Digital Skills Demand and Shortages and Their Impact in UK Regional Economies

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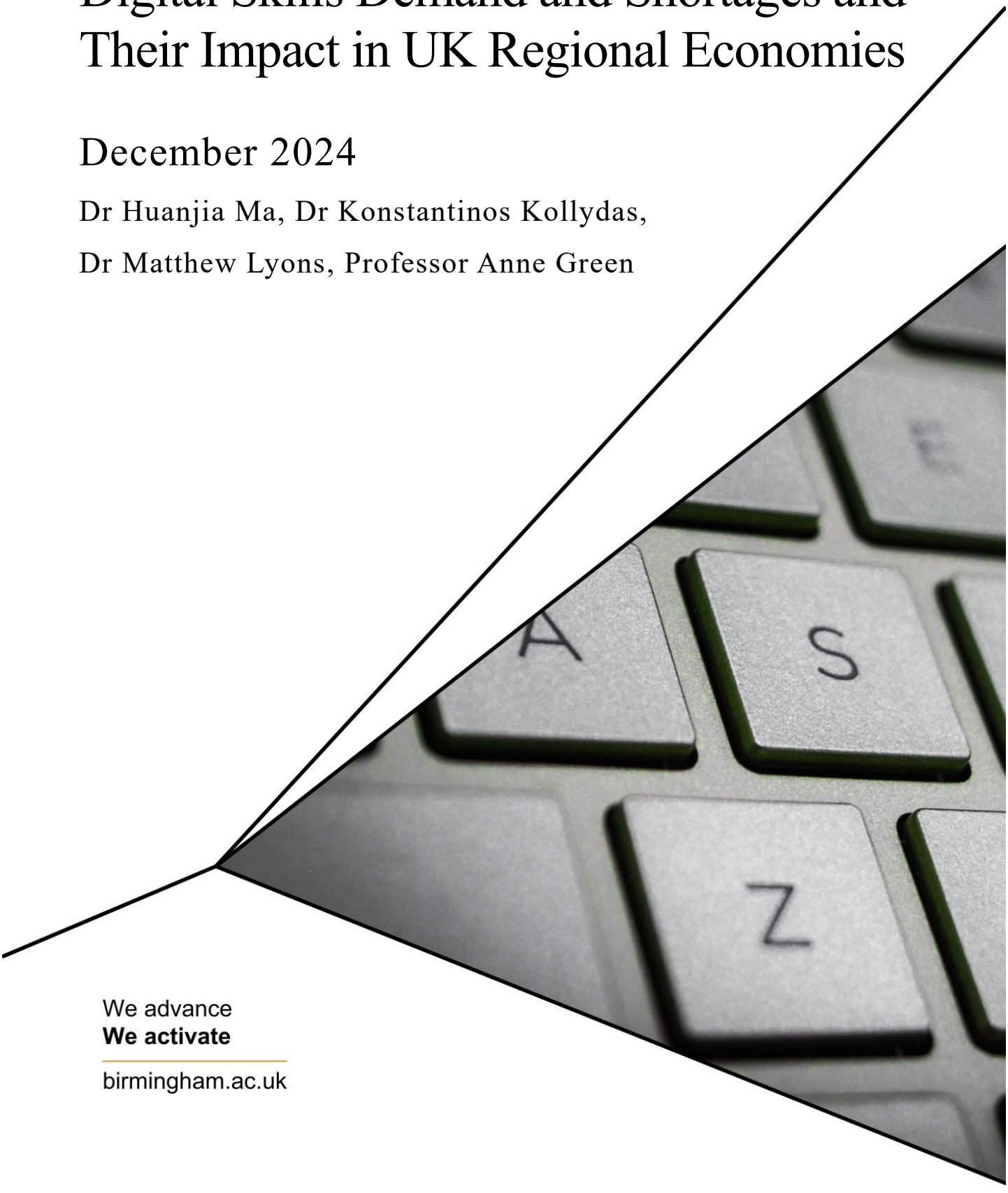

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Executive summary

This research report offers a comprehensive review of digital skills demand in the UK. It assesses whether the country is currently facing digital skills shortages and examines the potential future economic costs of such shortages, with a particular focus on regional differences.

Amid the rapid digitalisation of the economy, the UK has been described as facing a dire shortage in digital skills with warnings of a looming crisis and significant economic repercussions.

This research underscores the critical role and rapid evolution of digital skills in the UK, highlighting substantial demand across regions, sectors, and occupations, significant geographic and occupational disparities, and the risk of severe economic costs if digital skills shortages persist.

Main findings

- Over the past decade, the demand for digital skills in the UK has significantly increased. In 2022, job posts requiring any digital skills reached nearly 4.9 million, up from around 2.4 million in 2012. On average, 38.8% of job posts required some level of digital skills, underscoring the importance of digital competencies in the job market.
- There are significant geographic variations in digital skills demand, with London and the South East leading by a substantial margin in demand for digital skills across basic, intermediate and advanced levels.
- Regions outside the Greater South East, such as the North West, West Midlands, and Scotland, show notable demand for advanced and intermediate digital skills, reflecting their growing adoption of digital technologies and industrial diversification. However, regions like the North East show relatively lower demand for advanced digital skills, both numerically and proportionally, highlighting geographic variations in digital skill requirements.
- Digital skills are in demand across all occupational categories. Professional occupations have the highest requirements for advanced digital skills, but there is also substantial demand for basic and intermediate skills within elementary occupations.
- Skilled Trade occupations, along with Process, Plant, and Machine Operatives, have shown strong and consistent growth in the demand for digital skills at all levels, indicating rapid digitalisation in these occupations.
- The most in-demand advanced skills are associated with software development, including Agile methodology, SQL, C, and Java, with AI and Machine learning-related skills becoming increasingly important.
- For intermediate and basic skills, the demand is driven by productivity and efficiency-enhancing skills. Key areas include SAP applications, digital marketing, help desk support, and the Microsoft Office Suite, which are critical across various job functions.

- There is a clear trend towards increasing demand for AI, machine learning, cloud computing, and interactive content creation across all skill levels, highlighted by growing needs for Automation, Python, Microsoft Azure, Amazon Web Services, and Power BI. This reflects a broader shift in workplace technology, moving towards more integrated, cloud-based, and AI-driven technologies.

Using a combination of macroeconomic regional data and insights from job postings, this research has developed regional digital skills shortage indicators:

- The UK saw an increase in digital skills shortages across advanced, intermediate, and basic skill levels between 2018 and 2021, partly driven by the COVID-19 pandemic.
- Managers and professionals, including associate professionals, experienced the most acute shortages in 2021, while other occupations did not show obvious shortages.
- The devolved nations reported the highest shortages in advanced digital skills, with the South West and London also facing significant shortages in this area.
- Despite there being no national shortages in some occupations, significant regional variations exist, with occupations such as Elementary roles, Administrative roles, and Skilled Trades facing notable regional shortages, particularly in specific skill levels like advanced or basic digital skills.

This research used an input-output model to estimate the potential economic cost of digital skills shortages across regions and sectors:

- Assuming no improvement in the supply of digital skills, the economic cost of digital skills shortages in the UK could reach as much as £4.4 billion in 2024 and rise to as much as £27.6 billion by 2030. Additionally, more than 260,000 Full-Time Equivalent (FTE) jobs —particularly in professional and associate professional occupations—could be lost in 2024, increasing to over 380,000 by 2030.
- London and the Greater South East are expected to face the highest economic costs from digital skills shortages, although the North West, Yorkshire & the Humber, the East of England, and Scotland are also likely to bear significant costs relative to the size of their economies.
- Low-tech sectors, such as the manufacture of food, beverages, and textiles, along with wholesale industries, could face economic costs from digital skills shortages of up to £14 billion by 2030.
- Employment in professional and associate professional roles are likely to be most constrained, with projected FTE losses of over 69,000 and 60,000 respectively by 2030. However, elementary occupations will also face severe constraints, with an employment cost of up to 48,000 FTE jobs by 2030 as a result of digital skills shortages.

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1. Introduction

The increasing adoption of digital technologies in workplaces is reshaping the skills required by workers. In the UK, the digital economy contributed £158.3 billion in Gross Value Added (GVA) in 2022, accounting for 7.2% of the total UK GVA (DCMS, 2024). By 2030, the value of digital technologies to the UK economy is expected to reach £520 billion, driven by advancements such as AI, cloud computing, and data analytics (AWS, 2024). This projection underscores the crucial role of digitalisation, with 92% of UK businesses recognising technology as essential for their survival (Sage, 2022).

A defining feature of digital technology is its rapid pace of innovation, with new technologies frequently replacing older ones. For instance, in 2023, 39% of UK businesses reported adopting AI, an increase from 30% in 2022. Among those, 70% are already utilising generative AI or large language models (AWS, 2024). Such rapid technological advancement intensifies the demand for digital skills.

However, the supply of digital skills has not kept pace with this demand, leading to significant shortages that threaten economic growth and productivity. Existing research finds that almost 60% of the UK workforce (23.4 million people) cannot perform all 20 digital tasks deemed essential for work by industry and government. Over half of the workforce (17.1 million) lacks the digital skills needed for the workplace, and 11.7 million adults (22% of the adult population) are without the essential digital skills required for everyday life (FutureDotNow, 2023). These shortages are a major obstacle to both personal and business growth in the digital economy.

The benefits of the digital economy are also unevenly distributed across the UK. In 2020, London generated 38.4% of the UK's digital sector GVA, while the South East contributed 20.9% (DCMS, 2023a). Similarly, in terms of business sites, London accounted for 31.2% of digital sector businesses, with the South East comprising 19.2%—both higher than their shares of UK business sites overall (DCMS, 2023b). The shortage of digital skills also varies significantly by region, with some areas facing greater digital exclusion. The Digital Exclusion Heatmap (Go ON, 2017) revealed stark regional disparities in access to basic digital services and the possession of essential digital skills within local populations, which further exacerbates the uneven development of the digital economy across the UK.

The insufficient labour supply to meet the demand for digital skills could have serious repercussions for the wider economy. A lack of digital skills within the workforce limits businesses' ability to adopt new technologies, streamline operations, and innovate—critical drivers of economic expansion. With higher levels of skill gaps and shortages, firms face larger hiring costs due to increased search efforts, intensified competition for skilled workers, and weaker skill-matching effects (Haskel and Martin, 1993; Puga, 2010). Digital skills gaps can reduce overall productivity, slow down technological adoption, and inhibit the growth of emerging sectors, all contributing to slower economic growth (World Economic Forum, 2020; McKinsey & Company, 2021). Moreover, digital skills shortages create bottlenecks that can stifle economic dynamism and resilience by restricting access to high-quality jobs and limiting the ability to compete in the global market.

As demand and shortages of digital skills vary significantly across regions, they are likely to create unequal impacts across the UK. Regions with inadequate digital skills may struggle to attract and retain businesses, leading to disparities in regional

economic development. Furthermore, in regions characterised by a higher share of skill shortages or gaps, businesses may substitute skilled labour with less productive alternatives, potentially leading to low-skill traps (Finegold and Soskice, 1988; Gospel, 1998).

Despite the likely significant regional variations in demand, shortages and their economic impact, these aspects remain underexplored. This report focuses on the regional dimensions of digital skill shortages, aiming to understand the shortages of different levels of digital skills across regions and occupations, and how these shortages impose heterogeneous impacts on the UK economy.

A wide range of research has been dedicated to understanding the demand and supply of digital skills, spanning government, private sector, and academic studies (Burning Glass, 2019; Cunningham et al, 2022; FutureDotNow, 2023; and many more).

This report takes a regional perspective, examining the state of UK digital skills demand, shortages, and their heterogeneous impact on regional economies. Specifically, the analysis distinguishes between three levels of digital skills—advanced, intermediate, and basic—rather than treating digital skills as a single homogeneous category.

2. Defining digital skills

2.1 What are digital skills

The term 'digital skills' is broad and encompasses various categories of abilities. At its core, digital skills refer to the ability to use digital technologies, communication tools, and networks to access, manage, integrate, and evaluate information effectively. These skills are crucial for navigating and thriving in today's knowledge-based society, enabling individuals to solve problems, create content, and communicate in a digitally connected world (UNESCO, 2018; OECD, 2019).

While digital skills were initially associated with the specialised capabilities required by information and communication technology (ICT) professionals in the early stages of digitalisation, the widespread adoption of digital technology has broadened the scope of what constitutes digital skills. Today, these skills range from basic or foundational abilities, such as effectively using a computer, to more advanced competencies employed by ICT professionals, including programming and systems management (Cunningham et al., 2022).

In some cases, digital skills extend beyond technical abilities to include cognitive and soft skills necessary for solving problems using digital technology. For example, the UK Government's Essential Digital Skills Framework (Department for Education, 2019) highlights the importance of problem-solving using digital tools and online services, as well as the need for online safety and legal compliance as integral parts of the digital skillset.

Moreover, the concept of digital skills often encompasses more than just technical expertise. It includes a combination of behaviours, know-how, work habits, character traits, dispositions, and critical understandings (UNESCO, 2017). These aspects are essential for the effective and ethical use of digital technologies in various contexts.

This report adopts a narrower definition of digital skills, focusing specifically on the abilities required to use digital technologies. It considers digital skills as a continuum,

ranging from basic skills, involving the fundamental use of digital tools, to more advanced skills, typically utilised by ICT professionals, such as programming and data analysis.

2.2 Classifying digital skills

Digital skills frameworks vary across countries and organisations, but they commonly categorise skills into basic (foundational), intermediate, and advanced levels (as outlined below) to address different needs in society and the workforce.

Basic skills: These are essential for basic digital literacy and include fundamental tasks such as using digital devices, managing files, conducting internet searches, and maintaining cybersecurity. For instance, the Essential Digital Skills Framework (EDSF) (FutureDotNow, 2022) outlines these basic competencies as ensuring all individuals can perform rudimentary online activities without assistance. Similarly, the International Telecommunication Union (ITU)/International Labor Organization (ILO)'s Digital Skills Toolkit (ITU, 2018) also categorises foundational skills needed for basic digital tasks.

Intermediate skills: These skills enable individuals to effectively use digital technologies in everyday life and the workplace. They include competencies such as digital communication, content creation, online transactions, and problem-solving. Frameworks like DigComp (European Commission) and the EDSF's Life and Work levels (FutureDotNow, 2022) highlight the importance of these skills in enhancing personal and professional productivity. Intermediate skills also involve using more complex applications and understanding digital safety and legal considerations.

Advanced skills: These are necessary for specialised information and communications technologies (ICT) roles and involve higher-level competencies like programming, data analysis, and digital content development. Advanced skills are crucial for innovation in the digital economy and are typically required in sectors such as information technology (IT), multimedia, and cybersecurity. ECORYS (2016) emphasises the need for these skills to maintain competitive advantages in technology-driven markets. UNESCO's framework (2017) further categorises these advanced skills as essential for specialised ICT occupations.

Overall, these frameworks provide a structured approach to developing digital skills at various levels, ensuring individuals and workforces are equipped to meet the demands of a digital world. By focusing on foundational, intermediate, and advanced competencies, these frameworks aim to promote digital inclusion, enhance workforce capabilities, and drive technological innovation.

3. Data and methodology

3.1 Lightcast data on job vacancies

To understand the requirement for digital skills across regions, the main dataset used in this research is the Lightcast job posts database. Lightcast collects raw data from a vast network of over 160,000 online sources, including job boards and company websites. Raw data is then processed through proprietary algorithms, from which different information including job title, salary, experience required, skills required, regions, and many other pieces of information, is parsed and extracted. Particular attention has also been placed on the coding of occupations and industries for

maximum accuracy. In this research, the selected Lightcast job posts span from 2012 (the earliest available data) to 2023 (the latest full year of data). This includes 105,230,757 unique job posts that cover the entire UK[1].

Lightcast provides a skill taxonomy accompanying the job post data. Lightcast uses a big data approach to taxonomy development, allowing for real-time updates as skills evolve and new ones emerge. This means that not all skills within the skill taxonomy are represented in job posts, as new skills may have emerged in 2024, and old skills may have become obsolete. Therefore, only skills that are mentioned in the job posts within the sample period are retained, leaving a total of 26,282 skills, which are then grouped into 440 subcategories and 12 categories.[2]

3.2 Digital skills classification

While digital skills have received significant attention from policymakers, academia and the public, there is a lack of in-depth analysis across different digital skill levels in the UK. A key focus of this report is on providing such an analysis.

Only hard digital skills (i.e., involving the use of specific digital tools) are considered in this report. Soft digital skills – relating to the combination of interpersonal and cognitive abilities required to effectively use digital tools and technologies in the workplace (World Economic Forum, 2022) – are interpreted ambiguously and are hard to define, they are not included.

Previous frameworks on the classifications of digital skills, such as those by Burning Glass (2019), Beblavý et al. (2016), and Cunningham et al. (2022), provide useful guidance in identifying and classifying digital skills. Drawing on these studies, especially Cunningham et al. (2022), this research uses the following classification definitions for digital skills: basic, intermediate and advanced.

As shown in Table 1, basic digital skills relate to the ability to access and use digital technologies to perform basic tasks; intermediate skills are those skills relating to the ability to use professional or productivity-enhancing software, and advanced skills relate to the ability to perform specialised ICT tasks.

To determine the levels of skills, a subset of 94 subcategories is first identified as digital skills. For subcategories that are not inherently digital, both digital and non-digital skills may be present. To identify all digital skills within these subcategories, the following steps are undertaken:

Step 1. Any skills categorised as software are automatically considered digital skills.

Step 2. A keyword search based on 20 specific terms, shown in Appendix 1, is conducted on the descriptions of these skills.

[1] The representativeness of this data has been flagged as a potential issue. Previous research suggests that online job portals may cater to specific candidates, positions, or sectors, so the representativeness of online job posting data varies by region and sector. However, there is generally a good match between the Lightcast data and survey-based data on vacancies (Cammeraat and Squicciarini, 2021).

[2] The version of the Lightcast Skill Taxonomy used in this research is v9.9, published in February 2024.

This process results in identifying 9,377 skills as digital. To accurately categorise these digital skills into advanced, intermediate, and basic levels, two Natural Language Processing (NLP) [3]methods are used in conjunction:

(a). Description-Based Classification: Skills are categorised based on their descriptions. However, many skills are not straightforward to classify due to their ambiguous nature and potential for use at multiple levels.

(b). Context-Based Classification: This method classifies skills based on how they are mentioned in job posts, providing a more nuanced context for their usage.

Additional details on the methodology of identifying digital skills and classifying them into advanced, intermediate, and basic levels can be found in Appendix 1.1.

Table 1: Digital skills levels classification definitions

Level	Definition	Examples
Basic	Ability to access and use digital technologies to perform basic tasks	1.Functional use of digital devices 2.Online communication: e-mails, messaging 3.Finding, managing and storing digital information and content: web browsing, use of search engines, social media, Google Drive, OneDrive 4.Basic work-related tools: Google Calendaring, Video conferencing
Intermediate	Ability to use professional or productivity enhancing software	1.Using professional and productivity enhancing software for analytics, accounting, project management: -for a wide range of occupations or industries – Excel, Word, SaleForce; -for specific occupations or industries: AutoCad, Pardot, Peoplesoft; 2.Digital marketing, social media analytics, business analytics tools: PowerBI 3.Web design, graphic design
Advanced	Ability to perform specialised ICT tasks	1.Computer programming 2.Cloud computing, network management 3.Artificial intelligence 4.Data science, big data analytics: VBA, R, NumPy (Python), Matlab 5.Cybersecurity

Source: Cunningham et al. (2022) and own elaboration

In total, 6,829 advanced skills, 2,117 intermediate skills, and 431 basic skills are identified. This distribution suggests that advanced skills tend to be more niche and specialised, as evidenced by the higher number of distinct advanced skills. In contrast, intermediate and basic skills are fewer in number, indicating that these skills are more general and widely applicable across various occupations and contexts.

3.3 ITL1 regional digital skills shortage indicator

The demand for digital skills can rise and fall reflecting the fluctuation of several factors, including macroeconomic conditions, changes in the work environment, and the rise of new technologies, without necessarily indicating a shortage or surplus of digital skills supply. A key question this report seeks to address is whether the UK labour market has sufficient supply to meet the demand in the fast-changing landscape for digital skills.

[3] An overview of the NLP methodology can be found in Jurafsky and Martin (2024), and a list of resources can be found at: https://github.com/brianspiering/awesome-dl4nlp

By "shortage," it means that there is a lack of labour supply with appropriate digital skills to meet demand. To measure this, the composite indicator method, which combines different variables from various sources, is utilised. Similar to the one used by the OECD Skills for Jobs Indicator (2022), regional digital skills shortage indicators referred to in this report combine both supply and demand-side factors. The key idea behind this methodology is that occupations with shortages in certain skills would experience increases in wages, hours worked, and lower unemployment rates. These factors, weighted by the relative importance of the skills in demand, translate into an overall shortage indicator.

A full description of the methodology can be found in Appendix 1.2 and the OECD (2022) report. The key components of the indicator include:

Occupation Shortage Indicator: This composite indicator, at the regional level, focuses on the long-term trends of five key variables: unemployment growth, employment growth, under-qualification growth, wage growth, and growth in hours worked. Low unemployment and employment growth indicate increasing shortages. These variables are calculated at the International Territorial Level 1 (ITL1) regional level for nine major occupational groups, as provided by the UK Standard Occupational Classification (SOC) 1-digit code.

Calculating regional statistics by occupation could result in an insufficient sample size for each combination of occupation and region, leading to reduced accuracy and representativeness. To maximise the available sample and increase the representativeness of the data, three-year pooled Annual Population Survey data, from 2015 to 2022, are used, with the midpoint year representing the calendar year. This provides a range of available survey data between 2016 and 2021. Furthermore, to better capture the overall trend of digital skills demand and minimise noise in the data, only individuals in full-time employment aged between 16 and 64 are included. The shortage at the occupation level is determined by first calculating the growth rate for all five variables, followed by extracting the long-run trend component from these growth rate variables. The changes in this long-run trend component are then used to calculate the shortage indicator. Due to this methodology, the first two years of the available data are lost during the calculation, resulting in occupation shortages being calculated for 2018, 2019, 2020 and 2021.

Relative Comparative Advantage (RCA): This measures the relative importance of advanced digital skills, considering the demand for all types of skills at the regional and occupational levels.

The product of the occupation shortage indicator for occupation *i* and the RCA for skill level *s* in region *r* becomes the shortage indicator for skill *s*, for region *r* and occupation *i*. The occupational-level shortage indicator can be aggregated into a regional shortage indicator, weighted by the occupation's share of employment in region *r*. An indicator value above 0 indicates a shortage, while a negative value indicates no shortage or a surplus.

4. Digital skills demand across occupations and regions

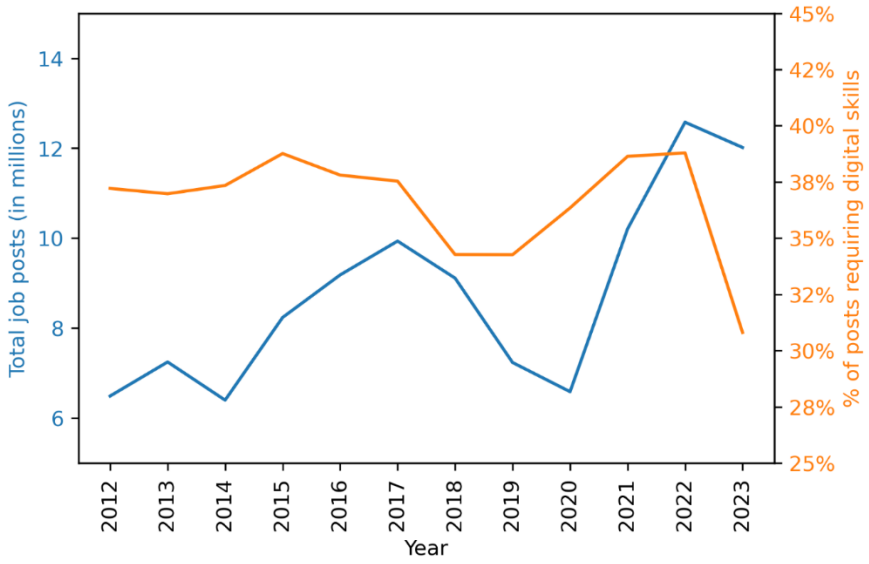
4.1 Overall trend of job posts and digital skills demand

Figure 1 illustrates the trend in the total number of posts observed in Lightcast data for this period, plotted on the left axis, along with the percentage of job posts requiring

at least one digital skill, plotted on the right axis. The number of job posts requiring digital skills grew at the same pace as the aggregate total job posts, with the exception of 2023, where the number of job posts requiring digital skills experienced a steep decline.

The percentage of posts requiring at least one digital skill reached 38.7% in 2022, up from 37% in 2014. However, this increase was not steady: from 2014 to 2018 the proportion of jobs requiring digital skills dropped to 34.1%, which was largely driven by the decrease in the number of job posts, as shown in Figure 1. The percentage of posts requiring digital skills rose steadily from 2020 to 2022. In 2023, the percentage of job posts requiring at least one digital skill reduced to 31%, driven mostly by the decline in demand for occupations that have the highest level of requirements for digital skills [4].

Figure 1: Number of job posts and percentage requiring digital skills - UK, 2012-2013



Source: Lightcast Data Base

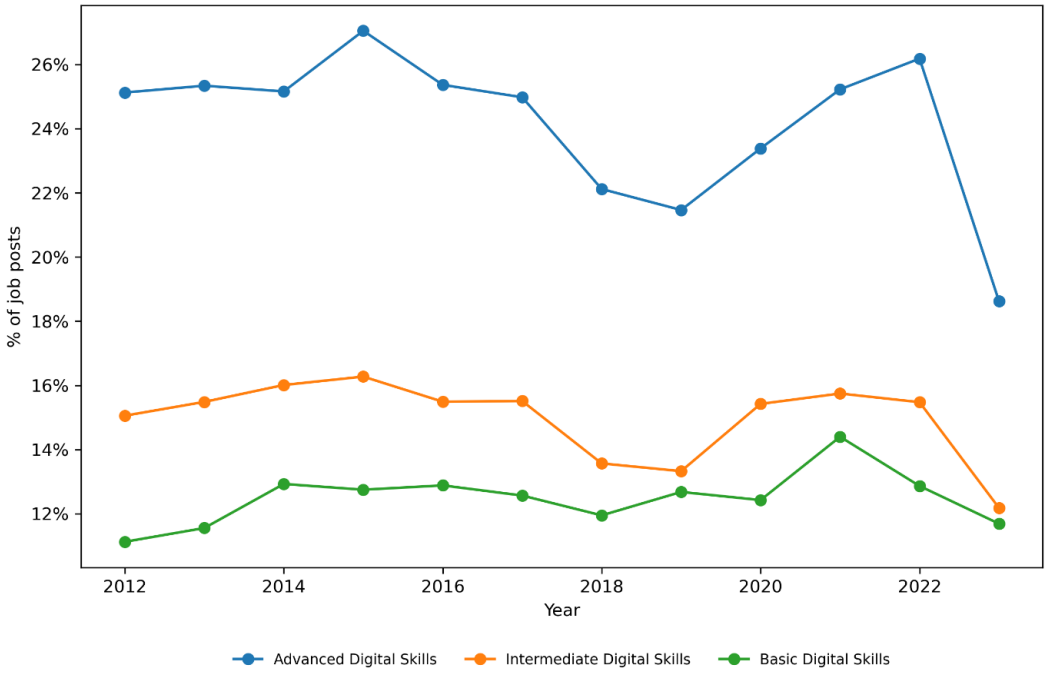
In terms of different levels of skills, from 2012 to 2023, the data on digital skills levels for Advanced, Intermediate, and Basic skills reveals varied trends. As shown in Figure 2, the proportion of job posts requiring advanced skills was 25% in 2012 and peaked at around 27% in 2015. Following this peak, there was a decline, with the proportion dropping to about 22% by 2018. A slight recovery occurred, reaching 26% in 2022, before a sharp drop to below 18% in 2023. This decline, consistent with the overall trend in digital skills shown in Figure 1, is primarily due to a sharp decrease in the number of vacancies for occupations that typically require high levels of digital skills, such as programmers and web designers.

Intermediate skills, on the other hand, accounted for a 15% share of job posts in 2012, gradually increasing to 16% by 2015. This level was maintained with minor fluctuations until 2020. Despite a brief recovery from 2019 to 2022, there was a significant dip thereafter, with the proportion falling to just over 12% in 2023.

[4] These occupations include Programmers and Software Development Professionals, as well as IT Business Analysts, Architects, and Systems Designers. The shortages in these roles are due to general economic conditions rather than a decline in demand for digital skills. Additional details can be found in Appendix 2.

Fewer job posts specify requirements for basic skills, suggesting that these skills may have become a standard expectation rather than an explicitly stated requirement. In 2012, 11% of job posts required at least one basic skill, steadily increasing to 13% by 2015. After 2015, there was a general downward trend with occasional fluctuations, eventually stabilising at around 12% in 2023. Overall, the data indicates a peak and subsequent decline in the demand for both advanced and basic skills, while the demand for intermediate skills showed smaller variations.

Figure 2: Percentage (%) of posts requiring digital skills by level of skills – UK, 2012-2023



Source: Lightcast Database

4.2 Regional level analysis

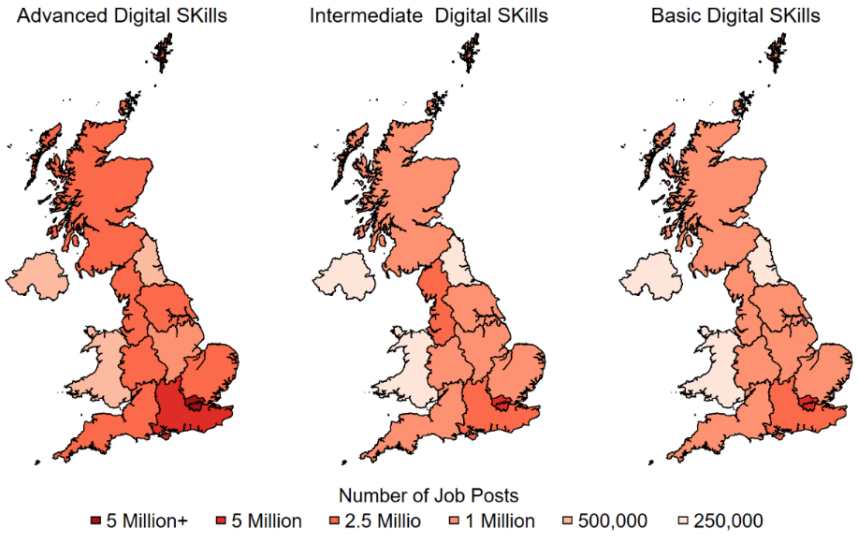
Figure 3 and Figure 4 show the number of posts and the percentages of posts requiring the three levels of digital skills by region across all years, respectively. London's labour market is characterised by a high concentration of occupations and sectors that demand significant digital skills. On the occupational front, 31% of London's workforce are Professionals, and 19% are Associate Professionals, both of which are roles that typically require intensive use of digital skills. From a sectoral perspective, London accounts for 34.5% of UK employment in the Information & Communication sector and 36% in the Financial and Professional Services sectors. As a result, it is unsurprising that London has the highest number of job posts requiring digital skills across all three levels, closely followed by the South East. Along with the East of England, which also experiences significant demand for digital skills, the Greater South East (GSE) collectively accounts for over 50% of all job vacancies requiring advanced digital skills.

Regions outside the GSE also play a crucial role in the UK's digital skills demand. The North West has shown strong demand for both advanced and intermediate skills, reflecting its manufacturing base and growing digital hubs. The West Midlands similarly demonstrates robust demand across all skill levels, driven by its industrial diversification. Scotland also stands out with a notably high demand for digital skills

across different levels, highlighting the region's increasing adoption of digital technologies. These patterns underline the vital contribution of regions outside the GSE to the UK's digital economy.

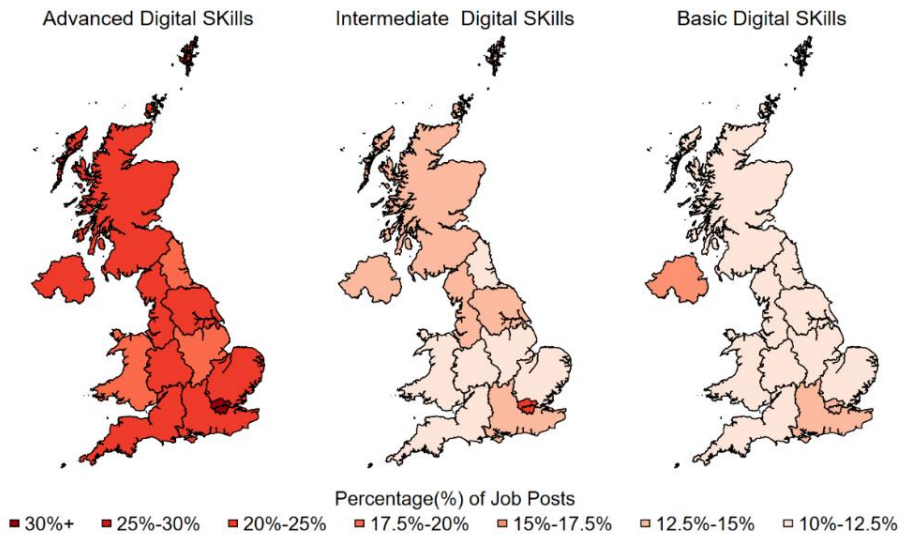
When examining the percentage of job posts requiring different levels of skills, a different picture emerges. London still has the highest percentage of job posts requiring both advanced and intermediate skills. The South East also has a relatively high percentage of job posts demanding both intermediate and basic digital skills. In particular, Northern Ireland has the highest percentage of job posts requiring basic skills. This aligns with Northern Ireland's Skills Barometer, which highlights a strong demand for a broad range of digital skills, including basic skills across various industries (Department for the Economy, 2021). Additionally, the West Midlands and Scotland show significant percentages of job posts requiring advanced digital skills, underlining the diverse technological advancements and digital integration in these regions' economic sectors.

Figure 3: Number of job posts requiring basic, intermediate, and advanced digital skills in ITL 1 regions – 2021



Source: Lightcast Database

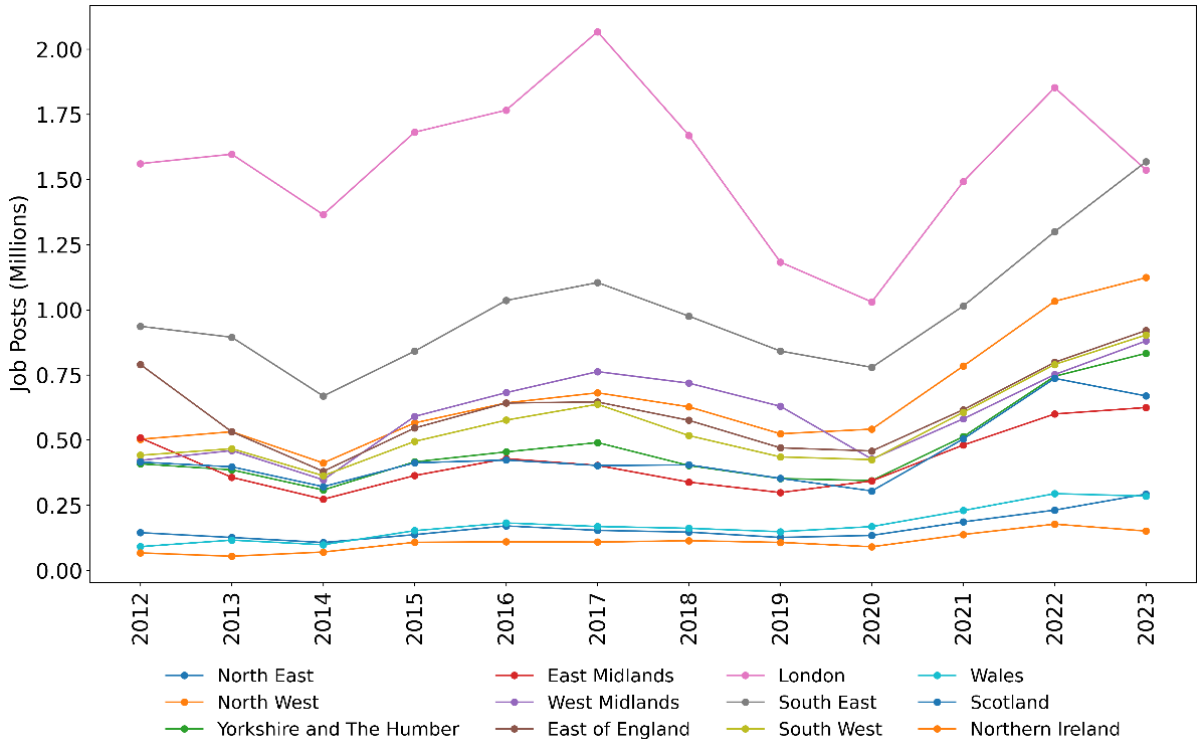
Figure 4: Percentage (%) of job posts requiring basic, intermediate, and advanced digital skills in ITL 1 regions – 2021



Source: Lightcast Database

Trends in demand for digital skills across regions also exhibit differences. Figure 5 plots the total number of job posts by region over the years between 2012 and 2023. While London had the highest number of job posts for most of the years, it experienced a significant drop in 2023 and was overtaken by the South East. The North East experienced steady growth from 2019 onward and overtook the West Midlands in the volume of job posts.

Figure 5: Trends in total number of job posts by ITL 1 region – 2012 to 2023

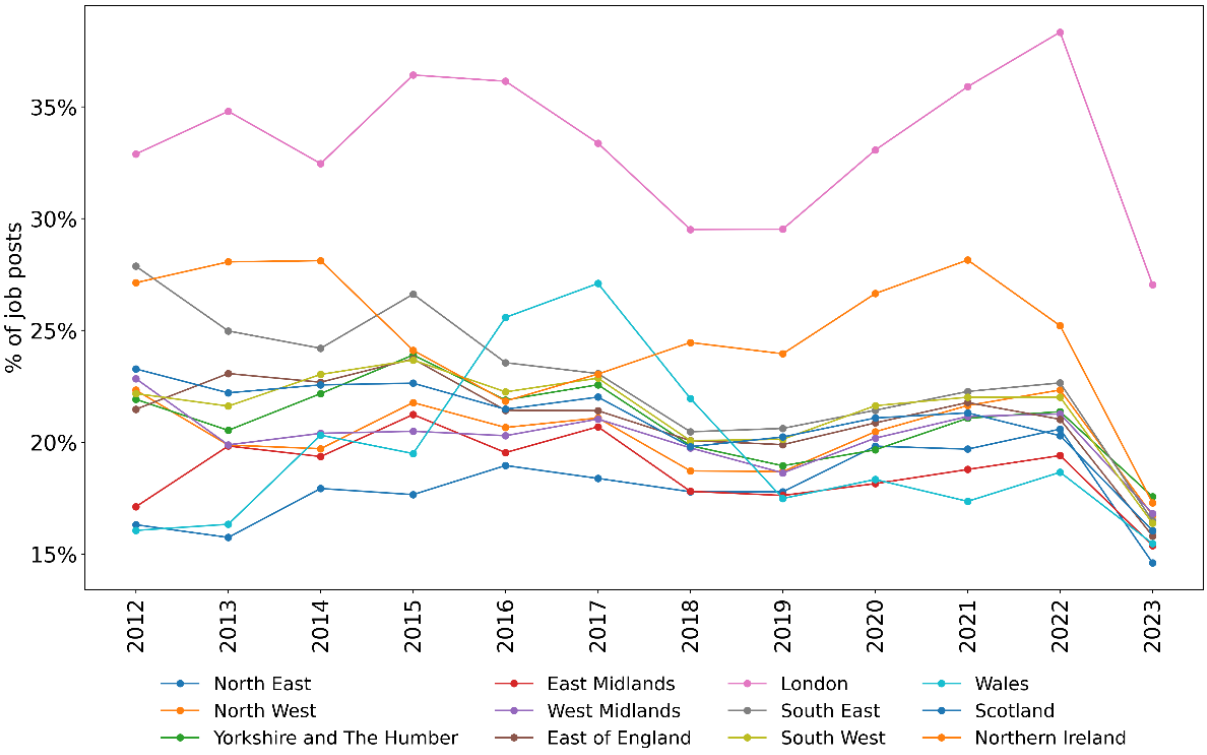


Source: Lightcast Database

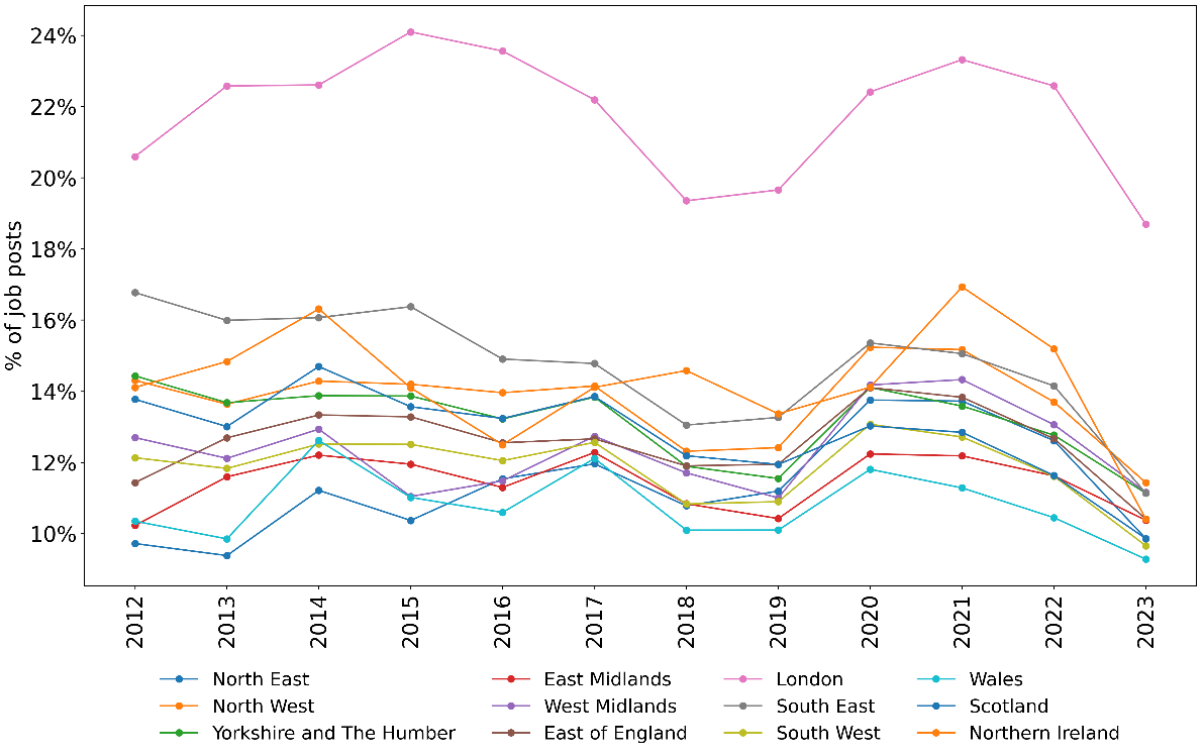
Subfigures (1) to (3) of Figure 6 show the percentage of job posts containing the three levels of digital skills, by region over the period 2012 to 2023. In general, the trends of digital skills requirements at all three levels are similar to the overall figure. However,

there are a few exceptions. In Wales, the proportion of job posts requiring advanced digital skills increased significantly in 2016 and 2017, before reverting to levels below other regions.

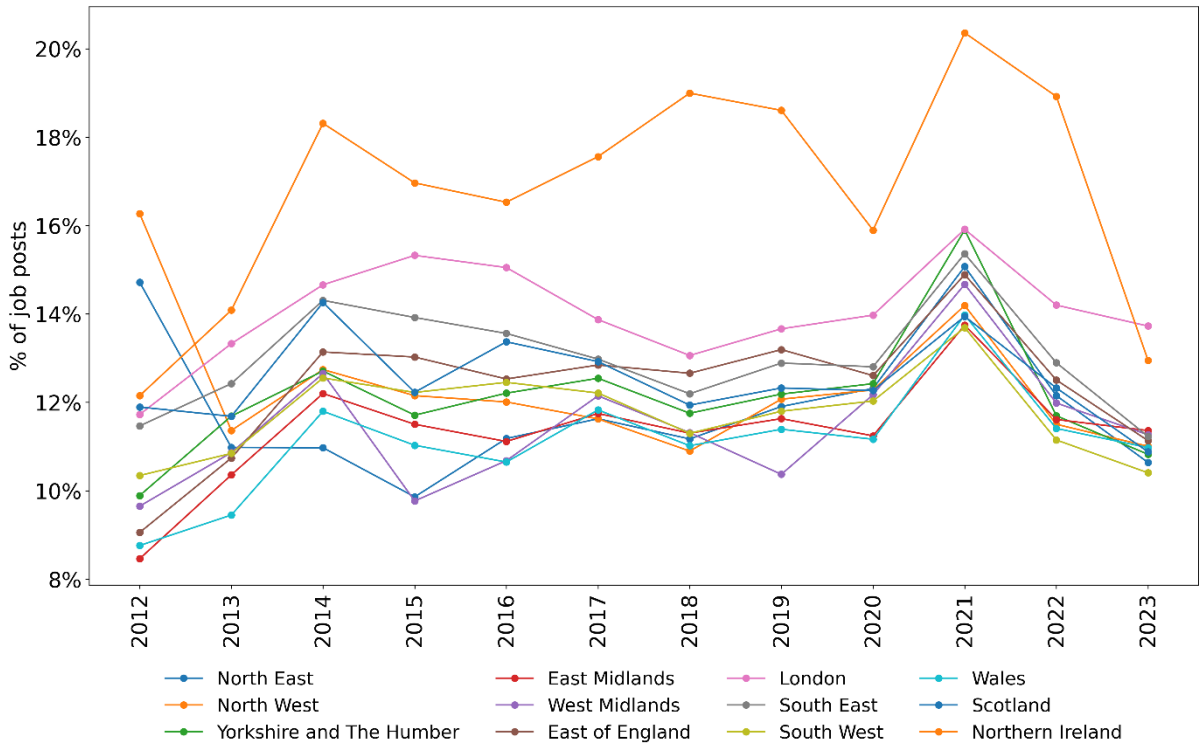
Figure 6: Trends in the number of job posts requiring digital skills by ITL 1 region – 2012 to 2023



(1) Advanced digital akills



(2) Intermediate digital skills



(3) Basic digital skills

Source: Lightcast Database

4.3 Occupation-level analysis

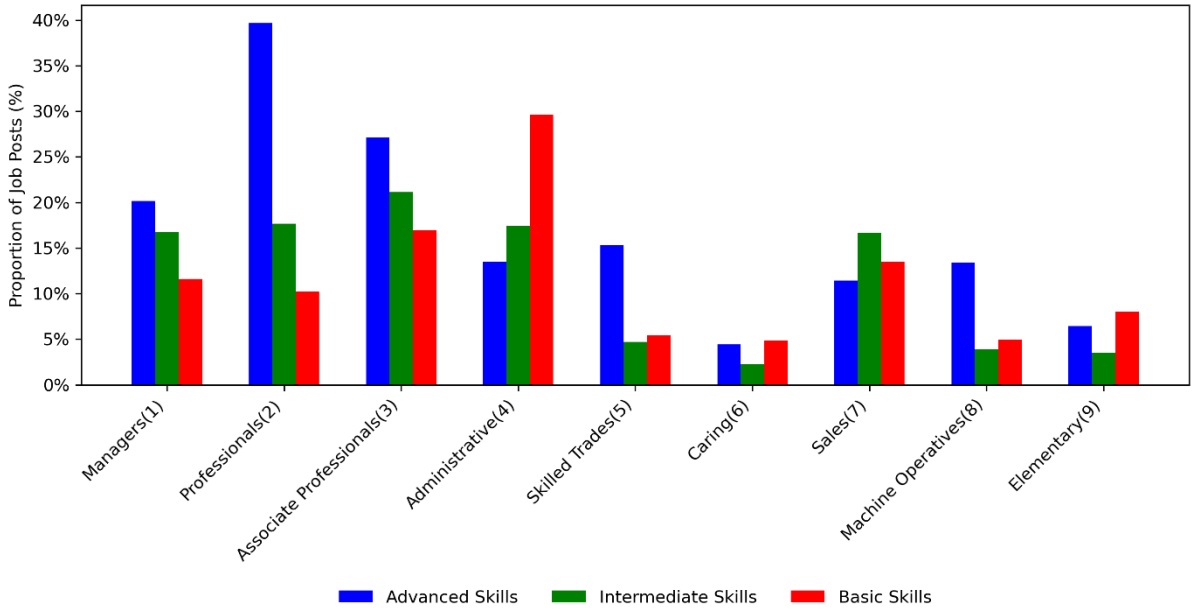
The occupational-level analysis offers valuable insights into the occupations driving digital skill demand. The findings indicate that digital skill requirements are concentrated in higher-skill occupations, with notable growth in digital demand in traditionally lower-digital fields such as Sales.

Figure 7 illustrates the demand for digital skills at three levels—advanced, intermediate, and basic—across occupations classified by the SOC major group (1-digit). At the major group level, advanced digital skills are most in demand in Managerial, Professional, and Associate Professional roles (SOC 1, 2, and 3), reflecting the technical expertise and leadership needed in these occupations.

Intermediate digital skills, like advanced skills, are in high demand among Professionals, Associate Professionals, and Managers. However, they are also increasingly required in Sales occupations. This reflects the growing digitalisation of these roles, including the rising importance of digital marketing, the use of social media platforms, and digital-based tasks such as data management in Sales.

Basic digital skills are more prevalent in Skilled Trades, Machine Operatives, and Elementary occupations (SOC 5, 8, and 9), where the use of digital tools is limited to fundamental operations and tasks.

Figure 7: Percentage (%) of digital skills by major occupation group – UK, 2012 to 2023 combined



Note: This figure illustrates the percentage of job postings requiring advanced, intermediate, and basic digital skills, combining data from 2012 to 2023, categorised by Major Occupation Group as defined by the 1-digit SOC classification.

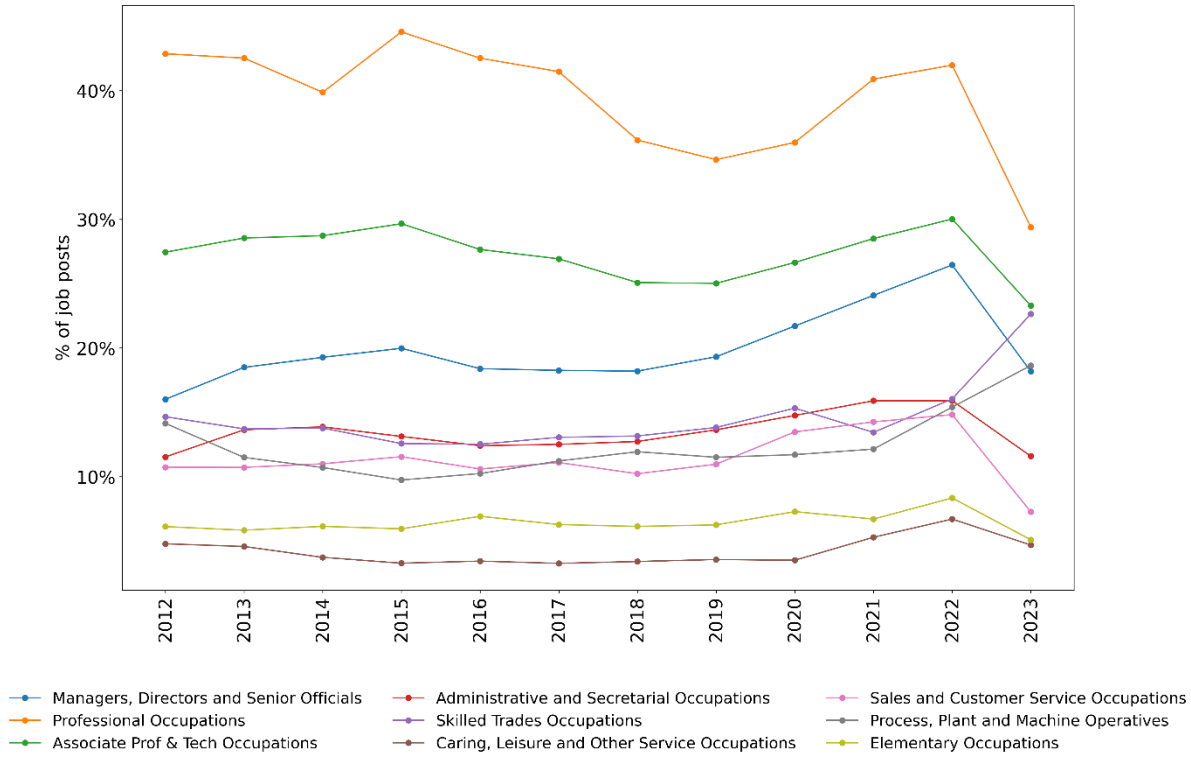
Source: Lightcast Database

Figure 8 (subfigures (1) to (3)) illustrates significant variations in the trend of digital skills demand across occupations. Despite a downturn in 2023, driven primarily by a decrease in the number of vacancies, many occupational groups have experienced an overall increase in digital demand over the past decade. For example, as shown in subfigure (1) of Figure 8, Managers (SOC 1) have seen a gradual increase in demand for advanced digital skills starting in 2016, illustrating a long-term shift towards more technologically integrated roles.

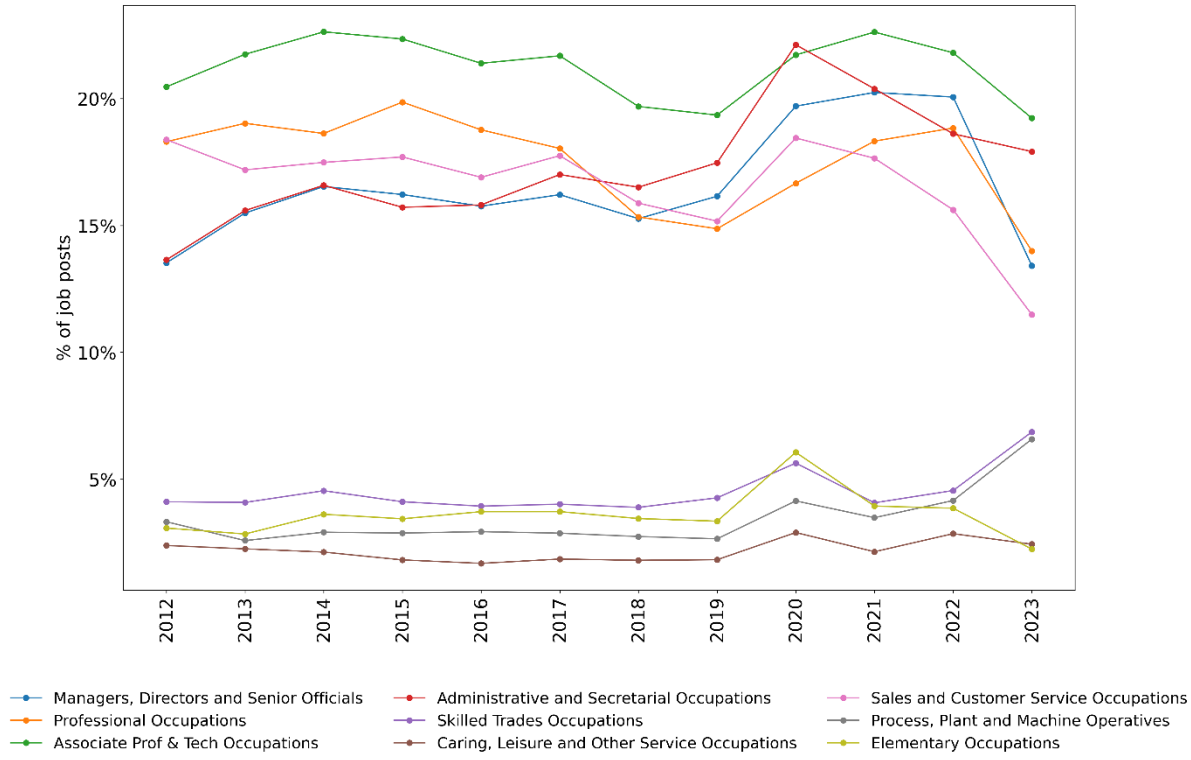
The COVID-19 pandemic markedly accelerated the demand for digital skills across several occupations. As shown in subfigure (2) of Figure 8, this surge is particularly evident in the heightened demand for intermediate digital skills within Administrative and Secretarial occupations (SOC 4), Managerial roles (SOC 1), as well as Elementary (SOC 9) and Sales occupations (SOC 7). Moreover, the demand for basic digital skills, as shown in subfigure (3), saw a significant spike in 2020 for Sales occupations, as well as Administrative and Secretarial occupations, reflecting a broad-based response to the new digital imperatives brought on by the pandemic.

Notably, while most occupations mirrored the overall trend in advanced digital skills demand and experienced a sharp decline in the proportion of job posts requiring all three levels of digital skills, Skilled Trade occupations (SOC 5) and Process, Plant, and Machine Operatives (SOC 8) have demonstrated steady growth in demand for all three levels of digital skills. This growth was most significant in advanced digital skills, even in 2023. Such persistent growth reflects ongoing digitalisation within the manufacturing sector, underscored by the integration of new technologies.

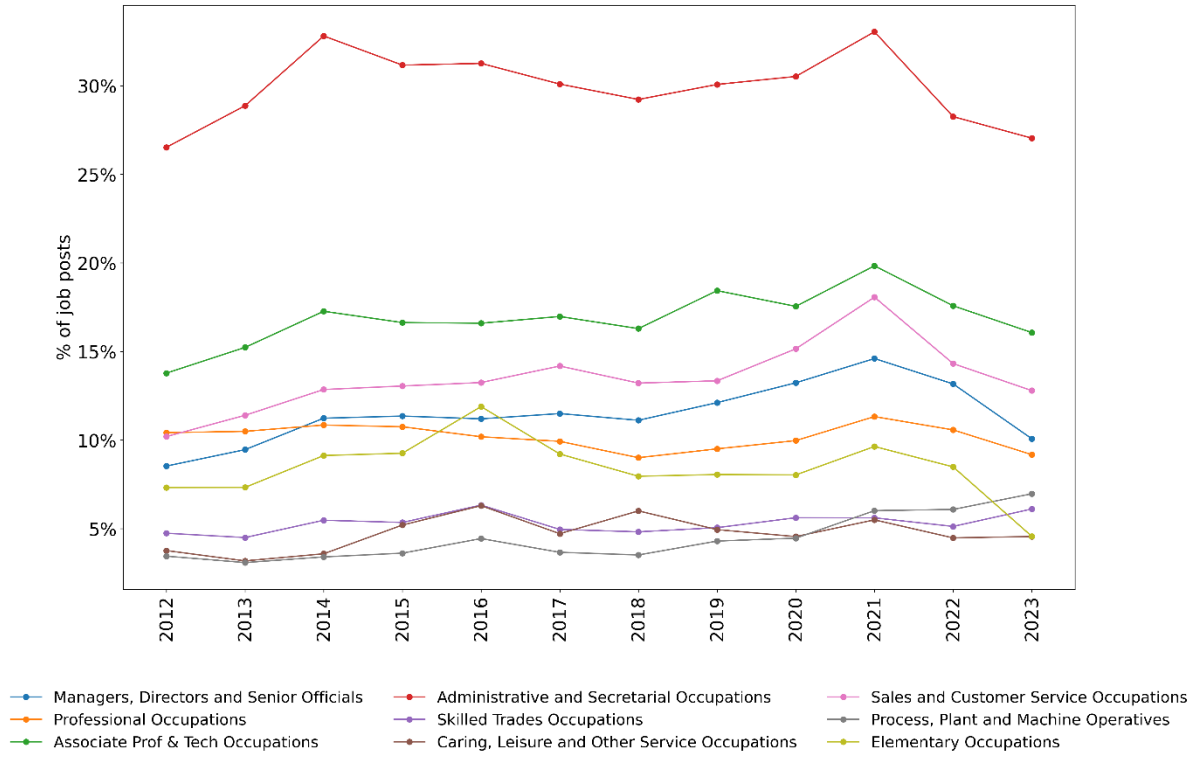
Figure 8: Changes in percentage (%) of job posts requiring digital skills by major occupation group – 2012 to 2023



(1) Advanced digital skills



(2) Intermediate digital skills



(3) Basic Digital Skills

Source: Lightcast Database

To analyse the change in digital skills demand in greater detail, Table 2 presents the proportion of job posts requiring three levels of digital skills by occupation, as defined by the SOC sub-major group (2-digit).

Science, Research, Engineering, and Technology Professionals (SOC 21) show the highest percentage of job posts requiring advanced digital skills, while Science, Engineering, and Technology Associate Professionals (SOC 31) have the highest proportion of posts requiring intermediate skills. Secretarial and Related Occupations (SOC 42) exhibit the highest proportion of posts requiring basic skills.

Across years, most occupations have experienced an increased demand for digital skills. To better understand this growth, Figure 9 highlights the trend in the proportion of job posts requiring digital skills at three levels between 2012 and 2023, focusing on the five occupations that saw the largest increase in digital skills demand. These include Process, Plant, and Machine Operatives (SOC 81) for advanced digital skills, Administrative Occupations (SOC 41) for intermediate skills, and Customer Service Occupations (SOC 72) for basic digital skills. Appendix 3 provides further details on the changes in digital skills demand for all SOC sub-major group occupations between 2012 and 2023.

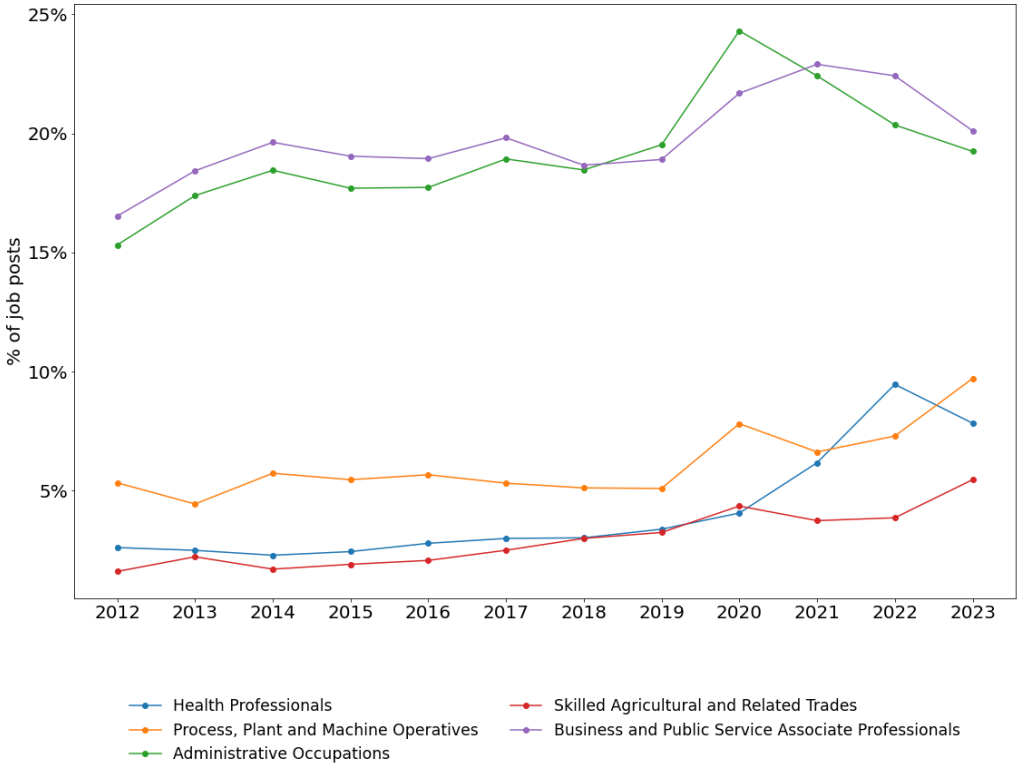
Table 2: Percentage (%) of job posts requiring basic, intermediate, and advanced digital skills by sub-major occupation group – UK, combined 2012 to 2023

Occupation	Advanced Digital Skills	Intermediate Digital Skills	Basic Digital Skills
Corporate Managers and Directors(11)	20.4%	19.1%	12.3%
Other Managers and Proprietors(12)	19.6%	11.3%	10.1%
Science, Research, Engineering and Technology Professionals(21)	71.0%	26.5%	13.3%
Health Professionals(22)	8.5%	4.6%	4.0%
Teaching and Educational Professionals(23)	6.8%	3.3%	3.7%
Business, Media and Public Service Professionals(24)	29.0%	19.7%	12.6%
Science and Engineering Associate Professionals(31)	47.9%	27.3%	20.3%
Health and Social Care Associate Professionals(32)	10.0%	5.7%	8.0%
Protective Service Occupations(33)	28.5%	9.5%	13.3%
Culture, Media and Sports Occupations(34)	29.4%	24.1%	13.2%
Business and Public Service Associate Professionals(35)	18.1%	19.9%	17.2%
Administrative Occupations(41)	14.1%	19.3%	27.7%
Secretarial and Related Occupations(42)	10.9%	10.1%	37.4%
Skilled Agricultural and Related Trades(51)	6.6%	3.4%	4.9%
Skilled Metal, Electrical and Electronic Trades(52)	25.1%	6.6%	7.2%
Skilled Construction and Building Trades(53)	6.0%	2.0%	2.9%
Textiles, Printing and Other Skilled Trades(54)	6.7%	3.5%	4.2%
Caring Personal Services(61)	4.3%	2.0%	4.7%
Leisure, Travel and Related Personal Service Occupations(62)	5.4%	3.6%	5.5%
Sales Occupations(71)	11.3%	16.8%	11.5%
Customer Service Occupations(72)	11.7%	16.4%	18.0%
Process, Plant and Machine Operatives(81)	23.3%	7.1%	7.4%
Transport and Mobile Machine Drivers and Operatives(82)	7.1%	1.9%	3.4%
Elementary Trades and Related Occupations(91)	5.3%	1.9%	2.8%
Elementary Administration and Service Occupations(92)	6.7%	3.8%	9.0%

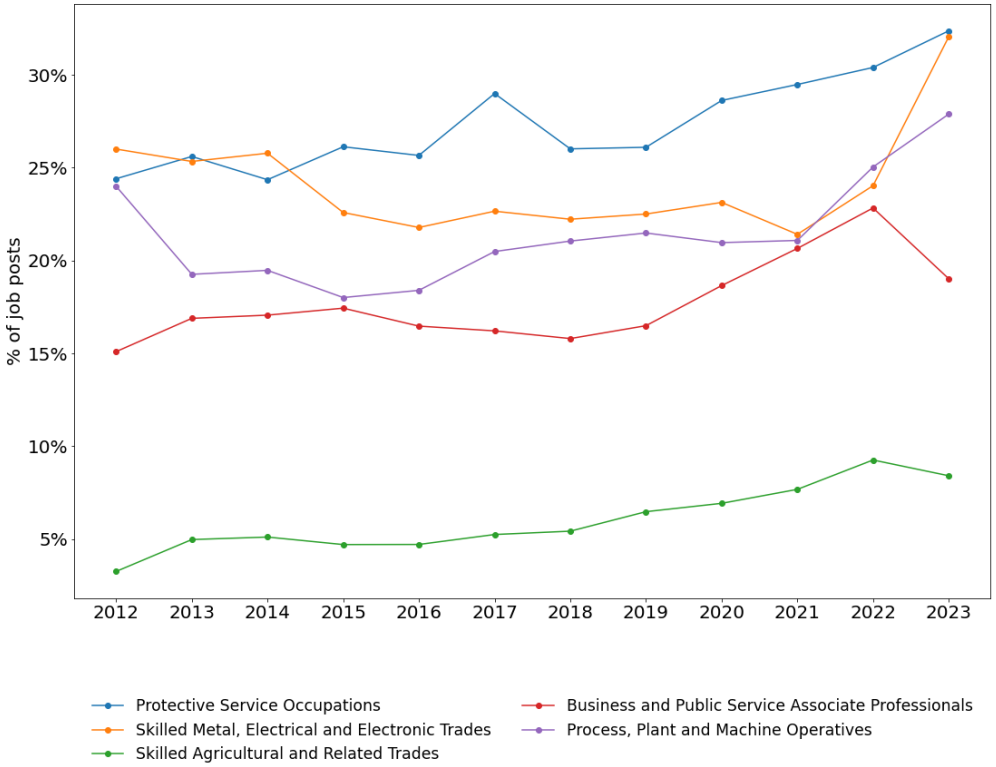
Note: This table shows the percentage of job posts requiring advanced, intermediate and basic digital skills by sub-major occupation group – combined 2012 to 2023. The values are colour-coded, with a red scale indicating higher percentages and a green scale indicating lower percentages

Source: Lightcast Database

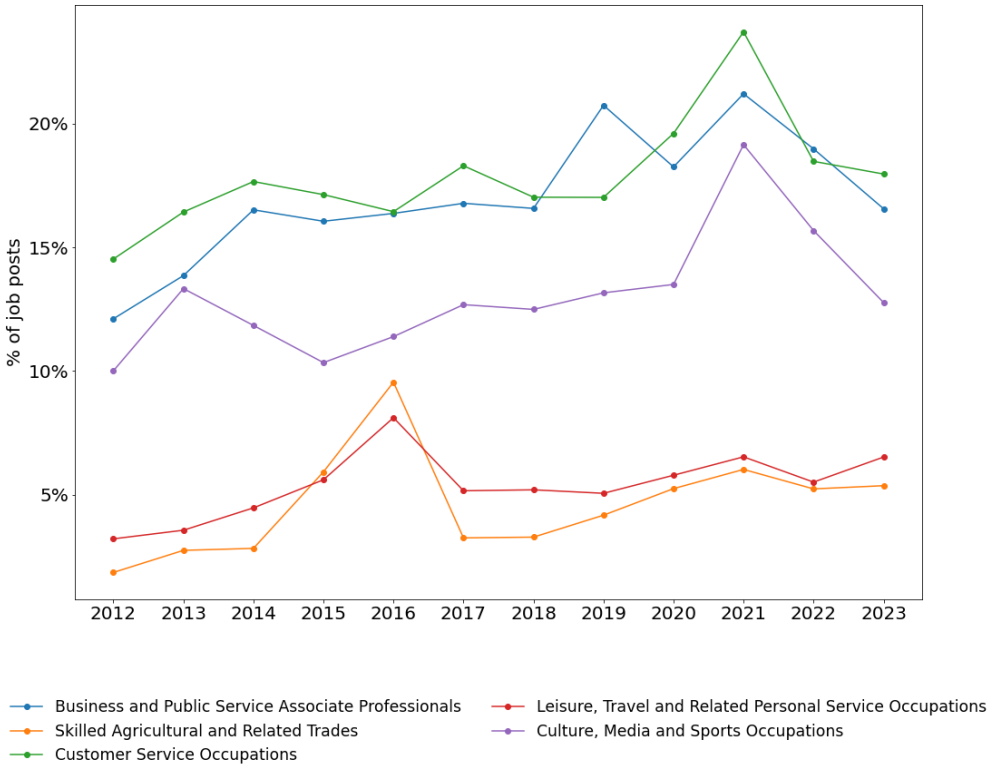
Figure 9: Top 5 sub-major group occupations with the fastest growth in the proportion of jobs requiring digital skills- UK, 2012 to 2023



(1) Advanced digital skills



(2) Intermediate digital skills



(3) Basic digital kills

Source: Lightcast Database

Analyses at both the SOC 1 major group and SOC 2 sub-major group levels reveal dynamic trends in digital skills demand, highlighting the need for a more detailed examination to understand the drivers of digitalisation across different occupations. Following the methodologies established by Vona et al. (2019) and Eliott et al. (2023)[5], a Digitalisation Index was developed for each SOC 4-digit occupation using the Lightcast data. This method takes into account both the importance—measured as the percentage of job posts that require at least one digital skill—and the level—defined by the percentage of digital skill occurrences among all skills mentioned—of digital skills required within each occupation. A higher score indicates a greater level of digitalisation or the higher importance of digital skills in an occupation, whereas a lower score reflects a lesser degree of digitalisation and the reduced importance of digital skills in that occupation.

Table 3 presents the top 10 and bottom 10 SOC 4-digit occupations based on the Digitalisation Index in 2023. Occupations with the highest Digitalisation Index include Web Design and Development Professionals (SOC 2137), Programmers and Software Development Professionals (SOC 2136), Architects (SOC 2431), Telecommunications Engineers (SOC 5242), IT Business Analysts, Architects and Systems Designers (SOC 2135), Architectural and Town Planning Technicians (SOC 3121), Chartered Architectural Technologists (SOC 2435), Information Technology and Telecommunications Professionals (SOC 2139), Graphic Designers (SOC 3421), and Metal Working Machine Operatives (SOC 8125). Overall, these findings indicate

[5] These studies focus on green jobs instead of digital jobs, using task-based methods based on data from ONET. In this case, we adapt the method in defining green jobs in defining digital jobs, furthermore, we are able to construct a skill-based classification rather than a task-based classification based on job posts data.

that occupations with strong technical, analytical, and creative components tend to have higher levels of digitalisation.

In contrast, the occupations with the lowest Digitalisation Index are Kitchen and Catering Assistants (SOC 9272), Plasterers (SOC 5321), Bar Staff (SOC 9274), Groundsmen and Greenkeepers (SOC 5114), Butchers (SOC 5431), Hairdressers and Barbers (SOC 6221), Waiters and Waitresses (SOC 9273), Chefs (SOC 5434), Cooks (SOC 5435), and Dispensing Opticians (SOC 3216). These occupations are primarily focused on manual or interpersonal skills, which often require physical presence and hands-on work.

The methodology for building the index is shown in Appendix 1.3. The Digitalisation Index for all SOC 4-digit occupations, across multiple years from 2012 to 2023, is provided in Online Appendix 1[6]. Comparing 2012 and 2023, the unit groups occupations with the largest increase in the digitalisation index include TV, video and audio engineers (SOC 5244), Architects (SOC 2431), Chartered architectural technologists (SOC 2435), Metal working machine operatives (SOC 8125), and Natural and social science professionals (SOC 2119).

Table 3: Top 10 and bottom 10 unit group occupations in Digitalisation Index – UK, 2023

	Occupation	SOC 4 digit	Digitalisation Index
Top 10	Web design and development professionals	2137	100.00
	Programmers and software development professionals	2136	99.73
	Architects	2431	99.46
	Telecommunications engineers	5242	99.19
	IT business analysts, architects and systems designers	2135	98.92
	Architectural and town planning technicians	3121	98.64
	Chartered architectural technologists	2435	98.37
	Information technology and telecommunications professionals	2139	98.10
	Graphic designers	3421	97.83
	Metal working machine operatives	8125	97.56
Bottom 10	Kitchen and catering assistants	9272	2.71
	Plasterers	5321	2.44
	Bar staff	9274	2.17
	Groundsmen and greenkeepers	5114	1.90
	Butchers	5431	1.63
	Hairdressers and barbers	6221	1.36
	Waiters and waitresses	9273	1.08
	Chefs	5434	0.81
	Cooks	5435	0.54
	Dispensing opticians	3216	0.27

Note: This table shows the five SOC unit group (4 digit) occupations with the highest and lowest Digitalisation Index, as defined in section 4.3. The Index ranges from 0 to 100, where a higher score indicates a higher level of digitalisation.

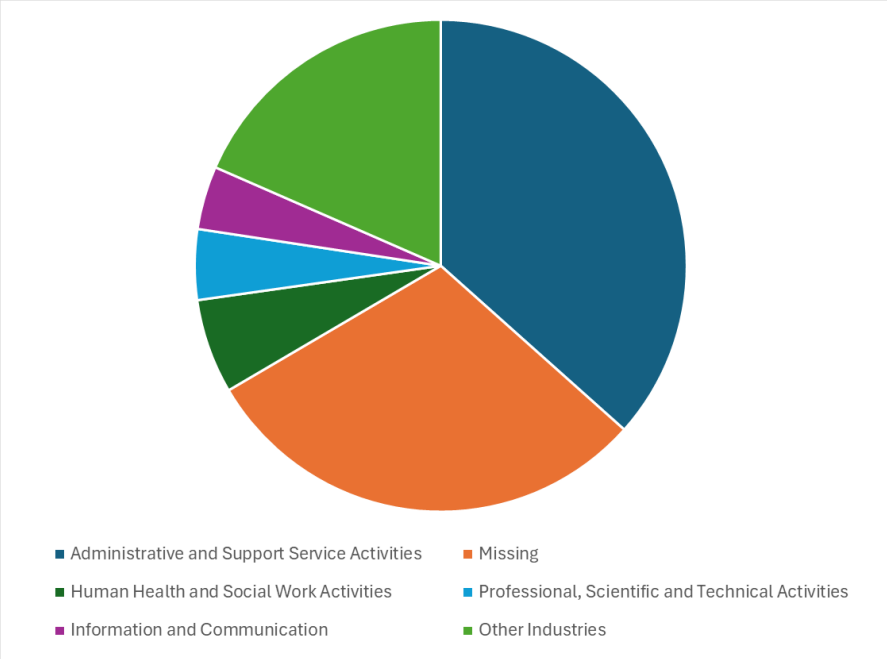
Source: Lightcast Database

[6] This can be found at: https://maxyyy110.github.io/digital-skill-UK/UK%20Occupation%20Digitalisation%20Index/index.html

4.4 Sectoral differences in digital skills

While sectoral differences in digital skills are important, this research refrains from making a comprehensive assessment of sectoral demand due to data limitations, which affect the representativeness of the findings. Of all job posts in the dataset, more than 40% are from staffing agencies. Figure 10, which shows the number of job posts by industry, as defined by the Standard Industrial Classification (SIC), illustrates this. The majority of these agencies belong to the Administrative and Support Service Activities (N) sector, which accounts for 37% of all job posts from 2012 to 2023, as shown in Figure 10. This is a stark contrast to the less than 5% of the UK workforce employed in this sector. Additionally, 30% of the job posts lack sectoral information, further reducing the representativeness of the dataset.

Figure 10: Number of job posts by industry (SIC Section Level) – UK, combined 2012 to 2023



Source: Lightcast Database

Table 4 shows the percentage of job posts requiring advanced, intermediate, and basic digital skills by sector, excluding Administrative and Support Service Activities.

Information and Communication (J), Financial and Insurance Activities (K), and Electricity, Gas, Steam and Air Conditioning Supply (D) lead in demand for advanced digital skills, reflecting their reliance on technology and specialised expertise. Manufacturing (C) and Professional, Scientific and Technical Activities (M) also show strong demand for advanced skills. In contrast, sectors like Agriculture, Forestry and Fishing (A) and Accommodation and Food Service Activities (I) demonstrate the lowest demand for advanced digital skills, suggesting slower digital transformation.

Intermediate skills are more evenly distributed across sectors. Industries such as Water Supply and Transportation and Storage (E) show significant demand, likely due to the need for digital literacy in operational roles. Even in sectors like Wholesale and Retail Trade (G), intermediate skills are becoming essential as e-commerce and digital payment systems grow.

The demand for basic digital skills is highest in sectors like Financial and Insurance Activities (K) and Electricity, Gas, Steam and Air Conditioning Supply (D), indicating the widespread need for foundational digital competencies across various roles.

Table 4: Percentage of job posts requiring basic, intermediate, and advanced digital skills by industry – UK, combined 2012 to 2023

Industries	Advanced Digital Skills	Intermediate Digital SKills	Basic Digital Skills
Agriculture, Forestry and Fishing	11.2%	13.0%	11.7%
Mining and Quarrying	23.7%	15.5%	12.4%
Manufacturing	29.7%	18.5%	17.2%
Electricity, Gas, Steam and Air Conditioning Supply	36.1%	22.7%	18.3%
Water Supply; Sewerage, Waste Management and Remediation Activities	25.4%	17.6%	17.1%
Construction	22.4%	14.6%	16.0%
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	13.7%	11.4%	11.9%
Transportation and Storage	23.3%	14.6%	14.9%
Accommodation and Food Service Activities	7.4%	5.3%	6.6%
Information and Communication	39.3%	24.5%	17.5%
Financial and Insurance Activities	36.8%	24.6%	19.7%
Real Estate Activities	19.4%	14.1%	15.4%
Professional, Scientific and Technical Activities	28.9%	19.2%	16.3%
Public Administration and Defence; Compulsory Social Security	15.9%	8.3%	11.9%
Education	20.0%	13.3%	11.7%
Human Health and Social Work Activities	11.3%	7.7%	9.7%
Arts, Entertainment and Recreation	17.9%	12.1%	10.5%
Other Service Activities	22.9%	14.9%	13.9%
Activities of Households as Employers; Undifferentiated Goods	17.3%	11.7%	12.0%
Activities of Extraterritorial Organisations and Bodies	17.8%	11.4%	7.7%

Note: *This table presents the percentage of digital skills by SIC section in the UK, aggregated from 2012 to 2023. The values are colour-coded, with a red scale indicating higher percentages and a green scale indicating lower percentages*

Source: Lightcast Database

4.5 Deep dive into types of digital skills

Analysis at the national, regional, and occupational levels reveals the dynamic nature of digital skills demand. Underlying this overall trend is the rapid evolution of specific skills required by businesses. This section provides an in-depth analysis of the digital skills reflected in the Lightcast vacancy data. Figure 11 presents three subfigures displaying word clouds for digital skills categorised by level—advanced, intermediate, and basic. Each word cloud is weighted by the frequency of appearance of each skill in the job posting data during the sample periods for 2012 and 2022.

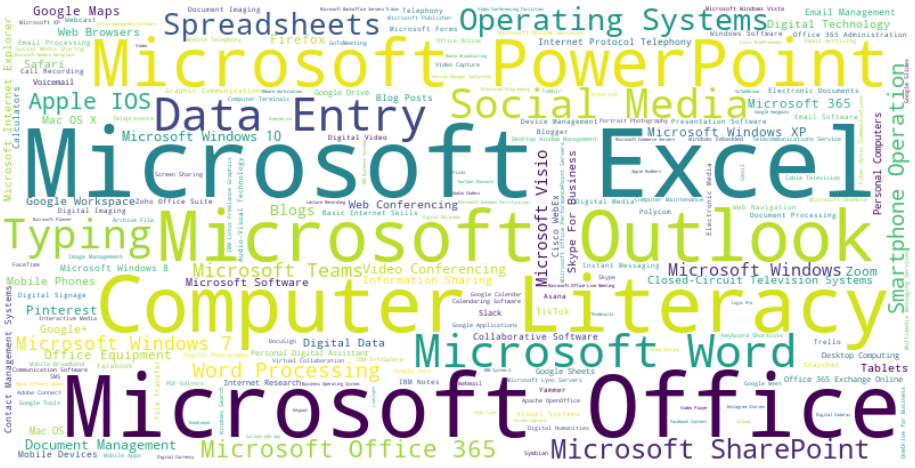
Over the entire sample period, the most prominent advanced skills are mainly related to software development, including Agile methodology, SQL, C, and Java. For intermediate skills, the top skills are primarily those required to complete specific complex tasks, such as SAP applications, digital marketing, and help desk support.

Basic skills are mostly productivity-related, with the most prominent being skills related to the Microsoft Office Suite

Figure 11: Word Cloud of digital skills – UK, combined 2012 to 2023

(1) Advanced digital skills

(2) Intermediate digital skills



(3) Basic digital skills

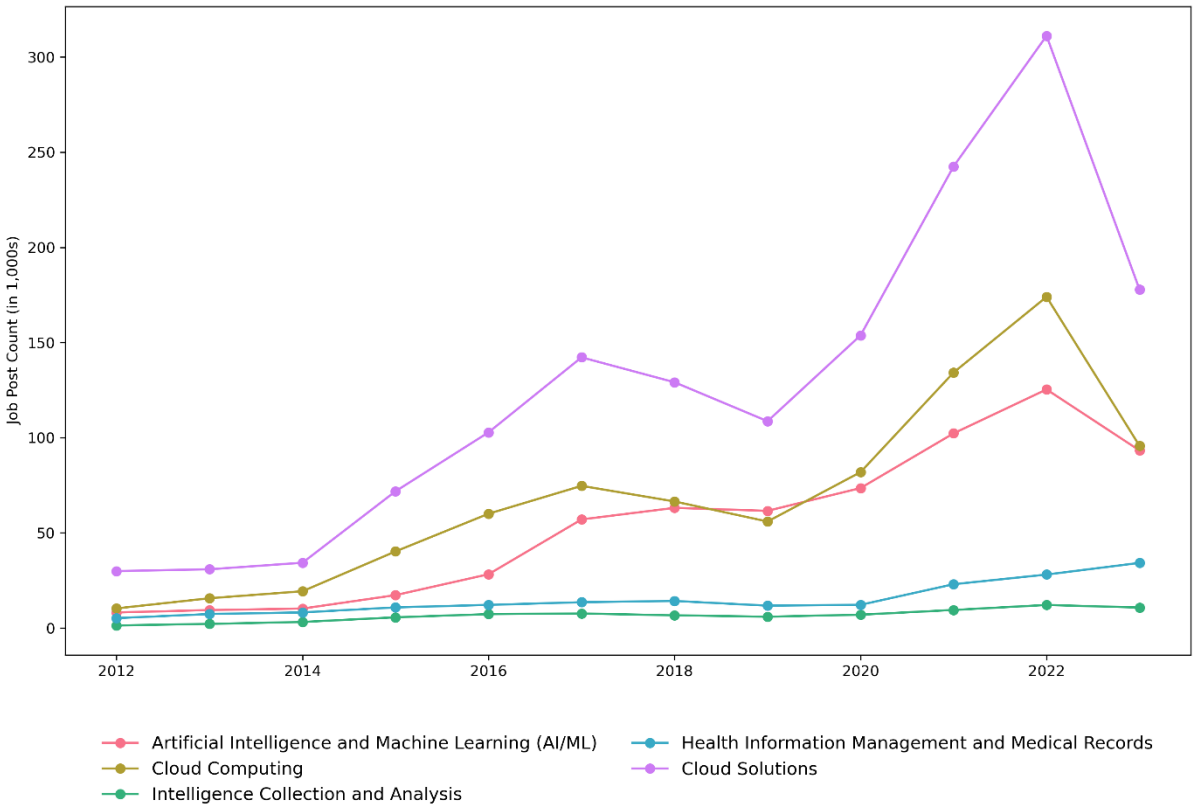
Note: *This word cloud visualises the prevalence of digital skills mentioned in job postings. Each word represents a specific digital skill, with the size of each word corresponding to its frequency or demand level. Larger words indicate skills that are in higher demand, reflecting their importance across job roles.*

Source: Lightcast

Skills demand is fast-changing and dynamic, with new technologies constantly replacing old ones. Appendix 4 shows the skills with the largest increase between 2012 and 2023. For advanced skills, there is a significant rise in demand for cloud-related skills, including Microsoft Azure and Amazon Web Services. Among intermediate skills, there is a notable increase in demand for data analysis skills, such as Power BI, Tableau, and Data Management. For basic skills, the skills that have experienced the largest increase include those in the Office suite, such as Microsoft Excel and Microsoft Outlook, as well as general computer literacy. This trend indicates an increasing level of digital requirements among lower-skill occupations.

Figure 12 further shows the top 5 skill subcategories that experienced the largest percentage changes[7]. Across all subcategories, those that experienced the largest percentage increases include Artificial Intelligence and Machine Learning (AI/ML), Cloud Computing, Intelligence Collection and Analysis, Health Information Management and Medical Records, and Cloud Solutions. Notably, while the analysis encompasses all skill subcategories, including non-digital skills, the subcategories with the largest increases are all digital. This underscores the growing importance of digital skills in society over the years.

Figure 12: Trend in skills subcategories with the largest increase – UK, 2012 and 2023



Source: Lightcast

In particular, AI and ML-related skills saw a tenfold increase, rising from 8,000 occurrences in 2012 to 92,371 occurrences in 2023. Coupled with the rapid rise in cloud-based skills, this trend highlights the symbiotic relationship between AI and

[7] To remove the effect of small base on the percentage changes, any subcategories that had less than 1000 occurrences in 2012 are removed.

cloud technologies. AI and cloud computing are driving firms to streamline processes, foster innovation, and enhance efficiency. For instance, 70% of companies acquire their AI capabilities through cloud-based software, while 65% develop AI applications using cloud services. This, in turn, motivates cloud providers to increase their investments in cloud technologies and further integrate AI capabilities (Mittal et al., 2019).

Table 5 compares the top 10 skills in 2012 and 2023, highlighting the shifting skill requirements across different job types. Among advanced digital skills, several that were prominent in 2012, such as HyperText Markup Language (HTML) and Cascading Style Sheets (CSS), which are essential for web development and webpage design, had lost their prominence by 2023.

In contrast, cloud-based skills such as Amazon Web Services (AWS) and Microsoft Azure, along with skills related to information privacy, have emerged as top digital skills in 2023. This shift clearly indicates a move away from Web 1.0, which focused heavily on webpage content, towards Web 2.0 and the ongoing evolution into Web 3.0. The latter is characterised by decentralised web content, more machine-readable content, and greater interconnections between different technologies such as the Internet of Things (IoT), as well as an increased emphasis on information privacy and control.

Furthermore, Python has replaced C# as the top programming language in the UK, owing to its broader applicability—not only in software development but also across various applications including machine learning and AI. The rising importance of AI and machine learning is also underscored by the increased demand for automation skills, which have become new top digital skills in 2023.

In terms of intermediate digital skills, the emergence of Power BI and data management as top skills highlights the increasing importance of data in everyday jobs, which could have profound impacts on both work and life. Additionally, new top skills such as Salesforce and content creation have replaced older skills like digital publishing and Photoshop. This change reflects a clear trend towards digital marketing's growing importance, signalling a shift from Web 1.0 to Web 2.0, and from centralised content creation to user-generated content.

While there have been fewer changes in the top basic skills, the shifts that have occurred also reveal evolving technology and approaches to our digital lifestyle. Notably, new top skills in 2023 such as data entry and social media reflect the broader changes seen in basic skills, underscoring the growing importance of data and interactive content creation.

Table 5: Top 10 skills by number of appearances in job posts – UK, 2012 and 2023

Top 10 Skills 2012	Top 10 Skills 2023	Classification
SQL (Programming Language)	Agile Methodology	Advanced
C# (Programming Language)	Information Privacy	
JavaScript (Programming Language)	Automation	
Java (Programming Language)	SQL (Programming Language)	
Agile Methodology	Microsoft Azure	
HyperText Markup Language (HTML)	Python (Programming Language)	
Cascading Style Sheets (CSS)	Software Engineering	
ASP.NET	Amazon Web Services	
Linux	JavaScript (Programming Language)	
Software Development	Technical Support	
Telemarketing	SAP Applications	Intermediate
SAP Applications	Digital Marketing	
Help Desk Support	Power BI	
Information Technology Infrastructure Library	Help Desk Support	
Search Engine Optimization	Data Management	
Adobe Photoshop	Search Engine Optimization	
Digital Publishing	Salesforce	
Call Centre Experience	Content Creation	
Digital Marketing	Call Centre Experience	
Microsoft Access	Xero (Accounting Software)	
Microsoft Excel	Microsoft Excel	Basic
Computer Literacy	Microsoft Office	
Microsoft Office	Computer Literacy	
Microsoft Outlook	Microsoft Outlook	
Microsoft PowerPoint	Microsoft PowerPoint	
Firefox	Data Entry	
Microsoft Internet Explorer	Microsoft Word	
Safari (Web Browser)	Social media	
Typing	Spreadsheets	
Microsoft Word	Typing	

Note: This table compares the top 10 digital skills by total number of appearances in job posts between 2012 and 2023, across three skill levels.

Source: Lightcast Database

Looking at skill demand at the industry and occupation level specifically, between 2012 and 2023, the increasing digitalisation of the workforce led to significant shifts in skill demand across occupations and industries. In online Appendix 2[8], a comprehensive list of the top 10 skills with the largest increase in demand between 2012 and 2023, categorised by occupation and industry, is provided for all ITL 1 regions. The main findings are summarised below.

For Managers, Directors, and Senior Officials (SOC 1), there was a move towards specialised skills like Automation and Information Privacy, reflecting the growing

[8] This can be found at: https://maxyyy110.github.io/digital-skill-UK/Top%20Skills/index.html. The industry classification is based on the 2007 version of the Standard Industrial Classification (SIC) at the section level (A–U), and the occupation classification follows the 2010 Standard Occupational Classification (SOC) at the major group level (1–9)

importance of AI, cloud technologies, and data security. In Professional Occupations (SOC 2), the focus shifted from Data Analysis and Software Development to Cloud Computing and Machine Learning, while Associate Professional and Technical Occupations (SOC 3) transitioned towards Agile Methodology, Automation, and Information Privacy, indicative of a more agile and secure IT environment.

Administrative and Secretarial Occupations (SOC 4) saw increased demand for Database Management and Project Coordination due to the digitisation of office operations. In Skilled Trades Occupations (SOC 5), traditional technical skills gave way to digital tools and environmental knowledge, signifying a shift towards sustainable and tech-integrated practices. Sales and Customer Service Occupations (SOC 7) evolved from basic customer service skills to digital competencies like Digital Marketing and CRM Software, driven by the rise of online engagement.

Industries also experienced widespread digitalisation[9]. Primary sectors like agriculture and utilities moved towards Automation and Data Management, while manufacturing and construction embraced Robotics and Building Information Modelling (BIM). The trade and transportation sectors shifted focus to Supply Chain Management and E-commerce, reflecting the need for digital efficiency. The financial sector gravitated towards FinTech and Blockchain, and professional, scientific, and technical activities prioritised Big Data and AI.

Public services and education sectors adapted to increasing demand for Cybersecurity and Online Teaching Platforms, while the arts and entertainment industry shifted towards Digital Content Creation and Social Media Management. Overall, the growing demand for digital skills across all sectors underscores the need for continuous upskilling to meet the evolving demands of the modern economy.

Most of the skills that experienced significant increases are advanced and intermediate skills, showing that digitalisation during the sample period has shifted mainly towards more sophisticated and specialised technological capabilities. This reflects the growing application of Web 2.0 and Web 3.0 technologies, such as cloud computing, blockchain, and AI-driven solutions, in various industries.

5. Shortages of digital skills

5.1 Descriptive analysis of labour market indicators

This section explores some of the main labour market metrics used to build the digital skills shortage index (see Appendix 1.2). Weighted data from the Annual Population Survey (APS) for the periods 2017-2019 to 2020-2022 is utilised. As discussed earlier, each three-year pooled APS dataset is represented by its midpoint year. The analysis focuses on people aged 16-64 in full-time employment.

Figure 13 displays employment growth rates in the UK by major occupation group. Professional (SOC 2) occupations saw significant year-over-year (YoY) growth, which peaked at 7.6% in 2020. Conversely, Skilled Trades and Elementary occupations experienced negative growth rates, particularly in 2019 and 2021. It appears that the latter occupations were hit harder by the economic disruptions caused by the COVID-19 pandemic. Overall, the employment growth rates remained positive, although they decreased from 1.4% in 2018 to 0.3% in 2021.

[9] Due to the limited representativeness of sectoral information, Lightcast may not fully reflect changes in digital skills by sector.

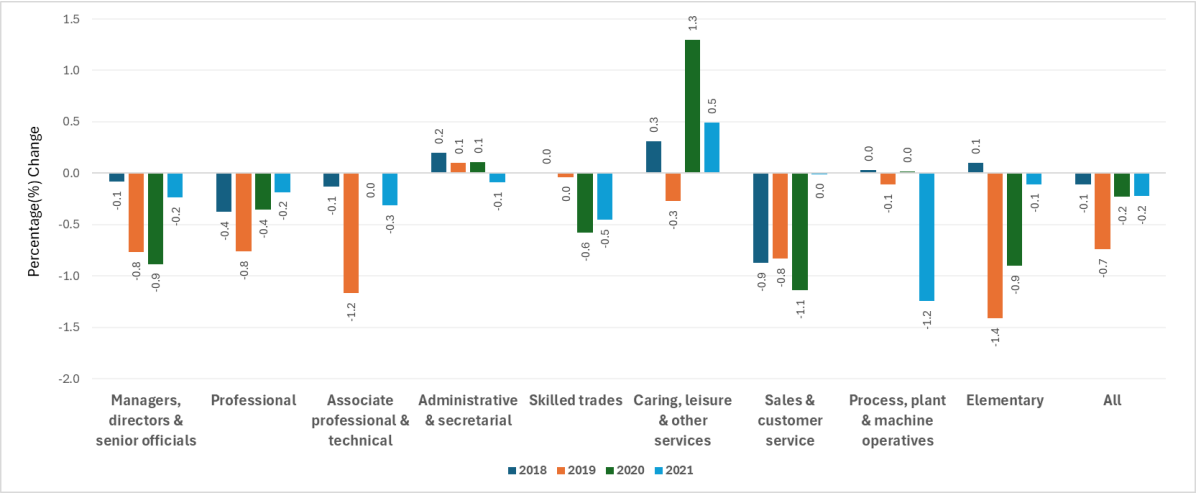
Figure 13: Year-over-year growth rate in the number of employed people by occupation group - UK, 2018 to 2021

Note: The figures refer to the working-age population (aged 16-64) in full-time employment in the UK. Note that some figures for 2020 and 2021 may be affected by the transition from the Standard Occupational Classification (SOC) 2010 to SOC 2020. This transition may have caused certain occupations that were previously categorised in one group under SOC 2010 to be reclassified into another group under SOC 2020. This particularly affects the "Professional" and "Associate professional & technical" occupation groups.

Source: Annual Population Survey 3-year pooled datasets (2017-2019 to 2020-2022).

Nationally, the average weekly number of hours worked (including overtime) decreased slightly between 2018 (46.9 hours) and 2021 (46.3 hours) in the UK. Nevertheless, there were some differences in the growth rates of hours worked across occupation groups and regions. Figure 14 reveals that Caring, Leisure & Other Services demonstrated the largest increase in both 2020 and 2021 (1.5% and 0.5%, respectively), possibly influenced by the higher demand for certain caring services during the pandemic. In contrast, Sales & Customer Service roles saw a decline, likely because of the reduced consumer activity and changing market needs. Regional data offer additional insights (Figure 15). In particular, the growth rate of hours worked improved to 0.6% in 2021 for Yorkshire & the Humber, thereby marking a recovery from previous years of decline. On the other hand, Northern Ireland shifted from a positive growth rate in 2018 (0.4%) to negative rates in later years. Similarly, the North West consistently recorded negative growth rates of hours worked throughout the period. These shifts might be related to changes in the characteristics of the workforce over time, including differences in age and gender profiles, health status, and the distribution of workers by occupation and level of education.

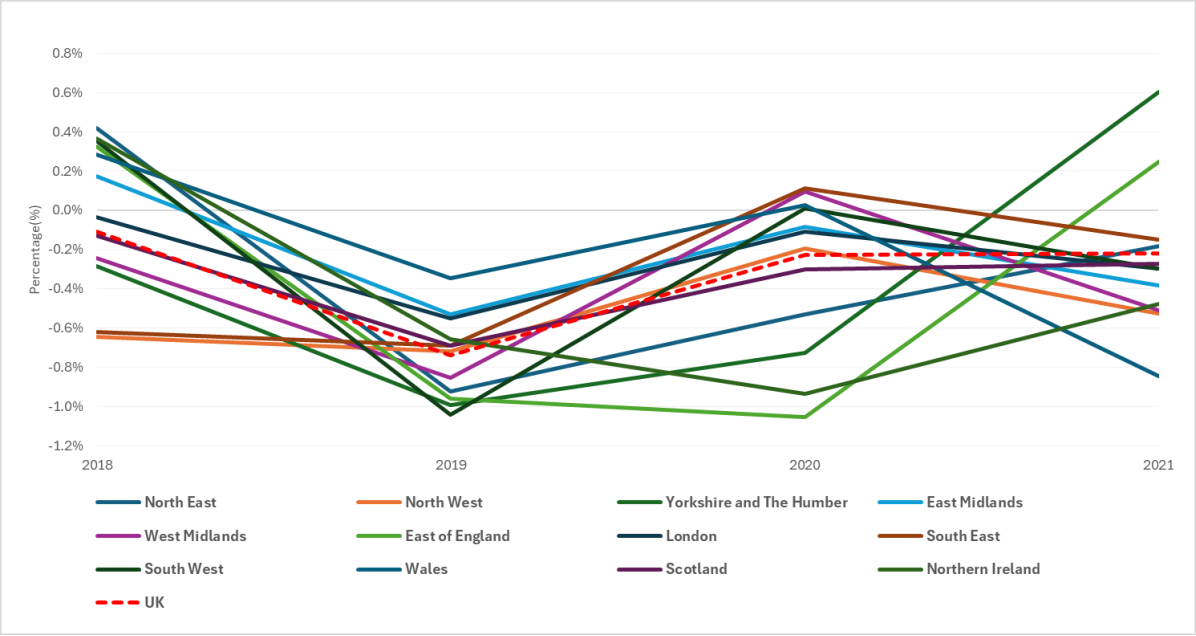
Figure 14: Year-over-year growth rate in average hours worked per week (including overtime) by occupation group – UK, 2018 to 2021



Note: The figures refer to the working-age population (aged 16-64) in full-time employment in the UK.

Source: Annual Population Survey 3-year pooled datasets (2017-2019 to 2020-2022).

Figure 15: Year-over-year growth rate in average hours worked per week (including overtime) by ITL 1 region – UK, 2018 to 2021



Note: The figures refer to the working-age population (aged 16-64) in full-time employment in the UK.

Source: Annual Population Survey 3-year pooled datasets (2017-2019 to 2020-2022).

Finally, Table 6 provides details on the proportion of full-time workers with a degree-level qualification by region. In the UK as a whole, this average share increased by 5.5 percentage points by 2021 compared to 2018, reflecting a nationwide trend towards greater educational levels among workers. Notably, all regions saw increases in this percentage. For instance, the West Midlands displayed the most significant improvement, as its share rose from 32.1% in 2018 to 39.0% in 2021, thus reducing the gap with the national average (43.8% in 2021). London, with the highest share at 65.2% in 2021, continues to lead in educational attainment.

Table 6: Percentage (%) of individuals with a degree (or equivalent qualification) by region – UK, 2018 to 2021

Region	2018	2019	2020	2021	Difference 2021-2018
North East	31.3	33.0	34.6	36.1	4.8
North West	34.7	36.6	38.7	40.7	6.0
Yorkshire and The Humber	32.3	35.1	36.0	37.1	4.8
East Midlands	30.6	32.7	33.2	35.0	4.3
West Midlands	32.1	34.8	37.1	39.0	7.0
East of England	33.9	35.4	36.5	37.7	3.8
London	58.4	60.5	63.1	65.2	6.9
South East	40.1	41.2	43.1	45.2	5.1
South West	35.4	36.6	38.2	39.2	3.8
Wales	34.1	35.3	37.1	37.8	3.7
Scotland	35.7	38.6	40.4	41.9	6.3
Northern Ireland	34.4	39.0	39.7	41.3	6.8
UK	38.3	40.3	42.1	43.8	5.5

Note: The figures refer to the working-age population (aged 16-64) in full-time employment in the UK.

Source: Annual Population Survey 3-year pooled datasets (2017-2019 to 2020-2022).

5.2 Digital skills shortages at the national level

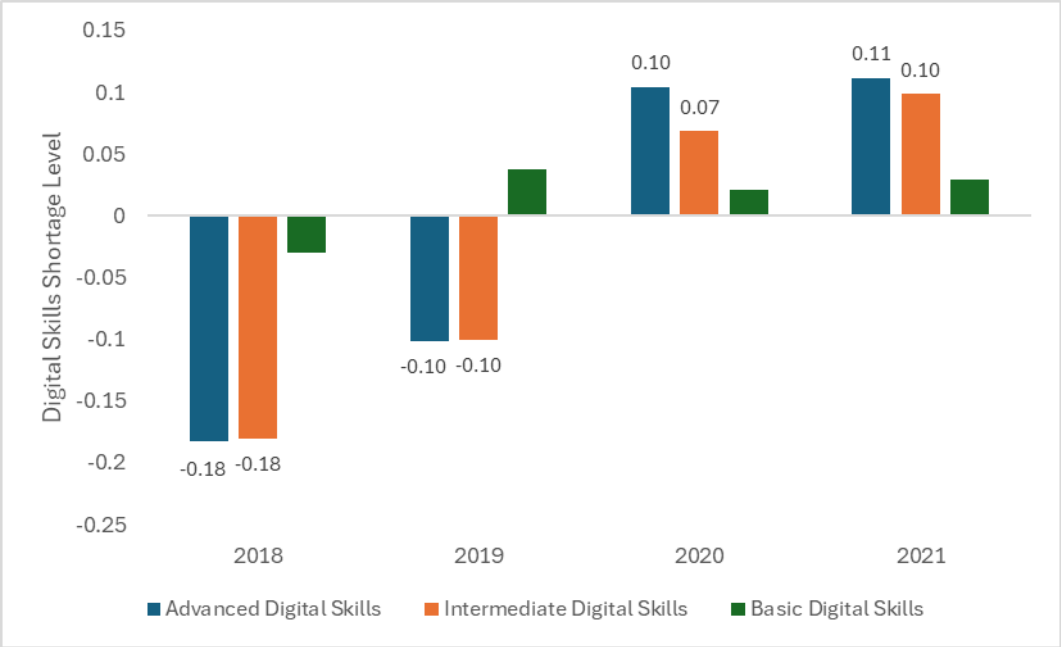
Based on the macro-level data presented in Section 5.1 and the methodology outlined in Section 3.3 and Appendix 1.2, this section presents the findings of the digital skills shortage indicator. At the UK national level[10], consistent with the OECD's Skills for Jobs Indicator (OECD, 2022), analysis indicates that the UK has experienced an increase in digital skills shortages across the three skill levels.

As shown in Figure 16, in 2020 and 2021, the skills level with the largest shortages was advanced digital skills. This is accompanied by the sharp increase in the shortage indicator from -0.182 in 2018 to 0.111 in 2021. The most significant increase occurred in 2021, coinciding with the impact of COVID-19.

Intermediate skills also shifted from a surplus in 2018-2019 to a shortage in 2020, and they experienced a further moderate increase in 2021. Although shortages in basic skills were relatively mild, the shortage indicator shows that the UK has been grappling with an insufficient supply of workers with foundational digital skills, even as early as 2019, before the pandemic. This indicates that the shortages are not solely a result of the increased demand for digital skills during the pandemic but also reflect ongoing structural issues in meeting digital skill demands across various levels.

[10] The national level indicator is a weighted sum of regional digital skills shortage indicators.

Figure 16: Digital skills shortage indicators by level of digital skills – UK, 2018 to 2021



Note: This figure presents the UK Digital Skills Shortage Indicator, categorised by advanced, intermediate, and basic skills. Values above zero signify a shortage in the supply of digital skills, while values below zero indicate a surplus. The magnitude of the values reflects the severity of the shortage or surplus.

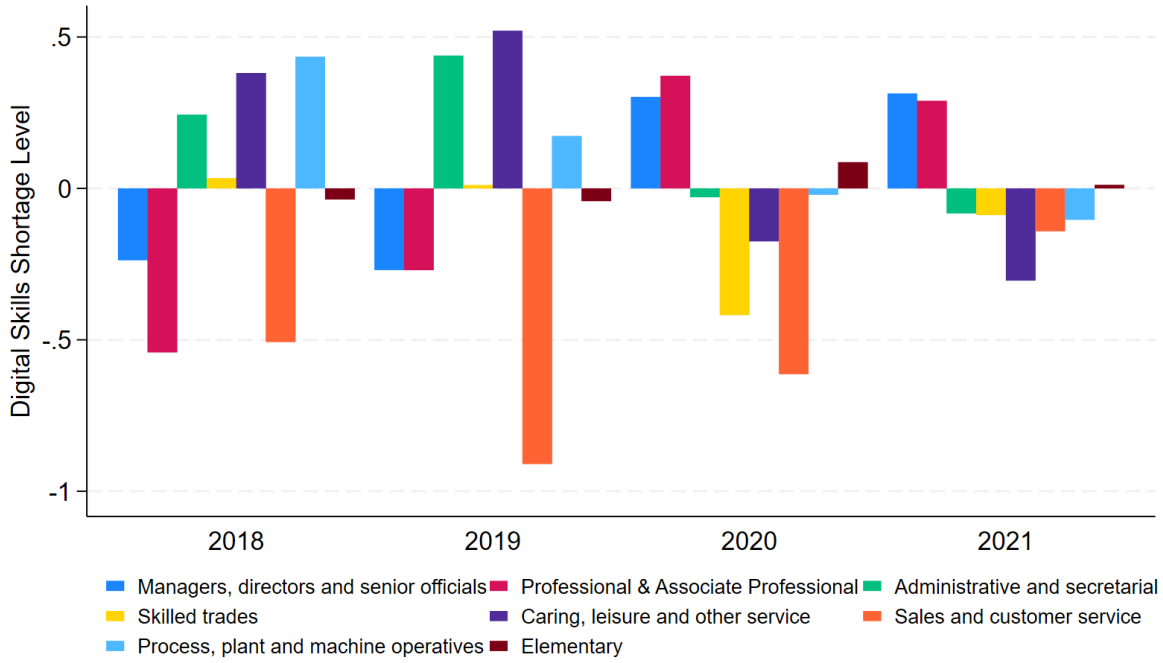
By construction, the shortage indicator for different skill levels moves in the same direction, although the values vary according to their relative importance. Occupational-level analysis highlights varying trends across different occupations. Subfigures (1) to (3) of Figure 17 illustrate the shortages of digital skills by occupation over a four-year span for which the indicator is available.

While Administrative and Secretarial occupations (SOC 4), Caring, Leisure, and Other Service occupations (SOC 6), and Process, Plant, and Machine Operatives (SOC 8) experienced significant shortages across all three skill levels—particularly in basic digital skills—these shortages gradually eased by 2021.

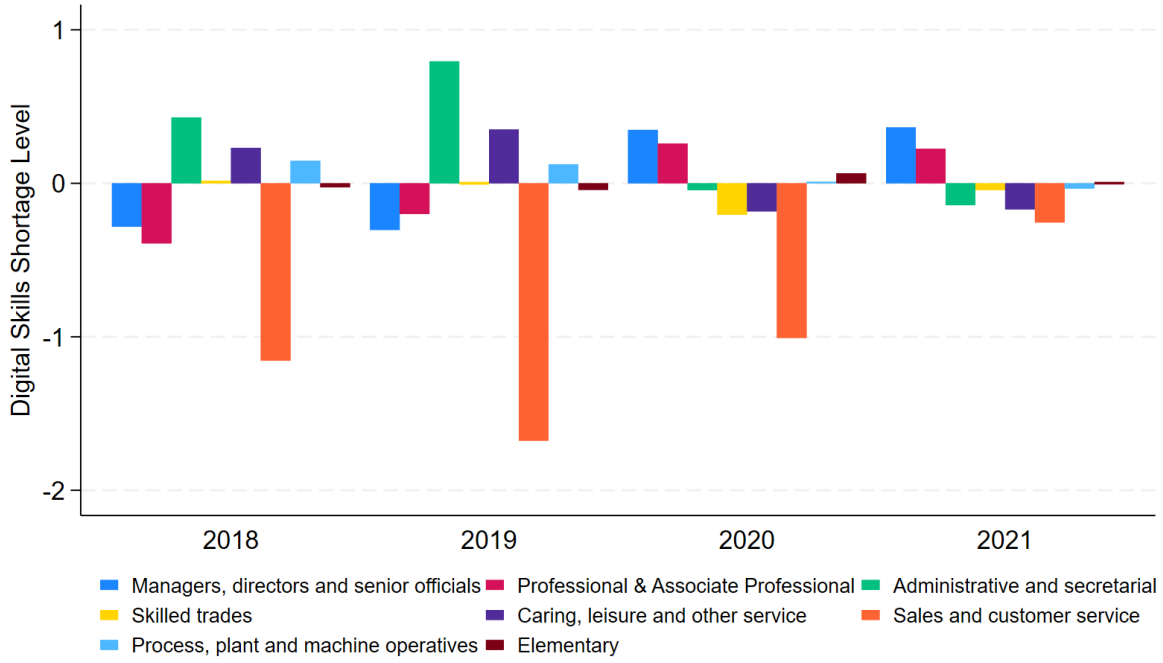
Conversely, Managers, Directors, and Senior Officials (SOC 1), along with Professionals (SOC 2) and Associate Professionals (SOC 3), encountered escalating skill shortages in 2021, despite no prior shortages in 2018 and 2019. This increase in demand for advanced digital skills was likely driven by two main factors: a significant rise in digital skills requirements due to rapidly evolving technologies and digitalisation, and a surge in vacancies for roles demanding high-level digital skills during the Covid-19 pandemic.

Elementary occupations (SOC 9) also saw an increase in skill shortages, with the shortage indicator turning positive in 2020, although the impact was relatively mild. This trend was most pronounced for basic digital skills, indicating a higher level of digital skill requirements in foundational occupations but with a workforce that is less prepared to meet these new challenges.

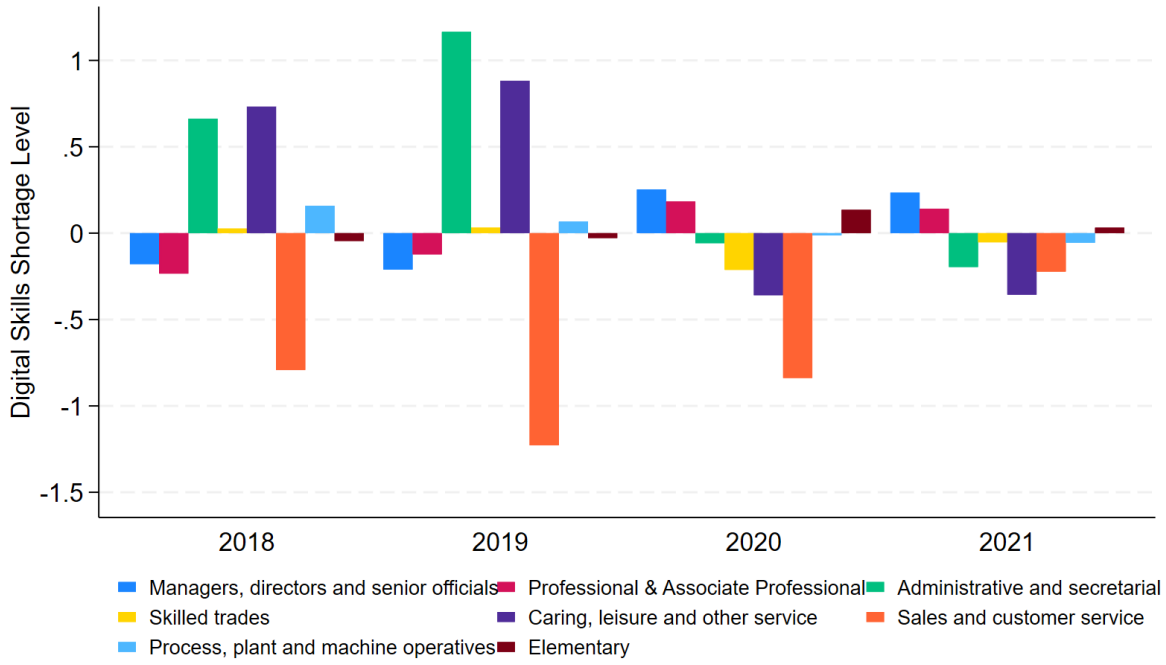
Figure 17: Digital skills shortage Indicator by major occupational group – UK, 2018 to 2021



(1) Advanced digital skills



(2) Intermediate digital skills



(3) Basic digital skills

Note: This figure displays the UK Digital Skills Shortage Indicator by occupation according to the UK Standard Occupational Classification (SOC) major groups and categorised by digital skill level: advanced, intermediate, and basic. A value above zero indicates a shortage of digital skills, while a value below zero suggests a surplus. *Larger negative and positive values represent higher levels of shortage and surplus, respectively.*

Source: Lightcast

5.3 Regional distribution of shortages

The regional distribution of digital skills shortages reveals that shortages do not always occur in regions with the highest demand. In fact, regions with relatively low demand for digital skills often experience the most severe shortages. This suggests that insufficient supply may be limiting the demand for digital skills, ultimately hindering regional development.

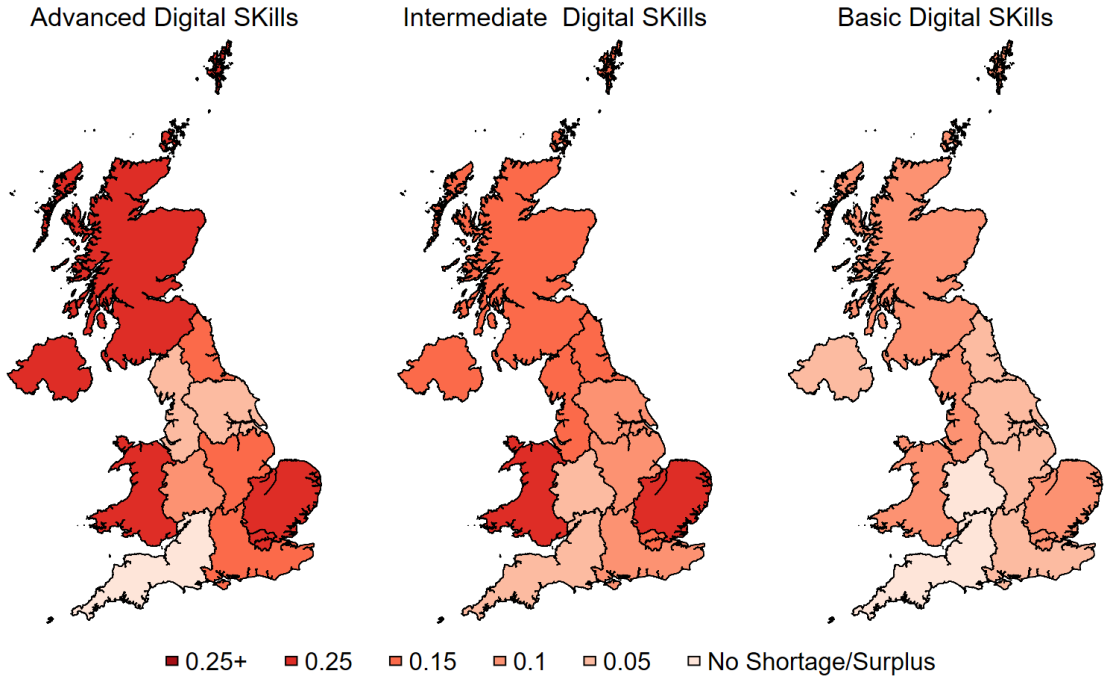
Figure 18 shows the map of digital skills shortages in 2021, categorised by three levels of skills. All UK regions have some degree of shortages in at least one level of digital skills, with regions including the East of England and the devolved nations showing the highest need for workers with digital skills.

For advanced skills, the South West is the only region in 2021 that does not exhibit shortages according to this analysis. Among regions with shortages in advanced skills, the devolved nations—Scotland, Wales, and Northern Ireland—along with the East of England and London, experience the most pronounced shortages. These are followed by the South East, the East Midlands, and the North East. The West Midlands shows relatively mild shortages.

In terms of intermediate skills, although all regions face more moderate shortages, no region is free from shortages. Wales and the East of England experience the most significant shortages.

The South West and the West Midlands do not exhibit shortages in basic skills, while a moderate degree of shortages is observed in the East of England, London, Wales, the North West, and Scotland.

Figure 18: Digital skills shortage indicators by ITL 1 region - 2021



Note: This figure illustrates the geographical distribution of the UK Digital Skills Shortage Indicator for 2021, by ITL 1 regions and categorised by skill levels: advanced, intermediate, and basic. Values above zero indicate a shortage of digital skills, while values below zero denote a surplus. The intensity of each shortage or surplus is represented by the shade of red, with darker shades indicating higher values.

Source: Lightcast and own elaboration

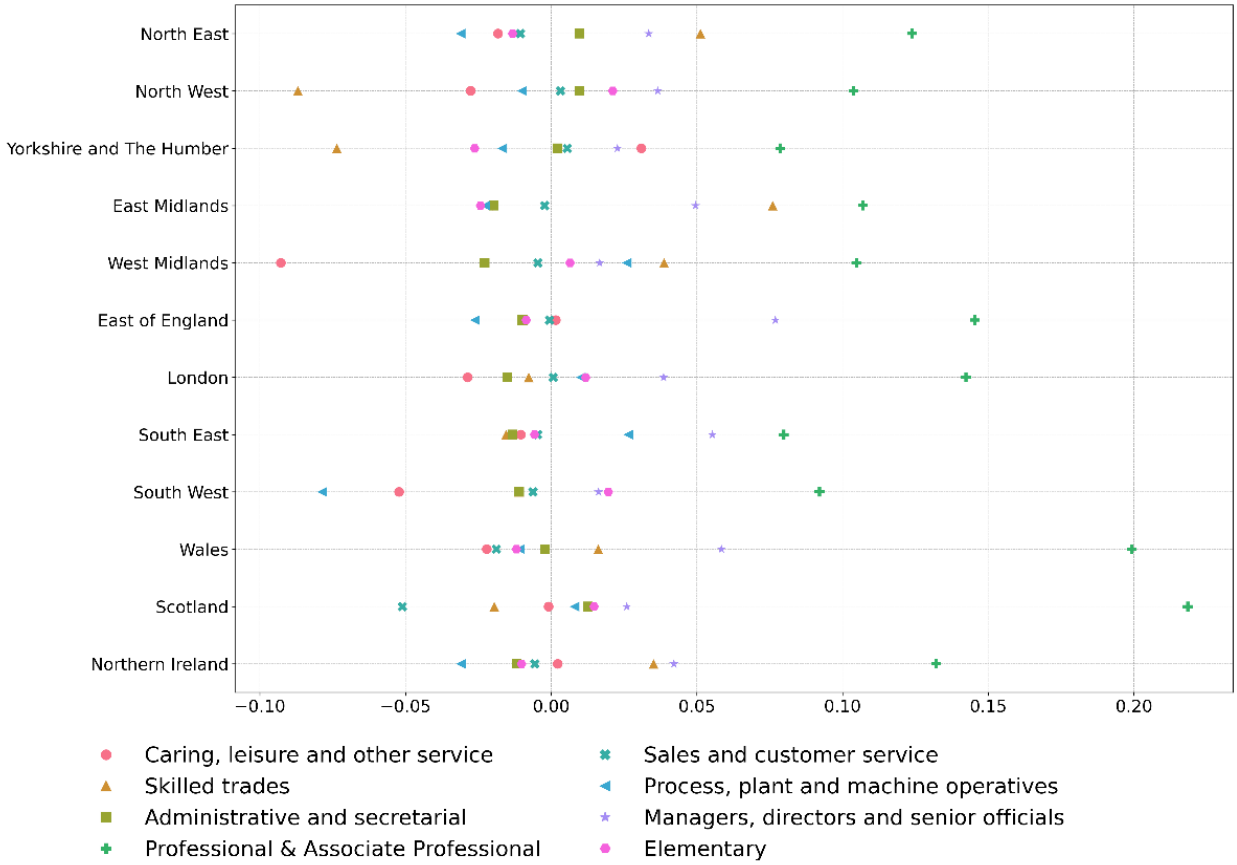
Subfigures (1) to (3) of Figure 19 present a Cleveland dot plot that illustrates shortages in digital skills across various regions and occupational groups in 2021. Each dot on the plot represents the extent of the shortage for a specific occupational group within a region, displayed on the Y-axis. This visualisation highlights regional variations in shortages for advanced, intermediate, and basic digital skills.

Managers, Directors, and Senior Officials (SOC 1), along with Professionals (SOC 2) and Associate Professionals (SOC 3), consistently show the most significant shortages across all regions and skill levels, reflecting a nationwide scarcity in these categories. Despite this broader national trend of shortage, Elementary occupations (SOC 9) face the most severe shortages in London, the South West, North West, and Scotland, particularly in basic skills, while experiencing smaller shortages or none at all in other regions.

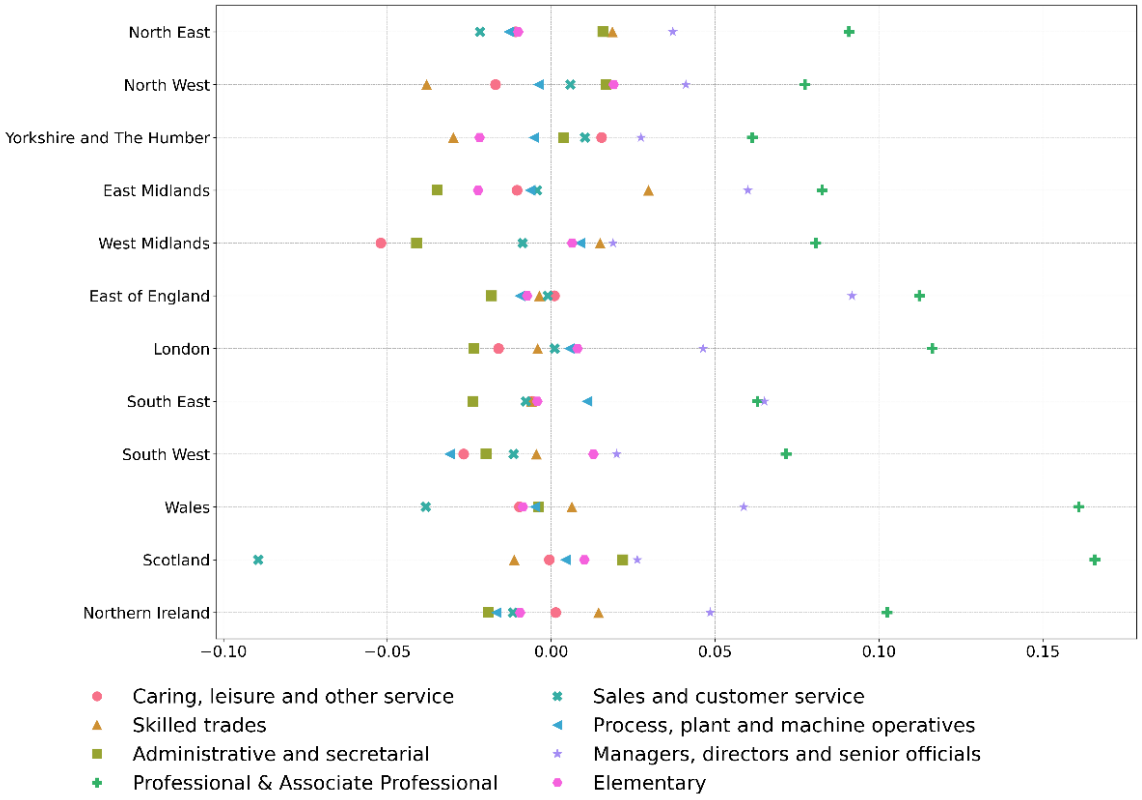
Despite other occupations experiencing no shortages on a national level in 2021, significant regional variations are evident. Administrative Occupations (SOC 4) faced shortages in the North East, North West, Yorkshire and the Humber, and Scotland, with Scotland exhibiting a particular shortfall in digital skills across all three levels. Skilled Trades occupations (SOC 5) in the North East, East Midlands, West Midlands, Wales, and Northern Ireland also experienced shortages, particularly in advanced digital skills, with the East Midlands experiencing the most pronounced shortages.

For Caring, Leisure, and Other Service Occupations (SOC 6), Yorkshire and The Humber, the East of England, and Northern Ireland faced shortages, with Yorkshire showing a relatively high level of shortages in basic digital skills for this occupation. The shortage indicator reveals that Sales and Customer Service Occupations (SOC 7) experienced shortages in the North West, Yorkshire and the Humber, and London, though the shortage was very mild in London. The most significant shortages are observed in intermediate skills in Yorkshire and The Humber. Process, Plant, and Machine Operative Occupations (SOC 8) face substantial shortages in London and the South East—unique as these are the only other occupations alongside Managers and Professionals to experience significant shortages in London—with additional shortages observed in the West Midlands and Scotland.

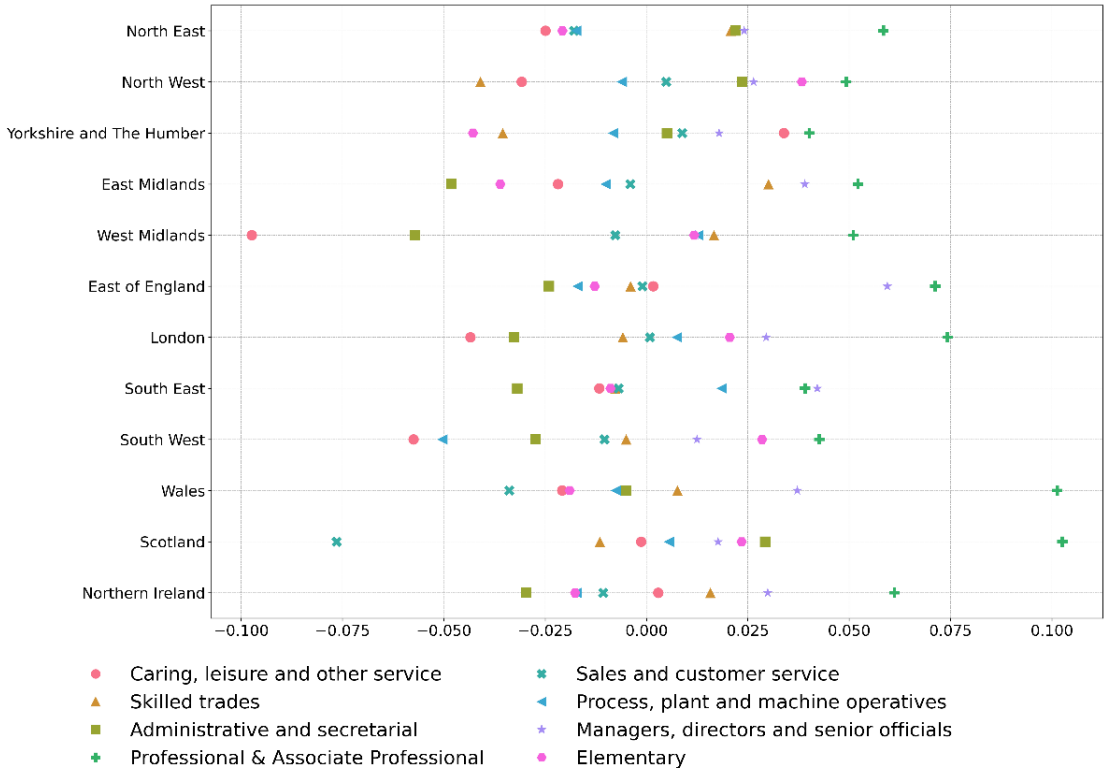
Figure 19: Digital skills shortages indicators by ITL 1 region and major occupation group -2021



(1) Advanced digital skills



(2) Intermediate digital skills



(3) Basic digital skills

Note: This figure is a Cleveland dot plot which displays the extent of digital skills shortages across ITL1 regions and Standard Occupational Classification (SOC) 1-digit occupations. Each dot on the plot represents the degree of shortage or surplus for a specific occupation within a region, arrayed along the Y-axis. Subfigures (1) to (3) differentiate the data by skill levels: advanced, intermediate, and basic. Values above zero indicate a shortage of

digital skills, while values below zero signify a surplus. The absolute values of the indicators quantify the magnitude of each shortage or surplus.

Source: Lightcast and own elaboration

Online Appendix 3 includes detailed data that shows the shortage indicator levels for all occupations across the 12 ITL1 regions in the UK, spanning from 2018 to 2021[11].

6. Modelling the impact of digital skills shortages on regional economies

This chapter examines the impact of digital skill shortages on regional growth trajectories. The Socio-Economic Impact Model for the UK (SEIM-UK), a macroeconomic Multi-Regional Input-Output (MRIO) model, is employed to project the potential economic costs associated with these shortages and to estimate the benefits that could be realised by addressing them. By modelling various scenarios, the SEIM-UK highlights how overcoming digital skill shortages could unlock significant growth potential across regions, fostering more balanced economic development.

6.1 Methodology

The SEIM-UK can model how changes in the economy at the regional or sectoral level affect other sectors or regions. Detailed explanations of input-output models can be found in Miller & Blair (2019), with specifics on the SEIM-UK provided by Carrascal-Incera et al. (2020). The SEIM-UK captures the UK economy at the ITL-1 regional level (12 regions) and across 30 industrial sectors[12].

The SEIM-UK enables the prediction of growth in output, employment, and GDP as a result of changes in final demand, such as capital investment and government spending. This makes the SEIM-UK particularly useful for understanding the potential impact of major investments, such as the Commonwealth Games (Lyons, 2024), R&D investment (Ma et al., 2024) and the impact of BBC on the West Midland (Todd et al., 2024).

A novel development in the SEIM-UK model links labour demand and labour supply, incorporating constraints in labour supply to account for labour mobility across regions and occupations. This allows the model to track bottlenecks in labour supply given increases in demand, as well as the associated economic impacts.

When the economy experiences an increase in final demand, labour demand fully adjusts in the absence of supply constraints, with no negative repercussions on the economy. In this context, labour shortages are defined by a constraint set by a minimum national unemployment rate by occupation, ensuring that the actual unemployment rate cannot fall below this minimum.

The model includes mechanisms to adjust labour demand in response to supply shortages, affecting wage income and, consequently, demand and output. Additionally, regional wage rates, influenced by consumer prices and unemployment rates, feed back into the determination of labour input coefficients and overall economic outcomes. Comparing modelling results with and without supply constraints reveals the cost of labour shortages on the economy. Full technical details of the model with labour

[11] This can be found at: https://maxyyy110.github.io/digital-skill-UK/shortage_by_years_table_itl1.html
[12] Sectors here refer to the SEIM-UK classification, which is derived from and aggregates the UK Standard Industrial Classification (SIC) 2007 version.

market dynamics can be found in Appendix 1.4. In this case, two scenarios are modelled:

1. No digital skills shortage: This scenario assumes that there are no restrictions on labour supply. Under this scenario, increased digital skills demand can be satisfied.

2. Digital skills shortage: This second scenario uses the labour dynamics detailed in the labour module to restrict labour supply. In this case, a shortage of digital skills leads to reduced output and increased wages.

For both scenarios, the positive impact of a digitalisation final demand shock on output, employment and GDP are simulated, denoted as S1 and S2 respectively, and the difference in simulated impact between the two scenarios shows us the impact of the digital skills shortage.

$$S1 - S2 = impact\ of\ digital\ skills\ shortage$$

To convert digital skills demand into a final demand vector, the first step is to forecast the growth of all SOC 4-digit occupations up to 2040. This is achieved by forecasting the average growth of each SOC 4-digit occupation over the period from 2012 to 2022, which is the latest data available. To prevent total employment from inflating excessively, the following process is adopted to forecast the growth of digital skills employment demand. First, total employment growth at the UK level between 2012 and 2022 is calculated, averaging 1.5% per annum. Next, total UK employment is forecasted up to 2030. Finally, employment growth for each 4-digit SOC occupation is projected to 2030, based on the average growth rate for each occupation between 2012 and 2022. This projection is then adjusted using the ratio between the total employment growth for all SOC 4-digit occupations and the forecasted aggregate employment across all occupations.

To estimate the increased demand for digital skills, the Digitalisation Index, as defined in Section 4.3 is used at the SOC 4-digit level. The growth in employment for each SOC 4-digit occupation is weighted by the Digitalisation Index of each occupation, which is considered to proxy the increase in digital skills-related employment. The amount is referred to as digital skills-related employment. Since the SEIM-UK model only utilises SOC 1-digit level data, the growth of weighted digital skills-related employment is aggregated to the major occupation group based on the share of employment in 2022.

Based on this, the increase in employment growth is then distributed across regions and sectors using a bridge matrix that contains information on the sectoral and regional distribution of employment. The SEIM-UK cannot model the increased demand for skills directly, but it can model the increase in final demand (FD) comprised of capital costs and costs covering intermediate input. To convert the growth in digital skills-related employment to FD, the employment at the regional and sectoral levels is then converted into final demand, which in this case can be considered as investment required from digitalisation, using the employment/FD ratio already present in the model.

Table 7 shows the distribution of FD shock by region, while Table 8 shows the distribution of FD shock by sector. In terms of distribution by region, London, and the South East are forecast to witness the highest growth in digital skills employment, leading to FD increases to £8.4 billion and £5.7 billion, respectively, in 2024. The

volume also surpasses other regions significantly, with the next region, East of England, experiencing an FD shock of £3.2 billion in 2024.

Table 7: Final demand shock by ITL 1 region – 2024 to 2030 (£ million)

Region	2024	2025	2026	2027	2028	2029	2030
North East	887	906	922	938	953	966	977
North West	2887	2947	2997	3045	3090	3129	3160
Yorkshire and the Humber	2140	2186	2225	2264	2299	2332	2358
East Midlands	1798	1838	1872	1906	1938	1967	1992
West Midlands	2654	2710	2757	2802	2844	2880	2908
East of England	3167	3232	3288	3341	3389	3431	3464
London	8485	8642	8772	8893	9001	9087	9142
South East	5690	5804	5900	5991	6073	6143	6195
South West	2351	2399	2440	2479	2515	2546	2569
Wales	1086	1108	1128	1146	1164	1180	1192
Scotland	2345	2391	2429	2465	2498	2527	2549
Northern Ireland	708	724	738	751	763	773	781

Source: SEIM-UK

As shown in Table 8, the sectoral distribution of converted FD shock is skewed towards sectors such as Information and Communication, Financial and Insurance Activities, Public Administration and Defence/compulsory social security, and Professional, scientific and technical activities, which are characterised by the application of high-tech or knowledge-intensive processes, which often involves workforce substantial knowledge in digital skills. For example, in 2030, the FD shock occurring in these four industries accounts for 34% of all FD shock.

Table 8: Final demand shocks by sector – 2024 to 2030 (£ million)

Sectors	2024	2025	2026	2027	2028	2029	2030
Agriculture, forestry and fishing	220	233	245	256	265	274	280
Mining and quarrying	1406	1433	1456	1477	1495	1509	1517
Manufacture of food, beverages and tobacco	921	944	965	986	1006	1025	1042
Manufacture of textiles, wearing apparel and leather	488	501	512	523	533	543	552
Manufacture of wood and paper products and printing	424	435	445	455	464	473	481
Manufacture of petroleum, chemicals and pharmaceuticals	1368	1402	1433	1462	1491	1518	1542
Manufacture of rubber, plastic and non-metallic minerals	739	758	776	793	809	825	839
Manufacture of basic and fabricated metal products	718	736	753	769	785	800	814
Manufacture of computer, electronic and optical products	638	654	668	682	696	708	720
Manufacture of electrical equipment	387	396	405	414	422	429	436
Manufacture of machinery and equipment	723	741	757	774	789	804	817
Manufacture of transport equipment	1702	1744	1782	1820	1856	1890	1919
Other manufacturing, repair and installation	622	638	653	667	681	694	705
Electricity, gas, steam and air-conditioning supply	1123	1145	1164	1182	1197	1209	1217
Water supply; sewerage and waste management	462	472	479	487	494	500	504
Construction	1712	1765	1812	1857	1899	1936	1966

Sectors	2024	2025	2026	2027	2028	2029	2030
Wholesale and retail trade; repair of motor vehicles	1464	1510	1551	1592	1632	1670	1706
Transportation and storage	829	849	867	884	901	917	931
Accommodation and food service activities	286	297	308	321	337	355	378
Information and communication	3415	3465	3502	3534	3559	3573	3571
Financial and insurance activities	3807	3869	3918	3962	3997	4020	4026
Real estate activities	2219	2250	2272	2290	2301	2305	2299
Professional, scientific and technical activities	2296	2332	2360	2385	2405	2419	2422
Administrative and support service activities	782	800	815	830	844	857	868
Public administration and defence; compulsory social security	2472	2508	2535	2559	2577	2589	2590
Education	785	792	796	800	805	809	813
Human health and social work activities	1147	1162	1174	1188	1203	1220	1241
Arts, entertainment and recreation	525	529	531	533	534	533	530
Other service activities	517	526	534	542	549	555	560
Activities of households	0	0	0	0	0	0	0

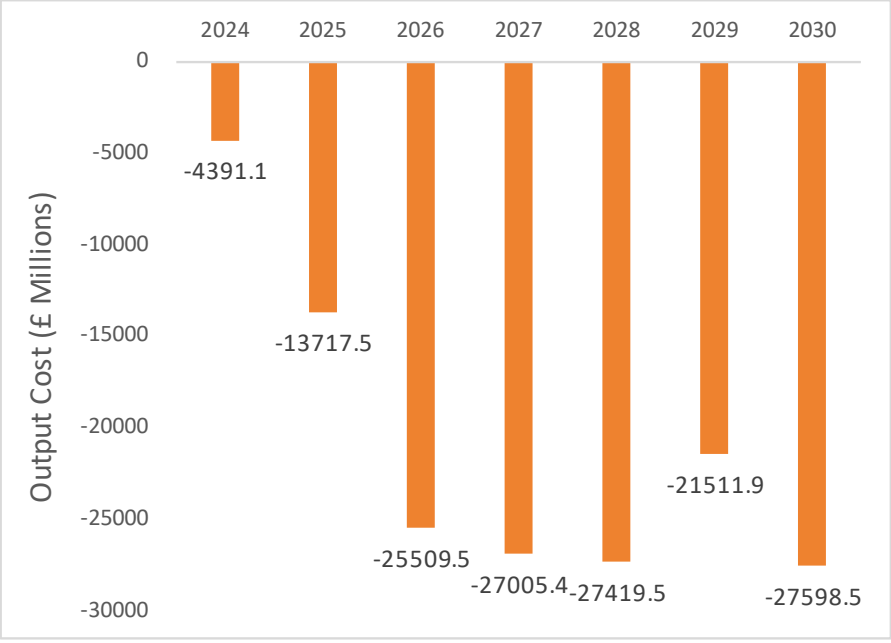
Source: SEIM-UK

6.2 Economic impact of digital skills shortages

Turning to the results from the SEIM-UK modelling, the findings predict a significant bottleneck in digital skills, with an increasingly adverse impact on regional economic growth. Notably, the cost of digital skills shortages is not borne solely by regions and sectors with the highest demand for these skills.

At the UK level, the economic cost of not fully addressing the shortage of digital skills is significant and growing. While the economic impact is relatively moderate in 2024, estimated at £4.4 billion, this figure is expected to rise sharply as the demand for digital skills increases across various regions and occupations. By 2030, the shortfall in digital skills could lead to an annual cost of approximately £27.6 billion to the UK economy, with likely further growth beyond that year.

Figure 20: Impact of digital skills shortages on economic output – UK, 2024 to 2030



Note: *This figure illustrates the economic cost of digital skills shortages on output, projected from 2024 to 2030 using the SEIM-UK input-output model for the UK. The figure shows the difference between the economic benefits*

from investments in digitalisation in two scenarios: one with skills bottlenecks and one without. The values are presented as negative figures, with larger absolute values indicating higher economic costs.

Source: SEIM-UK

Table 9 shows the geographical variation in the impact of digital skills shortages on economic output. The GSE region is estimated to experience the most substantial impact, consistent with its predominant role in the digital-related economy, and its high digital skills shortage indicator. However, given the size of its economy, GSE is a lesser affected region with 0.55% of London's output, 0.71% of South East's output lost in 2030 (using output[13] in 2024). On the other hand, regions such as the North West, Yorkshire and the Humber, and the East of England are also projected to incur significant economic costs, both in absolute terms and relative to the size of their economies. These regions may not have the highest levels of demand for digital skills, yet they are poised to bear significant economic impacts relative to the size of their economies. For instance, the South West is projected to lose 0.96% of its output in 2024, the highest among all regions. Similarly, substantial costs are expected in the North, with the North West anticipated to lose 0.83% of its output and Yorkshire and the Humber estimated to experience a 0.91% reduction in total output in 2024.

Table 9: Impact of digital skills shortages on economic output by ITL1 region, 2024-2030 (Million £)

Region	2024	2025	2026	2027	2028	2029	2030
North East	-112 (-0.09%)	-622 (-0.52%)	-913 (-0.76%)	-871 (-0.73%)	-838 (-0.70%)	-738 (-0.62%)	-867 (-0.72%)
North West	-497 (-0.13%)	-1645 (-0.43%)	-2849 (-0.75%)	-3267 (-0.86%)	-3121 (-0.82%)	-2351 (-0.62%)	-3158 (-0.83%)
Yorkshire and the Humber	-394 (-0.15%)	-1238 (-0.48%)	-1853 (-0.71%)	-2296 (-0.88%)	-2375 (-0.91%)	-1632 (-0.63%)	-2368 (-0.91%)
East Midlands	-358 (-0.15%)	-1090 (-0.47%)	-1858 (-0.80%)	-1562 (-0.67%)	-1974 (-0.85%)	-1575 (-0.68%)	-1821 (-0.78%)
West Midlands	-129 (-0.04%)	5 (0.00%)	-1880 (-0.61%)	-1372 (-0.45%)	-1543 (-0.50%)	-1392 (-0.45%)	-1552 (-0.51%)
East of England	-355 (-0.10%)	299 (0.09%)	-234 (-0.07%)	-2990 (-0.88%)	-2635 (-0.78%)	-199 (-0.06%)	-2635 (-0.78%)
London	-481 (-0.06%)	-2542 (-0.30%)	-4719 (-0.56%)	-5008 (-0.59%)	-4370 (-0.51%)	-4136 (-0.49%)	-4689 (-0.55%)
South East	-926 (-0.16%)	-2294 (-0.39%)	-3817 (-0.65%)	-3989 (-0.68%)	-4201 (-0.72%)	-3295 (-0.56%)	-4146 (-0.71%)
South West	-393 (-0.14%)	-1651 (-0.59%)	-2680 (-0.95%)	-2625 (-0.93%)	-2737 (-0.97%)	-2274 (-0.81%)	-2687 (-0.96%)
Wales	-149 (-0.11%)	-832 (-0.61%)	-1328 (-0.97%)	-1093 (-0.80%)	-1167 (-0.85%)	-1089 (-0.79%)	-1154 (-0.84%)
Scotland	-500 (-0.17%)	-1680 (-0.56%)	-2189 (-0.74%)	-1590 (-0.53%)	-2119 (-0.71%)	-1943 (-0.65%)	-2012 (-0.68%)
Northern Ireland	-101 (-0.12%)	-434 (-0.50%)	-1196 (-1.39%)	-348 (-0.40%)	-345 (-0.40%)	-892 (-1.04%)	-516 (-0.60%)

Note: *This table illustrates the economic cost of digital skills shortages on output, projected from 2024 to 2030 using the SEIM-UK input-output model for the ITL1 Regions. The figure shows the difference between the economic benefits of investments in digitalisation in two scenarios: one with skills bottlenecks and one without. The values are presented as negative figures, with larger absolute values indicating higher economic costs. The values are colour-coded, with a red scale indicating higher values and a green scale indicating lower values. The percentage of 2024 output level is shown in parentheses.*

Source: SEIM-UK

As shown in Table 10, when aggregating regions according to the classification by Masan and Maguire (2011), it becomes apparent that regions in the medium-tech

[13] This is the forecasted output in unconstrained SEIM-UK model.

manufacturing and service provision category[14], including the North West and West Midlands among others, incur the largest economic costs. In terms of economic cost relative to output in 2024, this is comparable to the projected economic costs for Knowledge and Technology Hubs, including the East of England, South East, and South West, which exhibit a significantly higher demand for digital skills across all three skill levels.

Table 10: Impact of digital skills shortages on output by types of regions – UK, 2024-2030 (Million £)

Region type	2024	2025	2026	2027	2028	2029	2030
Medium-tech manufacturing and service providers	-1738 (-0.11%)	-5852 (-0.39%)	-11874 (-0.78%)	-10806 (-0.71%)	-11361 (-0.75%)	-9668 (-0.64%)	-11433 (-0.75%)
Knowledge and technology hubs	-1673 (-0.14%)	-3645 (-0.30%)	-6730 (-0.56%)	-9604 (-0.80%)	-9572 (-0.79%)	-5767 (-0.48%)	-9466 (-0.78%)
Scotland (Service and natural resource regions in knowledge-intensive countries)	-500 (-0.17%)	-1680 (-0.56%)	-2189 (-0.74%)	-1590 (-0.53%)	-2119 (-0.71%)	-1943 (-0.65%)	-2012 (-0.68%)
London (Knowledge-intensive city/capital districts)	-481 (-0.06%)	-2542 (-0.30%)	-4719 (-0.56%)	-5008 (-0.59%)	-4370 (-0.51%)	-4136 (-0.49%)	-4689 (-0.55%)

Note: This table illustrates the economic cost of digital skills shortages on output, projected from 2024 to 2030 using the SEIM-UK input-output model by types of regions defined by Masan and Maguire (2011). The figure shows the difference between the economic benefits of investments in digitalisation based on two scenarios: one with skills bottlenecks and one without. The values are presented as negative figures, with larger absolute values indicating higher economic costs. The values are colour-coded, with a red scale indicating higher values and a green scale indicating lower values. The percentage of 2024 output level is shown in parentheses.

Source: SEIM-UK

Table 11: Impact of digital skills bottlenecks on output by types of sectors – UK, 2024-2030 (Million £)

Sector Type	2024	2025	2026	2027	2028	2029	2030
Other	-422 (-0.11%)	-1341 (-0.33%)	-2542 (-0.63%)	-2728 (-0.68%)	-2742 (-0.68%)	-2145 (-0.54%)	-2779 (-0.69%)
Low-Tech	-2246 (-0.16%)	-7114 (-0.51%)	-13286 (-0.95%)	-14142 (-1.01%)	-14267 (-1.02%)	-11185 (-0.80%)	-14365 (-1.03%)
Medium-Tech	-402 (-0.08%)	-1199 (-0.23%)	-2164 (-0.42%)	-2198 (-0.43%)	-2327 (-0.46%)	-1825 (-0.36%)	-2313 (-0.45%)
High-Tech/Knowledge Intensive	-1323 (-0.08%)	-4066 (-0.26%)	-7520 (-0.48%)	-7939 (-0.51%)	-8086 (-0.52%)	-6360 (-0.41%)	-8143 (-0.52%)

***Note:** This table illustrates the economic cost of digital skills shortages on output, projected from 2024 to 2030 using the SEIM-UK input-output model by types of regions defined by Masan and Maguire (2011). The figure shows the difference between the economic benefits from investments in digitalisation based on two scenarios: one with skills bottlenecks and one without. The values are presented as negative figures, with larger absolute values indicating higher economic costs. The values are colour-coded, with a red scale indicating higher values and a green scale indicating lower values. The percentage of 2024 output level is shown in parentheses.*

Source: SEIM-UK

To further examine how these impacts vary across industries, Table 11 presents the potential economic costs of digital skills shortages, categorised by the level of technology utilised within each industry[15]. Modelling results indicate that low-tech

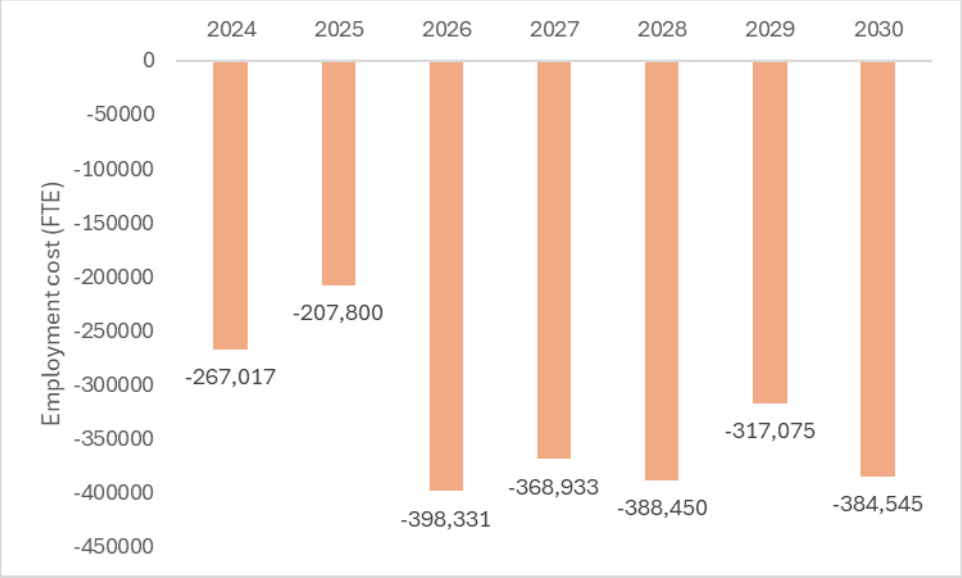
[14] This comprises the North East, North West (Including Merseyside), East Midlands, West Midlands, Yorkshire and Humberside, Wales and Northern Ireland.

[15] According to Eurostat, see: https://ec.europa.eu/eurostat/cache/metadata/en/htec_esms.htm. High-tech/knowledge intensive sectors include Manufacture of computer, electronic and optical products; Information and communication; Financial and

industries, including the manufacture of food, beverages, and tobacco; textiles, wearing apparel, and leather; and wood and paper products and printing, would bear the highest economic costs. These industries are projected to face shortages costing more than £14 billion per year by 2030, which accounts for 1% of output in baseline 2024 output. In line with high shortages in advanced digital skills across regions, the tech and knowledge-intensive sectors are also likely to be significantly affected, with economic costs projected to reach up to £8.1 billion by 2030. However, this is a much smaller percentage of its economy, as only 0.52% of output is lost.

At the UK level, in 2024 the bottleneck restricts employment by more than 267,000 FTEs in 2024, rising to 385,544 FTEs by 2030. The most significant increase in the impact of digital skills shortages on employment occurs between 2024 and 2025, with restricted employment surpassing 300,000 FTEs and remaining above this level through 2030.

Figure 21: Impact of digital skills shortages on employment – UK, 2024 to 2030 (FTE equivalent)



Note: *This figure illustrates the economic cost of digital skills shortages on employment measured in Full-Time equivalent, projected from 2024 to 2030 using the SEIM-UK input-output model for the UK. The figure shows the difference between the economic benefits of investments in digitalisation in two scenarios: one with skills bottlenecks and one without. The values are presented as negative figures, with larger absolute values indicating higher economic costs.*

Source: SEIM-UK

The regional impact of digital skills shortages highlights the risk of exacerbating regional inequalities. Table 12 shows that all regions would experience a decline in employment due to these shortages, with the impact worsening over time. However, some regions would be more severely affected than others.

insurance activities; Professional, scientific and technical activities; Public administration and defence; compulsory social security; Education; Human health and social work activities and Arts, entertainment and recreation. Medium-tech sectors include Manufacture of petroleum, chemicals and pharmaceuticals; Manufacture of rubber, plastic and non-metallic minerals ; Manufacture of basic and fabricated metal products; Manufacture of electrical equipment; Manufacture of machinery and equipment and Manufacture of transport equipment. Low-tech sectors include Manufacture of food, beverages and tobacco ; Manufacture of textiles, wearing apparel and leather ; Manufacture of wood and paper products and printing ; Other manufacturing, repair and installation ; Wholesale and retail trade; repair of motor vehicles ; Transportation and storage ; Accommodation and food service activities ; Real estate activities ; Administrative and support service activities ; Other service activities and Activities of households

While London bears the highest costs in terms of employment—ranging from 5,905 jobs in 2024 to 37,713 in 2030—this is proportionate to its high concentration of digital skills demand and shortages in skills, particularly for advanced skills. The North West sees larger overall job losses than London but a smaller change over time (from 39,576 jobs in 2024 to 46,625 jobs in 2030). Yorkshire & the Humber also experiences a sharp fall, losing 31,953 jobs by 2030.

Other areas, such as Northern Ireland, face a relatively smaller absolute economic cost, yet the proportionate impact on the local economy is disproportionate compared to their current digital skills demand. Compared with the employment level in 2024, Northern Ireland sees the highest relative employment cost, with digital skills shortages reducing employment by 2.23%. This is followed by the South East (1.73%), the South West (1.65%), and the East Midlands (1.58%). These figures underscore the uneven burden that digital skills shortages place on regional economies, particularly in areas with lower current demand for digital skills.

Table 12: Impact of digital skills shortages on employment by ITL 1 region – 2024 to 2030 (FTE equivalent)

Region	2024	2025	2026	2027	2028	2029	2030
North East	-7374 (-0.73%)	-3771 (-0.37%)	-12248 (-1.21%)	-7152 (-0.70%)	-12701 (-1.25%)	-6504 (-0.64%)	-12428 (-1.23%)
North West	-39576 (-1.24%)	-2335 (-0.07%)	-48550 (-1.52%)	-26004 (-0.82%)	-46684 (-1.46%)	-21572 (-0.68%)	-46625 (-1.46%)
Yorkshire and the Humber	-30594 (-1.33%)	-1908 (-0.08%)	-35999 (-1.57%)	-20669 (-0.90%)	-32404 (-1.41%)	-17196 (-0.75%)	-31953 (-1.39%)
East Midlands	-26203 (-1.30%)	-2166 (-0.11%)	-35084 (-1.74%)	-24130 (-1.20%)	-30706 (-1.52%)	-15706 (-0.78%)	-31861 (-1.58%)
West Midlands	-1960 (-0.08%)	-40719 (-1.64%)	-26884 (-1.08%)	-37800 (-1.52%)	-22784 (-0.92%)	-38450 (-1.55%)	-22840 (-0.92%)
East of England	-18421 (-0.69%)	-53294 (-1.99%)	-12180 (-0.45%)	-58228 (-2.17%)	-18288 (-0.68%)	-53920 (-2.01%)	-21044 (-0.78%)
London	-5905 (-0.12%)	-81797 (-1.64%)	-27794 (-0.56%)	-83675 (-1.68%)	-47964 (-0.96%)	-80801 (-1.62%)	-37713 (-0.76%)
South East	-58450 (-1.44%)	-3856 (-0.09%)	-77506 (-1.91%)	-47065 (-1.16%)	-68908 (-1.70%)	-34628 (-0.85%)	-70309 (-1.73%)
South West	-27885 (-1.18%)	-8847 (-0.38%)	-42886 (-1.82%)	-30487 (-1.29%)	-34589 (-1.47%)	-21436 (-0.91%)	-38823 (-1.65%)
Wales	-13688 (-1.12%)	-1107 (-0.09%)	-19620 (-1.60%)	-11523 (-0.94%)	-17533 (-1.43%)	-8852 (-0.72%)	-17770 (-1.45%)
Scotland	-30326 (-1.24%)	-4282 (-0.18%)	-40945 (-1.68%)	-23571 (-0.96%)	-37139 (-1.52%)	-18380 (-0.75%)	-37231 (-1.52%)
Northern Ireland	-6639 (-0.93%)	-3724 (-0.52%)	-18641 (-2.60%)	1365 (0.19%)	-18757 (-2.62%)	365 (0.05%)	-15955 (-2.23%)

Note: *This table illustrates the economic cost of digital skills shortages on employment measured in Full-Time equivalent, projected from 2024 to 2030 using the SEIM-UK input-output model for the UK. The figure shows the difference between the economic benefits of investments in digitalisation in two scenarios: one with skills bottlenecks and one without. The values are presented as negative figures, with larger absolute values indicating higher economic costs. The percentage of 2024 output level is shown in parentheses.*

Source: SEIM-UK

In terms of occupations, Professionals and Associate Professionals would have the biggest loss in employment given the existing shortage in digital skills, with digital skills shortage costing up to 69,695 FTE in 2030. This is consistent with the fact that both occupation groups have the highest proportion of job posts requiring digital skills, in particular advanced digital skills. This is followed by Managers, who have also witnessed a huge increase in digital skills demand in recent years. However, Elementary occupations, which have less demand for digital skills compared to other occupations, also experience significant employment losses due to digital skills

shortages. This could be caused by both the overall economic impact on Elementary occupations, as well as the spillover effect from the loss of digital skills in other occupations, and the future continued digitalisation of elementary occupations in the UK.

Table 13: Impact of digital skills bottlenecks on employment by major occupation group - UK, 2024-2030 (FTE equivalent)

Occupation	2024	2025	2026	2027	2028	2029	2030
Managers, Directors and Senior Officials,	-36116 (-1.07%)	-25519 (-0.76%)	-42476 (-1.26%)	-46436 (-1.38%)	-45768 (-1.36%)	-39427 (-1.17%)	-44204 (-1.31%)
Professional Occupations,	-60214 (-0.94%)	-44675 (-0.69%)	-66247 (-1.03%)	-81252 (-1.26%)	-72017 (-1.12%)	-69493 (-1.08%)	-69695 (-1.08%)
Associate Prof & Tech Occupations,	-51577 (-1.15%)	-30233 (-0.67%)	-58129 (-1.29%)	-61182 (-1.36%)	-62454 (-1.39%)	-51405 (-1.14%)	-60388 (-1.34%)
Administrative and Secretarial Occupations,	-31673 (-1.05%)	-19108 (-0.63%)	-37632 (-1.25%)	-37153 (-1.23%)	-39583 (-1.31%)	-32071 (-1.06%)	-37540 (-1.25%)
Skilled Trades Occupations,	-32353 (-1.23%)	-23248 (-0.89%)	-42391 (-1.61%)	-32730 (-1.25%)	-42743 (-1.63%)	-30235 (-1.15%)	-41943 (-1.60%)
Caring, Leisure and Other Service Occupations,	-7901 (-0.33%)	-15165 (-0.63%)	-28865 (-1.20%)	-23804 (-0.99%)	-20942 (-0.87%)	-20968 (-0.87%)	-22583 (-0.94%)
Sales and Customer Service Occupations,	-15656 (-0.64%)	-16663 (-0.68%)	-41898 (-1.71%)	-28259 (-1.15%)	-33014 (-1.35%)	-24707 (-1.01%)	-34447 (-1.40%)
Process, Plant and Machine Operatives,	-17907 (-1.02%)	-11935 (-0.68%)	-22818 (-1.30%)	-22572 (-1.29%)	-25792 (-1.47%)	-19309 (-1.10%)	-25009 (-1.43%)
Elementary Occupations	-13622 (-0.47%)	-21254 (-0.73%)	-57876 (-1.99%)	-35545 (-1.22%)	-46138 (-1.58%)	-29459 (-1.01%)	-48737 (-1.67%)

Note: This table illustrates the economic cost of digital skills shortages on employment measured in Full-Time equivalent, projected from 2024 to 2030 using the SEIM-UK input-output model for the UK. The figure shows the difference between the economic benefits from investments in digitalisation in two scenarios: one with skills bottlenecks and one without. The values are presented as negative figures, with larger absolute values indicating higher economic costs. The percentage of 2024 output level is shown in parentheses.

Source: SEIM-UK

7. Conclusion

Increasing digital skills shortages in the UK have prompted various government responses aimed at addressing this critical issue. Over recent years, the UK government has introduced several initiatives to reduce digital skills shortages and gaps and ensure that the workforce is equipped for future demands.

In 2017, the UK Government called for a significant transformation in the provision of digital skills training to meet the demands of the '4th Industrial Revolution' (HM Government, 2017). Since then, various policy initiatives have continued to emphasise the urgency of addressing the widening digital skills gap. The launch of the National Digital Strategy in 2022 (DCMS, 2022) marked a key milestone, prioritising efforts to close this gap and ensure the workforce is equipped for future digital challenges. Similarly, the Labour Party has identified bridging the digital skills divide as a central component of their mission, “Break Down Barriers to Opportunity”, one of five key goals outlined in their manifesto (The Labour Party, 2024). This collective focus

underscores the critical role digital skills play in shaping the UK's economic future and social equity.

Regional inequality in the UK has been flagged as a major issue. Inequalities in the demand and supply of digital skills, as well as the impact of shortages on regional economies, highlight the need for more targeted and comprehensive policy interventions. This research provides evidence supporting the need to address digital skills shortages at both national and regional levels.

- On average, over the last decade, more than 45% of UK job vacancies required at least one digital skill, with over 25% requiring advanced skills. Intermediate digital skills demand has remained steady at around 15%, reflecting fluctuations in specialised professions. Basic digital skills demand has experienced steady growth recently, despite a downturn during the Covid-19 pandemic.

- Digital skills are predominantly concentrated in higher-skilled occupations including professionals and associate professionals. However, demand for these skills is increasingly evident in lower-skilled roles, such as skilled trades and machine operatives, driven by the digitalisation of manufacturing processes.

- The rapid pace of digitalisation across sectors has led to significant changes in the types of digital skills required. Advanced digital skills have seen rapid changes, moving from programming language to AI, machine learning, and cloud computing-related skills where AI and Machine learning skills increased tenfold in the last decade. Intermediate and basic digital skills are becoming more important in roles like sales, which now heavily rely on digital marketing and data management tools. Basic digital skills have become foundational, appearing in positions such as machine operatives and elementary occupations, where digital literacy is a standard expectation. This shift underscores the need for robust, ongoing training strategies to adapt to rapidly evolving industry demands.

- The UK has seen an increase in digital skills shortages across all skill levels—basic, intermediate, and advanced. Advanced digital skills face the highest shortages, followed by intermediate and basic skills. The shortages were most pronounced in 2020 and 2021, reflecting the pandemic's exacerbation of the UK's digital skills gap.

- Regional demand for digital skills is highest in London and the South East, driven by their economic specialisations and concentration in knowledge-intensive industries. However, the demand for digital skills is widespread across the UK. Regions like the North West, Scotland and the West Midlands also exhibit significant demand across different levels. Northern Ireland stands out with the highest percentage of job posts requiring basic skills, as highlighted by its Skills Barometer (Department for the Economy, 2021).

- Regional digital skills shortage indicator indicates that London, the South East and the East of England also experience significant shortages across all skill levels, particularly advanced digital skills, consistent with their economic specialisation and level of demand for digital skills. However, regions with lower demand, such as the North East, Yorkshire and the Humber, and devolved nations (Wales, Scotland, and Northern Ireland), face even greater shortages relative to their

economic size and demand levels. This suggests that the low demand in some regions may reflect limited supply, constraining businesses and economic growth.

- SEIM-UK modelling indicates that, if shortages persist, the UK could face an economic loss of £27.6 billion in economic output and a reduction of 385,544 FTEs by 2030. Shortages in high-demand regions, such as London and the South East, create interregional spillover effects, disrupting less digitally intensive regions. Low-tech sectors reliant on digitally proficient supply chains and partners are particularly vulnerable, amplifying the urgency of addressing digital skills gaps.

- Digital skills shortages impose high economic costs on smaller regional economies and low-tech industries. These shortages disproportionately affect economically lagging regions outside London and the South East, where opportunities to attract and retain digital talent are more limited. Low-skilled workers in these regions face heightened risks of being left behind, exacerbating both regional and social inequalities. Without targeted interventions, these dynamics could further entrench disparities and limit the broader economic benefits of digitalisation.

The findings underscore the strong need for comprehensive and targeted action to address digital skills shortages across the UK. The economic costs, regional disparities, and evolving demand patterns for digital skills highlight the complexity of this challenge. Addressing these issues requires a multifaceted approach that balances national-level strategies with regionally tailored interventions.

- The UK needs to implement comprehensive measures to address shortages at all levels—basic, intermediate, and advanced. University education should build a pipeline of advanced talent, while on-site training programmes must scale to meet business needs and ensure workforce adaptability. Robust, adaptive training schemes are essential to align with rapidly evolving demands and prevent skills obsolescence.

- Regions with lower reported demand but high levels of shortage, such as the North East, Yorkshire and the Humber, and devolved nations, require tailored investments in training infrastructure. These measures should build local talent pools and unlock growth potential through digitalisation. Supporting smaller economies and low-tech industries is critical to reducing disparities and ensuring competitiveness.

- Shortages in high-demand regions, such as London and the South East, should be addressed to prevent ripple effects that exacerbate challenges elsewhere. Strengthening interregional collaboration and resource-sharing initiatives can distribute digital talent and expertise more equitably, enhancing the overall resilience of the UK economy.

- Policymakers need to establish mechanisms to monitor shifts in digital skill demands and ensure training programmes stay aligned with industry needs. Promoting self-learning initiatives and providing accessible tools and platforms will enable workers to independently update skills. Encouraging lifelong learning is critical to maintaining workforce agility and sustaining the UK's competitive edge in a digital economy.

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Appendix

Appendix 1. Methodology

A1.1 Classification

To determine these skills, first, a subset of 94 subcategories out of a total of 444 subcategories is identified as digital skills. The full list of subcategories considered digital is provided in Table A1.

Table A1: Lightcast Skills Subcategories Classified as Digital Skills

Subcategory Classification	Skills
Digital Skills	Cryptocurrency, Science Software, Bioinformatics, Web Content, Mainframe Technologies, Augmented and Virtual Reality (AR/VR), Clinical Informatics, Malware Protection, Streaming Media Systems, Hardware Description Languages (HDL), Natural Language Processing (NLP), Audio Production and Technology, Electronic Trading, Firmware, Search Engines, Image Analysis, Internet of Things (IoT), Marketing Software, Simulation and Simulation Software, Mathematical Software, Networking Software, Data Visualization, Backup Software, Digital Design, Human Resources Software, Education Software and Technology, Integrated Development Environments (IDEs), Distributed Computing, Microsoft Windows, Video and Web Conferencing, E-Commerce, Statistical Software, Data Storage, Animation and Game Design, Middleware, Mobile Development, Online Advertising, Graphic and Visual Design, iOS Development, Collaborative Software, Extensible Languages and XML, Accounting and Finance Software, Artificial Intelligence and Machine Learning (AI/ML), Virtualization and Virtual Machines, Cloud Computing, Network Security, Servers, Engineering Software, Scripting, Web Analytics and SEO, Database Architecture and Administration, C and C++, Graphic and Visual Design Software, Web Services, Social Media, IT Automation, Application Programming Interface (API), Network Protocols, Version Control, Software Development Tools, Cloud Solutions, JavaScript and jQuery, Digital Marketing, Microsoft Development Tools, User Interface and User Experience (UI/UX) Design, General Networking, Java, IT Management, Other Programming Languages, Software Quality Assurance, Cybersecurity, System Design and Implementation, Query Languages, Databases, Operating Systems, Agile Software Development, Scripting Languages, Computer Science, Web Design and Development, Software Development
Non-Digital Skills	Dance, Funeral and Mortuary Services, Religious Studies and Services, Speech Language Pathology, Injury Treatment, Concrete and Masonry, Power Tools, Hand Tools, Groundskeeping and Yard Care, Metal Fabrication, Carpentry, Welding, Brazing, and Soldering, First Aid, Plumbing, Language Competency, Social Skills, Critical Thinking and Problem Solving, Personal Attributes,

While other subcategories are not initially considered digital, they may still contain skills involving digital competencies. This step identifies a total of 10,926 skills. The search for all digital skills is conducted in two steps. First, all skills labelled as software are considered digital skills. Second, a keyword search based on the following 20 keywords is conducted on the skill descriptions:

> *digital, programming, coding, software, web, computer, spreadsheet, Microsoft, internet, cybersecurity, AI, artificial intelligence, email, machine learning, network, social media, algorithm, big data, information technology*

These steps identify an additional 10,926 digital skills. Given the ambiguity surrounding soft digital skills, this report focuses only on hard digital skills. A manual inspection removes 22 soft skills. Furthermore, an additional 1,209 skills are removed as they are either non-skills, such as hardware names (e.g., Xbox), or non-digital skills mistakenly captured during the keyword search process. Skills mentioned less than the amount of the bottom 1 percentile in the whole database or mentioned only in one year are also removed to avoid inaccuracies (Romanko and O'Mahony, 2022).

To categorise digital skills as advanced, intermediate, or basic, two methods are used in conjunction to achieve the best accuracy. The first method involves categorisation based on skill descriptions using an NLP classification method with a transformer-based deep-learning model, BERT (Bidirectional Encoder Representations), from the Hugging Face library. Using definitions from Table 1, a training dataset is labelled, comprising 6,829 advanced skills, 2,117 intermediate skills, and 431 basic skills. This dataset is used to fine-tune a classification model based on a pre-trained BERT model, achieving an F1-score above 0.9.

However, the skill levels are often ambiguous and context-dependent. Many skills have a wide range of functionalities, usable in either advanced or basic ways depending on job post context. Therefore, a context-based approach is also important. Similar to Romanko and O'Mahony (2022), a *Word2Vec* model is trained using the Gensim library, which translates words into vectors representing their semantic and contextual meanings. A 1000-dimension vector model is chosen for maximum accuracy. Once vectors for all available skills are obtained, a deep learning classification model using Convolutional Neural Networks (CNN) from the Keras library is trained with unambiguous skills, such as AI-related skills or email tasks. The model learns the context surrounding unambiguous advanced, intermediate, or basic skills and then predicts the class for other skills.

Finally, a manual inspection is conducted for skills that do not match each method's classifications.

A1.2 Shortage Indicator Building

To construct the shortage indicator, the methodology of OECD Skills for Jobs Indicators (OECD, 2017; 2022) is followed and adapted for a regional level analysis. Skills for Jobs indicator plots skills mismatches for a panel of OECD countries by industry, occupation, and required skills.

The indicator is constructed in two steps. The first step is to map skill requirements to each occupation at the SOC major group level (1 digit), using Lightcast job post data. For each level of digital skills and each region r, skill frequencies ($SF_{s,j}$), and occupation j is calculated as:

$$SF_{s,j} = \frac{Number\ of\ job\ posts\ requiring\ skill\ s\ in\ occupation\ j}{Number\ of\ job\ posts\ in\ occupation\ j} \quad (1)$$

For the Skill for Jobs indicator, keywords are grouped into 16 broad categories using a semi-supervised machine learning algorithm (OECD, 2022). Here, as described in previous sections, digital skills are identified first and then classified into advanced, intermediate and basic. An additional group, which is non-digital skills, is defined also allowing for comparisons.

To minimise the influence of volatilities across years and ensure that skills are comparable, relative Comparative Advantage (RCA) is used based on skill frequencies. The RCA is calculated as:

$$RCA_{s,j} = \frac{SF_{s,j} / \sum_{s' \neq s} SF_{s',j}}{\sum_{j' \neq j} SF_{s,j'} / \sum_{s' \neq s, j' \neq j} SF_{s',j'}} \quad (2)$$

The denominator refers to the importance of the skill relative to that of the same skill in all other occupations. The numerator refers to the importance of a skill relative to other skills in the same occupation. Finally, this measure is normalised by the maximum RCA, so it is bound between 0 and 1.

In the second step, for each occupation, an occupation shortage indicator is created based on hourly wage growth (w), employment growth (E), the unemployment rate (U), hours worked (H) and underqualification (UQ) obtained from macro-level data and micro-level survey data.

The five variables are obtained from three-year pooled Annual Population Survey (APS) datasets to enable sufficient sample size for each region-occupation combination. The sample period selected covers 2015 to 2022 to ensure that all variables are available in the survey, where the mid-year of each three-year pooled data is selected to represent data in the calendar year. The occupation shortage indicator is calculated at the major occupation level – 1-digit SOC 2010 code. As of changes in SOC 2020, and with no unique one-to-one mapping for occupations defined by SOC 2020 to SOC 2010, we merged Professionals (SOC 2), and Associate Professionals (SOC 3), where most changes in terms of proportion of workforce took place. Other occupation classifications are assumed to have remained the same between SOC 2020 and SOC 2010, given that the changes across major groups only affect a small proportion of the workforce, and thus are unlikely to affect the shortage indicator and hence the analysis.

This occupation shortage index for occupation i in region r is then calculated as:

$$\mathrm{OS}_{rit} = \mathrm{w}(\Delta w_{cit} - \Delta \overline{w}_{ct}) + 0.5\mathrm{w}(\Delta E_{cit} - \Delta \overline{E}_{ct}) + \mathrm{w}(\Delta H_{cit} - \Delta \overline{H}_{ct}) + \mathrm{w}(\Delta U_{cit} - \Delta \overline{U}_{ct}) + \mathrm{w}(\Delta UQ_{cit} - \Delta \overline{UQ}_{ct}) \quad (3)$$

Δw_{cit}, ΔE_{cit}, ΔH_{cit}, ΔU_{cit} and ΔUQ_{cit} are yearly changes in wage, employment, hours worked, unemployment and underqualification. $\Delta \overline{w}_{ct}, \Delta \overline{E}_{ct}, \Delta \overline{H}_{ct}, \Delta \overline{U}_{ct}$ and $\Delta \overline{UQ}_{ct}$ are estimated long-run trends of these five variables using the Hodrick-Prescott method (OECD, 2018). W is the weight of each component which equals 1/4.5[16]. All variables are standardised by their weighted standard deviation to ensure comparability.

Finally, the skill imbalance indicator of skill s in region r, year t is calculated as the:

$$Skill\ imbalance_{cs} = \sum_j (skill\ mapping_{s,j} * occ\ shorage\ index_{c,j} * occ\ employement\ share_j) \quad (4)$$

where the last component is the share of occupation j of total employment in region r.

A1.3: Occupation Digitalisation Index

Specifically, the method accounts for both the importance—measured as the percentage of job posts that require at least one digital skill—and the level—defined

[16] OECD (2018) recognise the choice of weight is entirely arbitrary and subject to researchers' interpretation.

by the percentage of digital skill occurrences among all skills mentioned—of digital skills required within each occupation. Mathematically, the digitalisation index of occupation j is expressed as:

$$Digitalisation_i = Importance_i * level_j \quad (5)$$

In term, the importance of digital skills of occupation i is defined as:

$$Importance_i = \frac{Number\ of\ job\ posts\ require\ at\ least\ one\ digital\ skill_i}{Total\ number\ of\ job\ posts_i} \quad (6)$$

While the level of digital skills of occupation I is defined as:

$$Importance_i = \frac{Occurance\ of\ Digital\ Skills_{si}}{Total\ number\ of\ skills\ occurance} \quad (7)$$

Next, the Digitalisation Index is normalised by dividing it by the maximum value of the digtalness across all SOC 4-digit occupations and then standardised by its rank percentile. This report utilises the 2023 Lightcast data to benefit from the most up-to-date information on the digitalisation of each occupation.

A1.4: The SEIM-UK Labour Model

The SEIM-UK 2.0-model is a macroeconomic input-output (IO) model covering *J* regions (*J* = 12 NUTS 1 regions) and *S* (*S*=30) industries.

The main equation of the IO quantity model of this MRIO system is defined as (s.: Miller and Blair, 2019):

$$\begin{pmatrix} A_{11} & \cdots & A_{1J} \\ \vdots & \ddots & \vdots \\ A_{J1} & \cdots & A_{JJ} \end{pmatrix} \begin{pmatrix} q_1 \\ \cdots \\ q_J \end{pmatrix} + \begin{pmatrix} F_{11} & \cdots & F_{1J} \\ \vdots & \ddots & \vdots \\ F_{J1} & \cdots & F_{JJ} \end{pmatrix} + \begin{pmatrix} ex_1 \\ \cdots \\ ex_J \end{pmatrix} = \begin{pmatrix} q_1 \\ \cdots \\ q_J \end{pmatrix} \quad (8)$$

with A_{jj} as matrices of technical coefficients for the s industries, output vectors q_j of s industries for each region, and F_{jj} as final demand matrices of *f* final demand components (private and public consumption, fixed capital formation, and inventories) for each region. Foreign exports are contained in the export vector ($ex_1 \ldots ex_J$).

The SEIM-UK 2.0-model extends the simple Leontief (type I) model by endogenizing final demand and allowing for substitution between labour (L) and capital (K) as well as productivity growth and mark-up pricing in the price model.

The labour and the capital coefficient are determined by applying a CES cost function with constant returns to scale, the composite price of capital and labour in an industry s in a region j:

$$p_{LK,s,j} = \left(d_{L,s,j} p_{L,s,j}^{1-\sigma_j} + \left(1 - d_{L,s,j}\right) p_{K,s,j}^{1-\sigma_j} \right)^{1/(1-\sigma_j)} \quad (9)$$

The CES function has become the main workhorse in CGE modelling (Burfisher, 2017), as it is more flexible than Cobb-Douglas in the sense that it allows different own price elasticity values than – 1. The factor demand equations in industry s with substitution elasticity (defined identical for industry s across regions j) are:

$$s_{L,LK,s} = d_{L,s} \left(\frac{p_{LK,s}}{p_{L,s}} \right)^{\sigma_j}$$

$$s_{K,LK,s} = \left(1 - d_{L,s}\right) \left(\frac{p_{LK,s}}{p_{K,s}} \right)^{\sigma_j} \quad (10)$$

The nominal factor shares ($d_{L,j}$) are kept constant in the comparative setting of this model. The price of labour p_L is determined in the labour market model and the price of capital p_K via output and import prices of capital goods. The composite input share of LK is determined by subtracting the total intermediate share (driven by an exogenous trend) from the total input share (constant over time). Multiplying this composite input share for LK with the shares for labour and capital determined in equation (9), finally yields the labour and capital input coefficients l = L/Q and b_K = K/Q . The labour input coefficient l is further split up into occupations i by fixed sub-shares for those occupations that are deemed as substitutes with capital and by fixed shares within output for those occupations that are thought of being complements to capital.

Notional labour demand by occupation i in an industry s and region j is then given by the labour (occupation) input coefficient ($\lambda_{i,s}^{j}$) and the output level:

$$L_i^j = \sum_s \lambda_{i,s}^j Q_s^j \tag{11}$$

This notional labour demand is only realized in situations without binding constraints from labour shortages in any occupation and region. The model integrates such binding labour supply constraints in a procedure that implicitly assumes some labour mobility between regions and occupations. The next step of model development from this stage is the integration of a matching model, as laid down in Diodato and Weterings (2015) and in Lankhuizen et al. (2022).

In the current version, labour supply simply represents a potential constraint for labour demand. The regional labour market is then specified at the level of occupations i, with unemployment Ui and labour force LF_i:

$$U_i^j = LF_i^j - L_i^j \tag{12}$$

and unemployment rates *ur* can be defined either only by occupation (national) or region (ur_i , ur^j) or for both dimensions (ur_i^j).

Labour shortages are defined by a minimum national unemployment rate by occupation ur_i* and the actual (national) unemployment rate ur_i cannot fall below this rate. This is a binding constraint at the UK level and labour mobility drives the regional differences between these occupational unemployment rates to a minimum. For case of simplicity, we assume that the base year relationship ($ur_{i,0}^j/ur_{i,0}$) reflects this minimum. Therefore, we define the constraint for employment by:

$$L_i^{j*} = \left[1 - ur_i^* \left(\frac{ur_{i,0}^j}{ur_{i,0}}\right)\right] LF_i^j \tag{13}$$

This gives a restricted function for employment:

$$L_i^j = \sum_s \lambda_{i,s}^j Q_s^j, \text{ when } \left[1 - \left(\frac{L_i^j}{LF_i^j}\right)\right] > ur_i^* \left(\frac{ur_{i,0}^j}{ur_{i,0}}\right)$$

$$L_i^j = L_i^{j*}, \text{ when } \left[1 - \left(\frac{L_i^j}{LF_i^j}\right)\right] < ur_i^* \left(\frac{ur_{i,0}^j}{ur_{i,0}}\right) \tag{14}$$

Regional employment by occupation is then transformed into regional employment by industry by applying the changes in occupational employment by region to occupational employment by region and industry, applying certain proportionality

assumptions. First, a matrix of coefficients of total regional employment by occupation in relation to regional output of sectors ($\frac{L_i^j}{Q_s^j}$) is calculated. This matrix changes in each year with new equilibrium of the model, where a new output vector q and new employment by occupation (according to (14)) are determined. Multiplying this matrix of coefficients $\frac{L_i^j}{Q_s^j}$ element by element with a matrix of sectoral employment structure by regions, i.e. with coefficients $\frac{L_s^j}{L^j}$, where the restriction $\sum_s \frac{L_s^j}{L^j} = 1$ holds for each j, gives a new matrix of labour (occupation) input coefficients ($\lambda_{i,s}^j$). This is how the labour shortages at the occupational dimension are transformed into sectoral labour shortages at the regional level.

In the solution algorithm of the model, notional labour demand adjusts to the supply shortages. For the methodology described above, this adjustment is 'macroeconomic' in the sense that restricted employment (as in equation (14)) leads to lower wage income than with notional labour demand, which in turn translates into lower (consumption) demand and therefore lower output and employment.

A second adjustment mechanism stems from the wage rate that reacts to regional unemployment. This can be implemented via a wage setting schedule that complements this labour market module and specifies the regional wage rate as a function of regional consumer prices and the regional unemployment rate. Industry and occupation dummies would allow to derive wage rates by occupation and region. These wage rates then could feed back to the determination of labour input coefficients (labour demand for given output) as well as wage income and demand (output) in a loop.

Appendix 2: SOC 4-digit level analysis

All major group occupations showed a steep drop in the level of demand for digital skills from 2022 to 2023. This could be due to two reasons. First, there may be a decrease in demand for specific occupations, particularly those requiring high levels of digital skills. Second, it may also indicate a general decrease in the demand for digital skills, although this is less likely.

To understand in more depth, changes in SOC 4-digit occupations are examined in more detail. Table A2 lists five SOC 4-digit occupations that experienced the most significant drop in demand for advanced, intermediate, and basic skills, respectively, along with the changes in the total number of job posts for each occupation.

The occupation that experienced the most significant drop in digital skill demand is Programmers and Software Development Professionals (2134). The total number of job posts for this occupation decreased by 275,550 between 2022 and 2023, reflecting the slowdown in the tech industry, which serves as the primary employer of programmers both in the UK and globally[17]. This corresponds to the number of posts requiring advanced digital skills dropping by 277,118. Given the nearly universal digital skills requirement for this occupation, it is the main driving force behind the sharp drop in digital skill requirements from 2022 to 2023.

Furthermore, other occupations on the list, such as IT business analysts, architects, systems designers, management consultants and business analysts are also digital skills intensive and have also experienced a decline in the number of job posts.

Therefore, the sharp decrease in the proportion of job posts requiring digital skills is more likely due to a drop in demand for certain occupations that have a high demand for digital skills rather than a general drop in demand for digital skills.

Table A2: Top 5 SOC unit group occupations with the largest decrease

Level	Occupations	SOC 4 digits	Changes in Skills Demand	Change in Total Job posts
A	Programmers and software development professionals	2134	-277118	-275550
	IT business analysts, architects and systems designers	2133	-47227	-48991
	Management consultants and business analysts	2431	-36729	-49494
	Project support officers	3543	-26632	-35522
	Database administrators and web content technicians	3133	-25850	-27887

[17] For more detail on this in the press, see: https://www.wsj.com/articles/it-employment-grew-by-just-700-jobs-in-2023-down-from-267-000-in-2022-adbd8a61

Appendix 3: Percentage of job posts requiring digital skills by SOC sub-major group occupations – 2012 to 2023

Table A3: Percentage (%) of job posts requiring digital skills by SOC sub-major occupations group – UK, 2012 to 2023

Panel A: Requiring advanced digital skills

Occupation	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Corporate Managers and Directors (11)	16%	18%	19%	20%	19%	19%	19%	20%	22%	24%	26%	20%
Other Managers and Proprietors (12)	16%	19%	20%	20%	18%	18%	17%	18%	21%	24%	27%	13%
Science, Research, Engineering and Technology Professionals (21)	70%	71%	71%	74%	72%	73%	69%	68%	74%	73%	72%	59%
Health Professionals (22)	12%	10%	11%	7%	7%	7%	7%	6%	7%	9%	11%	9%
Teaching and Educational Professionals (23)	5%	6%	5%	5%	6%	5%	6%	7%	7%	9%	11%	7%
Business, Media and Public Service Professionals (24)	28%	29%	29%	31%	29%	28%	26%	26%	27%	31%	34%	26%
Science and Engineering Associate Professionals (31)	52%	53%	54%	54%	50%	49%	45%	43%	45%	45%	47%	41%
Health and Social Care Associate Professionals (32)	9%	10%	11%	10%	11%	10%	9%	9%	9%	12%	12%	8%
Protective Service Occupations (33)	24%	26%	24%	26%	26%	29%	26%	26%	29%	29%	30%	32%
Culture, Media and Sports Occupations (34)	28%	27%	28%	29%	28%	30%	28%	28%	27%	34%	33%	29%
Business and Public Service Associate Professionals (35)	15%	17%	17%	17%	16%	16%	16%	16%	19%	21%	23%	19%
Administrative Occupations (41)	12%	14%	15%	14%	13%	13%	14%	14%	15%	17%	17%	12%
Secretarial and Related Occupations (42)	10%	11%	11%	10%	10%	10%	10%	11%	12%	13%	13%	10%
Skilled Agricultural and Related Trades (51)	3%	5%	5%	5%	5%	5%	5%	6%	7%	8%	9%	8%
Skilled Metal, Electrical and Electronic Trades (52)	26%	25%	26%	23%	22%	23%	22%	23%	23%	21%	24%	32%
Skilled Construction and Building Trades (53)	9%	5%	5%	4%	4%	5%	5%	5%	6%	6%	9%	8%
Textiles, Printing and Other Skilled Trades (54)	6%	6%	6%	5%	6%	5%	6%	7%	9%	8%	10%	6%
Caring Personal Services (61)	5%	5%	4%	3%	3%	3%	3%	3%	3%	5%	7%	4%
Leisure, Travel and Related Personal Service Occupations (62)	5%	5%	4%	4%	4%	4%	5%	4%	6%	7%	8%	6%
Sales Occupations (71)	11%	11%	11%	12%	11%	11%	10%	11%	14%	14%	15%	5%
Customer Service Occupations (72)	10%	11%	12%	11%	10%	11%	10%	11%	13%	14%	14%	10%
Process, Plant and Machine Operatives (81)	24%	19%	19%	18%	18%	20%	21%	21%	21%	21%	25%	28%
Transport and Mobile Machine Drivers and Operatives (82)	9%	8%	6%	6%	6%	7%	7%	6%	7%	8%	10%	6%
Elementary Trades and Related Occupations (91)	9%	5%	5%	4%	4%	4%	5%	5%	5%	6%	7%	5%
Elementary Administration and Service Occupations (92)	6%	6%	6%	6%	7%	7%	6%	7%	8%	7%	9%	5%

Source: Lightcast Database

Panel B: Requiring intermediate digital skills

Occupation	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Corporate Managers and Directors (11)	16%	17%	19%	18%	18%	19%	18%	19%	22%	23%	22%	15%
Other Managers and Proprietors (12)	9%	11%	12%	12%	11%	10%	9%	10%	14%	14%	15%	8%
Science, Research, Engineering and Technology Professionals (21)	26%	28%	30%	30%	28%	27%	24%	23%	27%	26%	26%	22%
Health Professionals (22)	3%	2%	2%	2%	3%	3%	3%	3%	4%	6%	9%	8%
Teaching and Educational Professionals (23)	3%	3%	3%	3%	3%	3%	3%	3%	5%	4%	4%	3%
Business, Media and Public Service Professionals (24)	19%	20%	20%	20%	20%	20%	18%	18%	21%	22%	22%	17%
Science and Engineering Associate Professionals (31)	29%	31%	33%	32%	29%	28%	25%	23%	27%	26%	25%	24%
Health and Social Care Associate Professionals (32)	4%	5%	5%	5%	5%	5%	5%	6%	7%	7%	7%	5%
Protective Service Occupations (33)	10%	10%	11%	10%	10%	11%	9%	9%	11%	10%	9%	7%
Culture, Media and Sports Occupations (34)	24%	23%	23%	23%	22%	26%	24%	24%	24%	29%	27%	21%
Business and Public Service Associate Professionals (35)	17%	18%	20%	19%	19%	20%	19%	19%	22%	23%	22%	20%
Administrative Occupations (41)	15%	17%	18%	18%	18%	19%	18%	20%	24%	22%	20%	19%
Secretarial and Related Occupations (42)	8%	9%	10%	9%	9%	10%	9%	10%	12%	12%	12%	10%
Skilled Agricultural and Related Trades (51)	2%	2%	2%	2%	2%	2%	3%	3%	4%	4%	4%	5%
Skilled Metal, Electrical and Electronic Trades (52)	7%	6%	7%	6%	6%	6%	5%	5%	7%	6%	6%	9%
Skilled Construction and Building Trades (53)	2%	1%	1%	1%	1%	1%	2%	2%	4%	2%	2%	3%
Textiles, Printing and Other Skilled Trades (54)	3%	3%	4%	3%	3%	3%	3%	4%	5%	4%	4%	4%
Caring Personal Services (61)	2%	2%	2%	1%	1%	1%	1%	1%	3%	2%	3%	2%
Leisure, Travel and Related Personal Service Occupations (62)	3%	4%	4%	4%	3%	4%	3%	4%	4%	3%	4%	4%
Sales Occupations (71)	19%	18%	18%	18%	17%	18%	16%	15%	18%	17%	15%	8%
Customer Service Occupations (72)	15%	16%	17%	17%	16%	17%	16%	15%	19%	18%	16%	15%
Process, Plant and Machine Operatives (81)	5%	4%	6%	5%	6%	5%	5%	5%	8%	7%	7%	10%
Transport and Mobile Machine Drivers and Operatives (82)	2%	2%	2%	2%	2%	2%	2%	1%	2%	2%	2%	2%
Elementary Trades and Related Occupations (91)	2%	2%	2%	1%	1%	1%	1%	2%	4%	2%	2%	2%
Elementary Administration and Service Occupations (92)	3%	3%	4%	4%	4%	4%	4%	4%	7%	4%	4%	2%

Source: Lightcast Database

Panel C: Requiring basic digital skills

Occupation	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Corporate Managers and Directors (11)	9%	10%	12%	12%	12%	12%	12%	13%	14%	15%	14%	11%
Other Managers and Proprietors (12)	8%	9%	10%	10%	10%	10%	9%	11%	12%	12%	12%	8%
Science, Research, Engineering and Technology Professionals (21)	14%	15%	16%	14%	13%	13%	12%	13%	14%	13%	12%	12%
Health Professionals (22)	3%	2%	3%	3%	4%	3%	3%	4%	4%	5%	6%	5%
Teaching and Educational Professionals (23)	3%	3%	3%	4%	3%	3%	3%	4%	4%	6%	5%	3%
Business, Media and Public Service Professionals (24)	11%	12%	12%	12%	12%	12%	12%	12%	13%	15%	14%	12%
Science and Engineering Associate Professionals (31)	19%	20%	23%	22%	21%	21%	19%	19%	20%	21%	19%	20%
Health and Social Care Associate Professionals (32)	7%	7%	7%	7%	8%	7%	7%	8%	9%	10%	9%	8%
Protective Service Occupations (33)	11%	11%	13%	13%	13%	14%	12%	15%	18%	15%	13%	12%
Culture, Media and Sports Occupations (34)	10%	13%	12%	10%	11%	13%	12%	13%	13%	19%	16%	13%
Business and Public Service Associate Professionals (35)	12%	14%	17%	16%	16%	17%	17%	21%	18%	21%	19%	17%
Administrative Occupations (41)	24%	26%	30%	28%	29%	28%	27%	28%	29%	32%	28%	26%
Secretarial and Related Occupations (42)	36%	39%	43%	41%	40%	40%	38%	37%	37%	39%	31%	34%
Skilled Agricultural and Related Trades (51)	2%	3%	3%	6%	10%	3%	3%	4%	5%	6%	5%	5%
Skilled Metal, Electrical and Electronic Trades (52)	7%	7%	8%	7%	7%	7%	7%	7%	7%	7%	7%	7%
Skilled Construction and Building Trades (53)	2%	1%	2%	2%	3%	2%	2%	3%	3%	3%	3%	4%
Textiles, Printing and Other Skilled Trades (54)	3%	4%	5%	5%	6%	4%	4%	4%	4%	5%	4%	3%
Caring Personal Services (61)	4%	3%	3%	5%	6%	5%	6%	5%	4%	5%	4%	4%
Leisure, Travel and Related Personal Service Occupations (62)	3%	4%	4%	6%	8%	5%	5%	5%	6%	7%	6%	7%
Sales Occupations (71)	9%	10%	11%	12%	12%	12%	11%	12%	13%	15%	12%	8%
Customer Service Occupations (72)	15%	16%	18%	17%	16%	18%	17%	17%	20%	24%	18%	18%
Process, Plant and Machine Operatives (81)	6%	5%	6%	6%	7%	6%	6%	7%	7%	8%	8%	9%
Transport and Mobile Machine Drivers and Operatives (82)	2%	2%	2%	3%	3%	2%	2%	3%	3%	5%	5%	5%
Elementary Trades and Related Occupations (91)	3%	2%	2%	2%	4%	2%	2%	2%	3%	4%	3%	3%
Elementary Administration and Service Occupations (92)	8%	8%	10%	11%	13%	11%	9%	9%	9%	11%	9%	5%

Source: Lightcast Database

Appendix 4: Top 10 skills with the largest increase/decrease by skill levels (2012 to 2023)

Table A4: Top 10 skills with largest increase by category (2012-2023)

Skill Level	Skill Name	Number Job post in 2012	Number Job post in 2023	Change in numbers	Change in Percentage (%)
Advanced	Microsoft Azure	2093	87748	85655	4092%
	Information Privacy	22730	106883	84153	370%
	Agile Methodology	103180	167990	64810	63%
	Python	21942	84260	62318	284%
	Amazon Web Services	2723	62842	60119	2208%
	Automation	43140	97844	54704	127%
	DevOps	2148	49876	47728	2222%
	Cyber Security	966	39697	38731	4009%
	React.js	1332	33231	31899	2395%
	Application Programming Interface (API)	16794	48488	31694	189%
Intermediate	Power BI	0	44659	44659	-
	Xero	139	27981	27842	20030%
	Content Creation	3901	30480	26579	681%
	Digital Marketing	24250	49513	25263	104%
	Salesforce	9950	34173	24223	243%
	Data Management	18952	39273	20321	107%
	Accounting Software	7735	27684	19949	258%
	Data Collection	5538	21304	15766	285%
	Payroll Systems	4880	20337	15457	317%
	Tableau	494	15430	14936	3023%
Basic	Microsoft Excel	144873	316025	171152	118%
	Microsoft Office	108135	269099	160964	149%
	Microsoft Outlook	67083	174003	106920	159%
	Computer Literacy	121520	183308	61788	51%
	Microsoft PowerPoint	65061	123356	58295	90%
	Microsoft Teams	304	42358	42054	13834%
	Data Entry	38846	78414	39568	102%
	Social Media	19321	56080	36759	190%
	Microsoft Office 365	883	35985	35102	3975%
	Spreadsheets	26556	52542	25986	98%

Source: Lightcast Database

Table A5: Top 10 skills with largest decrease by category (2012-2023)

Skill Level	Skill Name	Number Job post in 2012	Number Job post in 2023	Change in numbers	Change in Percentage (%)
Advanced	SQL	200502	96240	-104262	-52%
	C#	154089	50671	-103418	-67%
	JavaScript	140160	62143	-78017	-56%
	HyperText Markup Language (HTML)	102508	28912	-73596	-72%
	Cascading Style Sheets (CSS)	98253	28618	-69635	-71%
	ASP.NET	73898	5610	-68288	-92%
	Java	104090	43631	-60459	-58%
	PHP	65091	15140	-49951	-77%
	Microsoft SQL Servers	61740	12156	-49584	-80%
	Active Server Pages (ASP)	46276	1910	-44366	-96%
Intermediate	Firefox	51738	182	-51556	-100%
	Microsoft Internet Explorer	49501	92	-49409	-100%
	Safari (Web Browser)	49368	511	-48857	-99%
	Web Browsers	21388	1532	-19856	-93%

	Microsoft Windows 7	19199	2188	-17011	-89%
	Microsoft Windows XP	14709	188	-14521	-99%
	Microsoft Windows	12992	8268	-4724	-36%
	Microsoft SharePoint	36294	33373	-2921	-8%
	Microsoft Visio	10543	7799	-2744	-26%
	Web Navigation	2802	687	-2115	-75%
Basic	Digital Publishing	30460	1361	-29099	-96%
	SQL Server Reporting Services	20343	5904	-14439	-71%
	SQL Server Integration Services (SSIS)	19897	5972	-13925	-70%
	Online Marketing	17637	3907	-13730	-78%
	Microsoft Exchange Servers	14221	1825	-12396	-87%
	Information Technology Infrastructure Library	37839	26210	-11629	-31%
	Adobe Photoshop	31142	22126	-9016	-29%
	Oracle Databases	10980	2076	-8904	-81%
	SQL Server Analysis Services	11042	2633	-8409	-76%
	Microsoft Access	21988	14017	-7971	-36%

Source: Lightcast Database