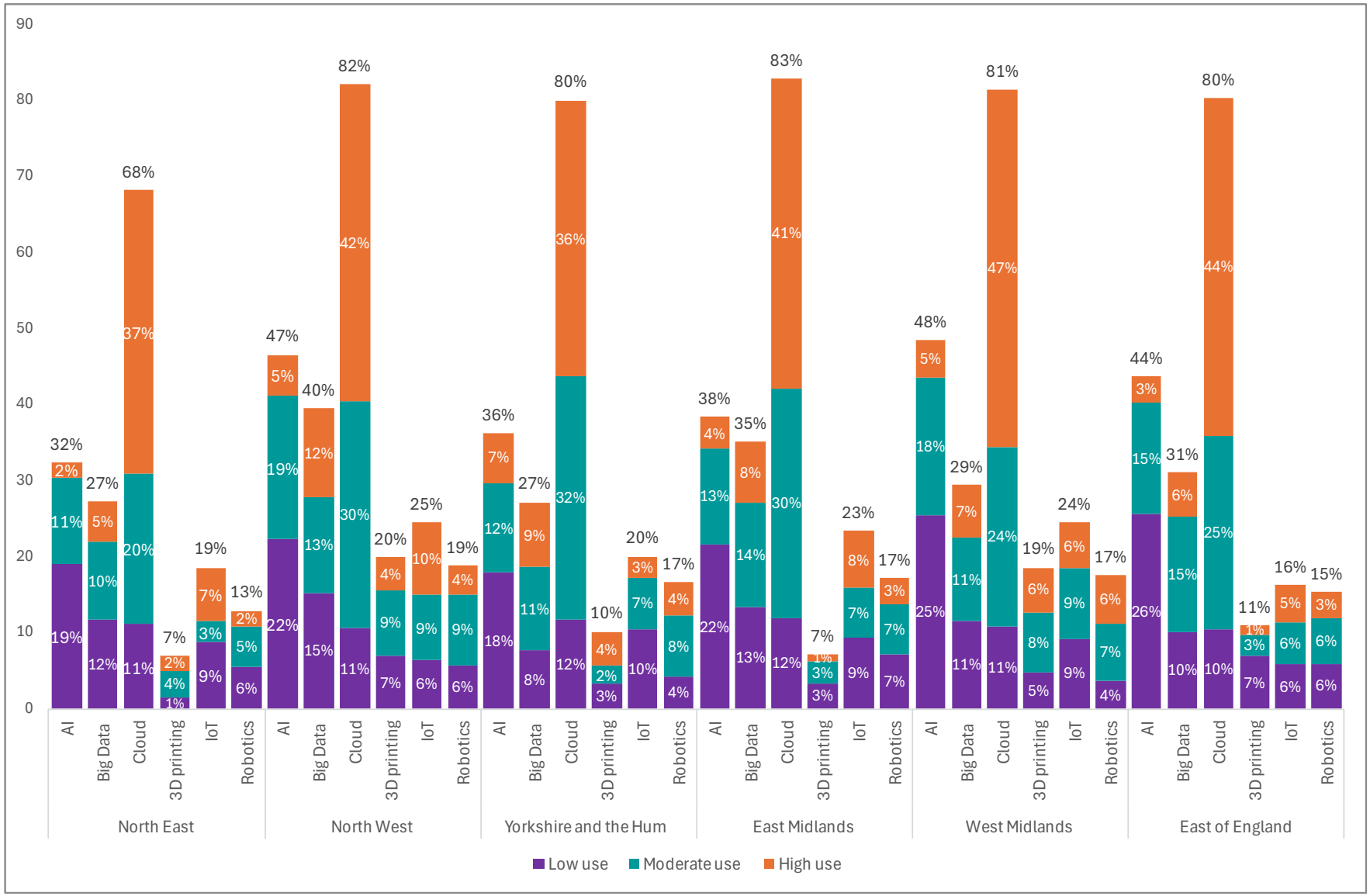


Note: Weighted sample (n = 3,175).

Across all regions, Cloud Computing, AI, and Big Data are more widely adopted, while IoT, Robotics, and 3D Printing are less commonly used. Cloud Computing is adopted by at least three-quarters of companies in every region. AI ranks as the second most adopted technology, with London leading, followed by the South East, the West Midlands, and the North West. In other regions, AI adoption ranges from 32% (North East) to 44% (East of England). Big Data is primarily adopted in London and the North West, followed closely by Scotland, the East Midlands, and the South East. IoT adoption is highest in London, Northern Ireland, and the North West, with adoption in other regions remaining lower. Robotics and 3D Printing have lower adoption rates, with the highest levels in London, the North West, and the West Midlands.

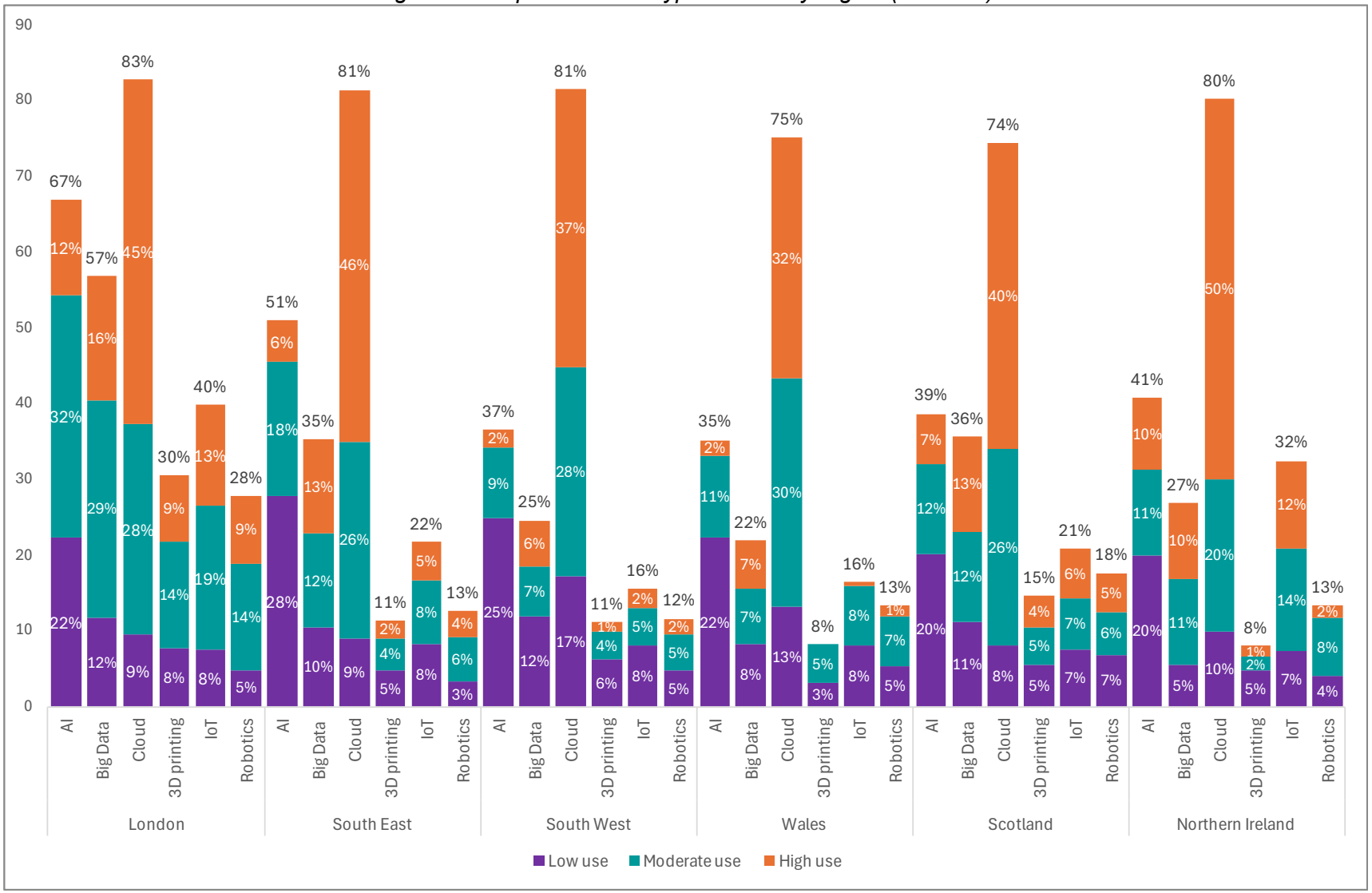
Examining the intensity of use for the most adopted technologies, Cloud Computing stands out as the most widely used ADT, with about half of adopters in each region reporting high use. In contrast, AI is generally used at low levels in most regions, except in London. Big Data usage intensity is more balanced in terms of levels of use. For the other three technologies (IoT, 3D Printing, and Robotics), adoption rates are too low to distinguish clear usage intensity patterns, except in London, where companies report primarily moderate use of these technologies. Annex V reports significant differences between regions (as well as sector and company size) by type of technology (adoption and intensity of use).

Figure 8. Adoption of each type of ADT by region



Note: Weighted sample (AI: n = 1,516; Big Data: n = 1,174; Cloud Computing: n = 2,559; 3D printing: n = 513; IoT: n = 788; Robotics: n = 570).

Figure 8. Adoption of each type of ADT by region (continue)



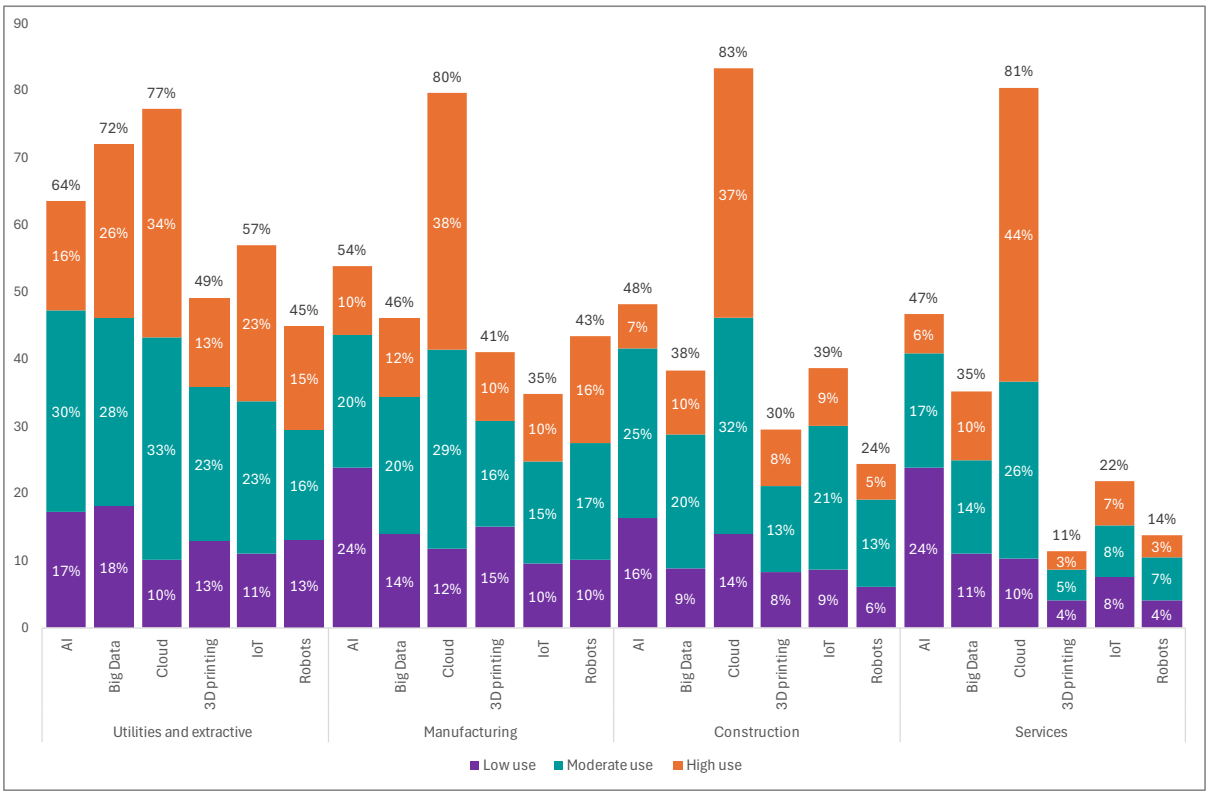
Note: Weighted sample (AI: n = 1,516; Big Data: n = 1,174; Cloud Computing: n = 2,559; 3D printing: n = 513; IoT: n = 788; Robotics: n = 570).

Figure 9 presents ADT adoption by industry sector, distinguishing between utilities and extractive, manufacturing, construction, and services. Cloud Computing is the most adopted technology across all sectors. The utilities and extractive sectors lead in adoption for all ADTs, with Cloud Computing followed by Big Data, AI, and IoT. Nearly half of companies in this sector also adopt 3D Printing and Robotics. In manufacturing, ADT adoption is more evenly distributed, with AI adopted by about 50% and IoT by one-third of companies in the sample. Robotics is adopted by almost half of manufacturing companies, representing the second-highest rate of Robotics adoption among sectors. IoT adoption in manufacturing is only higher than in services, with other ADTs showing intermediate adoption rates. In contrast, ADT adoption in services is more polarized, with high adoption of Cloud Computing, followed by AI and Big Data, while other ADTs like 3D Printing, Robotics, and IoT show the lowest adoption rates across all sectors.

When examining technology use intensity, there is a consistent pattern of moderate use across all technologies. However, in manufacturing and services, AI is primarily used at low levels.

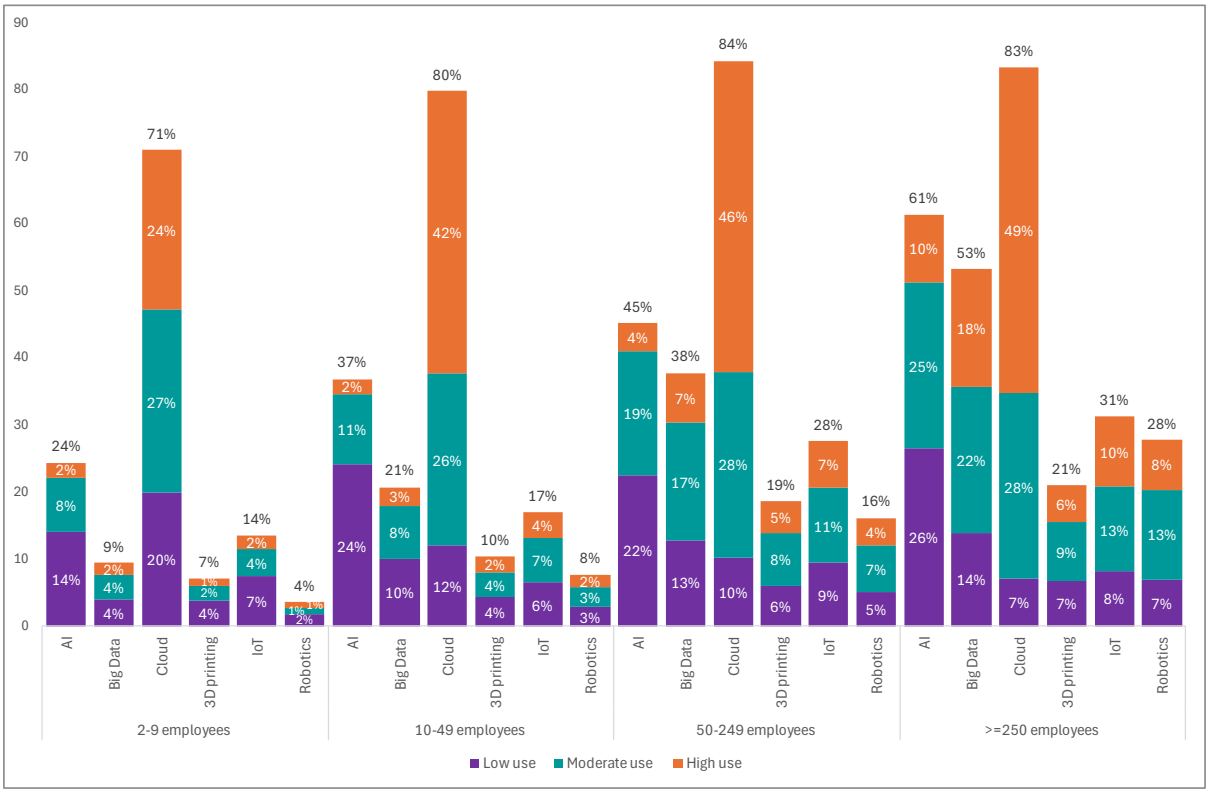
Figure 10 displays adoption rates by company size. Larger businesses generally show higher ADT adoption rates, except for Cloud Computing, where companies with 50–249 employees have a slightly higher adoption rate. Companies with fewer than 50 employees report Cloud Computing adoption rates similar to those of large firms; however, there are fewer adopters of AI in small firms (one in three) compared to almost two out of three in larger firms. Usage intensity also increases with company size, with larger firms using ADTs more intensively. Nonetheless, the highest percentage of AI adoption remains in the low-intensity category across all company sizes, while other technologies tend to see moderate use.

Figure 9. Adoption of each type of ADT by primary industrial sector



Note: Weighted sample (AI: n = 1,516; Big Data: n = 1,174; Cloud Computing: n = 2,559; 3D printing: n = 513; IoT: n = 788; Robotics: n = 570).

Figure 10. Adoption of each type of ADT by firm size



Note: Weighted sample (AI: n = 1,516; Big Data: n = 1,174; Cloud Computing: n = 2,559; 3D printing: n = 513; IoT: n = 788; Robotics: n = 570).

4.3 Digital Platforms

4.3.1 Adoption of Platforms

This section addresses the adoption of platforms. Platform adopters are defined as respondents who reported "high use," "moderate use," or "low use" of at least one platform, whether operations-centred or distribution-centred. Conversely, those who indicated "did not use" or "tested but did not use" are categorized as non-adopters. Additionally, respondents who selected "don't know" are also included in the non-adopter category.

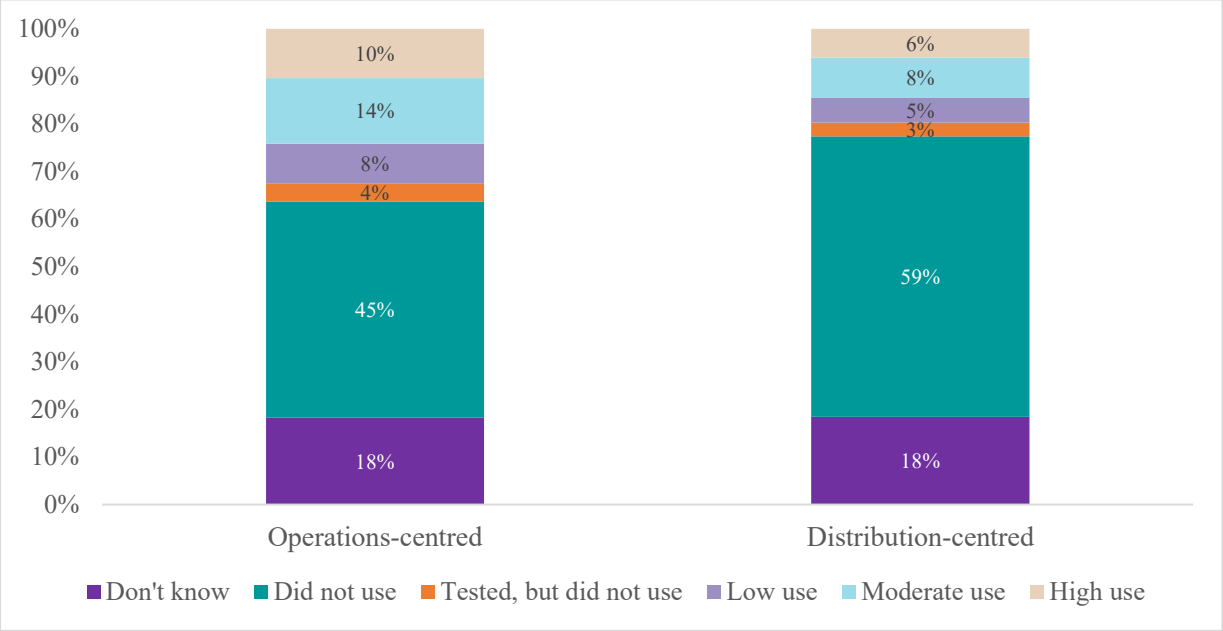
Figure 11 presents adoption rates for platforms. The adoption of operations-centred platforms was more prevalent compared to distribution-centred platforms, though a significant proportion of firms remained non-adopters in both cases. For operations-centred platforms, 32% of firms indicated some level of usage, whereas only 19% adopted distribution-centred platforms. Non-adoption rates, however, remained high across both platform types, driven partly by firms reporting barriers or limited perceived benefits.

The non-adoption could be attributed, in part, to firm size, as smaller firms may face greater challenges in integrating such technologies due to resource constraints or perceived limited benefits. Figure 12 further explores this relationship by breaking down adoption rates by firm size, measured by the number of employees.

For operations-centred platforms, adoption rates increase steadily with firm size. Micro firms (2 to 9 employees) show limited adoption at just 13%, with non-adopters comprising a vast

majority. Medium-sized firms (50 to 249 employees) exhibit a moderate adoption rate of 37%, while large firms (250 or more employees) lead adoption at 41%. Despite this upward trend, a notable proportion of firms across all sizes, especially smaller firms, remain non-adopters, underscoring persistent barriers to platform integration.

Figure 11. Adoption of Platforms



Note: Weighted sample (n = 3,175).

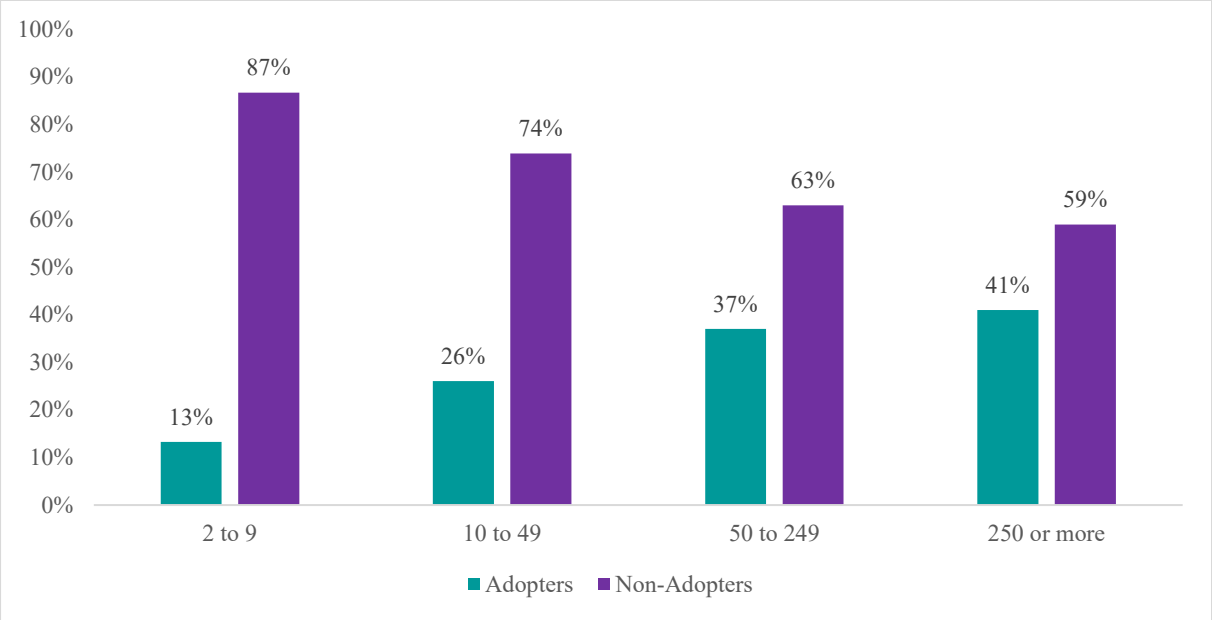
Similarly, the adoption of distribution-centred platforms rises with firm size but at significantly lower rates. The micro firms (2 to 9 employees) show a mere 10% adoption rate, with large firms (250 or more employees) achieving a modest 25%. Even among the largest firms, non-adoption remains prevalent, indicating substantial challenges in the adoption of distribution-centred platforms, irrespective of firm size.

Figure 13 highlights platform adoption by company sector and suggests that it is largely driven by the service sector, which significantly outpaces other industries. Services dominate both operations-centred and distribution-centred platform adoption, reflecting their alignment with digitalisation trends in the broader economy. Manufacturing shows moderate adoption rates, indicating gradual integration of platform technologies, while sectors such as construction, electricity, gas, water supply, and mining exhibit minimal adoption, underscoring barriers in less digitally integrated industries.

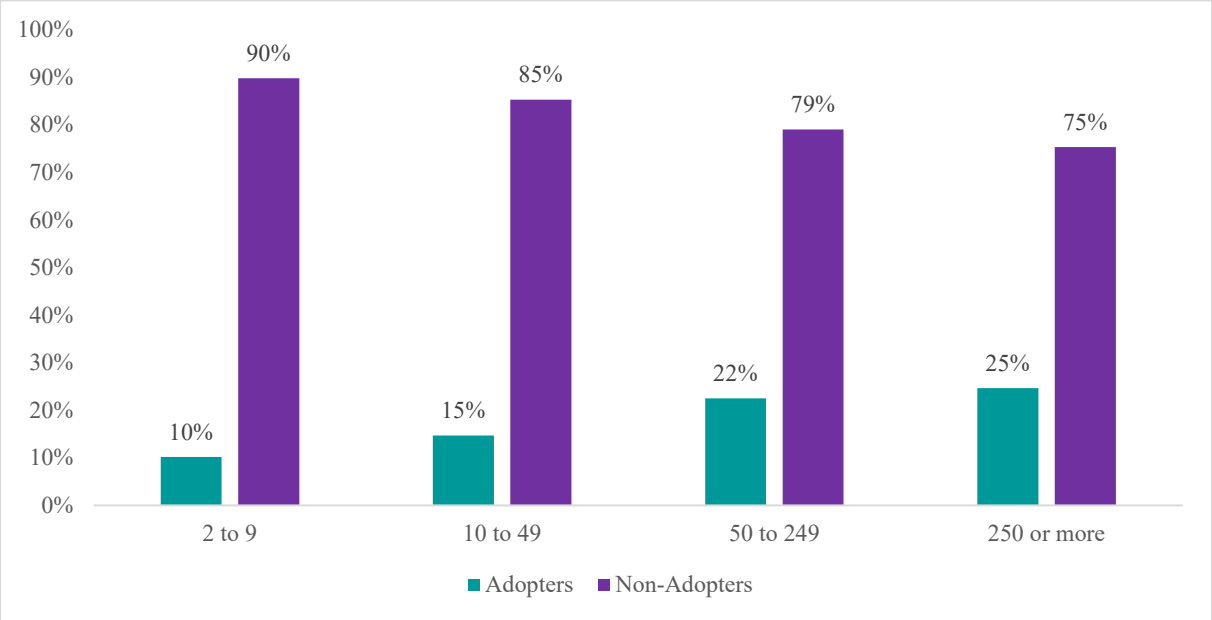
Figure 14 focuses on sectors and reveals a pronounced regional disparity in platform adoption across the UK. Adoption is concentrated in London and the South East, which together account for a substantial share of both operations-centred and distribution-centred platform users. Other regions, such as the East Midlands, Wales, and Northern Ireland, show significantly lower uptake, reflecting limited access to or interest in platform technologies outside economic hubs. These regional trends highlight the uneven distribution of platform benefits, potentially exacerbating existing economic disparities between more and less industrially active regions.

Figure 12. Adoption of Platforms by Size of Firms

(a) Operations-centred Platforms



(b) Distribution-centred Platforms



Note: Weighted sample (n = 3,175).

Figure 13. Adoption of Platforms by sector

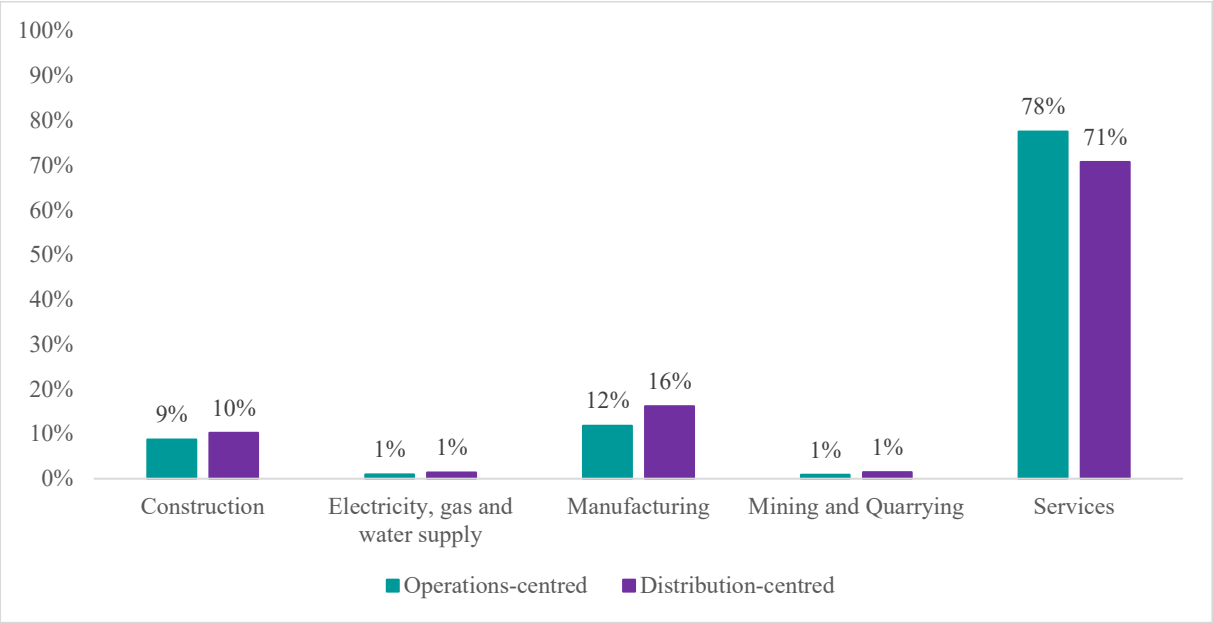
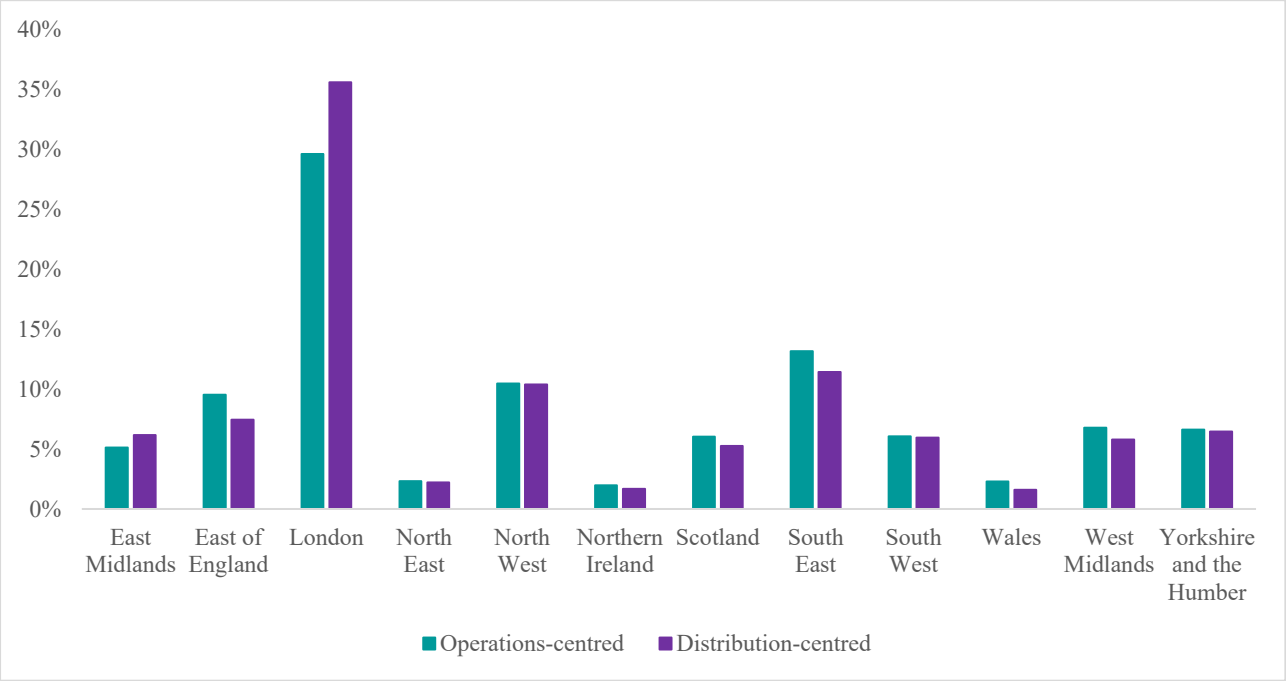


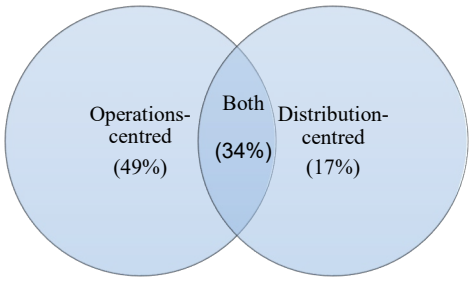
Figure 14. Adoption of Platforms by Region



Note: Weighted sample (n = 1,033 for operations-centred, n = 725 for distribution-centred).

Figure 15 illustrates the distribution of platform adoption among firms, showing distinct patterns for operations-centred and distribution-centred platforms. Out of 1,238 firms, 49% have adopted only operations-centred platforms, while 17% have adopted only distribution-centred platforms. Notably, 34% of firms use both types of platforms, suggesting an overlap that highlights strategic complementarities. The significant overlap in adoption indicates that firms leveraging both platforms may benefit from aligning operational efficiencies with enhanced distribution capabilities. This dual adoption could enable firms to streamline internal processes while effectively managing market-facing activities, fostering a more cohesive approach to platform integration.

Figure 15. Platform Adoption Patterns Among Firms



Note: Weighted sample (n = 420).

Figure 16 shows the characteristics of firms that adopt both types of platforms in terms of size, primary activities, and regional distribution. Overall, the characteristics of firms adopting both operations-centred and distribution-centred platforms are consistent with the general patterns observed in the above analyses. There is a clear trend towards higher adoption rates in the manufacturing and services sectors and among larger firms. In terms of region, London accounts for approximately 44% of the firms adopting both platforms. This regional skew could underscore the prominence of London as a hub for dual-platform adoption, likely driven by its economic scale and technological ecosystem.

In sum, despite the growing prevalence of operations-centred platforms over 2021–2023, non-adoption rates remain high, with limited uptake of distribution-centred platforms highlighting significant barriers. The adoption of digital platforms remains concentrated among larger firms, with smaller firms struggling to keep up. More specifically, dual-platform adoption is driven by larger firms in manufacturing and services, with London emerging as the leading hub for integrating operational and distribution capabilities. Platform adoption is dominated by the service sector and concentrated in London and the South East, exposing a stark digital divide across industries and regions in the UK.

4.3.2 Impact of Platforms Adoption on Efficiency and Innovation

Figures 17 and 18 demonstrate the positive effects of operations-centred and distribution-centred platforms on firm performance, specifically in terms of efficiency and innovation. While both platform types deliver substantial benefits, differences in their magnitude and consistency are notable.

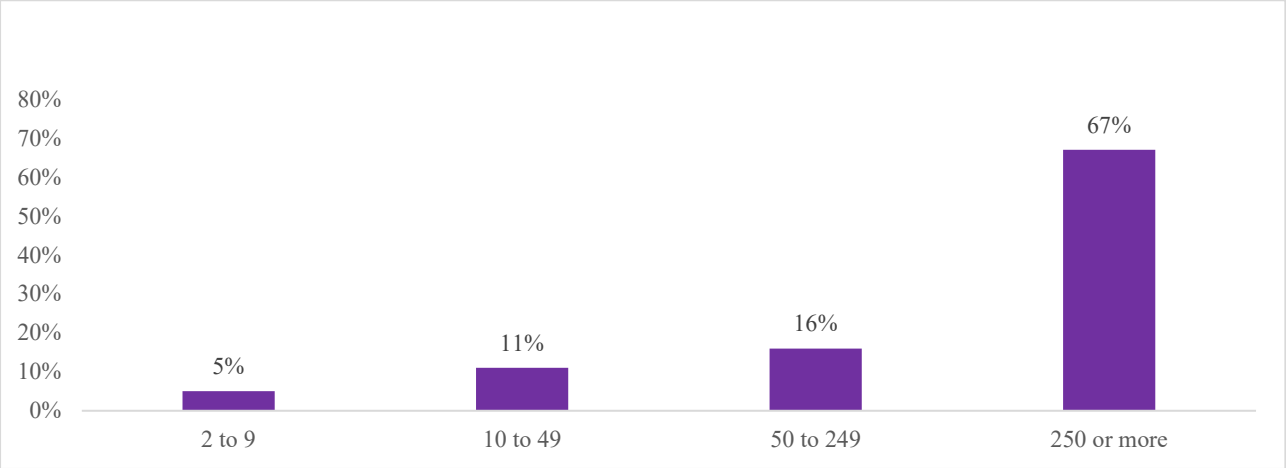
In relation to efficiency, as shown in Figure 17(a) and Figure 18(a), operations-centred platforms significantly enhance efficiency, with 81% of respondents reporting improvements. Among these, 31% experienced a substantial increase, and 50% observed a moderate increase. Respondents were informed that efficiency improvements referred to reductions in the time required for production or service provision and better utilisation of resources. Only 4% reported a decline, and 13% noted no change. Similarly, Figure 18(a) highlights a strong positive impact of distribution-centred platforms, with 77% of respondents reporting efficiency improvements (37% substantial and 40% moderate). However, a slightly higher proportion of firms (17%) reported no change with distribution-centred platforms, indicating slightly less consistency compared to operations-centred platforms.

For innovation, Figure 17(b) and Figure 17(b) reveals that 62% of firms experienced improvements after adopting operations-centred platforms, with 23% indicating a substantial increase and 39% reporting a moderate increase. Respondents were informed that innovation referred to the introduction of new products or services. A notable 32% of firms reported no change, reflecting variability in the impact of these platforms on innovation. By comparison,

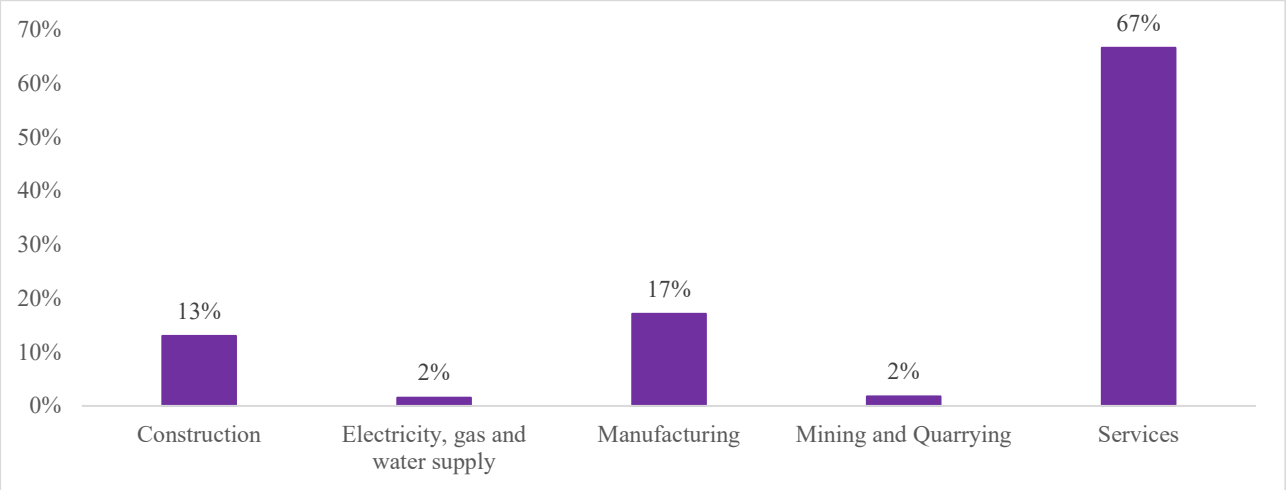
Figure 18(b) shows a stronger effect of distribution-centred platforms on innovation, with 73% of firms reporting positive outcomes (36% substantial and 37% moderate). Additionally, fewer firms (23%) reported no change, suggesting that distribution-centred platforms may have a more consistent positive impact on fostering innovation.

Figure 16. Characteristics of Firms that Adopt Both Platforms

(a) Size of Firms



(b) Primary Activities



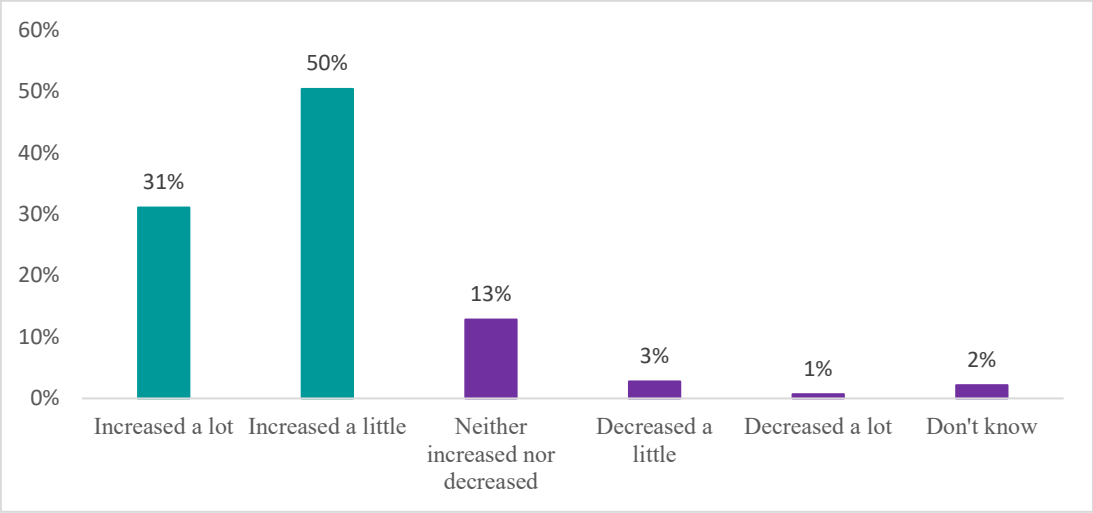
(c) Region

Note: Weighted sample (n = 420).

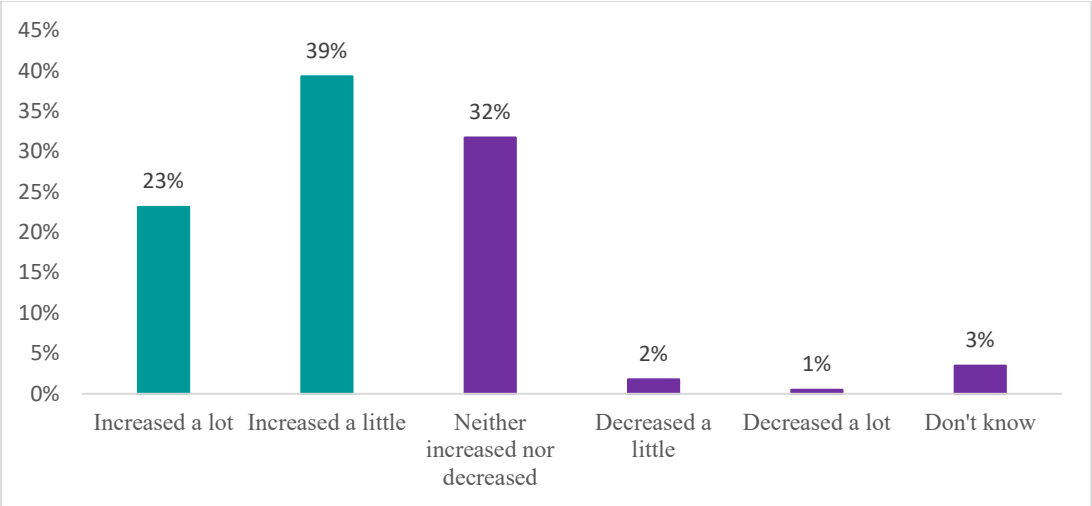
Taken together, the findings indicate that both platform types enhance efficiency and innovation, with efficiency gains being more consistent across firms. Distribution-centred platforms appear to have a stronger overall impact on innovation, likely due to their direct influence on product delivery and customer-facing processes. In contrast, operations-centred platforms excel in streamlining internal processes, which primarily enhance efficiency. These insights underscore the complementary nature of the two platform types, as they contribute to firm performance in distinct yet mutually reinforcing ways.

Figure 17. Impact of Operations-centred Platforms on Efficiency and Innovation

(a) Efficiency



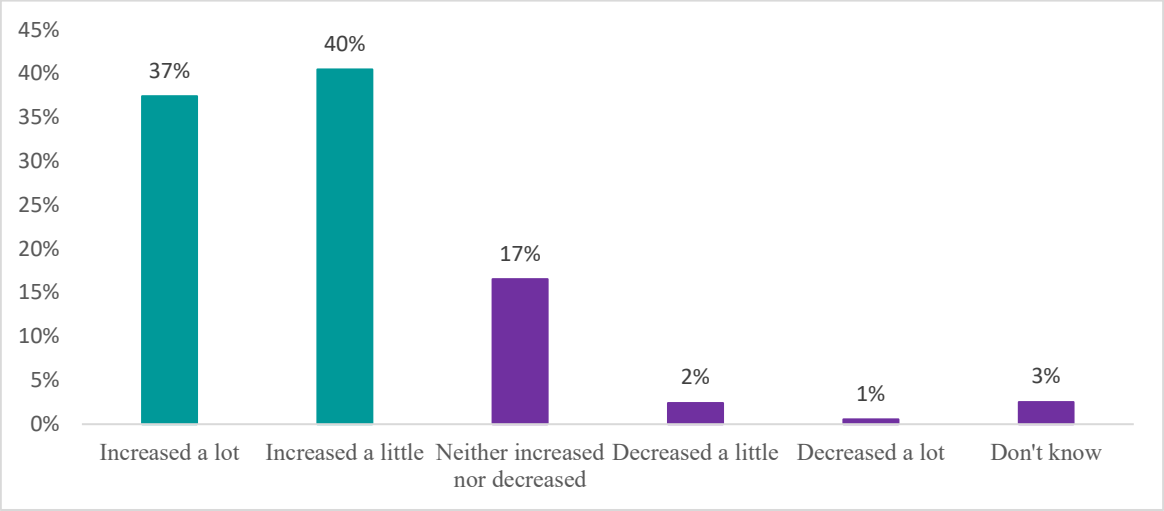
(b) Innovation



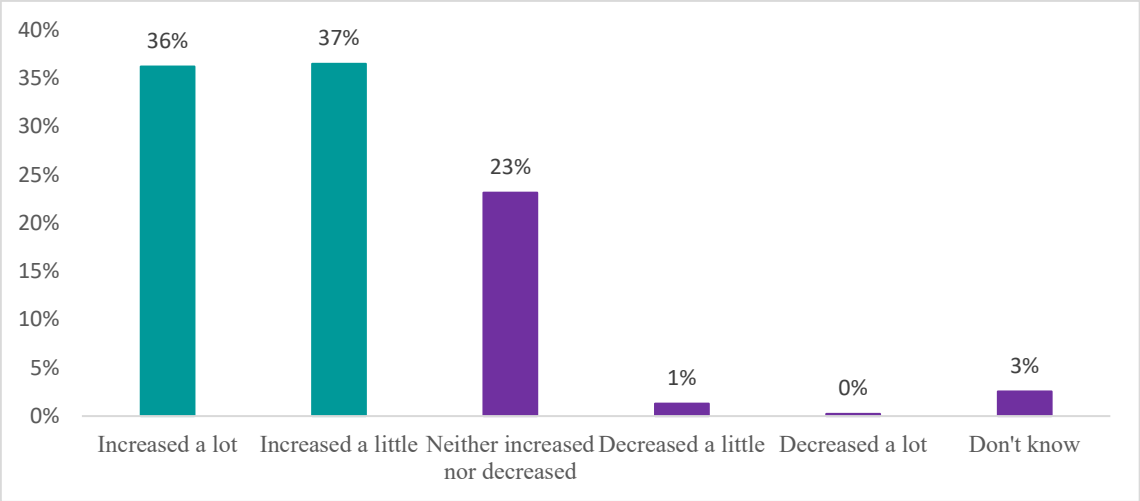
Note: Weighted sample (n = 1,033).

Figure 18. Impact of Distribution-centred Platforms on Efficiency and Innovation

(a) Efficiency



(b) Innovation



Note: Weighted sample (n = 725 for distribution-centred).

4.3.3 Drivers of Improved Efficiency and Innovation

Figure 19 reveals several core factors driving efficiency and innovation across operations-centred and distribution-centred platforms, highlighting both commonalities and distinct areas of emphasis.

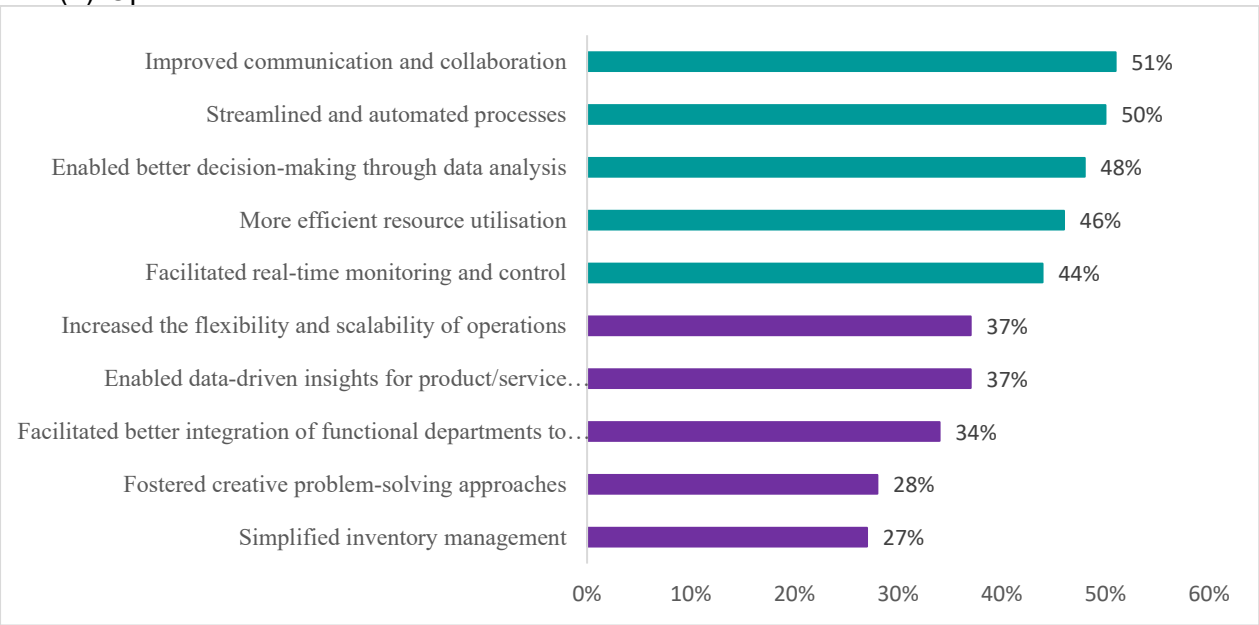
Looking at operations-centred platforms (Figure 19(a)), adopters of these platforms benefit primarily from improved internal processes, with key factors including enhanced communication, streamlined workflows, and data-driven decision-making. These platforms enable firms to optimise resource utilisation and facilitate better integration across departments, promoting collaboration and efficiency. Real-time monitoring and control further aid proactive management, while scalability and flexibility allow for gradual operational adjustments. The emphasis is on refining internal operations to maximise productivity and consistency.

In contrast, distribution-centred platforms (Figure 19(b)) focus more on external responsiveness and adaptability. Flexibility and scalability emerge as the most critical factors, reflecting the need to meet dynamic market demands and supply chain challenges. Data-

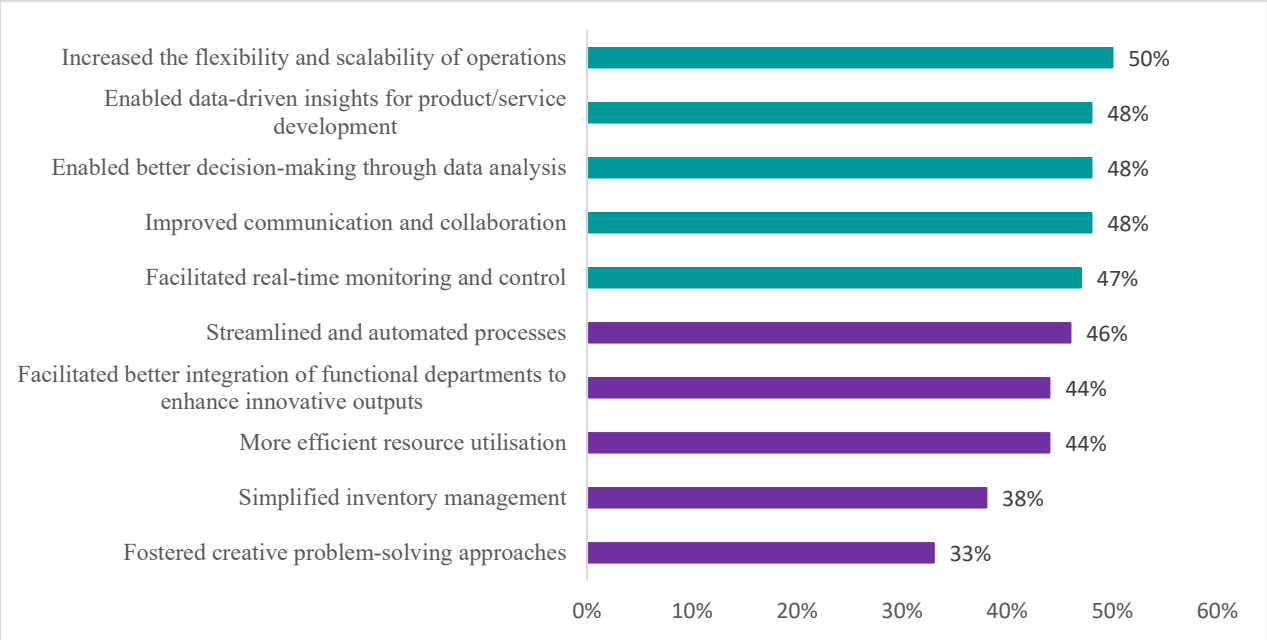
driven insights play a crucial role in tailoring products and services to customer needs, fostering innovation while improving operational efficiency. These platforms also enhance communication and real-time monitoring, enabling firms to better coordinate supply chain processes and customer-facing activities.

Figure 19. Reasons for Improved Efficiency and/or Innovation

(a) Operations-centred Platforms



(b) Distribution-centred Platforms



Note: Weighted sample (n = 1,033 for operations-centred, n = 725 for distribution-centred).

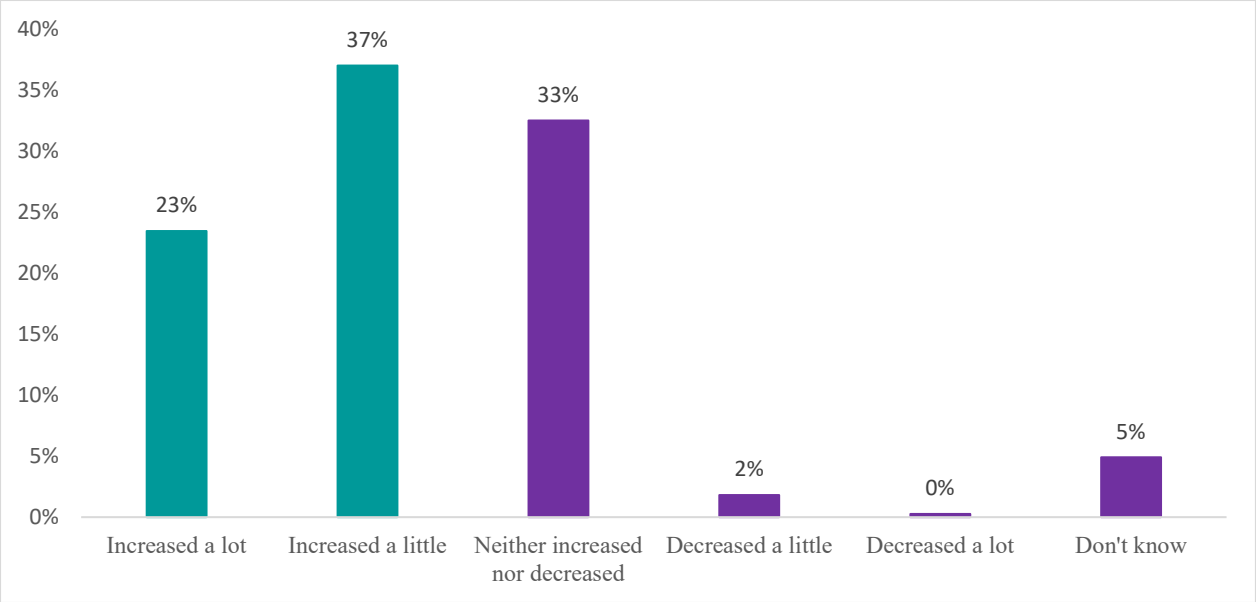
While both platform types share benefits like improved communication, resource optimisation, and process automation, the focus diverges in their primary impact areas. Operations-centred platforms prioritise internal efficiency and decision-making, whereas distribution-centred platforms excel in adaptability, innovation, and market responsiveness. As mentioned earlier, these distinctions reflect the complementary nature of the two platform types, with each contributing uniquely to firm performance based on its operational focus.

4.3.4 Impact of Platforms Adoption on Customer Satisfaction and Market Competitiveness

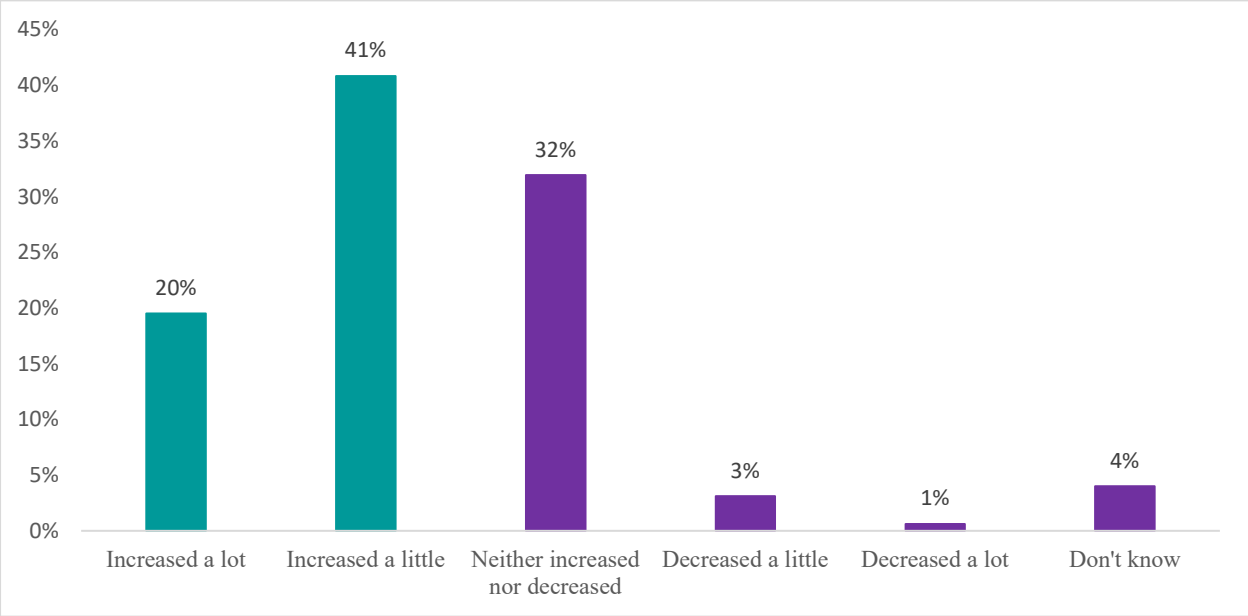
Figures 20 and 21 illustrate the impact of operations-centred and distribution-centred platforms on customer satisfaction and market competitiveness. Across both platform types, the survey results indicate predominantly positive outcomes, with notable differences in the magnitude of their effects on these two dimensions.

Figure 20. Impact of Operations-centred Platforms

(a) Customer Satisfaction



(b) Market Competitiveness



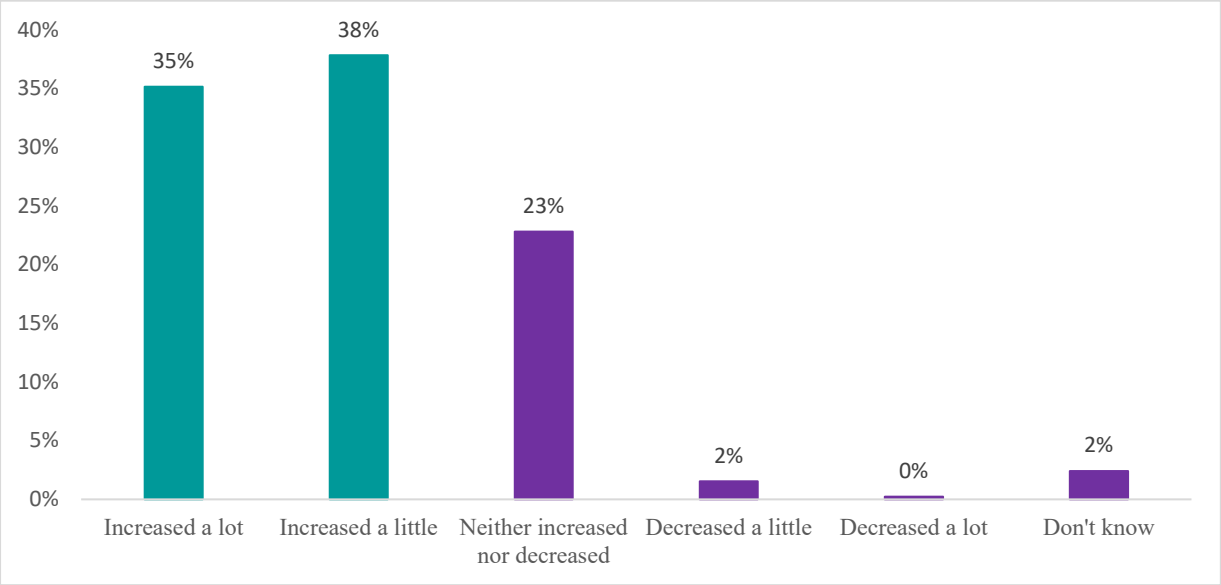
Note: Weighted sample (n = 1,033).

As shown in Figure 20(a), 60% of respondents reported improvements in customer satisfaction following the adoption of operations-centred platforms, with 23% indicating a substantial increase and 37% reporting a moderate increase. However, a significant share (33%)

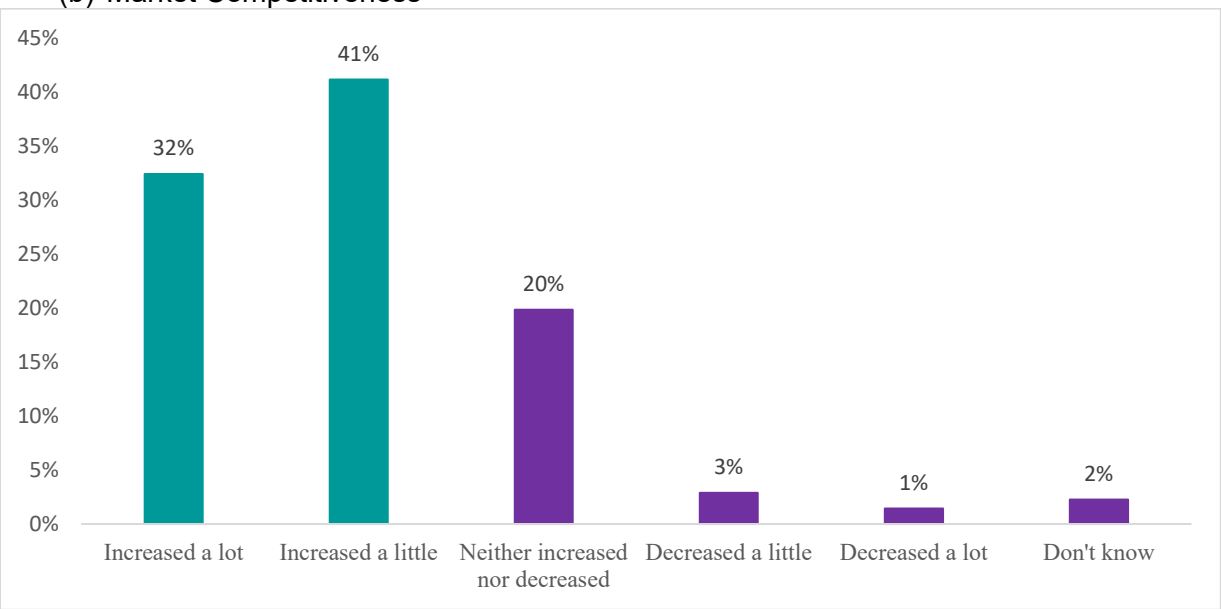
observed no change, reflecting the internal focus of these platforms. In contrast, Figure 21(a) reveals a stronger impact of distribution-centred platforms on customer satisfaction, with 73% of respondents reporting positive outcomes. This includes 35% experiencing a substantial increase and 38% reporting a moderate increase. Notably, fewer respondents (23%) reported no change with distribution-centred platforms, suggesting a more consistent positive effect.

Figure 21. Impact of Distribution-centred Platforms

(a) Customer Satisfaction



(b) Market Competitiveness



Note: Weighted sample (n = 725 for distribution-centred).

For market competitiveness, Figure 20(b) shows that 61% of respondents reported improvements from operations-centred platforms, with 20% indicating a substantial increase and 41% reporting a moderate increase. Approximately one-third of firms reported no change, suggesting that while beneficial, the effects may be contingent on external or firm-specific factors. By comparison, Figure 21(b) demonstrates a stronger and more consistent impact from distribution-centred platforms, with 73% of firms reporting improvements (32%

substantial and 41% moderate). Only 20% of firms observed no change, reinforcing the view that distribution-centred platforms more directly influence competitive positioning.

Taken together, the findings suggest that distribution-centred platforms have a more immediate and pronounced effect on customer satisfaction and market competitiveness compared to operations-centred platforms. This difference is likely due to the external, customer-facing nature of distribution-centred platforms, which enhance product delivery, availability, and responsiveness to market demands. In contrast, operations-centred platforms primarily focus on internal efficiencies and process optimisations, which, while valuable, may not translate as directly into improvements in customer-facing metrics or competitive advantages. These insights highlight the complementary roles of the two platform types, with distribution-centred platforms excelling in outward-facing outcomes and operations-centred platforms enhancing internal capabilities.

4.3.5 Drivers of Improved Customer Satisfaction and Market Competitiveness

Figure 22 highlights distinct ways in which operations-centred and distribution-centred platforms contribute to customer satisfaction and market competitiveness, reflecting their respective strengths in internal processes and external responsiveness.

Operations-Centred Platforms focus on internal efficiencies, driving improvements in consistency, quality, and speed of delivery. By streamlining processes and enhancing communication, they enable firms to deliver reliable and high-quality services. These capabilities not only enhance customer satisfaction but also strengthen competitive positioning through better responsiveness and tailored offerings. The emphasis is on maintaining high operational standards to meet customer expectations effectively.

In contrast, distribution-centred platforms prioritise external-facing capabilities. Streamlined interactions with suppliers, broader customer options, and increased transparency directly impact customer experiences, fostering trust and satisfaction. These platforms also enhance flexibility and adaptability, enabling firms to respond dynamically to market shifts and customer demands. By facilitating smoother supply chain operations, they empower firms to differentiate themselves and remain competitive in fast-changing environments.

While operations-centred platforms excel in building reliability and efficiency internally, distribution-centred platforms emphasise customer-facing outcomes, such as adaptability and choice. Together, they highlight a strategic trade-off: firms prioritising operational consistency may lean toward operations-centred platforms, while those focused on market responsiveness and flexibility might favour distribution-centred platforms. Tailoring platform adoption to specific business priorities is crucial to maximising their impact.

4.3.6 Barriers to Platform Adoption

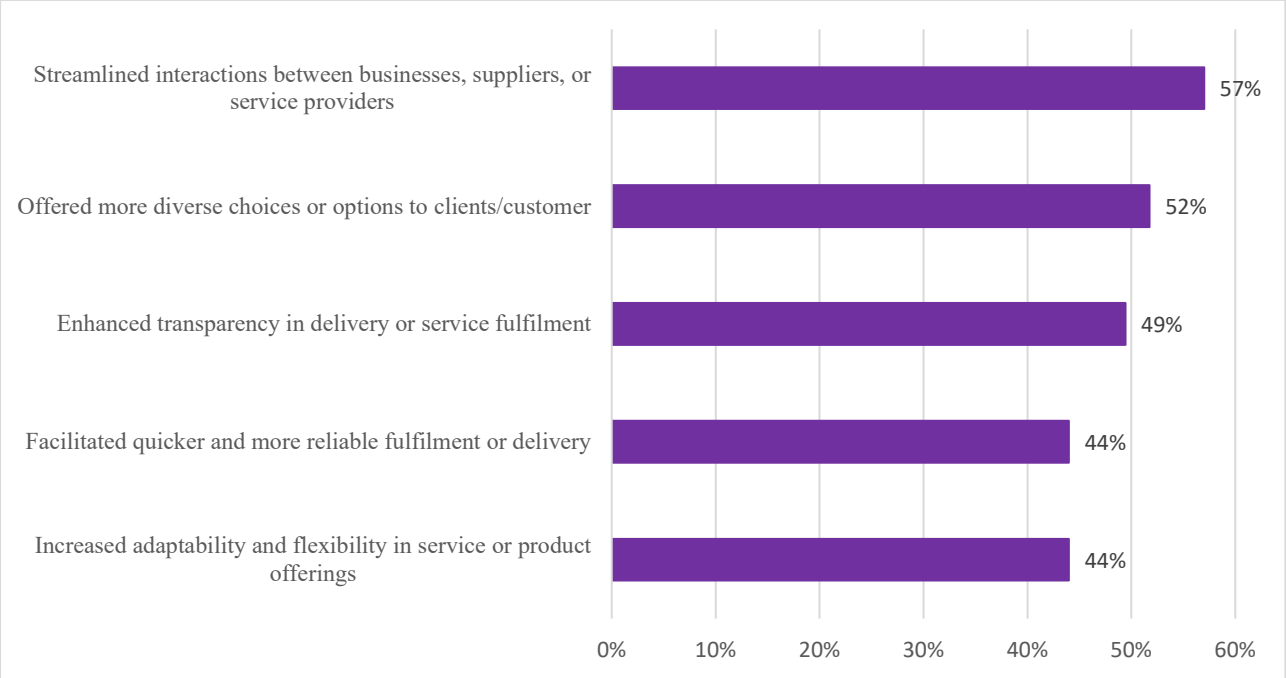
Figure 23 identifies key barriers to adopting operations-centred and distribution-centred platforms among non-adopters, highlighting both shared and unique challenges.

In the case of operations-centred platforms**, t**he most cited barrier (39%) was the perceived inapplicability of the technology to the business, reflecting a misalignment between platform capabilities and organisational needs. Additionally, 29% of respondents reported no specific adverse factors, suggesting a lack of perceived need or benefit. Structural challenges, such as the inability to make necessary organisational changes (9%) and costs (8%), also featured prominently. Other barriers, such as limited skills, immature technology, and security concerns, were less influential but still present.

Figure 22. Reasons for Improved Customer Satisfaction and Market Competitiveness

(a) Operations-centred Platforms

(b) Distribution-centred Platforms



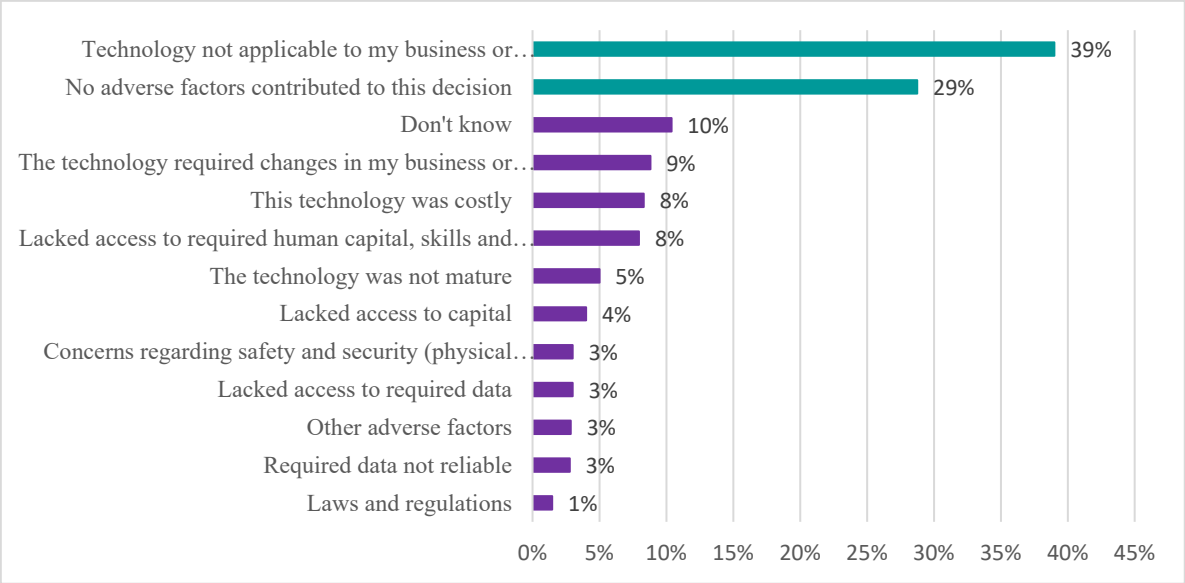
Note: Weighted sample (n = 1,033 for operations-centred, n = 725 for distribution-centred).

Similarly, the primary barrier for distribution-centred platforms was their perceived inapplicability, cited by 51% of respondents. A significant proportion (27%) also reported no adverse factors, underscoring a lack of perceived urgency or benefit. Additional challenges included organisational resistance to change (5%) and a lack of understanding or information about the technology (8%). Factors such as safety concerns, regulatory issues, and data-related problems were mentioned but played a minor role.

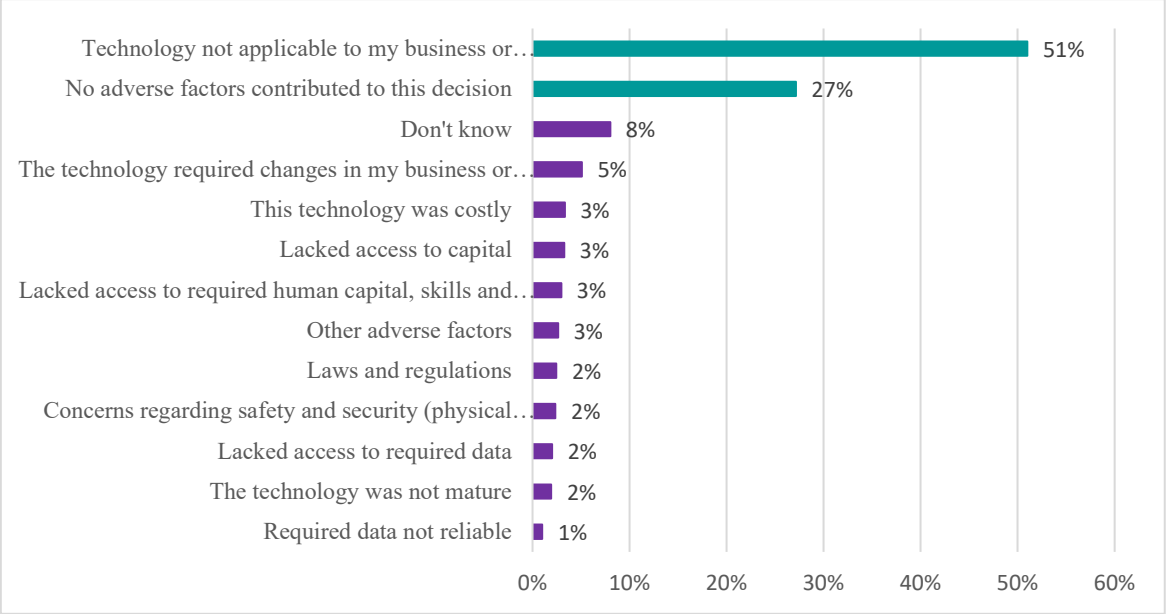
For both platform types, the perception that the technology is not applicable to the business represents the most significant obstacle, indicating a need for better alignment between platform offerings and business contexts. The high proportion of firms reporting no specific barriers suggests a broader lack of awareness about the potential benefits and competitive advantages these platforms can provide. Addressing these gaps in understanding and communication is critical to increasing adoption rates, particularly for businesses that may not yet recognise the need for innovation or digital transformation.

Figure 23. Barriers to Platform Adoption

(a) Operations-centred Platforms



(b) Distribution-centred Platforms



Note: Weighted sample (n = 1,033 for operations-centred, n = 725 for distribution-centred).

5. Conclusions

This study offers a unique collection of data on the adoption of different advanced ADTs (AI, Big Data, Cloud Computing, 3D Printing, IoT, and Robotics) and digital platforms (operations-centered and distribution-centered) in the UK. By employing a high-resolution lens, we can accurately characterise the broader effects of technology adoption on firms' outputs and processes. To the best of our knowledge, this is the first study that allows for regional, sectorial, and organizational comparisons of adoption rates. These results add a new level of detail to our understanding of ADTs, particularly through our discussion of usage intensity, specific skills required, regional nuances in ADT adoption, and the mixed short-term impacts on productivity-related and other outcomes and costs. The main results are explained below.

First, *ADTs are widely diffused, with Cloud Computing dominating across the board*. In the UK economy, which is predominantly based on the service sector, 4 out of 5 businesses in each region are using at least one form of ADT. London, the North West, and the West Midlands have the highest adoption rates (up to 95%), demonstrating that regions with more established business hubs tend to adopt ADTs more extensively. However, within specific sectors, the differences become clearer. The utilities and extractive sectors, for example, are particularly strong in ADT adoption across a range of technologies. Similarly, our study suggests that SMEs find the adoption of ADTs more challenging compared to larger companies, which tend to adopt and use more ADTs, a result consistent with the US case (Zolas et al., 2020). An exception is the case of Cloud Computing, where SMEs report similar figures to larger companies, probably because less resourceful small firms can still take advantage of Cloud services as a substitute for costly in-house computing capabilities with outsourced IT services (Jin & McElheran, 2017).

Among all technologies, Cloud Computing is also the most widely adopted (about four out of five companies) in all regions and sectors, with high use rates among both SMEs and large companies. Its wide reach stems from its flexibility and broad applicability, benefiting everything from storage to collaboration and data analytics. Cloud Computing's high-capacity usage outpaces that of other ADTs, illustrating that companies are not only adopting but also investing in deep, sustained use. However, ADTs are not adopted in isolation and show a certain level of complementarity (Ciarli et al., 2021; Cho et al., 2022). Almost one out of four companies have adopted at least two technologies, suggesting some joint use. The most frequent combinations of technologies are Cloud Computing and AI, and Cloud Computing and Big Data, reinforcing the importance of data and signalling a strong move toward digital-first business processes. For example, firms wanting to use AI require large datasets to train their algorithms, which can be generated and collected at scale using Big Data practices and processed and stored on Cloud Computing services (OECD, 2019).

AI ranks as the second most adopted technology (nearly 50%), a result not much higher than the combined figure for the EU, 42% (Kazakova et al., 2020). However, its usage intensity is predominantly low, especially outside London. This suggests that while companies recognize AI's potential, many are still testing or using it at a moderate capacity, likely due to its complexity and higher associated skill demands. Against the common view that once technologies are tested, they tend to be adopted, we highlight that in the case of more sophisticated ADTs, adoption requires integration and adaptation to guarantee company

readiness and intensive use of the technology (McKinsey, 2016; Vial, 2019). Big Data, adopted by about one-third of companies, shows a more balanced usage intensity, indicating companies may find it easier to integrate into existing processes compared to AI. In contrast, more specialized, physical ADTs like Robotics and 3D Printing have lower adoption rates, particularly outside of manufacturing and extractive sectors.

Second, *motivations and barriers for technology adoption present distinct patterns across different ADTs and sectors*. Process improvement, quality enhancement, and automation are primary motivations driving ADT adoption, with Cloud Computing and Big Data especially linked to quality and process improvements. Barriers vary by technology, but high costs, safety/security concerns, and skill shortages consistently limit adoption, especially for Robotics and 3D Printing.

The technological specificity of the benefits may have implications for adopters. For example, Cloud Computing and Big Data are heavily used to streamline data management and analytics, which directly contribute to product and service improvements. AI and Robotics, however, are more frequently adopted for automation, with companies in these sectors focusing on optimizing repetitive or labour-intensive tasks. Similarly, there are sector-specific motivations for ADT adoption (EIB, 2021). AI adoption in the manufacturing sector is motivated by automation and process efficiency, helping manufacturers address production speed and quality control. In the services sector, results are more polarised, with Cloud Computing's main benefit being its ability to facilitate seamless operations and enhance customer interactions, while AI assists in decision-making processes based on customer data analytics. This reveals a tailored approach to digital technology adoption that matches sector-specific needs.

Regarding the barriers to adoption, the perceived immaturity of AI and safety/security concerns for Cloud Computing and IoT reflect caution around emerging technologies, particularly those involving sensitive data. This calls for further data regulations, as suggested by the OECD (2019), requesting governments to prioritize the development of policies addressing data access and strengthen the responsiveness and agility of policies in view of rapidly changing contexts, to include security as well as ethical considerations around AI. For Big Data and other specialized technologies, a lack of necessary digital skills, which affects nearly 17% of companies, is a significant impediment. High adoption costs also restrict ADT expansion, particularly in technologies like 3D Printing and Robotics, where initial investment requirements can be substantial.

Third, *ADT adoption generates skill enhancement and positively affects productivity-related and other outcomes, although there are mixed impacts depending on the specific ADT*. ADTs increase the need for STEM capabilities and digital skills among employees, which are necessary for operating advanced technologies. Digital skills are more critical for ADT adopters, who report a pronounced need for skills like digital information literacy and cybersecurity, reflecting the increasing reliance on data and the necessity for secure information handling. But non-digital skills—particularly in resource management and social skills—are also highly relevant. Skills in areas such as system management and teamwork are needed to support effective ADT adoption, indicating that successful ADT implementation requires a blend of digital and non-digital skills (Balsmeier and Woerter, 2019; World Economic Forum, 2020). To achieve this, many companies have introduced on-the-job training, especially for Cloud Computing, AI, and Big Data, highlighting a growing emphasis on skill

development to support ADT use across company sizes and sectors. However, the preference for on-the-job training and blended learning, rather than formal off-site education, suggests that companies value customized, context-specific skill development for ADT and application-driven learning approaches over traditional training models (McKinsey, 2021).

Companies adopting ADTs also report benefits on productivity-related and other outcomes. The data show that nearly 50% of adopters report improved service quality, and just above one-third report enhanced product quality. Companies utilizing Cloud Computing, Big Data, and 3D Printing particularly benefit from gains in product/service diversification and production volume, indicating that ADTs allow companies to expand their offerings and reach a broader customer base. While many ADTs are introduced to improve operational efficiencies, some, like AI and robotics, introduce cost and time pressures, with a noticeable percentage of adopters reporting increased production costs and longer delivery times. This trend could reflect the initial challenges, including learning, adaptation, and restructuring of business processes associated with implementing complex technologies, and the ongoing need to refine these processes to balance cost and efficiency in the firm integration strategy.

Fourth*, there is regional variability in ADT adoption, and London plays a distinctive role in the intensity of use*. While ADT adoption rates are generally high across regions, the intensity of use for most technologies is distinctively higher in London. This pattern suggests that although companies in all regions are embracing ADTs, London firms are investing more heavily in developing and deeply integrating these technologies, with comparatively higher AI usage intensity and robotics adoption rates. This is in line with the literature that highlights urban centres leading in terms of technology adoption due to infrastructure and talent availability (DCMS, 2021; EC, 2020). London, as a tech hub, is frequently noted for its higher rates of ADT adoption compared to other regions. This observation challenges the perception that adoption alone at the country level indicates digital maturity, revealing that high usage intensity in certain regions like London may accelerate their overall digital transformation and widen the regional digital divide.

Furthermore, our survey highlights significant trends and insights into digital platform adoption, revealing both the growing potential of these technologies and the challenges that remain across various sectors and regions in the UK. In this regard the fifth conclusion is *that adoption rates for digital platforms are steadily increasing*, with firms prioritizing operations-centred (32%) and distribution-centred platforms (19%) to address distinct strategic goals. Larger firms dominate adoption due to their capacity for integration, while smaller firms continue to face challenges such as resource constraints and perceived misalignment of benefits. The service sector leads adoption, reflecting its alignment with digital transformation, while the manufacturing sector demonstrates steady growth. While these trends indicate progress, significant non-adoption rates highlight that much work remains, particularly to support smaller firms and less digitally integrated industries.

Sixth, *platform adoption is concentrated among larger firms and specific regions, reflecting disparities in both firm size and regional access to ADTs*. Larger firms are better equipped to integrate platforms, gaining competitive advantages, while smaller firms often lack the resources or perceived benefits to adopt. Geographically, adoption is heavily concentrated in London and the South East, where firms benefit from greater access to digital infrastructure and economic opportunities. In contrast, regions such as Wales and Northern Ireland exhibit

much lower adoption rates, underscoring challenges related to infrastructure, digital access, and economic density. These trends suggest that firms in major business hubs and larger organizations are well-positioned to strengthen their competitive positions, potentially exacerbating existing inequalities across regions and firm sizes.

Seventh, *for firms that have adopted platforms, the benefits appear highly promising*. Among operations-centred platform adopters, 81% report increased efficiency through streamlined processes and resource optimization, while 73% of distribution-centred platform adopters note enhanced innovation, particularly in product development and service offerings. These platforms also drive improvements in market competitiveness and customer satisfaction, with 73% of distribution-centred adopters reporting better customer engagement. However, a non-negligible proportion of firms—13% for efficiency and 23% for innovation—report no notable impact, suggesting that complementary investments in areas such as organizational changes, R&D, and digital infrastructure are essential to unlocking the full potential of these platforms.

Finally, *barriers to platform adoption remain significant, particularly among smaller firms.* Up to 51% of non-adopters cite the perceived irrelevance of the technology to their business needs, reflecting misalignment between platform capabilities and operational contexts. High initial costs, alongside the structural adjustments required for effective integration, further deter broader adoption. These challenges underscore the need for tailored support, accessible resources, and better communication of platform benefits to enable firms of all sizes and across regions to fully embrace digital transformation.

To conclude, our findings reflect a complex ADT landscape in the UK, where adoption is widespread yet varied in depth and intensity, shaped by sector-specific needs, and hindered by barriers such as skill shortages and cost constraints. For companies, the challenge remains to balance ADT investments with skill development and cost management, ensuring that technology adoption aligns with organizational goals and workforce capabilities.

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Annex I. Representativeness of the sample

		Population	Unweighted sample	Weighted sample
Region	East Midlands	8.1%	6.9%	7.4%
	East of England	11.6%	8.8%	10.7%
	London	23.1%	19.6%	20.7%
	North East	2.9%	4.9%*	2.7%
	North West	10.6%	9.1%	9.7%
	Northern Ireland	2.1%	3.3%*	2.0%
	Scotland	6.5%	6.6%	6.1%
	South East	14.8%	15.9%*	14.0%
	South West	7.7%	7.7%	7.6%
	Wales	3.3%	3.3%	3.2%
	West Midlands	9.1%	6.8%	8.4%
	Yorkshire and the Humber	8.3%	7.1%	7.5%
Sector	Utility and extractive	1.5%	2.0%*	1.0%
	Construction	5.9%	9.3%*	8.0%*
	Manufacturing	10.5%	20.4%*	10.0%
	Services	82.1%	67.0%	81.0%
Size	2to9	17.2%	19.0%*	18.0%
	10to49	19.1%	18.8%	19.0%
	50to249	15.8%	16.5%	14.3%
	250 or more	47.9%	45.7%	48.7%

Note: Distribution of population of non-agricultural companies with 2 or more employees based on employment number (thousands) based on the 2023 Business Population Estimates for the UK and Regions. * Significance differences between the sample and the population at 5%.

Annex II. Measurement of adoption of ADTs, impact

Usage and development of ADTs

The respondents were asked about the extent to which their businesses used each of the six digital technologies during 2021-2023: “did not use”, “tested, but did not use”, “low use”, “moderate use” or “high use”. If the technologies were adopted, the year of adoption and the mode of access of the ADTs (i.e., “developed in-house” or “purchased from an external provider”) would be requested.

Motivations to adopt ADTs

If a particular ADT was adopted, respondents would be also asked the firms’ motivations, which could be any number of the seven options listed:

- automation
- improving goods/services quality
- expanding the range of goods/services
- upgrading outdated processes
- improving process quality,
- adopting standards and accreditation, and
- consequences of the pandemic.

Barriers to adopt ADTs

For the businesses where digital technologies were not used, respondents were asked to select all possible barriers from the following list, or indicate no barriers:

- technology not applicable to my business or organisation,
- this technology was costly,
- the technology was not mature,
- lacked access to required data,
- required data not reliable,
- lacked access to required human capital, skills and talent,
- laws and regulations,
- concerns regarding safety and security (physical security and/or cyber security),
- lacked access to capital, and
- the technology required changes in my business or organisation that we were not able to make.

Impact of adopting ADTs on employment and productivity-related outcomes

The adopters were also asked about the impact of adopting the particular digital technology in respect of employment and productivity-related outcomes.

The employment effect considers the number, skill level and STEM skills of employees, each of which is measured by a five-point Likert scale: “decreased a lot”, “decreased a little”, “neither increased nor decreased”, “increased a little” and “increased a lot”.

With the same measure, the productivity-related and other outcomes effect concerns eleven aspects:

- production costs/cost of processes,
- selling price of the goods and/or service,
- volume of production,
- product diversification,
- quality of product,
- time to deliver product,
- number of customers,
- types of customers,
- service diversification,
- quality of service, and
- time to deliver services.

Usage of digital platforms

The respondents were asked about the extent to which their businesses used each of the digital platforms during 2021-2023: “did not use”, “tested, but did not use”, “low use”, “moderate use” or “high use”. If the technologies were adopted, the year of adoption would be requested.

Impact of digital platforms

The adopters were also asked about the impact of adopting the particular digital platform in respect of efficiency, innovation, customer satisfaction and market competitiveness.

Each impact is measured by a five-point Likert scale: “decreased a lot”, “decreased a little”, “neither increased nor decreased”, “increased a little” and “increased a lot”.

The efficiency/innovation effects concern ten aspects:

- Faster delivery times
- Improved communication
- Expanded customer types
- Simplified inventory
- Enhanced service quality
- Flexible operations
- Scalable infrastructure
- Insightful development
- Creative problem-solving
- Functional integration

The customer satisfaction/market competitiveness concern five aspects:

- Faster, reliable delivery
- Consistent quality
- Market adaptability
- Efficient customer support
- Customised solutions

Barriers to adopt digital platforms

For the businesses where digital platforms were not used, respondents were asked to select all possible barriers from the following list, or indicate no barriers:

- technology not applicable to my business or organisation,
- this technology was costly,
- the technology was not mature,
- lacked access to required data,
- required data not reliable,
- lacked access to required human capital, skills and talent,
- laws and regulations,
- concerns regarding safety and security (physical security and/or cyber security),
- lacked access to capital, and
- the technology required changes in my business or organisation that we were not able to make.

Importance of skills

In addition to the six digital technologies and two digital platforms, the survey asked about digital and other skills in terms of their importance to the businesses, which are measured by a five-point Likert scale: “not at all important”, “somewhat unimportant”, “neither important nor unimportant”, “somewhat important” and “very important”. There are ten groups and a total number of fifty-four skills. We measure the importance of each group of the skills by the mean points within the group. The groups of skills are:

- digital information and data literacy
- digital communication and collaboration
- digital content creation
- digital safety
- digital problem solving
- practical skills
- social and soft skills
- technical skills
- system skills
- resource management skills.

Training

Respondents were also asked about training in relation to the adoption of each of the six digital technologies: “off-the-job-training”, “on-the-job-training”, “both off-the-job and on-the-job training” or “training was not organised”.

Annex III. Digital and non-digital skills

1. **Digital skills**

1a. Information and data literacy

1a.1. Browsing, searching and filtering data, information and digital content: to articulate information needs to search for data and information in digital environments.

1a.2. Evaluating data, information and digital content: to analyse, compare and critically evaluate the credibility and reliability of digital sources.

1a.3. Managing data, information and digital content: to organise, store and retrieve data and information in digital environments.

1b. Communication and collaboration

1b.1. Interacting through digital technologies: to interact through different digital technologies and understand digital communication.

1b.2. Sharing through digital technologies: to share data and information with others trough digital technologies

1b.3. Engaging in citizenship through digital technologies: to participate in society through digital services.

1b.4. Collaborating through digital technologies: to use digital tools and technologies for collaborative processes and co-creation.

1b.5. Netiquette: to be aware of behavioural norms and know-how while using digital environments.

1b.6. Managing digital identity: to create and manage digital identities while protecting one's own reputation.

1c. Digital content creation

1c.1. Developing digital content: to create and edit digital content in different formats.

1c.2. Integrating and re-elaborating digital content: to modify, refine, improve and integrate information and content.

1c.3. Copyright and licences: to understand how copyright and licenses apply to digital content.

1c.4. Programming: to plan and develop a sequence of understandable instructions for a computing system.

1d. Safety

1d.1. Protecting devices: to protect devices and digital content understanding risks and threats.

1d.2. Protecting personal data and privacy: to protect personal data and privacy in digital environments.

1d.3. Protecting health and wellbeing: to be able to avoid health risks and threats to physical and psychological wellbeing using digital technologies.

1d.4. Protecting the environment.

1e. Problem solving

1e.1. Solving technical problems: to identify technical problems when operating devices and using digital environments and to solve them.

1e.2. Identifying needs and technological responses: to assess needs and identify, evaluate, select and use digital tools to solve them.

1e.3. Creatively using digital technologies: to use digital tools and technologies to create knowledge and to innovate processes and products.

1e.4. Identifying digital competence gaps: to understand where one's own digital competence needs to be improved or updated.

2. **Non-digital skills**

2a. Basic and practical skills: developed capacities that facilitate learning or the more rapid acquisition of knowledge, such as:

- 2a.1. Basic numerical skills and understanding
- 2a.2. Communication in a foreign language
- 2a.3. Computer literacy/basic IT skills
- 2a.4. Manual dexterity – e.g., to mend, repair, assemble, construct
- 2a.5. Reading and understanding instructions, guidelines, manuals or reports
- 2a.6. Writing instructions, guidelines, manuals or reports

2b. Social and soft skills: developed capacities used to work with people to achieve goals, such as:

- 2b.1. Analytical thinking
- 2b.2. Customer handling skills
- 2b.3. Flexible thinking
- 2b.4. Instructing, teaching or training people
- 2b.5. Making speeches or presentations
- 2b.6. Managing their own feelings, or handling feelings of others
- 2b.7. Networking
- 2b.8. Persuading or influencing others
- 2b.9. Sales skills
- 2b.10. Strategic thinking
- 2b.11. Team working

2c. Technical skills: developed capacities used to design, set-up, operate, and correct malfunctions involving application of machines or technological systems, such as:

- 2c.1. Achievement focus
- 2c.2. Adapting to new equipment or materials
- 2c.3. Advanced numerical or statistical skills
- 2c.4. Advanced or specialists IT skills
- 2c.5. Complex problem-solving skills
- 2c.6. Drafting skills
- 2c.7. Processing advanced knowledge of products and services offered by their organisation
- 2c.8. Specialist skills or knowledge needed to perform the role

2d. System skills: developed capacities used to understand, monitor, and improve socio-technical systems, such as:

- 2d.1. Judgment and decision making
- 2d.2. Systems analysis and evaluation

2e. Resource management skills: developed capacities used to allocate resources efficiently, such as:

- 2e.1. Management of financial and material resources
- 2e.2. Management of personnel resources
- 2e.3. Strategic thinking and networking
- 2e.4. Time management

Annex IV. Disaggregation of the manufacturing and service sector

Manufacturing	**Freq.**	**%**
Basic pharmaceutical products and pharmaceutical preparations	26	8.1
Chemicals and chemical products	18	5.7
Computer, electronic and optical products	38	11.9
Electrical and optical equipment; Transport equipment	48	15.1
Food, clothing, wood, paper, publish & print	80	25.3
Fuels, chemicals, plastic metals & minerals (Except Chemical and pharmaceutical products)	31	9.8
Furniture; Other manufacturing	65	20.5
Repair and installation of machinery and equipment	11	3.6
Total	**318**	**100**
Service		
Accommodation & food service	142	5.5
Arts, entertainment and recreation	91	3.5
Education	110	4.3
Employment activities	19	0.7
Financial and insurance	318	12.4
Human health and social work activities	136	5.3
Land & pipelines transport	34	1.3
Media and publishing; Information service activities	122	4.8
Office administrative, office support and other business support activities	25	1.0
Professional services	569	22.1
Public administration and defence; Compulsory social security	1	0.1
Real estate	68	2.6
Rental and leasing	16	0.6
Security and investigation	9	0.4
Services to buildings and landscape activities	16	0.6
Telecommunications; Computer programming	260	10.1
Travel agency, tour operator reservation service and related activities	26	1.0
Warehousing & transportation support; postal and courier activities	41	1.6
Water & air transport	31	1.2
Wholesale and retail	192	7.5
Other service activities	261	10.2
Activities not elsewhere classified	84	3.3
Total	**2,572**	**100**

Note: sector refers to the primary industrial sector reported by companies

Annex V. Significant differences by region, sector and size

Region

		North East	North West	Yorkshire and the Hulm	East Midlands	West Midlands	East of England	London	South East	South West	Wales	Scot-land	Northern Ireland
North West	**Use**	CC, 3DP											
	Intensity of Use												
Yorkshire and the Hulm	**Use**												
	Intensity of Use		IoT										
East Midlands	**Use**	CC	3DP										
	Intensity of Use												
West Midlands	**Use**	CC			3DP								
	Intensity of Use												
East of England	**Use**												
	Intensity of Use			3DP		3DP							
London	**Use**	AI, BD, CC, 3DP, IoT, R	AI, BD, 3DP, IoT, R	AI, BD, 3DP, IoT, R	AI, BD, 3DP, IoT, R	AI, BD, 3DP, IoT, R	AI, BD, 3DP, IoT, R						
	Intensity of Use	AI		IoT	AI	AI	AI, 3DP						
South East	**Use**	AI, CC	3DP	AI	AI			AI, BD, 3DP, IoT, R					
	Intensity of Use							AI, IoT					
South West	**Use**	CC						AI, BD, 3DP, IoT, R	AI				
	Intensity of Use	CC, 3DP	CC, IoT					AI, IoT					

Wales	**Use**		BD					AI, BD, 3DP, IoT, R					
	Intensity of Use							AI					
Scotland	**Use**							AI, BD, 3DP, IoT, R					
	Intensity of Use												
Northern Ireland	**Use**			IoT				AI, BD, 3DP, IoT, R					
	Intensity of Use												

Note: AI= Artificial Intelligence; BD=Big Data; CC=Cloud Computing; 3DP=3D Printing; IoT=Internet of Things; R=Robotics. Significant difference between regions at 10% or lower reported in the table for the indicated technology. For example, there are significant differences in the use of CC and 3DP between North West and North East. Similarly, there are significant differences in the intensity of use AI between London and North East.

Sector

		Utility and Extractive	**Manufacturing**	**Construction**	**Services**
Manufacturing	**Use**	BD, IoT			
	Intensity of Use	AI			
Construction	**Use**	AI, BD, 3DP, IoT, R	3DP, R		
	Intensity of Use				
Services	**Use**	AI, BD, 3DP, IoT, R	AI, BD, 3DP, IoT, R	3DP, IoT, R	
	Intensity of Use	AI, IoT	AI, R	AI, CC,	

Note: AI= Artificial Intelligence; BD=Big Data; CC=Cloud Computing; 3DP=3D Printing; IoT=Internet of Things; R=Robotics. Significant difference between sectors at 10% or lower reported in the table for the indicated technology. For example, there are significant differences in the use of BD and IoT between the manufacturing and the utility and extractive sectors. Similarly, there are significant differences in the intensity of use AI between the manufacturing and the utility and extractive sectors.

Size

		2-9 employees	10-49 employees	50-249 employees	250+ employees
10-49 employees	**Use**	AI, BD, CC			
	Intensity of Use	CC			
50-249 employees	**Use**	AI, BD, CC, 3DP, IoT, R	AI, BD, 3DP, IoT, R		
	Intensity of Use	CC, 3DP, IoT	AI, BD		
250+ employees	**Use**	AI, BD, CC, 3DP, IoT, R	AI, BD, 3DP, IoT, R	AI, BD, R	
	Intensity of Use	AI, BD, CC, 3DP, IoT	AI, BD, CC, IoT	AI, BD	

Note: AI= Artificial Intelligence; BD=Big Data; CC=Cloud Computing; 3DP=3D Printing; IoT=Internet of Things; R=Robotics. Significant difference between firms' size at 10% or lower reported in the table for the indicated technology. For example, there are significant differences in the use of AI, BD and CC between micro (2-9 employees) and small (10-49 employees) companies. Similarly, there are significant differences in the intensity of use CC between micro (2-9 employees) and small (10-49 employees) companies.