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Emerging Trends in AI Skill Demand Across 14 OECD Countries

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This report analyses the demand for positions that require skills needed to develop or work with AI systems across 14 OECD countries between 2019 and 2022. It finds that, despite rapid growth in the demand for AI skills, AI-related online vacancies comprised less than 1% of all job postings and were predominantly found in sectors such as ICT and Professional Services. Skills related to Machine Learning were the most sought after. The US-focused part of the study reveals a consistent demand for socio-emotional, foundational, and technical skills across all AI employers. However, leading firms – those who posted the most AI jobs – exhibited a higher demand for AI professionals combining technical expertise with leadership, innovation, and problem-solving skills, underscoring the importance of these competencies in the AI field.

Keywords: Artificial Intelligence, Online vacancies, Skills.

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Résumé

Ce rapport analyse la demande d'emplois nécessitant des compétences pour développer ou travailler avec des systèmes d'IA dans 14 pays de l'OCDE entre 2019 et 2022. Il constate que, malgré la croissance rapide de la demande de compétences en IA, les offres d'emploi en ligne liées à l'IA représentaient moins de 1 % de l'ensemble des offres d'emploi et se trouvaient principalement dans des secteurs tels que les TIC et les services professionnels. Les compétences liées à l'apprentissage automatique (Machine Learning) sont les plus recherchées. La partie de l'étude consacrée aux États-Unis révèle une demande constante de compétences socio-émotionnelles, fondamentales et techniques de la part de tous les employeurs du secteur de l'IA. Toutefois, les entreprises leaders - celles qui affichent le plus grand nombre d'offres d'emploi dans le domaine de l'IA - affichent une demande plus importante de professionnels de l'IA combinant expertise technique et compétences en matière de leadership, d'innovation et de résolution de problèmes, ce qui souligne l'importance de ces compétences dans le domaine de l'IA.

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Executive summary

Artificial intelligence (AI) is rapidly reshaping economies and societies. It is more and more pervasive among products and services used every day by consumers, and may help tackle societal challenges, such as climate change or access to medical care, while bringing challenges for governments and citizens alike. Despite the transformative power of AI to improve efficiency and innovative capacity, when left unchecked, it gives rise to concerns that underscore the importance of placing the human element at the forefront in driving these advancements.

This work focuses on the human behind AI by exploring recent patterns in the demand for AI-related skills across countries and leverages comprehensive information from online job postings provided by Lightcast[1] for the period 2019-22. These data are available for 14 OECD countries, and combine information available for selected English-speaking (Australia, Canada, New Zealand, the United States, the United Kingdom) and European (Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland) countries.

Job postings that require AI skills are identified using a novel methodology based on the presence of both generic and specific AI keywords mentioned in online vacancies. The demand for positions that require AI skills is then characterised across several dimensions, focusing on its evolution over time across countries and industries, its heterogeneity across occupations, and the types of AI skills demanded by different employers.

First, results indicate that AI-related online vacancies represent a small share of all vacancies posted online in the 14 countries analysed. Indeed, in 2022 the share of AI-related online vacancies was highest in the United States where AI-related vacancies represented 0.84% of all vacancies. The share of AI-related vacancies never exceeded 1% in any of the countries and years under analysis.

Second, in most countries the share of AI-related online vacancies grew markedly between 2019 and 2022. Over this period, on average across countries, the share of online vacancies requiring AI skills increased by 33%. Such growth was generally stronger in countries with lower shares in 2019. Only in Austria and Sweden, the share of online vacancies requiring AI skills did not grow over the period.

Third, the demand for AI-related jobs is highly concentrated, both in terms of industries and occupations. Most job postings requiring AI skills are for positions referring to ICT and Professional Services. At the same time, the analysis reveals some cross-country heterogeneity, possibly reflecting differences in the sectoral composition of labour markets. Concerning occupations, on average across European countries considered in the analysis around 73% of online vacancies requiring AI skills aim at hiring Professionals, 9% look for Managers, and 8% for Technicians and Associate Professionals. On average across English-speaking countries, for which a more detailed occupational classification is available, around 44% of AI job postings relate to jobs in Information Technology, 23% to Planning and Analysis, and 7% to Engineering.

Fourth, some skills – notably those related to Machine Learning – appear particularly pervasive among AI-related online vacancies. Indeed, across all countries, between 29% (in France) and 39% (in the United States) of all AI job postings require skills related to Machine Learning. Skills related to Autonomous Driving

and Robotics appear on average less in demand, possibly reflecting their more industry-specific nature, and also exhibit a high degree of cross-country variation.

A final set of analyses zooms in on the United States, the country in which the demand for AI-related jobs has been comparatively highest over the period considered. These distinguish top AI employers, defined as the ten US employers posting the highest shares of AI-related jobs online *within* or *across* industries in 2022, and identify differences in the AI skill profiles such companies look for relative to other AI employers in the United States.

AI job postings by top ten AI employers are high *within* Information, Professional Services, Finance and Insurance, and Manufacturing industries, reflecting the overall cross-sectoral distribution of AI vacancies. Interestingly, AI vacancies appear more concentrated among top AI employers in Retail Trade or Agriculture. Top ten AI employers *across* all US industries operate instead in Retail Trade, Finance and Insurance, Professional Services, and Manufacturing.

In the realm of AI vacancies, top AI employers mainly look for Software Developers and Data Analysts or Mathematicians, similarly to other AI employers, and for Network Engineers, even more than other AI employers in the United States. Although top AI employers are increasingly demanding skills related to Amazon Web Services, Big Data or Business Intelligence, their demand for technical skills does not differ substantially from that of other AI employers. Differences are more considerable when focusing on socio-emotional and foundational skills: overall top AI employers tend to more frequently demand Leadership and Management, as well as Innovation and Problem-Solving skills. This may reflect the importance these companies place on their AI employees having a broad skill mix and is corroborated when zooming in on the skill profiles these firms expect from their AI managers.

This analysis is complementary to other OECD work focusing on the diffusion of AI across firms, and its role for productivity, innovation, and labour markets. The findings are particularly relevant in the context of “building human capacity and preparing for labour market transformation”, one of the key OECD recommendations consistent with the OECD AI principles. Indeed, exploring the human element behind advances in AI may help design interventions aimed at fostering the diffusion of AI across the economy, especially among employers and industries that have not yet fully benefited from its potential, ensuring an inclusive human-centric digital transformation in the age of AI.

Synthèse

L'intelligence artificielle (IA) remodèle rapidement les économies et les sociétés. Elle est de plus en plus répandue dans les produits et services utilisés quotidiennement par les consommateurs et peut contribuer à relever des défis sociétaux, tels que le changement climatique ou l'accès aux soins médicaux, tout en entraînant des difficultés pour les gouvernements et les citoyens. Malgré son pouvoir de transformation pour améliorer l'efficacité et la capacité d'innovation, l'intelligence artificielle, si elle n'est pas contrôlée, suscite des inquiétudes qui soulignent l'importance de placer l'élément humain au premier plan dans la conduite de ces progrès.

Ce travail se concentre sur l'humain derrière l'IA en explorant les tendances récentes de la demande de compétences liées à l'IA dans les différents pays et exploite des informations complètes sur les offres d'emploi en ligne fournies par Lightcast[1] pour la période 2019-22. Ces données sont disponibles pour 14 pays de l'OCDE et combinent les informations disponibles pour certains pays anglophones (Australie, Canada, Nouvelle-Zélande, États-Unis, Royaume-Uni) et européens (Autriche, Belgique, France, Allemagne, Italie, Pays-Bas, Espagne, Suède, Suisse).

Les offres d'emploi qui requièrent des compétences en IA sont identifiées à l'aide d'une nouvelle méthodologie basée sur la présence de mots-clés génériques et spécifiques à l'IA mentionnés dans les offres d'emploi en ligne. La demande de postes nécessitant des compétences en IA est ensuite caractérisée à travers plusieurs dimensions, en se concentrant sur son évolution dans le temps à travers les pays et les industries, son hétérogénéité à travers les professions, et les types de compétences en IA requises par les différents employeurs.

Tout d'abord, les résultats indiquent que les offres d'emploi en ligne liées à l'IA représentent une faible part de l'ensemble des offres d'emploi publiées en ligne dans les 14 pays analysés. En effet, en 2022, la part des offres d'emploi en ligne liées à l'IA était la plus élevée aux États-Unis, où les offres d'emploi liées à l'IA représentaient 0,84 % de l'ensemble des offres d'emploi. La part des offres d'emploi liées à l'IA n'a jamais dépassé 1 % dans aucun des pays et aucune des années analysés.

Deuxièmement, dans la plupart des pays, la part des offres d'emploi en ligne liées à l'IA a considérablement augmenté entre 2019 et 2022. Au cours de cette période, en moyenne dans tous les pays, la part des offres d'emploi en ligne nécessitant des compétences en IA a augmenté de 33 %. Cette croissance a généralement été plus forte dans les pays dont la part était plus faible en 2019. Il n'y a qu'en Autriche et en Suède que la part des offres d'emploi en ligne nécessitant des compétences en IA n'a pas augmenté au cours de la période.

Troisièmement, la demande d'emplois liés à l'IA est très concentrée, à la fois en termes de secteurs et de professions. La plupart des offres d'emploi nécessitant des compétences en IA concernent des postes liés aux TIC et aux services professionnels. Dans le même temps, l'analyse révèle une certaine hétérogénéité entre les pays, reflétant peut-être des différences dans la composition sectorielle des marchés du travail. En ce qui concerne les professions, en moyenne, dans les pays européens considérés dans l'analyse, environ 73 % des offres d'emploi en ligne exigeant des compétences en IA visent à recruter des professionnels, 9 % des cadres et 8 % des techniciens et des professionnels associés. En moyenne, dans

les pays anglophones, pour lesquels une classification des professions plus détaillée est disponible, environ 44 % des offres d'emploi en IA concernent des postes dans les technologies de l'information, 23 % dans la planification et l'analyse, et 7 % dans l'ingénierie.

Quatrièmement, certaines compétences - notamment celles liées à l'apprentissage automatique (Machine Learning) - semblent particulièrement répandues parmi les offres d'emploi en ligne liées à l'IA. En effet, dans tous les pays, entre 29 % (en France) et 39 % (aux États-Unis) de toutes les offres d'emploi dans le domaine de l'IA requièrent des compétences liées à l'apprentissage automatique. Les compétences liées à la conduite autonome et à la robotique semblent en moyenne moins demandées, ce qui reflète peut-être leur nature plus spécifique à l'industrie, et présentent également un degré élevé de variation d'un pays à l'autre.

Une dernière série d'analyses se concentre sur les États-Unis, pays dans lequel la demande d'emplois liés à l'IA a été comparativement la plus forte au cours de la période considérée. Ces analyses distinguent les principaux employeurs dans le domaine de l'IA, c'est-à-dire les dix employeurs américains qui affichent en ligne le plus grand nombre d'offres d'emploi liées à l'IA au sein d'un même secteur ou dans l'ensemble des secteurs en 2022, et identifient les différences dans les profils de compétences en IA recherchés par ces entreprises par rapport aux autres employeurs dans le domaine de l'IA aux États-Unis.

Les offres d'emploi en IA des dix premiers employeurs en IA sont nombreuses dans les secteurs de l'information, des services professionnels, de la finance et de l'assurance, et de l'industrie manufacturière, ce qui reflète la répartition intersectorielle globale des postes vacants dans le domaine de l'IA. Il est intéressant de noter que les postes vacants dans le domaine de l'intelligence artificielle semblent plus concentrés chez les principaux employeurs du secteur du commerce de détail ou de l'agriculture. Les dix premiers employeurs en matière d'intelligence artificielle, tous secteurs confondus, se situent plutôt dans le commerce de détail, la finance et l'assurance, les services professionnels et l'industrie manufacturière.

En ce qui concerne les postes vacants dans le domaine de l'IA, les principaux employeurs de l'IA recherchent principalement des développeurs de logiciels et des analystes de données ou des mathématiciens, comme les autres employeurs de l'IA, et des ingénieurs réseau, plus encore que les autres employeurs de l'IA aux États-Unis. Bien que les grands employeurs de l'IA exigent de plus en plus de compétences liées à Amazon Web Services, au Big Data ou à la Business Intelligence, leur demande de compétences techniques ne diffère pas sensiblement de celle des autres employeurs de l'IA. Les différences sont plus substantielles lorsqu'on se concentre sur les compétences socio-émotionnelles et fondamentales : dans l'ensemble, les principaux employeurs en IA ont tendance à demander plus fréquemment des compétences en leadership et en gestion, ainsi qu'en innovation et en résolution de problèmes. Cela peut refléter l'importance que ces entreprises accordent à ce que leurs employés en IA aient un large éventail de compétences, ce qui est corroboré lorsqu'on se penche sur les profils de compétences que ces entreprises attendent de leurs managers en IA.

Cette analyse complète d'autres travaux de l'OCDE portant sur la diffusion de l'IA dans les entreprises et sur son rôle pour la productivité, l'innovation et les marchés du travail. Les résultats sont particulièrement pertinents dans le contexte du "renforcement des capacités humaines et de la préparation à la transformation du marché du travail", l'une des principales recommandations de l'OCDE conformes aux principes de l'OCDE en matière d'IA. En effet, l'exploration de l'élément humain derrière les progrès de l'IA peut aider à concevoir des interventions visant à favoriser la diffusion de l'IA dans l'économie, en particulier parmi les employeurs et les industries qui n'ont pas encore pleinement bénéficié de son potentiel, garantissant ainsi une transformation numérique inclusive centrée sur l'humain à l'ère de l'IA.

1 Introduction

Many of today's political and social tensions arising in response to the automation of tasks previously carried out by humans in labour markets revolve around questions of whether digital technologies substitute or complement workers, give rise to better or worse labour market conditions, and ultimately are associated with an increase or a decrease in labour market opportunities. In addition to the direct implications that AI and digital technologies have on productivity and growth, the key to answering these questions is to better understand what tasks technologies are able to accomplish and what skills humans need to make the most of technological change (Violante, 2008[1]). Overall, the empirical evidence to date, suggests that past waves of technological developments did not lead to overall lower employment opportunities and net job destruction in the long run (OECD, 2019[2]; 2023[3]; Calligaris et al., 2023[4]). In fact, over the 20th century the employment-to-population ratio rose, and the unemployment rate did not change over the long run (Autor, 2015[4]).

As a result of past waves of technological progress, today's workplaces demand people who can solve non-routine problems alongside technology (Autor, Levy and Murnane, 2003[5]; Ikenaga and Kambayashi, 2016[6]; Spitz-Oener, 2006[7]). It is possible that the advent of AI systems will radically change the demand for skills in the future as non-routine tasks are within the scope of what machines can perform reliably (Georgieff and Hyee, 2021[8]). Contrary to previous technological advances, AI is a general-purpose technology that has the potential and capacity to transform economies and societies by interpreting, analysing, and learning from data (Brynjolfsson, Rock and Syverson, 2017[9]). On the one hand, technology may obviate the need for humans to perform certain tasks. On the other hand, technologies may complement humans, requiring workers to learn to work effectively with new technologies (Arntz, Gregory and Zierahn, 2016[10]; Georgieff and Hyee, 2021[8]) as some tasks, but not all, will be affected by automation (Bessen, 2016[11]).

Although the employment implications of technological innovations are often considered through the lens of a human vs. machine dichotomy, there is no such dichotomy because until general AI is developed, AI remains 'artificial'. Behind the pretence of an intelligent automata lies the intelligence and work of human beings. Even large language models at the basis of now widely known AI systems such as ChatGPT© were developed by humans and become useful only when they are put to use by humans to solve the questions and challenges humans face. However, ChatGPT© and other forms of AI systems, rely on the work and skills of individuals to be developed and maintained to be of practical use in economic systems and processes.

The aim of this work is to identify and analyse the skills required of those individuals who develop and work with AI, as well as the occupations and industries they work in. Given the nature of modern economies, these individuals are responsible for how complex economic systems collect, store, and use data to make predictions ranging from cancer detection (Bi et al., 2019[12]) to providing instantaneous translation between different languages (Borgonovi, Hervé and Seitz, 2023[13]).

The literature examining the size of the AI workforce and the characteristics of individuals engaged in the development and use of AI systems primarily relies on evidence emerging from vacancies posted on line by prospective employers. This is because existing taxonomies in the context of official statistics on employment do not have dedicated categories to capture individuals working on and with AI.

Although estimates of the number of people engaged in developing and working with AI tools and systems vary (see Box 2.2 for estimates of AI workforce shares in the US), they all suggest that few individuals worldwide are involved in the development and professional use of AI technologies. However, considering the evolution of the demand for AI professionals, what skills they are required to possess, and how such demand differs depending on occupation, industry, and the characteristics of employers is crucial since AI plays a key role in the use of information and decision-making in modern economies and societies.

Exploring the existing heterogeneity in skills demanded by different types of employers appears particularly relevant. Recent evidence has indeed documented increasing productivity gaps between the best-performing firms and the rest of the business population (Andrews, Criscuolo and Gal, 2016[14]), reflecting a slowdown in technology diffusion. Skills are key for such a diffusion process, especially in the current stages of digital transformation. Recent OECD work has explored the characteristics of firms adopting AI (Calvino et al., 2022[15]; Dernis et al., 2023[16]) and the links between AI use and productivity (Calvino and Fontanelli, 2023[17]), highlighting not only significant heterogeneity by firm size, age, and industry, but also and relevantly a key role of complementary assets – notably including skills – both for AI adoption and for the productivity advantages of AI users. In this context, understanding which sets of skills different types of AI employers demand may also contribute to help better understand some of the sources of existing differences between firms, and informs policies aimed at fostering an inclusive digital transformation.

Previous efforts to map the demand for workers that work with or could advance the development of AI systems focused on English-speaking countries and exploited different algorithms as well as AI-related keywords to identify AI-related skills and jobs in online job postings data (Alekseeva et al., 2020[18]; 2021[19]; Babina et al., 2020[20]; Samek, Squicciarini and Cammeraat, 2021[21]; Squicciarini and Nachtigall, 2021[22]; Manca, 2023[23]). More recently, Green and Lamby (2023[24]) widened the scope, providing estimates of the size and characteristics of the AI workforce across OECD countries. By calculating the share of vacancies requiring AI skills within occupations in the United States, they build an occupation-based measure for AI intensity. This is then weighted based on the distribution of occupations in labour force surveys across countries and results indicate that the AI workforce represents just over 0.3% of employment in 2019.

This paper builds on and significantly extends this strand of work by examining the evolution in the demand for professionals who work with or can advance the development of AI systems and tools between 2019 and 2022 directly using, for the first time, big data from 14 English and non-English-speaking OECD countries, namely Australia, Austria, Belgium, Canada, France, Germany, Italy, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

By analysing the text of vacancies posted online by employers, this work characterises for each country and year, the number of positions for workers who would be required to use skills crucial to the development and use of AI in their role. As further discussed in the next section, the approach used to identify AI-related job postings builds upon the existing literature using AI-related keywords and attempts to maximise comparability across the aforementioned English and non-English-speaking countries.

This work explores the characteristics of positions that require AI skills, analysing their heterogeneity across countries, industries, occupations, and skill clusters. The analysis then zooms in on the country with the highest share of AI-related online vacancies, the United States, and focuses on online vacancies requiring AI-related skills among the top AI employers, defined as the ten US employers posting the highest shares of online vacancies requiring AI-related skills *within* each industry in 2022. In a follow-up exercise, top AI employers are also defined as the ten US employers posting the highest shares of AI-related online vacancies *across* all industries. The analyses identify differences in the profile of AI vacancies that top AI employers advertise relative to the profiles advertised by other AI employers in the United States.

While focusing on the demand for AI-related skills, this work is also broadly related to the wider micro-economic literature that analyses patterns of AI diffusion and its implications for economic outcomes. Existing contributions rely on different data sources, including data from Intellectual Property Rights (such

as patents and trademarks), information available on websites, official firm-level surveys, commercial or smaller-scale surveys, and import information (see for instance Calvino et al. (2022[15]) or Maslej et al., (2023[25]) for additional discussion).

The rest of the paper is organised as follows. Section two describes the data used in the analysis and the methodology employed to identify online vacancies requiring AI-related skills. Section three illustrates the demand for professionals possessing AI-related skills in different countries, industries, and occupations and considers the evolution of such demand between 2019 and 2022. Section four focuses on the top AI employers in the United States. Section five presents conclusions and directions for further policy-relevant analyses.

2 Data and methodology

2.1. Lightcast data

The use of official labour market statistics to capture small but rapidly evolving economic activities is challenging. In particular, the questionnaires employed in survey data often evolve slowly which can prevent picking up rapidly emerging trends. Furthermore, samples collected in employment surveys are often inadequate to reflect relevant information on small but rapidly evolving economic activities. For these reasons, data from online marketplaces, such as online job vacancies, are increasingly used to map trends in the demand of workers in fields such as AI and their skills.

Analyses in this paper were conducted using information from online job vacancies provided by Lightcast. Lightcast collects postings from over 51,000 online job sites to develop a comprehensive, real-time portrait of online labour market demand currently available for 28 countries. Besides information on company names, occupation, industry information, salary, geographical information, qualifications, and full or part-time employment, the data provide a list of skills which are required by employers at the job posting level.

The following analyses are based on 14 OECD countries, including selected English-speaking (Australia, Canada, New Zealand, the United States, the United Kingdom) and European countries (Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland). Both sets of countries stem from different databases (henceforth “English-speaking” and “European countries” databases). Differences between the databases exist for example in the data structure or the type of taxonomies used for classifying industries, occupations or skills (for more details see Annex A). The databases cover the time span between January 1st 2019 and (including) October 31st 2022.

Depending on the database and type of taxonomy used, Lightcast’s online vacancy information provides more than 32,000 different unique skills. To meaningfully analyse skills information, skills are grouped and, in the analysis, AI skills are assigned to one of seven skill clusters. The English-speaking and European countries databases rely on different skill taxonomies. Further details about data collection, identification of job postings, representativeness, and differences between the English-speaking and European countries’ skill taxonomies are discussed in Box 2.1.

Box 2.1. From job postings to online vacancy data

Scraping

Lightcast collects data from a comprehensive set of online sources. Lightcast identifies websites with employment opportunity related content utilising spider technology to search those sites for employment opportunities. Currently, Lightcast maintains two kinds of spiders, which: 1) continually monitor or scout websites to identify those that include employment opportunities; and 2) continually spider and extract employment opportunity related information from a master list of websites. The use of "scout" spiders enables Lightcast to recognise new sites and queue them for addition to the master list. This sophisticated, two-step process enables Lightcast to retrieve job listings from a much broader range of sources, including job boards, government agencies, educational institutions, and thousands of employers of all sizes, locations, and industries.

Deduplication

Lightcast deduplicates job postings to ensure that the dataset does not contain the same posting multiple times. The deduplication process uses a machine learning algorithm to determine whether two job postings are duplicates. Two postings that are duplicates usually are not exactly identical. The deduplication process uses a statistical classifier that has been trained to detect duplicates by comparing a number of fields in the postings, including location, job title, similarity of posting text, contact information in the posting, and company name.

Representativeness

Despite the strength of the data in their wealth of information (firm-level information and skill and educational prerequisites) and granularity at the same time, not all vacancies are posted on line, potentially limiting the representativeness of online vacancy information (OECD, 2022[26]; OECD, 2022[27]). Several studies assessed the representativeness of online vacancies by comparing information contained in such vacancies with information extracted from official employment data. Evaluating the representatives of online vacancy information in the United States yields that online vacancy information and vacancy microdata from the Bureau of Labor Statistics' Job Openings and Labor Market Turnover (JOLTS) have a high overlap, follow a similar trend over time and mirror the industry distribution reasonably well (Carnevale, Jayasundera and Repnikov, 2014[28]; Hershbein and Kahn, 2018[29]; Azar et al., 2020[30]). However, even though small in magnitude, some differences remain, highlighting over- and under-representation of online vacancy data in specific industries (Hershbein and Kahn, 2018[29]) and under-representation of, for example, low-skilled jobs (Cammeraat and Squicciarini, 2021[31]; Hershbein and Kahn, 2018[29]). In addition to these representativeness analyses provided in the literature, Lightcast conducted representativeness analyses for Australia, Canada, New Zealand, the United Kingdom, and the United States (analyses are available upon request). As part of the analyses, Lightcast compares job postings to official government sources and analyses data representativeness with regard to time, industry and occupation. Overall, job vacancies are captured by Lightcast reasonably well. With respect to the labour market in the United States, for example, Lightcast captures 98.9% of monthly jobs captured by the JOLTS program. Overall, analyses by industry show, for example, that Lightcast data is comparatively less representative in areas such as construction where word of mouth, offline postings, or perpetually open positions play a large role in recruitment. However, as representativeness of data varies across countries, cross-country comparisons should be made with caution.

Skill Taxonomies

The "English-speaking" and "European countries" database are based on different skill taxonomies. While the English-speaking database relies on Lightcast taxonomy for Occupations, Occupation Groups, and Skills, the European countries database relies on the European Skills, Competences, Qualifications and Occupations (ESCO) taxonomy. The Lightcast Skills taxonomy includes over 32,000 unique skills. They include competencies, knowledge, and specific software. Each skill is classified as a technical skill, a human skill, or a certification. The taxonomy is built based on Lightcast job posting data and includes a three-tiered hierarchy of Skills, Skill Subcategories, and Skills/Certifications. In contrast, the ESCO Skills taxonomy covers 13,890 unique skills, competences, and knowledge.

2.2. Identifying AI-related job postings

This paper examines vacancies posted on line for jobs requiring prospective applicants to possess AI-related skills. Postings are classified as being AI-related whenever the text of the posting contained a list of pre-identified AI keywords. This keyword list was originally developed in English and validated using previous OECD work (Baruffaldi et al., 2020[32]), and was extended based on additional skills extracted from online vacancies of English-speaking countries. The complete list can be found in Annex Table A C.1. For the non-English-speaking countries, keywords that are also commonly used in local languages were first translated from English into the respective language of interest and then the two language versions were used to classify postings as being AI-related. [2]

Each AI keyword was classified into a generic or specific skill by labour market experts who study AI skills. Generic skills include AI-related skills that may also be common in roles that do not primarily deal with the development or maintenance of AI systems. These include, for instance, 'machine learning', 'artificial intelligence', 'computer vision' and 'machine translation'. Specific skills encompass instead AI skills that are likely to relate to specific applications, methods, or tools used by workers in AI-related roles, such as 'gradient boosting', 'natural language processing', 'convolutional neural networks', and 'deep learning'. A job posting is considered to be an AI-related job posting if it contains at least two generic or one specific skill.

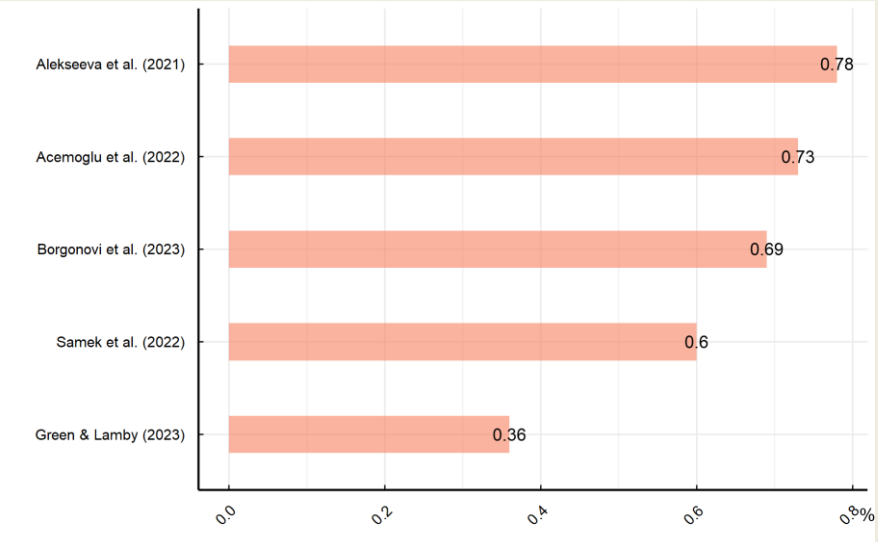
Also considering the broader scope of analysis, this approach is more conservative with respect to the part of the existing literature that focuses on English-speaking countries. When extending the scope of analysis beyond English-speaking countries, requiring at least two generic (AI) skills helps improve cross-country comparability, given possible cross-linguistic differences and changes in their use over time. While generic skills may be present for longer, specific ones are instead more likely to have appeared in the latest years across most countries. In fact, being more related to specific AI applications or methods, they are also likely to exhibit less country specificities. When focusing on the United States, a country for which multiple analyses identifying AI-related jobs based on online job postings are available, this approach provides estimates that are qualitatively in line with existing evidence, to some extent closer to the lower bound (an overview can be found in Box 2.2).[3]

Box 2.2. Comparison of estimates for AI workforce shares using different methodologies

Different methodological approaches, relying on online job postings from Lightcast, have been adopted to identify AI jobs. Most commonly, empirical strategies leverage lists of AI-related keywords to categorise those into AI-related skills and hence classify AI job postings. While Aleekseva et al. (2021[19]) and Acemoglu et al. (2022[33]) identify AI jobs when at least one such skill from their respective keyword list is evident in the posting, Samek et al. (2021[21]) build on the work by Squicciarini and Nachtigall (2021[22]) and apply a more conservative approach, drawing AI keywords from Baruffaldi et al. (2020[32]). More specifically, they require vacancies to contain at least two AI-related skills belonging to different concepts or methodologies, only one of which may be a software-related skill. In other words, a vacancy containing the words "deep neural networks" and "convolutional neural networks" is not considered to be AI-related unless it contains another keyword, such as "computer vision". Given the similar approaches, it is not surprising that these studies reveal a similar share of AI jobs in the United States in 2019, ranging between 0.6 and 0.8%. Conversely, Gelhaus and Mutis (2021[34]) use online vacancy data, among other sources, but concentrate on a subset of occupations that (potentially) participate in AI product and application development, resulting in a much higher estimate of the US AI workforce of over 11% in 2019. More recently, Green and Lamby (2023[24]) depart slightly from previous work by providing representative estimates of employment shares of the AI workforce as opposed to changing demand for online vacancies alone. By calculating the share of vacancies requiring AI skills (based on the AI skills list in Aleekseva et al. (2021[19])) within an occupation, they build an occupation-based measure for AI intensity which is then weighted to employment by the occupation distribution in labour force surveys. They find the AI workforce to represent just below 0.4% of employment in the US in 2019.

Figure 2.1. Different methodologies result in qualitatively similar AI workforce shares

Percentage of employment/online vacancies requiring AI skills, United States, 2019



Note: The Figure compares the shares of AI online vacancies (those requiring AI skills) that different authors identify in the United States in 2019.
Source: Authors' elaboration based on Lightcast™ (December 2022); Aleekseva et al. (2021[19]), Acemoglu et al. (2022[33]), Samek et al. (2021[21]) and Green and Lamby (2023[24]).

3 Characterising positions that require AI skills across countries

This section evaluates the demand for workers engaged in the development and use of AI technologies across and within countries as reflected in vacancies posted on line by employers. The analyses are based on online vacancy data from Lightcast covering the time period 2019-22. The analyses focus on 14 OECD countries, including selected English-speaking (Australia, Canada, New Zealand, the United Kingdom, the United States) and selected European countries (Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland) for which data are available. The analyses explore differences in the demand for AI workers, proxied by online vacancies that contain AI-related keywords as discussed above, across industries, occupations, and skill clusters.

3.1. Evolution of online vacancies requiring AI skills across countries

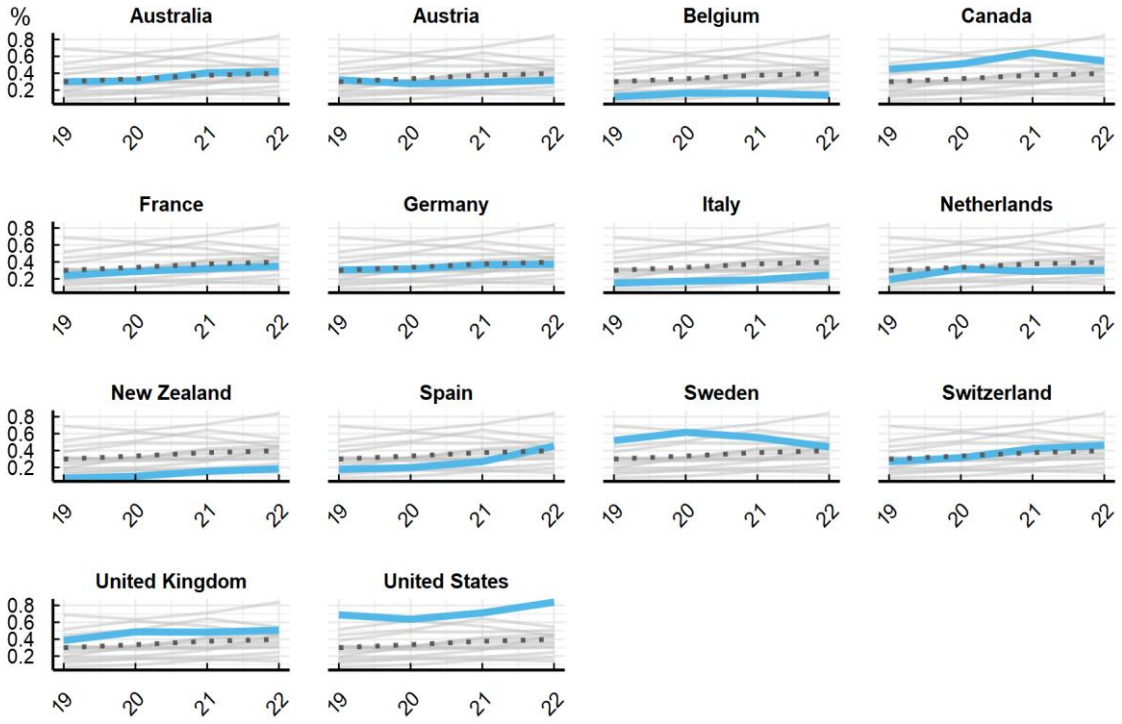
The share of online vacancies that require AI-related skills and its evolution over time varies across the 14 OECD countries with available data. Figure 3.1 provides an overview of the evolution of the share of online vacancies advertising positions requiring AI skills between 2019-22 relative to the overall volume of jobs posted on line in each country. The solid thick blue line represents the country average, the dotted line represents the average across all countries, and the solid thin grey lines portray the average for each country for comparison purposes.

In 2019, the share of positions requiring AI skills ranged between 0.07% in New Zealand to 0.69% in the United States while in 2022, the share of positions requiring AI skills ranged between 0.14% in Belgium to 0.84% in the United States. While initial levels differed across countries, in most countries the share of overall vacancies requiring AI-related skills increased between 2019 and 2022 except for Austria and Sweden. At the same time, the share of all online vacancies requiring AI skills did not exceed 1%, not even in the most recent year under analysis.

These estimates do not shed light on the actual stock of workers with AI-related skills in the labour market but, rather, the evolution of the demand for workers that would be required to use AI skills in their job. As such, estimates suggest that only few occupations require the set of specialised skills that are necessary to develop AI systems and work with them.

Figure 3.1. Trend in online vacancies requiring AI skills, by country and year (2019-22)

Percentage of online vacancies advertising positions requiring AI skills, by country and year



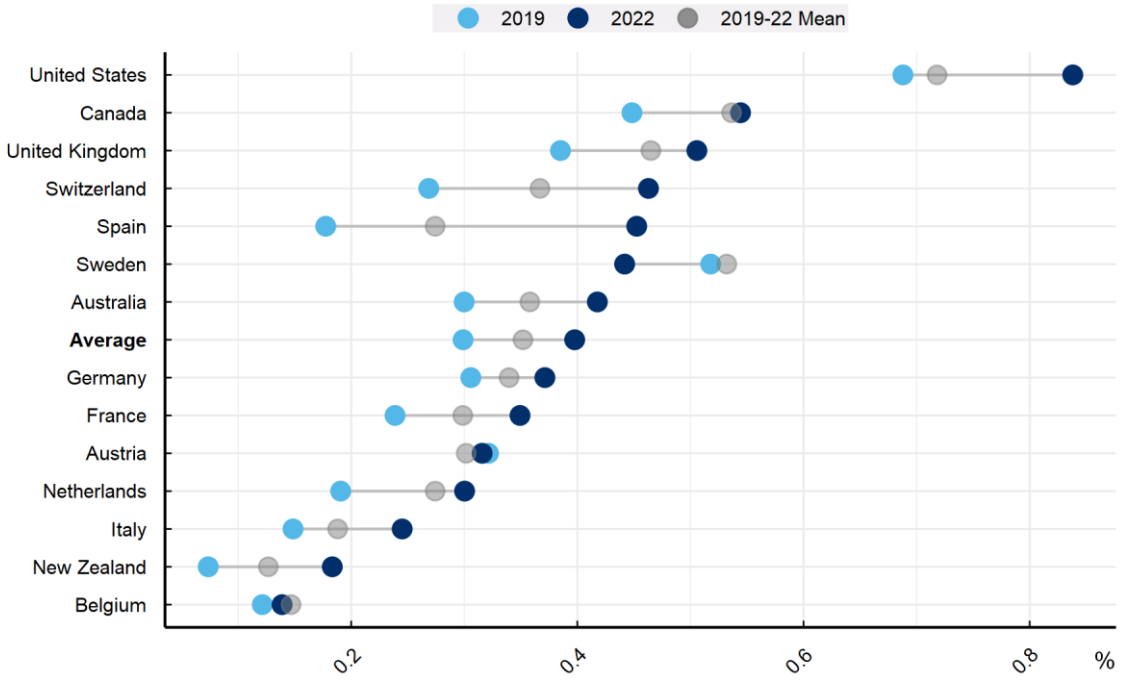
Note: The Figure shows the percentage of AI online vacancies in a given year, by country, which is the total number of online vacancies requiring AI skills relative to all vacancies advertised in the same country in a specific year. The blue line represents the country average, the dotted line represents the average across all 14 countries, and the solid thin grey lines portray the average for each country for comparison purposes. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were specified in the vacancy text (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

Figure 3.2 shows in detail how the share of online vacancies advertising positions requiring AI skills changed between 2019 to 2022. On average across countries, the share of online vacancies requiring AI skills increased from 0.30% in 2019 to 0.40% in 2022 (estimates are in line with other related studies, such as Green and Lamby (2023[24]), see Box 2.2). In 2022, the United States was the country with the highest share of postings demanding AI skills (0.84%), followed by Canada (0.54%) and the United Kingdom (0.51%). The countries with the lowest shares of postings demanding AI skills were New Zealand (0.11%), Belgium (0.14%), and Italy (0.24%).

On average across countries, the share of online vacancies requiring AI skills increased by 33%. Over time, the diffusion of AI skills varied across countries. In some countries, the diffusion of AI skills is well beyond this average increase. For example, in Spain and New Zealand, countries with initially relatively low shares of online vacancies requiring AI skills, shares increased by 155% and 150% respectively between 2019 to 2022. Spain ranked 11th out of 14 countries when considering the share of positions requiring AI skills in 2019 but ranked 5th in 2022. New Zealand ranked last in 2019 and second last in 2022. For countries that started with relatively high shares of online vacancies requiring AI skills in 2019, the increase over time has been more modest. In the United States, for example, the country with the highest share of online vacancies requiring AI skills in 2019, the increase has been of around 22%. In a few countries, such as Sweden and Austria, no increase over time has been observed.

Figure 3.2. Trend in the share of online vacancies requiring AI skills, by country (2019-22)

Percentage of online vacancies advertising positions requiring AI skills, by country



Note: The Figure shows the percentage of AI online vacancies by country, which is the total number of online vacancies requiring AI skills relative to all vacancies advertised in a country. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). Countries are sorted in descending order by the highest average share of vacancies requiring AI skills in 2022.
Source: Authors' elaboration based on Lightcast™ (December 2022).

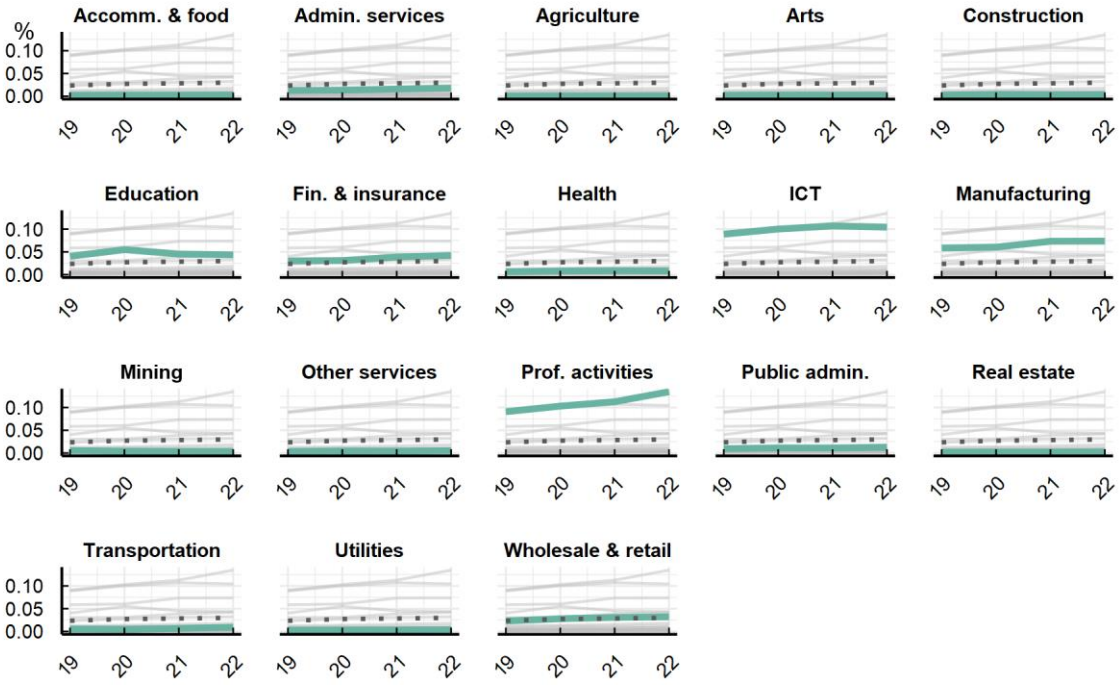
3.2. Evolution of online vacancies requiring AI skills across industries

The share of online vacancies that require AI skills and their evolution over time also vary across industries. Figure 3.3 illustrates the evolution of the number of online vacancies advertising positions requiring AI skills in an industry relative to the overall number of online vacancies across all industries, averaged across all 14 countries, between 2019 and 2022. The solid thick green line presented in each Panel in Figure 3.3 illustrates the evolution between 2019 and 2022 of the industry-specific average share of online vacancies requiring AI skills, whereas the dotted line represents the average across all industries. For comparison purposes, each Panel also contains solid thin grey lines portraying the industry-specific share of industries other than the one of interest (in green).

Focusing on the heterogeneity across industries, Professional Activities, ICT and Manufacturing account for the bulk of online vacancies requiring AI skills. In other industries, such as Accommodation and Food, Agriculture, and Transportation, the share of postings requiring AI skills is close to zero. Focusing on the evolution over time, industries that accounted for the smallest portion of AI-related vacancies in 2019 exhibited little change over time, whereas other industries, such as Manufacturing, ICT, and Professional Activities, in which the shares were already comparatively high in 2019, exhibited substantial increases over time. For example, in 2022, shares ranged between 0.07% (Manufacturing), 0.10% (ICT) and 0.13% (Professional Activities).

Figure 3.3. Trend in the share of online vacancies requiring AI skills, by industry and year (2019-22)

Percentage of online vacancies advertising positions requiring AI skills, by industry and year



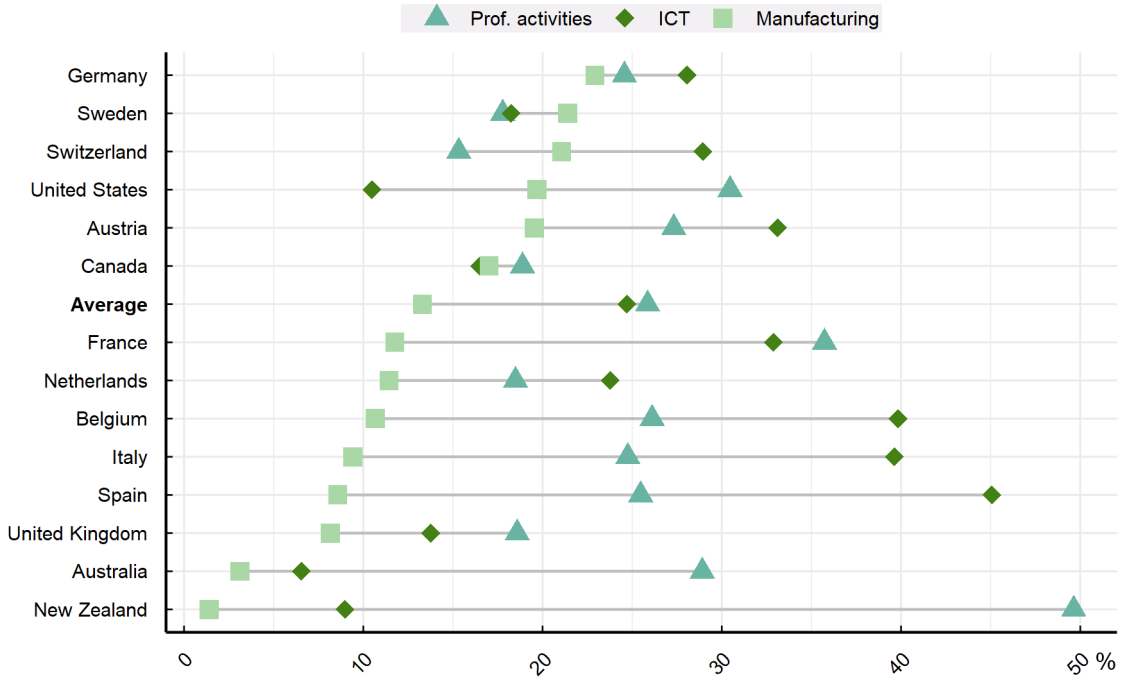
Note: The Figure shows the percentage of AI online vacancies in a given year, by industry, which is the total number of online vacancies requiring AI skills in an industry relative to all vacancies advertised across all industries in a specific year, averaged across all countries in the sample. While the green line represents the industry-specific average, the dotted line is the average across all industries and the solid thin grey lines portray the average for each industry for comparison purposes. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). For cross-country comparisons, this exercise required the harmonisation of industries across European countries and English-speaking countries, see Annex Table A B.2. .
Source: Authors' elaboration based on Lightcast™ (December 2022).

While the previous Figures highlighted the share of online vacancies that require AI skills compared to the rest of the economy, the following considers only vacancies advertising positions requiring AI skills and how they are distributed across the top 3 industries (as identified in Figure 3.3) and different occupation groups. Figure 3.4 shows the share of online vacancies for positions requiring AI skills that are posted in ICT, Manufacturing, and Professional Activities. These are the three industries that rank highest in terms of demand across all countries and years over the 2019-22 period.

On average across English-speaking and European countries, the average share of positions requiring AI skills was 25% for Professional Activities, 24% for ICT and 13% for Manufacturing. The country with the highest share of vacancies requiring AI skills in Professional Activities was New Zealand (50%), followed by France (36%) and the United States (30%). Among postings requiring AI skills in the ICT industry, shares were highest in Spain (45%), Belgium (40%) and Italy (40%). For Manufacturing, shares were highest in Germany (23%), Sweden (21%), and Switzerland (21%). Within countries, the relative share of positions requiring AI skills can differ substantially between industries, likely reflecting differences in specialisation.

Figure 3.4. Top 3 industries in which online vacancies requiring AI skills are advertised, by country (2019-22)

Percentage of online vacancies advertising positions requiring AI skills in specific industries and averaged across 2019-22, by country



Note: The Figure shows the percentage of AI online vacancies (reported in this Figure for the top three industries), which is the total number of online vacancies requiring AI skills in a given industry and country relative to all vacancies requiring AI skills across all industries in a given country. Countries are sorted in descending order of the highest average share of vacancies requiring AI skills in manufacturing. The top three industries are based on the highest share of vacancies requiring AI- skills across countries and years. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). Annex Table A B.2. details how the harmonisation of industrial classifications across European countries and English-speaking countries was conducted given differences in the taxonomies used by Lightcast in the compilation of data for English-speaking countries and countries in Europe. Average refers to the average across countries with available data.
Source: Authors' elaboration based on Lightcast™ (December 2022).

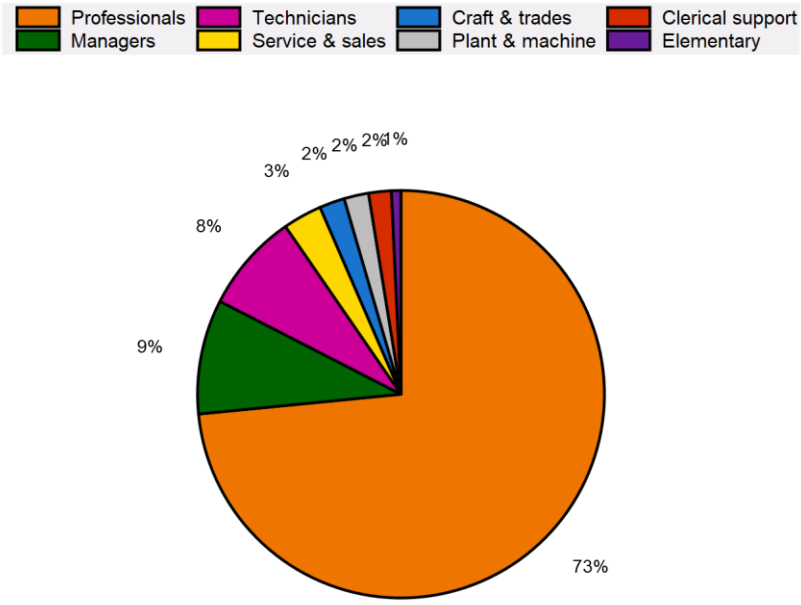
3.3. Online vacancies requiring AI skills across occupations

While the previous section focused on heterogeneity across industries, this section explores how positions requiring AI skills vary across occupations. Whereas industry information was harmonised across all English-speaking and European countries, it was not fully possible for occupations based on the underlying data. Therefore, data on European and English-speaking countries are presented separately (see Annex Table A A.2. on differences in the occupation classifications between English-speaking and European countries).

Figure 3.5 shows the share of online vacancies advertising positions requiring AI skills in different occupations in European countries. Occupations were classified according to major groups of the ISCO-08 classification. Online vacancies requiring AI skills are concentrated in very few occupations. Around 73% of online vacancies requiring AI skills advertise positions for professionals, 9% for Managers, 8% for Technicians and Associate Professionals, and the remaining 10% for the other occupations combined.

Figure 3.5. Online vacancies requiring AI skills in selected European countries, by occupation (2019-22)

Percentage of online vacancies advertising positions requiring AI skills in specific occupations

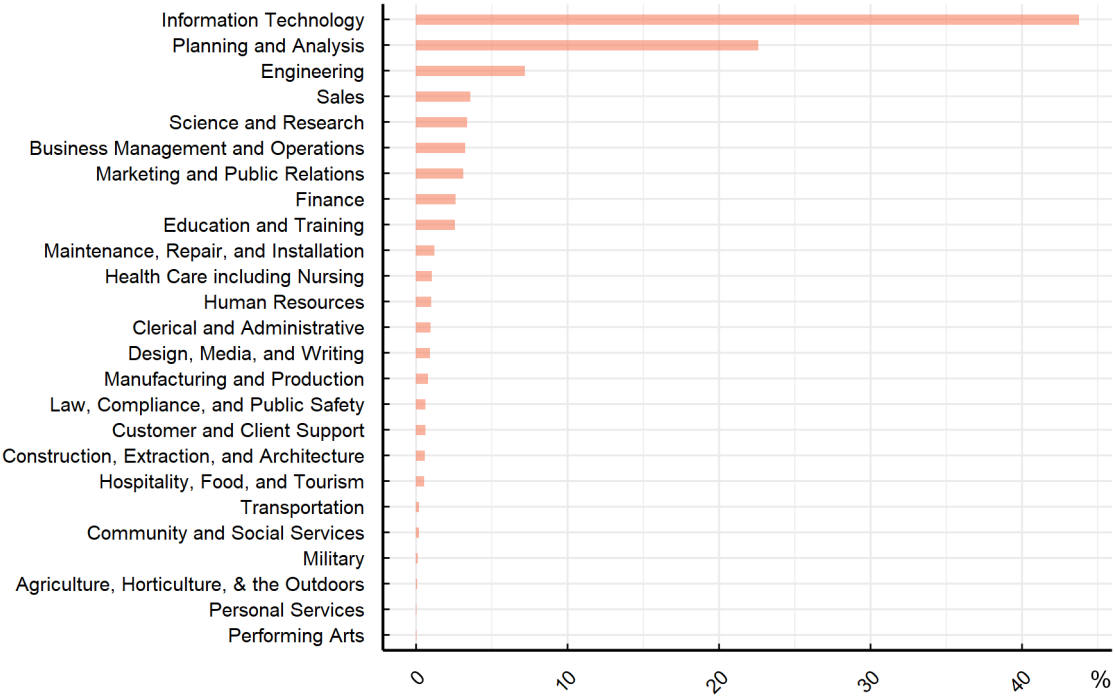


Note: The Figure shows the percentage of AI online vacancies in specific occupations (ISCO-08 major groups) for European countries (Austria, Belgium, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland), which is the total number of online vacancies requiring AI skills in a specific occupation relative to the total number of AI vacancies across occupations. The share of AI vacancies looking for agriculture-related workers is less than 1% and hence is dropped from the pie chart. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

Figure 3.6 shows the share of online vacancies advertising positions requiring AI skills in different occupations in English-speaking countries. The distribution of vacancies requiring AI skills in English-speaking countries is similar to that in European countries. A large share of online vacancies requiring AI skills are concentrated in few occupations. Around 44% of such postings are in Information Technology jobs, 23% in Planning and Analysis jobs, 7% in Engineering jobs, and 5% or less are found in other occupations.

Figure 3.6. Demand for AI workers for English-speaking countries, by occupation (2019-22)

Percentage of online vacancies advertising positions requiring AI skills in different occupations



Note: The Figure shows the percentage of AI online vacancies in specific occupations for English-speaking countries (Australia, Canada, New Zealand, the United States, the United Kingdom), which is the total number of online vacancies requiring AI skills in a specific occupation relative to the total number of AI vacancies across occupations. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). Occupations are sorted in descending order by the share of vacancies requiring AI skills.
Source: Authors' elaboration based on Lightcast™ (December 2022).

3.4. What type of skills are most requested in online vacancies demanding AI skills?

While the previous analyses focused on the distribution of positions requiring AI skills across countries, industries and occupations, this section focuses on the type of skills required by employers when looking for AI talent to hire.

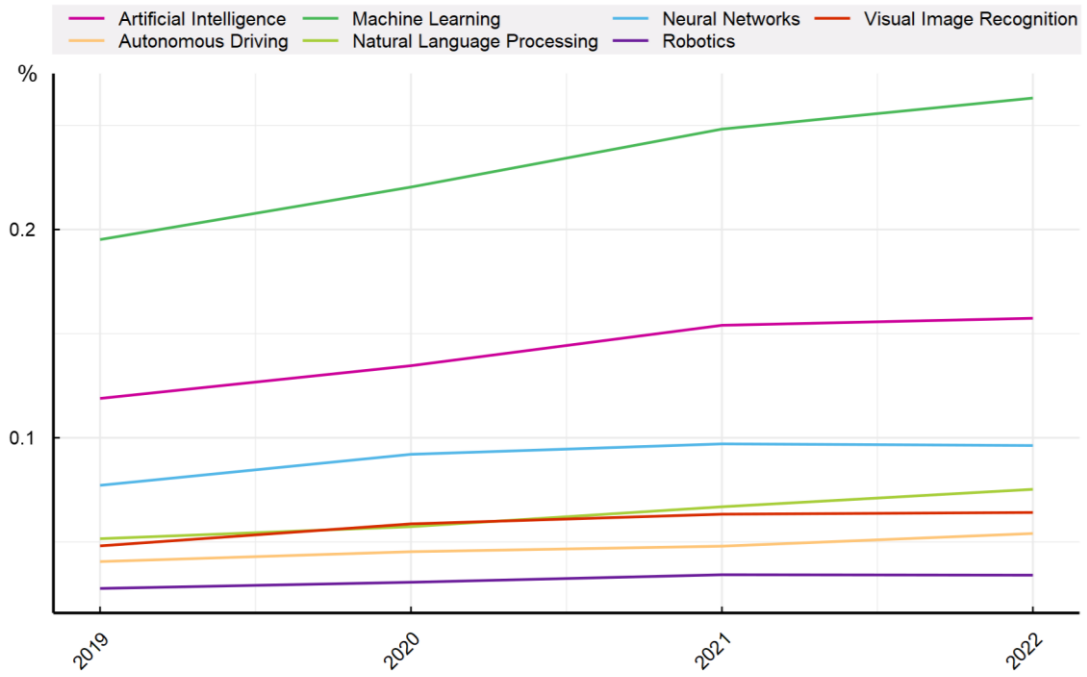
In order to meaningfully describe the skills required in AI-related postings, the list of 211 skills used to categorise positions was condensed into skill clusters. These clusters were determined based on industry expert assessment of skills common in these topic areas or implementations of AI. Skills were grouped into the following seven skill clusters: *Artificial Intelligence*, *Autonomous Driving*, *Machine Learning*, *Natural Language Processing*, *Neural Networks*, *Robotics* and *Visual Image Recognition* (Annex Table A C.1. provides the assignment of individual AI skills to specific clusters).[4] While all clusters comprise AI skills, the *Artificial Intelligence* cluster is rather used as an umbrella term to reflect, among others, broader AI skills such as "Computational Intelligence" or even the general term "Artificial Intelligence" mentioned in online vacancies.

Figure 3.7 shows the evolution of online vacancies advertising positions requiring AI skills by skill cluster between 2019 to 2022. In 2022, the skill cluster mentioned most frequently in postings was the cluster

referring to *Machine Learning* skills. *Machine learning* skills were required in more than 0.25% of all vacancies posted on line. Among postings requiring AI skills, which account for around 0.35% of total online vacancies in 2022 (see Figure 3.2), almost 35% require *Machine Learning* skills (see Figure 3.8). *Artificial intelligence* is the second most frequently requested skill cluster, possibly reflecting its broad nature encompassing more general AI skills, with around 0.16% of postings requesting such skills in 2022, which is almost 21% of postings among those that require AI skills (see Figure 3.8). The remaining skill clusters are demanded in less than 0.1% of all vacancies posted on line, with *Robotics* and *Autonomous Driving* being the skills clusters requested least frequently (0.04% and 0.06%), likely because they are highly industry- and country-specific.

Figure 3.7. Trend in the demand for AI workers, by skill cluster (2019-22)

Percentage of online vacancies requiring AI skills, by skill cluster and year



Note: The Figure shows the percentage of AI online vacancies, by skill cluster and year, which is the total number of online vacancies requiring a specific skill cluster relative to all vacancies. Annex Table A C.1. shows which AI skills are assigned to which cluster. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

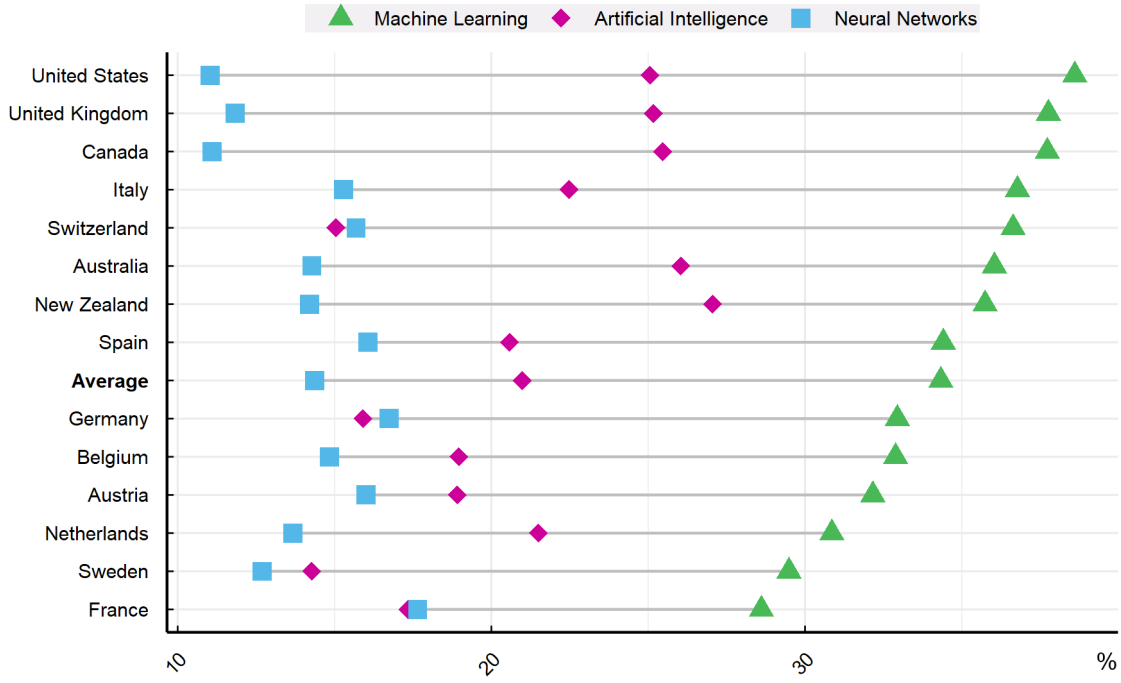
Figure 3.8 shows the relative demand for the top three out of seven skill clusters mentioned in postings requiring AI skills in each country between 2019 and 2022. On average over the period under analysis and across the 14 countries with available data, 34% of online vacancies requiring AI skills required skills from the *Machine Learning* cluster, followed by 21% that required skills in the *Artificial Intelligence* cluster, and 14% that require skills in the *Neural Networks* cluster.

Across all countries, the *Machine Learning* cluster ranked highest, ranging from 39% in the United States to 29% in France. In 11 out of 14 countries, skills in the *Artificial Intelligence* cluster were the second most frequently requested skill cluster, with the highest shares being observed in New Zealand (27%) and the lowest in Sweden (14%). In Switzerland, Germany, and France, the share of AI-related postings requiring *Artificial Intelligence* skills is smaller than the one requiring *Neural Networks*. However, France and

Germany were leading the distribution of postings requiring *Neural Networks* skills with 18% and 17%, respectively.

Figure 3.8. Top 3 skills clusters demanded in postings requiring AI skills (2019-22)

Percentage of online vacancies requiring AI skills averaged across 2019-22, by skill cluster and country

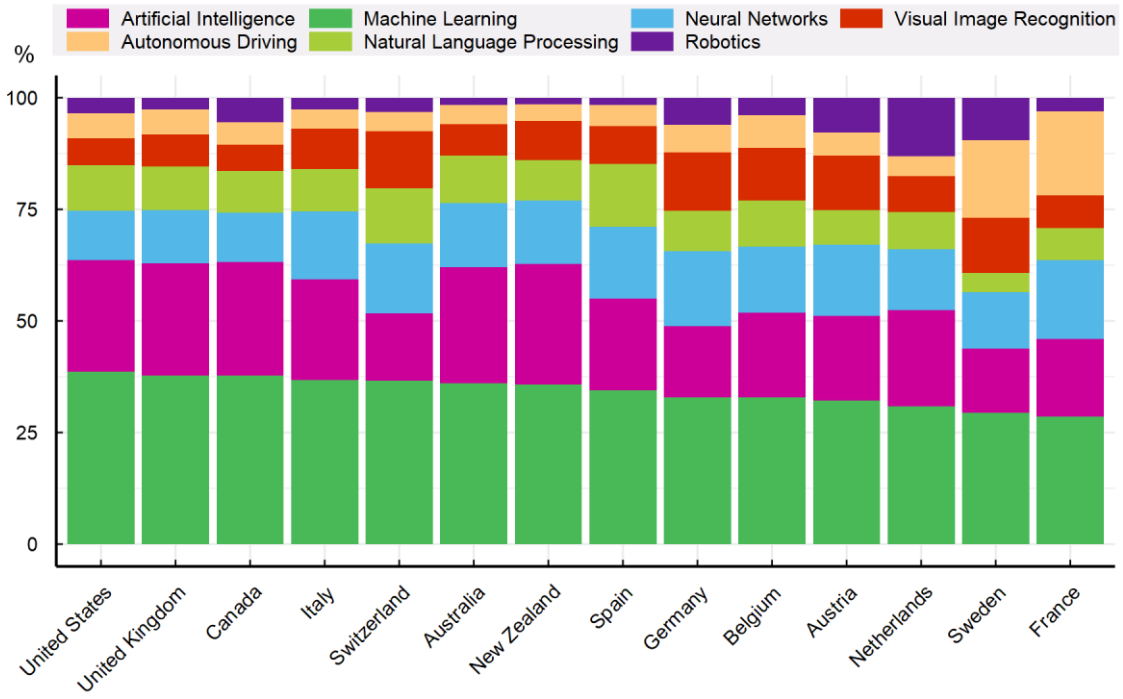


Note: The Figure shows the percentage of AI online vacancies for specific skill clusters, for the top 3 skill clusters, by country, which is the total number of online vacancies requiring a specific skill cluster relative to the total number of AI vacancies. Annex Table A C.1. shows which AI skills are assigned to which cluster. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). Countries are sorted in descending order by percentage of vacancies requiring Machine Learning skills. Average refers to the average across countries with available data.
Source: Authors' elaboration based on Lightcast™ (December 2022).

Examining the type of skills required in positions requiring AI skills indicates that two skill clusters are especially prevalent over the 2019-22 time period (Figure 3.7) and across countries (Figure 3.8): *Machine Learning* and *Artificial Intelligence*. Nonetheless, Figure 3.9 suggests that when other skills clusters are considered, countries vary with respect to the relative demand for skills in the less demanded clusters. In particular, whereas Figure 3.7 showed that two skill clusters have, compared to all other clusters, relatively low shares on average across countries in 2022 (*Autonomous Driving* [0.05%] and *Robotics* [0.03%]), Figure 3.9 indicates that the share of postings requiring skills related to the *Autonomous Driving* cluster was comparatively high in France (where 19% of positions requiring AI skills require skills in this cluster) and Sweden (where 17% of positions requiring AI skills require skills in this cluster). This was very low in New Zealand (where only 3.7% of positions requiring AI skills require skills in this cluster). For the *Robotics* cluster, demand was comparatively strong in the Netherlands (13%), followed by Sweden (9%) and lowest in New Zealand and Spain (1.5%).

Figure 3.9. Geographical distribution of AI skills clusters (2019-22)

Percentage of online vacancies requiring AI skills averaged across 2019-22, by skill cluster and country



Note: The Figure shows the percentage of AI online vacancies requiring specific skill clusters relative to the total number of AI vacancies averaged across 2019-22, by country. Annex Table A C.1. shows which AI skills are assigned to which cluster. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). Countries are sorted in descending order by percentage of vacancies requiring Machine Learning skills.
Source: Authors' elaboration based on Lightcast™ (December 2022).

4 Zooming in on the "top" AI employers in the United States

This section focuses on a subset of AI employers in the United States, the country with the highest demand for AI talent in online job postings among selected countries in this study. More specifically, this section considers the demand for workers with AI skills among the top ten employers *within each industry*,[5] which make up around 43% of all AI postings with industrial classification information (just under 315,000 AI postings) in the United States in 2022.

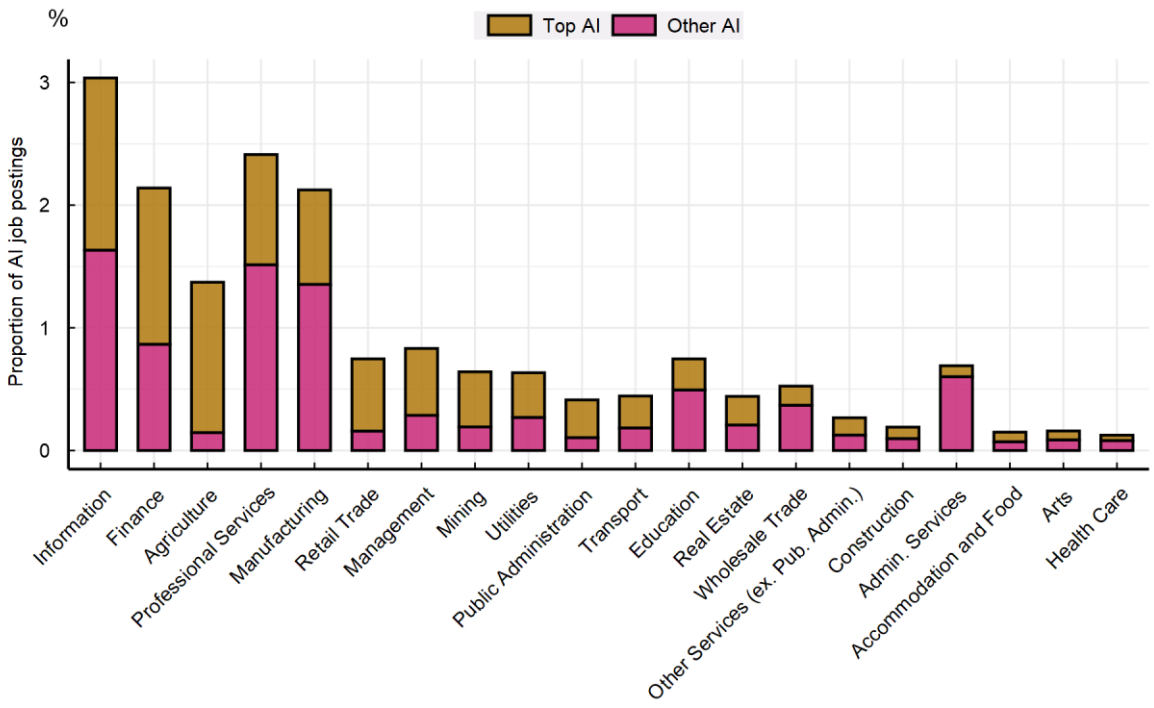
Similar to the previous analyses, this section explores differences in the number of vacancies for positions requiring AI skills across industries, occupations, and skill clusters. However, in this section the hiring patterns are further distinguished by employer type. In particular, AI online vacancies posted by the top ten AI employers (hereafter, "top AI") are compared to the remaining AI postings (hereafter, "other AI"). To put any potential differences into perspective, the analyses extend also to postings not mentioning any AI-related skills, i.e. not looking for any AI talent (hereafter, "non-AI").

4.1. Distribution of AI job postings within industries: top AI vs. other AI employers

As presented in section 3.2, the largest proportion of vacancies requiring AI skills in the United States in 2022 is found in sectors such as Information (3.0%), Professional Services (2.4%), Finance and Insurance (2.1%) and Manufacturing (2.1%). These are also the industries with the highest share of AI vacancies posted by top ten AI employers. Interestingly, Figure 4.1 shows that AI vacancies posted by top AI employers are instead much more concentrated, i.e. the share of postings requiring AI skills by top employers related to postings by other AI employers, is higher among industries where overall AI vacancy shares are comparatively low. For example, although around 3% of vacancies in the US Information industry require AI skills, only around 46% of those are posted by the top ten AI employers. Instead in Agriculture around 1.4% of postings require AI skills, but almost 90% are posted by the top ten AI employers.

Figure 4.1. Share of AI vacancies posted by US top AI and other AI employers, by industry (2022)

Percentage of online vacancies requiring AI skills posted by top ten AI and other AI employers, by industry, United States



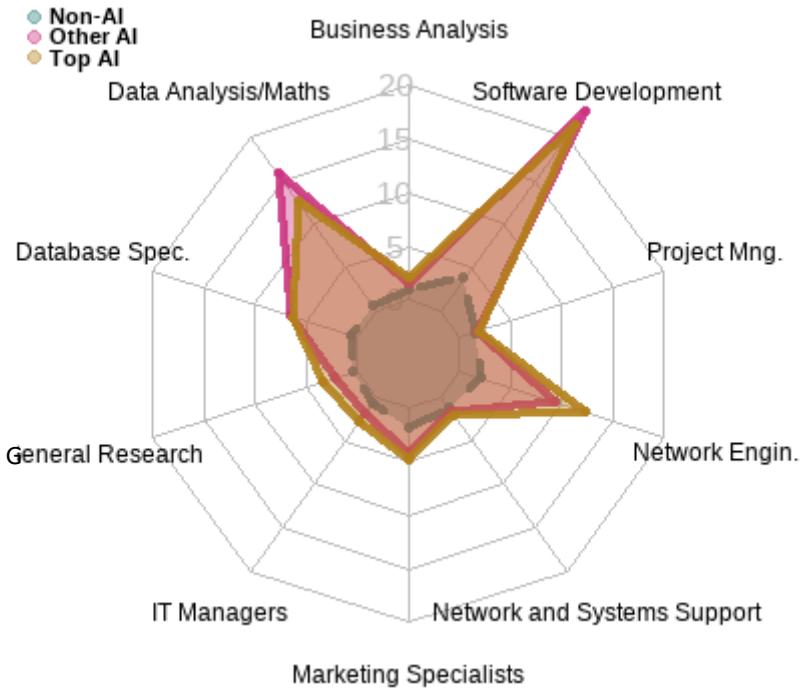
Note: The Figure shows, for the United States, the percentage of AI online vacancies by industry, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", mustard) from those posted by other AI employers ("Other AI", pink). The top ten AI employers are the ten firms in each industry that posted the largest share of AI vacancies. For both, the top ten AI and other AI employers, the share is defined as their total number of online vacancies requiring AI skills (posted by the top ten AI vis-à-vis other AI employers) relative to the total number of online vacancies posted by all employers in a given industry. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). Industries are sorted in descending order by the percentage of vacancies requiring AI skills posted by the top ten AI employers.
Source: Authors' elaboration based on Lightcast™ (December 2022).

4.2. Distribution of AI job postings across occupations

The occupation profiles demanded by the top ten AI and the other AI employers are rather similar. Figure 4.2 displays the share of AI online vacancies across occupations posted by AI employers, focusing on the ten occupations most frequently demanded by the top ten AI employers.[6] The Figure shows that Software Developers are most in demand among the top ten AI employers (21%) and are similarly demanded by other AI firms (23%). Data Analysts or Mathematicians (13% and 16%, respectively) as well as Network and System Engineers (abbreviated as 'Network Engin.' in the Figure; 12% and 9%, respectively) follow next, reflecting the need for skills related to architecture/infrastructure, management and maintenance of data. AI firms also look for AI talent in Research, Marketing, Database or Project Management. However, top AI firms demand a higher proportion of Network and System Engineers whereas other AI employers look for a marginally higher proportion of Data Analysts or Mathematicians and Software Developers. To put these distributions into perspective, the Figure also displays the share of the remaining vacancies, which do not mention any AI-related skills in their postings. In comparison, these non-AI vacancies rarely aim at hiring workers in these occupations, with the exception of Software Developers.

Figure 4.2. Top ten occupations in AI job postings by top AI employers (2022)

Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies across occupations, United States



Note: The Figure shows, for the United States, the occupational distribution of online vacancies requiring AI skills, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", mustard) from those posted by other AI employers ("Other AI", pink). The top ten AI employers are the ten firms in each industry that posted the largest share of AI vacancies. The Figure displays only the top 10 occupations based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies in a specific occupation relative to their total number of AI vacancies across occupations, hence the shares across all occupations (not only the top ten displayed here) sum up to 100%. The Figure also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that are for the same specific occupation. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). The underlying data to the Figure are provided in Table A D.1. , which presents the top 20 occupations with their corresponding AI vacancy shares.
Source: Authors' elaboration based on Lightcast™ (December 2022).

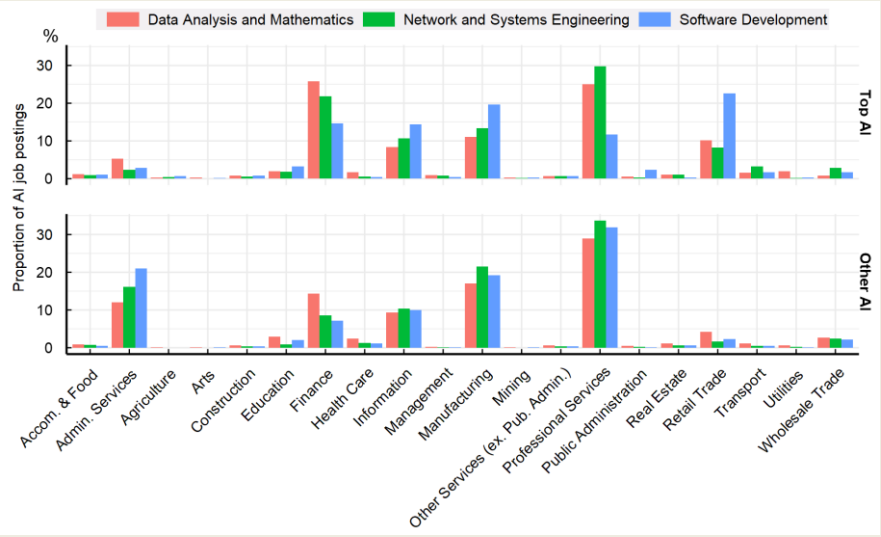
Box 4.1. Top three occupations most demanded and their distribution across industries

Software Developers, Data Analysts and Mathematicians as well as Network and System Engineers are the most demanded occupations in AI-related online vacancies by top ten AI employers. As shown in the top Panel of Figure 4.3, the latter two are particularly concentrated in Finance and Insurance (abbreviated as 'Finance' in the Figure) as well as Professional Services followed by Manufacturing, Information and Retail Trade. Software Developers, in comparison, are most demanded in Retail Trade and Manufacturing, and only to a lesser extent in Information, Finance and Insurance, and Professional Services. Nonetheless, demand for each of those occupations is widespread across all US industries.

Although the same industries stand out when focusing on AI online vacancies posted by other AI employers (beyond the top ten AI employers) in the bottom Panel, the distribution of these occupations displays less heterogeneity across industries. Software Developers, Data Analysts and Mathematicians as well as Network and System Engineers are all most widely demanded in Professional Services, followed by Manufacturing. However, conversely to the pattern observed in the top Panel for top AI employers, demand for these occupations is also relatively high in Administrative Services, followed by Information as well as Finance and Insurance. The equivalent Figure for General Researchers and Marketing Specialists, i.e. the two most frequently demanded non-STEM (Science, Technology, Engineering, and Mathematics) occupations, is presented in Annex Figure A D.1. .

Figure 4.3. Top three occupations in AI job postings by AI employers, (2022)

Percentage of AI online vacancies by top AI vs. other AI employers across industries, by occupation, United States



Note: The Figure shows, for the United States, the distribution across industries of online vacancies requiring AI skills for the top three occupations, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", top Panel) from those posted by other AI employers ("Other AI", bottom Panel). The top ten AI employers are the ten firms in each industry that posted the largest share of AI vacancies. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies in a specific industry and occupation relative to their total number of AI vacancies across industries in the respective occupation, hence the shares for each occupation sum up to 100% across all industries. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). The equivalent Figure for General Researchers and Marketing Specialists, i.e. the two most frequently demanded non-STEM occupations, is presented in Annex Figure A D.1. .
Source: Authors' elaboration based on Lightcast™ (December 2022).

4.3. Share of AI job postings mentioning specific skills

The following Figure focusses on the technical, socio-emotional and foundational skills required by the different AI employer types in the United States. More specifically, Figure 4.4 shows the share of AI online vacancies posted by the top ten AI and other AI employer firms that mention a specific technical (Panel A) or socio-emotional and foundational (Panel B) skill in their job description, focusing on the 20 skills most frequently demanded in AI job postings by the top ten AI employers.

The skill profiles demanded by top ten AI and other AI employers do not vary substantially, with programming languages accounting for many of the most demanded technical skills, especially Python. This is followed by skills related to Computer and Data Science as well as skills associated with the widely adopted cloud and computing service Amazon Web Services (AWS).[7]

Compared to other AI firms, a larger share of the top AI employers requires skills related to AWS, Business Intelligence, Microsoft Azure, Apache Hadoop, Java, Software Engineering, Data Analysis, and Big Data. Unsurprisingly, none of these skills are particularly evident in non-AI online vacancies, i.e. vacancies not requiring any AI-related skills.

By contrast, the frequency with which socio-emotional and foundational skills appear in AI and non-AI online vacancies is more similar. In particular, Communication skills are very common in postings across the board. However, more AI-related online vacancies, compared to non-AI postings, demand Leadership and Management skills, as well as Innovation, Research, Problem-Solving and Mentorship. In fact, except for Customer Service and skills related to Sales, employers demand either of the remaining socio-emotional and foundational skills presented in Figure 4.4 more frequently in AI than non-AI postings.

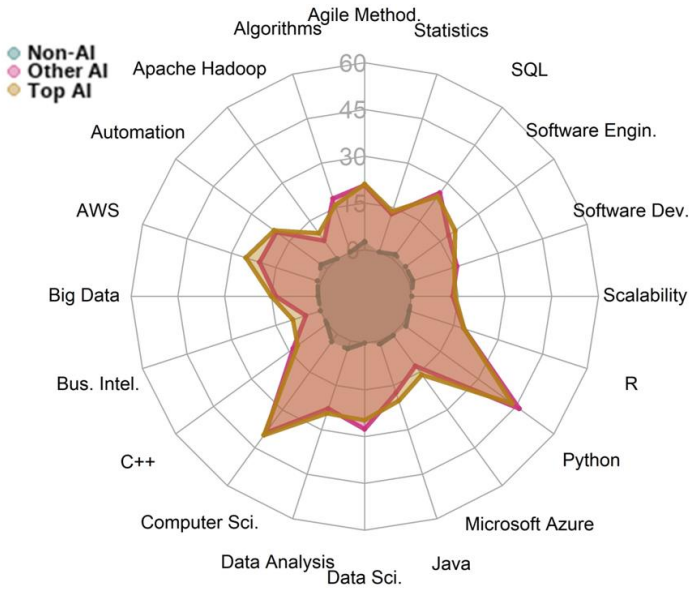
In particular, top ten AI employers put relatively more emphasis on Leadership, Mentorship and Management skills – as well as Innovation and Problem-Solving skills – than other AI employers. Compared to other AI firms, the top ten firms also more frequently request skills related to Customer Service, Forecasting, Operations, Planning or Maths. Interestingly, although different types of Communication skills are highly demanded across all online vacancies, top AI employers demand Interpersonal Communication and Presentation skills more often. The underlying data to Figure 4.4 for technical as well as socio-emotional and foundational skills are provided in Table A D.2. and Table A D.3. , respectively.

When examining the skill composition of an average AI vacancy posted by top and other AI employers, AI skills account for almost 10%, socio-emotional and foundational skills for more than 20% and other technical skills for the remainder of the overall skill bundle. This average composition of AI and other technical skills as well as socio-emotional and foundational skills is rather similar across top and other AI employers. However, when focusing on all vacancies, AI employers, and especially top AI employers require on average a larger number of skills from each of these three different skill groups, reflecting the need for AI workers to be endowed with a broad skill mix, including technical as well as socio-emotional and creativity-related skills.[8]

Figure 4.4 Top 20 skills in AI job postings by top AI employers (2022)

Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies requiring specific skills, United States

A. Technical skills



B. Socio-emotional and foundational skills

Note: The Figure shows, for the United States, the percentage of AI online vacancies mentioning a specific technical (Panel A) or socio-emotional and foundational (Panel B) skill, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", mustard) from those posted by other AI employers ("Other AI", pink). The top ten AI employers are the ten firms in each industry that posted the largest share of AI vacancies. For each Panel, the Figure displays only the top 20 skills based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies requiring a specific skill relative to their total number of AI vacancies, hence the shares across all skills can exceed 100%. The Figure also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that mention the same specific skill. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). The underlying data to the Figure for technical and socio-emotional and foundational skills are provided in Table A D.2. and Table A D.3. , respectively.
Source: Authors' elaboration based on Lightcast™ (December 2022).

4.4. Defining "top" AI employers differently

Top AI employers in terms of hiring patterns can be defined in different ways. So far, the top ten AI employers have been defined as the ten firms *within* each industry that posted the highest share of vacancies online for workers with the skills needed to perform AI tasks. A more restrictive definition of the top ten AI employers can instead rather focus on the largest share of AI-related online vacancies *across* all industries. This would allow zooming in on a lower number of firms: the ten employers posting the highest number of AI-related online vacancies in the US. Therefore, this section presents further evidence of their hiring patterns when the latter definition is used.

The top ten AI employers – when defined across all US industries – capture 14% of all AI vacancies (representing just over 51,000 AI vacancies) in the United States in 2022. They operate in the following four industries: Retail Trade, Finance and Insurance, Professional Services and Manufacturing. The Retail Trade industry is the one in which top AI employers account for the highest share of AI vacancies (see Figure A D.2.). Most AI vacancies posted by this group of firms are however in Professional Services (see Figure A D.3.). In fact, more than one in three AI vacancies posted by these employers are in Professional Services; one-quarter is in Retail Trade; and one-fifth each is in Finance and Insurance as well as in Manufacturing.

Other AI employers (beyond the top ten AI firms) look for AI talent in a wider range of industries. The majority of AI online vacancies are still found in Professional Services (although only one in five) and a similar proportion in Manufacturing, but the demand for AI talent in Retail Trade as well as in Finance and Insurance is much lower, reflecting the fact that almost one in ten AI online vacancies posted by other AI employers are also in Information and around 4% are in Education and Administrative Services each.[9]

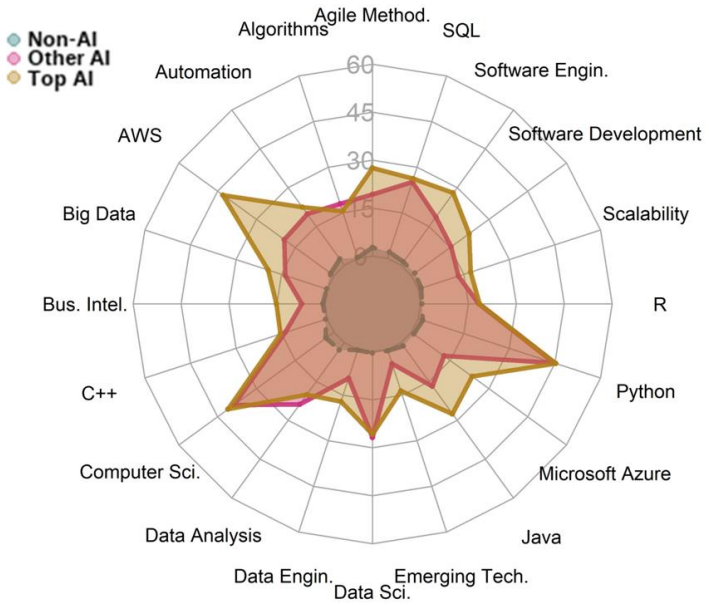
The occupational hiring pattern is very similar across AI firms regardless of the definition used to identify the top ten AI employers, with Software Developers, Data Analysts and Mathematicians as well as Network and System Engineers standing out (see Figure A D.4.). However, when AI online vacancies posted by the top ten AI employers across all industries are analysed, a higher demand for Database Specialists becomes evident for this group of employers. In addition, Accountants and Engineering Managers make the list of the top ten occupations, reflecting the fact that large Accounting and Consultancy firms are among the top ten AI employers when defining those across all US industries.

As can be seen from Panel A in Figure 4.5, the skill profiles demanded by top ten AI and other AI employers differ more substantially when defining top AI firms based on their AI posting counts across all industries rather than within industries.[10] This likely reflects not only the skill demand of particularly large employers but also the specific industries they operate in. For instance, compared to other AI firms, top ten AI employers mention relatively more often skills related to AWS, Microsoft Azure, Java, Emerging Technologies, Business Intelligence, Big Data, Scalability, Agile Methods and Software Engineering as well as Development. The demand pattern for socio-emotional and foundational skills shown in Panel B in Figure 4.5 is very similar regardless of how the top ten AI employers are defined, with an apparent difference in the demand for Leadership and Management skills not only between AI and non-AI postings but also between vacancies posted by top ten AI and other AI firms. This is further explored in Box 4.2.

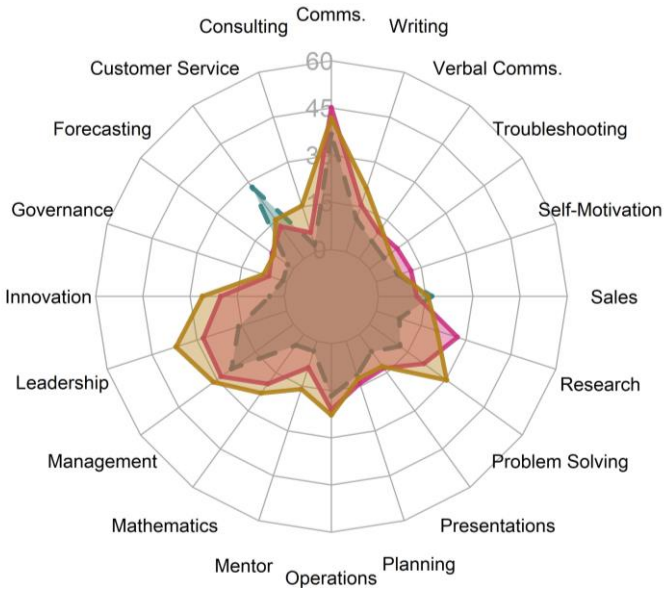
Figure 4.5. Top 20 skills in AI job postings by top AI employers across industries (2022)

Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies requiring specific skills, United States

A. Technical skills



B. Socio-emotional and foundational skills



Note: The Figure shows, for the United States, the percentage of online vacancies requiring AI skills mentioning a specific technical (Panel A) or socio-emotional and foundational (Panel B) skill, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", mustard) from those posted by other AI employers ("Other AI", pink). The top ten AI employers are the ten firms that posted the largest share of AI vacancies across industries. For each Panel, the Figure displays only the top 20 skills based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies requiring a specific skill relative to their total number of AI vacancies, hence the shares across all skills can exceed 100%. The Figure also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that mention the same specific skill. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). The underlying data to the Figure for technical and socio-emotional and foundational skills is provided in Table A D.4. and Table A D.5. , respectively.
Source: Authors' elaboration based on Lightcast™ (December 2022).

Box 4.2. Skills required of Managers by the top AI firms

With Leadership and Management skills consistently appearing as some of the most demanded skills in AI online vacancies, it is important to better understand the skill profiles of Managers given their role in adopting operational plans, supervising personnel and shaping technology adoption decisions.

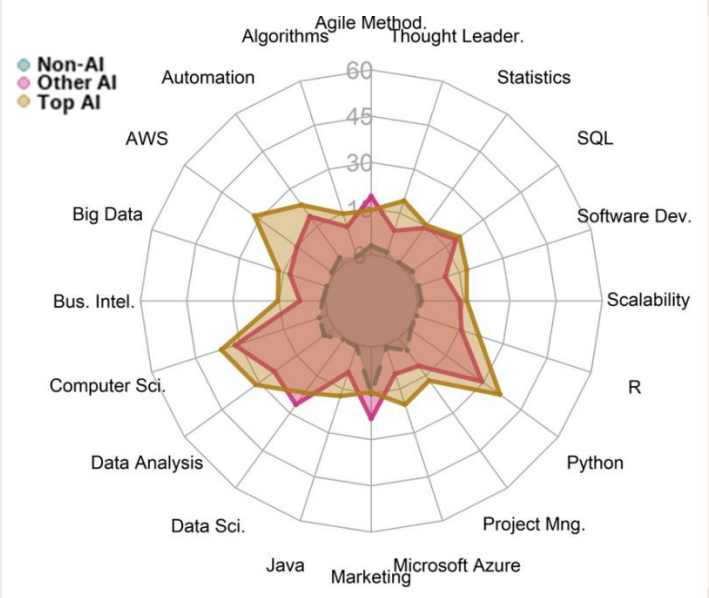
As shown in Figure 4.6, AI employers demand Managers to be endowed with a broad skill mix encompassing both technical and socio-emotional and foundational skills when working in prospective AI jobs. These technical skills very much mirror the skills demanded by AI talent overall and hence provide evidence that Managers in AI firms need to understand the business as well as the technical side of AI use. The share of AI online vacancies mentioning those skills is even higher among the top ten AI employers.

Moreover, socio-emotional and foundational skills demanded by top AI employers in AI online vacancies go beyond the typical skills associated with Managers, such as Leadership, Relationship Management, Decision-Making or different types of Communication (Interpersonal, Negotiation and Written) skills, and extend to Innovation, Problem-Solving, Maths and Ethical Standards and Conduct. The latter is of particular relevance given that AI systems have the potential to support and improve decision-making and perform complex analytical tasks and, at the same time, pose unique challenges related to privacy, digital security risk management, and responsible business conduct. These are all skills that the top ten AI employers mention relatively more often than other AI firms in their vacancies.

Figure 4.6. Top 20 skills in AI job postings for Managers by top AI employers across industries (2022)

Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies requiring specific skills, United States

A. Technical skills



B. Socio-emotional and foundational skills

Note: The Figure shows, for the United States, the percentage of Managers' online vacancies requiring AI skills mentioning a specific technical (Panel A) or socio-emotional and foundational (Panel B) skill, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", mustard) from those posted by other AI employers ("Other AI", pink). The top ten AI employers are the ten firms that posted the largest share of AI vacancies across industries. For each Panel, the Figure displays only the top 20 skills based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies requiring a specific skill relative to their total number of AI vacancies, hence the shares across all skills can exceed 100%. The Figure also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that mention the same specific skill. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

5 Concluding remarks

This work provides a novel perspective on the role human input continues to play in the development and use of AI, mapping the skills which are considered crucial by employers in jobs that are at the heart of recent advances in AI. Even large language models such as GPT4 are nothing but tools that were created by humans and that at their core combine in complex ways work previously conducted by other humans (Lanier, 2023[35]). For the first time, patterns in the demand for AI-related jobs were examined using comparable methods and data from across 14 OECD countries over the period 2019-22. These are: Australia, Austria, Belgium, Canada, France, Germany, Italy, the Netherlands, New Zealand, Spain, Sweden, Switzerland, the United States, and the United Kingdom.

In line with previous work (Alekseeva et al., 2020[18]; 2021[19]; Babina et al., 2020[20]; Samek, Squicciarini and Cammeraat, 2021[21]; Squicciarini and Nachtigall, 2021[22]; Manca, 2023[23]), the paper exploits data from online job vacancies sourced by Lightcast to characterise AI-related jobs. Information present in online job vacancies is well suited to consider changes in the overall demand for professionals working in the field of AI as well as to map the changing landscape of the skills required in the development of and work with AI. This is because timely data are needed given rapid changes in AI technologies and because the nature of the job makes the use of online marketplaces pervasive among workers in technology-related industries. In line with previous work exploiting online vacancies to map the demand for individuals working on AI and their skillset, this work characterises online vacancies on the basis of information contained in the vacancy text, in particular focusing on whether AI skills are demanded in a vacancy or not. At the same time, this work proposes a novel characterisation of AI job postings, based on keywords identifying a set of generic and specific AI skills. Such characterisation is used to explore patterns in the demand for AI-related jobs across countries, industries and occupations, as well as the existing heterogeneity in the types of AI skills demanded by different AI employers.

First, results indicate that AI-related online vacancies represent a small share of all job vacancies that were posted on line in the 14 countries analysed: in 2022 the share of AI-related online job vacancies was highest in the United States where AI-related vacancies represented 0.84% of all vacancies. In Canada and the United Kingdom, 0.54% and 0.51% of all vacancies advertised positions requiring AI skills respectively, whereas Belgium and New Zealand were the countries with the lowest share of vacancies advertising positions requiring AI skills (0.14% and 0.18% respectively of all vacancies). In no country did the share of AI-related vacancies exceed 1% of all vacancies in any of the years under analysis. Indeed, on average across the countries in the sample, shares of online vacancies requiring AI skills were 0.30% in 2019 and 0.40% in 2022.

Second, the share of vacancies posted on line for AI professionals grew markedly between 2019 and 2022 in most countries and grew the most in countries with lower shares in 2019. For example, in the United States, AI-related vacancies represented 0.69% of all vacancies in 2019 but 0.84% by 2022. Similarly, in Canada or the United Kingdom AI-related vacancies represented 0.45 and 0.39% of all vacancies in 2019 but 0.54 and 0.51% by 2022, respectively. In some countries, such as Austria, Belgium, and Sweden, shares of vacancies requiring AI skills remained instead flatter during the period considered.

Third, the demand for AI-related jobs is highly concentrated, both in terms of industries and in terms of occupations. The majority of job postings requiring AI skills are for positions referring to Professional Services, ICT, and Manufacturing. Indeed, on average across the countries in the sample, the share of

vacancies requiring AI skills was 25% in Professional Services, 24% in ICTs, and 13% in Manufacturing. These are also the industries that exhibited the most significant increases in the share of AI-related vacancies being posted online between 2019 and 2022. At the same time, analyses reveal some cross-country heterogeneity in the distribution across industries of AI jobs demanded by employers, possibly – at least partly – explained by cross-country differences in industrial specialisation and sectoral composition of the labour market. Concerning occupations, in European countries around 73% of online vacancies requiring AI skills aim at hiring Professionals, while 9% Managers, and 8% Technicians and Associate Professionals. In English-speaking countries, for which a more detailed occupational cut-off is available, around 44% of AI job postings relate to jobs in Information Technology, 23% to Planning and Analysis, and 7% to Engineering.

Fourth, some skills – notably those related to Machine Learning – appear particularly pervasive among AI-related job postings. Indeed, across all countries, between 29% (in France) and 39% (in the United States) of all AI job postings require skills related to Machine Learning. Skills related to Autonomous Driving and Robotics appear on average less demanded, possibly reflecting their more industry-specific nature, and also exhibit a high degree of cross-country variation, possibly reflecting the relative importance of different industries in different countries and their likely evolution given industry-specific trends and industrial investment decisions.

A final set of analyses examines differences in skills requirements among different firms in the United States, the country in which the AI sector has been comparatively large for longest. Such analyses consider the top AI employers in the United States, defined as the ten US employers posting the highest shares of AI-related jobs online *within* and *across* industries in 2022, and identify differences in the profile of AI vacancies such companies advertise relative to the profiles advertised by other AI firms in the United States.

AI job postings by top AI employers are high *within* Information, Retail Trade, Finance and Insurance, Professional Services, and Manufacturing industries, reflecting the overall cross-sectoral distribution of AI vacancies. Interestingly, AI vacancies appear more concentrated among top AI employers in Agriculture, Retail Trade or Agriculture. Top ten AI employers *across* industries operate instead in Retail Trade, Finance and Insurance, Professional Services, and Manufacturing but still account for a significant share of overall online job postings.

Regardless of the definition, in the realm of AI vacancies, top AI employers mainly advertise vacancies for Software Developers and Data Analysts or Mathematicians, similarly to other AI employers, and for Network and System Engineers, even more than other AI employers in the United States. They also tend to demand more intensively some technical skills, such as competencies related to AWS, Big Data or Business Intelligence, than other AI firms. However, while skill profiles demanded by top AI and other AI employers generally do not differ considerably with regards to technical skills, they vary when considering socio-emotional and foundational skills. When comparing the vacancies posted by top AI employers with those posted by other AI firms, the former demand more frequently Leadership and Management skills, as well as Innovation and Problem-Solving. This reflects the importance such companies place on their employees having a broad skill mix. This is also supported when zooming in on skill profiles top AI firms expect their AI managers to exhibit: first evidence suggests that they both need to understand the business as well as the technical side of AI use and should have skills related to Innovation, Problem-Solving, Maths, as well as Ethical Standards and Conduct.

Findings presented in this work are complementary to other work conducted by the OECD focusing on the diffusion of AI across firms, its role in productivity, innovation, and labour markets, and appear relevant in the context of “building human capacity and preparing for labour market transformation”, one of the key OECD recommendations consistent with the OECD AI principles.[11]

Analysing the human element behind advances in AI allows assessing the size of and the heterogeneity in the demand for AI jobs and skills and may help design interventions aimed at fostering the diffusion of

AI across the economy, especially among employers and industries that have not yet fully benefited from its potential. Such analyses are also a useful reminder that humans drive technical developments in AI diffusion and adoption and, as such, AI developments are ultimately driven by human decision-making. While this work significantly contributes to deepening the existing understanding of the demand for AI jobs across countries in most recent years, its scope – already comprehensive in several respects – could be further extended into several directions in the future.

One possible avenue for additional analysis would be to further explore the differences among AI employers, e.g., broadening the focus of the previous section beyond the United States or further zooming in on the differences in skills required by other types of AI employers beyond top players.[12]

Continuing to monitor the demand for AI jobs and skills is also important because recent advancements in AI systems, such as large language models, and the growth of AI-related businesses could lead to further changes in this demand. At the same time, it is necessary to differentiate between temporary effects caused by the COVID-19 pandemic and long-term structural changes. Observing patterns and variations in AI job demand helps understanding these factors better.

Further linking the human element behind advances in AI to economic and social outcomes in a cross-country perspective also appears promising and may bring additional policy-relevant insights. For instance, further exploring the relationship between the demand for AI-related jobs and subsequent changes in overall labour and skills demand, at different levels of aggregation across countries, may shed additional light on the labour market implications of the diffusion of AI and on the complementarities between AI-related and other skills.

Furthermore, linking the demand for AI-related human capital with economic outcomes such as productivity may be also particularly relevant to better understand the role of complementary assets, notably skills, for economic growth. In this respect, the presence or acquisition of certain skills or skills bundles may be associated with systematically higher productivity premia. If these skills are demanded by employers that have already a leading position in their industry, this may further increase existing divergences between best-performing firms and the rest of the business population, with relevant implications for the inclusiveness of economic growth.

Finally, future work may explore the role of the human element behind AI for societal challenges, for instance focusing on the complementarity of AI skills with those relevant for the green transition or for supporting ageing populations.

Endnotes

[1] www.lightcast.io

[2] As computer science borrows extensively from the English language, some of the technical terms – including for instance software names, such as Python – were kept instead in English.

[3] Similarly to most of the approaches that are based on the use of keywords, relevant caveats relate to a possible degree of subjectivity in the choice of such keywords, or in their appearance criteria, and to the extent to which the chosen keywords are contextualised in job postings' texts, given the identification based on their mere presence rather than on broader context. These are limitations common to this type of analyses. The current approach however builds upon a widely used set of keywords validated by experts and adopts a conservative criterion that, as discussed (Box 2.2), results in estimates in line with existing evidence, possibly to be considered as lower bounds.

[4] *Autonomous Driving* focuses on the development of vehicles operating and navigating without human intervention and involves, e.g., sensors and control systems; *Machine Learning* enables learning from experience without explicit programming to make predictions based on identified patterns, e.g. recommendations provided by online platforms; *Natural Language Processing* deals with the interaction between computers and human language, allowing for e.g., language translation or chatbots; *Neural Networks* are a type of machine learning model inspired by the structure of the human brain, these models are used, e.g., to detect fraudulent activities or diseases; *Robotics* focuses on the design and construction of devices that can (semi-)autonomously perform physical tasks, e.g., autonomous drones and humanoid robots; *Visual Image Recognition* refers to the use of algorithms to analyse and interpret visual data, such as images or videos; *Artificial Intelligence* is a broad field encompassing the development of machine-based systems, including each of the aforementioned sub-fields.

[5] The top ten AI employers are the ten firms in each industry that posted the largest share of vacancies online for workers with the skills needed to perform AI tasks. AI vacancies of top ten AI employers *across* industries make up 14%.

[6] For presentation purposes only the top ten occupations based on the distribution of AI jobs posted by the top ten AI employers are displayed in Figure 4.2 but a more extensive list of the top 20 occupations is presented in Table A D.1.

[7] AWS stands as a comprehensive suite of services offered by Amazon and provides businesses with the digital infrastructure to manage data, execute applications, and perform a myriad of other tasks via the internet, bypassing the need for physical servers.

[8] Results from the analyses on the skill composition and skill intensity are not reported in this paper but can be made available upon request.

[9] The distribution of non-AI online vacancies across the top ten US industries in which AI jobs are posted looks very different, with a large proportion of job postings also being in Health and Social Care (see Figure A D.3), possibly also reflecting the health context of the period under analysis.

[10] As the top 20 skills in each Panel are based on the share of AI online vacancies posted by the top ten AI employers and the definition of top ten AI employers used in Figure 4.4 and Figure 4.5 differs, the composition of skills displayed can vary. However, irrespective of the definition used the top technical skills required in AI postings remain the same: Python, AWS and Computer Science.

[11] See OECD (2022[37]; 2023[3]) and https://oecd.ai/en/ai-principles.

[12] For instance, further exploring the patterns in the demand for AI-related jobs by start-ups or by firms with different hiring intensities – e.g., focusing on those hiring only AI talent – may help better understand the implications of AI diffusion. Given Managers' role in shaping technology adoption decisions, further analysing and comparing skill profiles of different types of Managers within the realm of AI and beyond could be another extension of this workstream.

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Annex A. Lightcast data

Data collection, databases and enrichment process

Job posting data overview

To support these analyses, Lightcast mined its dataset of millions of job postings collected since 2010. Lightcast collects postings from over 51,000 online job sites to develop a comprehensive, real-time portrait of labour market demand. It aggregates job postings, removes duplicates, and extracts data from job postings text. This includes information on job title, employer, industry, and region, as well as required experience, education, and skills.

There are two job posting databases used in this analysis covering separate sets of geographies. While the aggregation process is largely the same, these databases differ slightly in terms of enrichment process, data structure, and taxonomies. The databases cover selected English-speaking countries (henceforth "English-speaking countries" database) and selected European countries (henceforth "European countries" databases) and include the following countries:

Table A A.1. Geographies included in both databases

"English-speaking countries" database	"European countries" databases
Australia	Austria
Canada	Belgium
New Zealand	France
United Kingdom	Germany
United States	Italy
	Netherlands
	Spain
	Sweden
	Switzerland

Source: Authors' elaboration based on Lightcast™ (December 2022).

Data collection – scraping

Lightcast collects data from a comprehensive set of online sources. It identifies websites with employment opportunity related content utilising spider technology to search those sites for employment opportunities. Currently, Lightcast maintains two kinds of spiders, which: 1) continually monitor or scout websites to identify those that include employment opportunities; and 2) continually spider and extract employment opportunity related information from a master list of websites. The use of "scout" spiders enables Lightcast to recognise new sites and queue them for addition to a master list. This sophisticated, two-step process enables Lightcast to retrieve job listings from a much broader range of sources, including job boards, government agencies, educational institutions, and thousands of employers of all sizes, locations, and industries.

Data collection – deduplication

Lightcast deduplicates job postings to ensure that the dataset does not contain the same posting multiple times. The deduplication process uses a machine learning algorithm to determine whether two job postings are duplicates. As duplicates usually are not exactly identical, the deduplication process uses a statistical classifier that has been trained to detect duplicates by comparing a number of fields in the postings, including location, job title, similarity of posting text, contact information in the posting, and company name.

Data collection – Enrichment Process and Data Structure

Once the postings data is scraped and deduplicated, it undergoes further enrichment and cleaning. The steps for assigning these fields in each dataset are described below.

Table A A.2. Enrichment process and data structure

Field	"English-speaking" database	"European countries" databases
Company	A company (advertiser) is assigned to each job posting based on the text present in the posting. This data includes the normalised company name, local industry code, company size, company location, whether the company is a staffing company, and other information. All subsidiary entities are reported at the top-level corporate enterprise.	A company (advertiser) is assigned to each job posting based on the text present in the posting with some basic cleaning applied to remove extra words.
Industry	The industry classification is directly linked to the name of the company. Taxonomy: North American Industry Classification System (NAICS)	The industry classification is based on a machine learning model that takes into account the whole text of the posting. Taxonomy: NACE
Occupation	The occupation is inferred from the job title and the job text. Taxonomy: Lightcast Occupations	The occupation is inferred from the job title and the job text. Taxonomy: ESCO Occupations
Skill	Skills data are extracted using the text of the posting based on classification rules. Lightcast takes the text of the posting and looks for specific sequences of words that indicate skills. For example, the text "use Microsoft Word", "write Word documents", and "draft documents in Microsoft Word" would all be tagged as the skill "Microsoft Word". The Lightcast taxonomy team maintains a complete list of these phrases for each skill and continuously improves them. Taxonomy: Lightcast Skills	Skills data are extracted using a machine learning model that is trained on hand-annotated job postings. The Lightcast model team continuously refines this model. Taxonomy: ESCO Skills

Source: Authors' elaboration based on Lightcast™ (December 2022).

Skills classification

The Lightcast database for the "English-speaking" database relies on Lightcast's taxonomy for Occupations, Occupation Groups, and Skills. It includes over 32,000 unique skills, which encompass competencies, knowledge, and specific software. Each skill is classified as a technical skill, a human skill,

or a certification. The taxonomy is built based on Lightcast's job posting data and includes a three-tiered hierarchy of Skill Categories, Skill Subcategories, and Skills/Certifications.

The Lightcast "European countries" database relies on the ESCO taxonomy for Occupations (ESCO Level 4), Occupation Groups (ESCO Level 1), and Skills (ESCO Skills). This taxonomy was built to provide a common language to help job seekers find jobs that match their skills, connect employment and education providers, and connect labour markets across Europe.[1] It covers 13,890 unique skills, competences, and knowledge but suffers from two primary limitations. First, many of the skills in the taxonomy do not align with the language used in job postings. For example, some skills that appear in the taxonomy but do not appear in job postings include "apply anti-oppressive practices" (too broad) and "adjust envelope cutting-settings" (too specific). Because of this, only 5,750 of the 13,890 ESCO skills appear in job postings. Second, it is not hierarchical and does not cluster similar skills. For example, the skills "use spreadsheets" and "use spreadsheets software" exist separately. It also features both, specific software skills and the broader group of skills to which they belong: "computer programming" and types of computer programming, such as "Python" and "Java", coexist. In order to stay consistent with the ESCO taxonomy, we refer to unique ESCO skills as unique or separate skills, even if implicit in those skills are clusters or groups of skills.

[1] https://esco.ec.europa.eu/en/classification/skill_main

Annex B. Industry and occupation information

Industry classifications are not consistent across English-speaking and European countries in the sample. The “English-speaking” and “European countries” databases differ in their classification used to categorise industries and in the way industry information is extracted. Table A B.1. shows how both databases differ in terms of taxonomy and extraction of industry information. For cross-country comparisons, a harmonisation of industries across European and English-speaking countries is required, as provided in Table A B.2. . The share of postings with available industry information is provided in Annex Table A B.3..

Occupation classifications in the “English-speaking” and “European countries” database use different taxonomies. The English-speaking database uses an occupation taxonomy developed by Lightcast. This occupation taxonomy is hierarchical and includes four levels: Career Areas, Occupation Groups, Occupations, and Specialised occupations. The analyses in this paper primarily rely on Occupation Groups. To categorise occupations in the European countries database, the taxonomy developed by the European multilingual classification of Skills, Competences and Occupations (ESCO) is used. In both databases, the type of occupation is inferred from the job title and the job text. Annex Table A B.3. shows the share of postings with available occupation information.

Table A B.1. Databases differences related to industry classifications

	English-speaking	European countries
Taxonomy	Local taxonomy, e.g. NAICS in the United States and Canada	Nomenclature of Economic Activities (NACE)
Extraction	Industry classification is linked to the company name	Industry classification is based on a machine learning model that takes into account the whole text of the posting

Note: The table shows differences between both databases in terms of taxonomy and extraction of industry information.
Source: Lightcast™ (December 2022).

Table A B.2. Industry harmonisation

Industries				Final
European countries	**Canada, United States**	**United Kingdom**	**Australia, New Zealand**	**Hamornised across countries**
Agriculture, forestry, and fishing	Agriculture, Forestry, Fishing and Hunting	agriculture, forestry and fishing	Agriculture, Forestry and Fishing	Agriculture
Mining and quarrying	Mining, Quarrying, and Oil and Gas Extraction	mining and quarrying	Mining	Mining
Construction	Construction	construction	Construction	Construction
Manufacturing	Manufacturing	manufacturing	Manufacturing	Manufacturing
Information and communication	Information	information and communication	Information Media and Telecommunications	ICT
Professional, scientific and technical activities	Professional, Scientific and Technical Services	professional, scientific and technical activities	Professional, Scientific, and Technical Services	Prof. activities
Education	Educational Services	education	Education and Training	Education
Transportation and storage	Transportation and Warehousing	transportation and storage	Transport, Postal and Warehousing	Transportation

Arts, entertainment and recreation	Arts, Entertainment, and Recreation	arts, entertainment and recreation	Arts and Recreation Services	Arts
Real estate activities	Real Estate and Rental and Leasing	real estate activities	Rental, Hiring and Real Estate Services	Real estate
Administrative and support service activities	Administrative and Support and Waste Management and Remediation Services	administrative and support service activities	Administrative and Support Services	Admin. Services
Public administration and defense; compulsory social security	Public Administration	public administration and defense; compulsory social security	Public Administration and Safety	Public admin.
Human health and social work activities	Health Care and Social Assistance	human health and social work activities	Health Care and Social Assistance	Health
Financial and insurance activities	Finance and Insurance	financial and insurance activities	Financial and Insurance Services	Fin. & insurance
Electricity, gas, steam and air conditioning supply	Utilities	electricity, gas, steam and air conditioning supply	Electricity, Gas, Water and Waste Services	Utilities
Water supply; sewerage, waste management and remediation activities		water supply; sewerage, waste management and remediation activities		Utilities
Wholesale and retail trade; repair of motor vehicles and motorcycles	Wholesale Trade	wholesale and retail trade; repair of motor vehicles and motorcycles	Wholesale Trade	Wholesale & retail
	Retail Trade		Retail Trade	Wholesale & retail
Accommodation and food service activities	Accommodation and Food Services	accommodation and food service activities	Accommodation and Food Services	Accomm. & food
Other service activities	Other Services (except Public Administration)	other service activities	Other Services	Other services

Note: The table shows the different industry classifications by country or group of countries represented in the analysis. The following industries have been excluded from the analysis: Activities of extraterritorial organisations and bodies (European countries), Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use (European countries), Management of Companies and Enterprises (Canada and the United States), Activities of extraterritorial organisations and bodies (United Kingdom) and activities of households as employers; undifferentiated goods-and services-producing activities of households for own use (United Kingdom). The last column presents the industry titles used in the paper.
Source: Authors' elaboration based on Lightcast™ (December 2022).

Table A B.3. Available industry and occupation information

Country	Number of postings (2019)	Number of postings (Jan - Nov 2022)	Industry coverage (Jan - Nov 2022)	Occupation coverage (Jan - Nov 2022)
United States	35,134,032	38,807,164	74%	96%
United Kingdom	6,929,109	9,502,705	58%	91%
Canada	1,456,835	2,174,112	55%	93%
Australia	1,109,112	1,184,389	59%	83%
New Zealand	323,405	314,531	46%	78%
Italy	1,275,218	2,135,833	97%	99.6%
Germany	7,535,552	10,873,984	99.6%	99%
Spain	1,468,362	1,219,714	96%	96%
Sweden	558,763	920,428	96%	93%
Switzerland	1,594,105	1,831,825	99.8%	98%
Belgium	1,394,434	1,654,203	99.8%	97%
Netherlands	1,496,235	1,373,754	98.2%	98%
France	4,683,566	8,952,048	99.8%	97%
Austria	534,863	907,712	99.2%	97%

Source: Lightcast™ (December 2022).

Annex C. AI skills classification

In order to measure the demand by employers of AI skills, Lightcast uses its skills taxonomy of over 32,000 skills. The list of AI skills from Lightcast data is shown below, with associated skill clusters. While some skills are assigned to the AI cluster itself, for the purposes of this report, all skills below were considered AI skills. The skills were then broken down into two different categories: 'generic' and 'specific'. A job posting is considered to be an AI job posting if it contains at least two generic or one specific AI skill.

Table A C.1. Categorisation of AI skills

Skill	AI Skill Cluster	Category
AIOps (Artificial Intelligence For IT Operations)	Artificial Intelligence	specific
Applications Of Artificial Intelligence	Artificial Intelligence	generic
Artificial General Intelligence	Artificial Intelligence	generic
Artificial Intelligence	Artificial Intelligence	generic
Artificial Intelligence Development	Artificial Intelligence	generic
Artificial Intelligence Markup Language (AIML)	Artificial Intelligence	specific
Artificial Intelligence Systems	Artificial Intelligence	generic
Azure Cognitive Services	Artificial Intelligence	specific
Baidu	Artificial Intelligence	generic
Cognitive Automation	Artificial Intelligence	specific
Cognitive Computing	Artificial Intelligence	specific
Computational Intelligence	Artificial Intelligence	specific
Cortana	Artificial Intelligence	generic
Expert Systems	Artificial Intelligence	generic
Intelligent Control	Artificial Intelligence	generic
Intelligent Systems	Artificial Intelligence	generic
Interactive Kiosk	Artificial Intelligence	generic
IPSoft Amelia	Artificial Intelligence	specific
Knowledge-Based Configuration	Artificial Intelligence	generic
Knowledge-Based Systems	Artificial Intelligence	generic
Multi-Agent Systems	Artificial Intelligence	generic
Open Neural Network Exchange (ONNX)	Artificial Intelligence	specific
OpenAI Gym	Artificial Intelligence	specific
Reasoning Systems	Artificial Intelligence	specific
Soft Computing	Artificial Intelligence	generic
Syman	Artificial Intelligence	generic
Watson Conversation	Artificial Intelligence	generic
Watson Studio	Artificial Intelligence	specific
Weka	Artificial Intelligence	generic
Advanced Driver Assistance Systems	Autonomous Driving	generic
Autonomous Cruise Control Systems	Autonomous Driving	specific
Autonomous System	Autonomous Driving	specific
Autonomous Vehicles	Autonomous Driving	specific
Guidance Navigation And Control Systems	Autonomous Driving	generic
Light Detection And Ranging (LiDAR)	Autonomous Driving	generic
OpenCV	Autonomous Driving	specific
Path Analysis	Autonomous Driving	generic
Path Finding	Autonomous Driving	generic
Remote Sensing	Autonomous Driving	generic
Unmanned Aerial Systems (UAS)	Autonomous Driving	generic
AdaBoost (Adaptive Boosting)	Machine Learning	generic
Apache MADlib	Machine Learning	specific
Apache Mahout	Machine Learning	specific
Apache SINGA	Machine Learning	generic
Apache Spark	Machine Learning	generic

Association Rule Learning	Machine Learning	specific
Automated Machine Learning	Machine Learning	specific
Autonomic Computing	Machine Learning	generic
AWS SageMaker	Machine Learning	specific
Azure Machine Learning	Machine Learning	specific
Boosting	Machine Learning	generic
CHi-Squared Automatic Interaction Detection (CHAID)	Machine Learning	specific
Classification And Regression Tree (CART)	Machine Learning	specific
Cluster Analysis	Machine Learning	specific
Collaborative Filtering	Machine Learning	specific
Confusion Matrix	Machine Learning	generic
Cyber-Physical Systems	Machine Learning	generic
Dask (Software)	Machine Learning	generic
Data Classification	Machine Learning	generic
Dbscan	Machine Learning	specific
Decision Models	Machine Learning	specific
Decision Tree Learning	Machine Learning	specific
Dimensionality Reduction	Machine Learning	specific
Dlib (C++ Library)	Machine Learning	specific
Ensemble Methods	Machine Learning	specific
Evolutionary Programming	Machine Learning	generic
Expectation Maximization Algorithm	Machine Learning	specific
Feature Engineering	Machine Learning	specific
Feature Extraction	Machine Learning	specific
Feature Learning	Machine Learning	specific
Feature Selection	Machine Learning	generic
Gaussian Process	Machine Learning	generic
Genetic Algorithm	Machine Learning	specific
Google AutoML	Machine Learning	specific
Google Cloud ML Engine	Machine Learning	specific
Gradient Boosting	Machine Learning	specific
H2O.ai	Machine Learning	specific
Hidden Markov Model	Machine Learning	generic
Hyperparameter Optimization	Machine Learning	specific
Inference Engine	Machine Learning	specific
K-Means Clustering	Machine Learning	specific
Kernel Methods	Machine Learning	generic
Kubeflow	Machine Learning	specific
LIBSVM	Machine Learning	specific
Machine Learning	Machine Learning	generic
Machine Learning Algorithms	Machine Learning	generic
Markov Chain	Machine Learning	generic
Matrix Factorization	Machine Learning	generic
Meta Learning	Machine Learning	generic
Microsoft Cognitive Toolkit (CNTK)	Machine Learning	specific
MLflow	Machine Learning	specific
MLOps (Machine Learning Operations)	Machine Learning	specific
mlpack (C++ Library)	Machine Learning	specific
Naive Bayes	Machine Learning	generic
Perceptron	Machine Learning	generic
Predictionio	Machine Learning	specific
PyTorch (Machine Learning Library)	Machine Learning	specific
Random Forest Algorithm	Machine Learning	specific
Recommendation Engine	Machine Learning	specific
Recommender Systems	Machine Learning	specific
Reinforcement Learning	Machine Learning	specific
Scikit-learn (Machine Learning Library)	Machine Learning	specific
Semi-Supervised Learning	Machine Learning	specific
Soft Computing	Machine Learning	generic
Sorting Algorithm	Machine Learning	specific
Supervised Learning	Machine Learning	specific
Support Vector Machine	Machine Learning	specific
Test Datasets	Machine Learning	generic
Torch (Machine Learning)	Machine Learning	generic
Training Datasets	Machine Learning	generic
Transfer Learning	Machine Learning	specific
Unsupervised Learning	Machine Learning	specific
Vowpal Wabbit	Machine Learning	specific

Xgboost	Machine Learning	specific
Amazon Textract	Natural Language Processing	specific
ANTLR	Natural Language Processing	generic
BERT (NLP Model)	Natural Language Processing	specific
Chatbot	Natural Language Processing	generic
Computational Linguistics	Natural Language Processing	generic
DeepSpeech	Natural Language Processing	specific
Dialog Systems	Natural Language Processing	generic
fastText	Natural Language Processing	specific
Fuzzy Logic	Natural Language Processing	generic
Handwriting Recognition	Natural Language Processing	generic
Hugging Face (NLP Framework)	Natural Language Processing	specific
Hugging Face Transformers	Natural Language Processing	specific
Intelligent Agent	Natural Language Processing	generic
Intelligent Software Assistant	Natural Language Processing	generic
Intelligent Virtual Assistant	Natural Language Processing	generic
Kaldi	Natural Language Processing	specific
Latent Dirichlet Allocation	Natural Language Processing	specific
Lexalytics	Natural Language Processing	generic
Machine Translation	Natural Language Processing	generic
Microsoft LUIS	Natural Language Processing	specific
Natural Language Generation	Natural Language Processing	specific
Natural Language Processing	Natural Language Processing	specific
Natural Language Processing Systems	Natural Language Processing	specific
Natural Language Programming	Natural Language Processing	specific
Natural Language Toolkits	Natural Language Processing	specific
Natural Language Understanding	Natural Language Processing	specific
Natural Language User Interface	Natural Language Processing	generic
Nearest Neighbour Algorithm	Natural Language Processing	specific
OpenNLP	Natural Language Processing	specific
Optical Character Recognition (OCR)	Natural Language Processing	generic
Screen Reader	Natural Language Processing	generic
Semantic Analysis	Natural Language Processing	generic
Semantic Interpretation For Speech Recognition	Natural Language Processing	generic
Semantic Parsing	Natural Language Processing	generic
Semantic Search	Natural Language Processing	generic
Sentiment Analysis	Natural Language Processing	generic
Seq2Seq	Natural Language Processing	specific
Speech Recognition	Natural Language Processing	generic
Speech Recognition Software	Natural Language Processing	generic
Statistical Language Acquisition	Natural Language Processing	generic
Text Mining	Natural Language Processing	specific
Tokenization	Natural Language Processing	specific
Voice Interaction	Natural Language Processing	generic
Voice User Interface	Natural Language Processing	generic
Word Embedding	Natural Language Processing	specific
Word2Vec Models	Natural Language Processing	specific
Apache MXNet	Neural Networks	specific
Artificial Neural Networks	Neural Networks	specific
Autoencoders	Neural Networks	specific
Caffe	Neural Networks	specific
Caffe2	Neural Networks	specific
Chainer (Deep Learning Framework)	Neural Networks	specific
Convolutional Neural Networks	Neural Networks	specific
Cudnn	Neural Networks	specific
Deep Learning	Neural Networks	specific
Deeplearning4j	Neural Networks	specific
Keras (Neural Network Library)	Neural Networks	specific
Long Short-Term Memory (LSTM)	Neural Networks	specific
OpenVINO	Neural Networks	specific
PaddlePaddle	Neural Networks	specific
Pybrain	Neural Networks	specific
Recurrent Neural Network (RNN)	Neural Networks	specific
TensorFlow	Neural Networks	specific
Advanced Robotics	Robotics	specific
Cognitive Robotics	Robotics	specific
Motion Planning	Robotics	generic
Nvidia Jetson	Robotics	specific

Robot Framework	Robotics	specific
Robot Operating Systems	Robotics	specific
Robotic Automation Software	Robotics	specific
Robotic Liquid Handling Systems	Robotics	specific
Robotic Programming	Robotics	specific
Robotic Systems	Robotics	specific
Servomotor	Robotics	generic
SLAM Algorithms (Simultaneous Localization And Mapping)	Robotics	generic
3D Reconstruction	Visual Image Recognition	generic
Activity Recognition	Visual Image Recognition	generic
Computer Vision	Visual Image Recognition	generic
Contextual Image Classification	Visual Image Recognition	generic
Digital Image Processing	Visual Image Recognition	generic
Eye Tracking	Visual Image Recognition	generic
Face Detection	Visual Image Recognition	generic
Facial Recognition	Visual Image Recognition	generic
Image Analysis	Visual Image Recognition	generic
Image Matching	Visual Image Recognition	generic
Image Processing	Visual Image Recognition	generic
Image Recognition	Visual Image Recognition	generic
Image Segmentation	Visual Image Recognition	generic
Image Sensor	Visual Image Recognition	generic
Imagenet	Visual Image Recognition	specific
Machine Vision	Visual Image Recognition	generic
Motion Analysis	Visual Image Recognition	generic
Object Recognition	Visual Image Recognition	generic
OmniPage	Visual Image Recognition	generic
Pose Estimation	Visual Image Recognition	generic
Realsense	Visual Image Recognition	specific

Note: The table provides the categorisation of each AI skill in generic and specific and the assignment into one of the seven skill clusters.
Source: Lightcast™ (December 2022).

Annex D. Supporting material

Table A D.1. Top 20 occupations in AI job postings by top AI employers (2022)

Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies across occupations, United States

Occupation	Top AI	Other AI	Non-AI
Software Development	21.4	22.9	3.7
Data Analysis and Mathematics	12.5	15.7	0.6
Network and Systems Engineering	12.3	9.3	2.1
Database Specialists	6.3	6.5	0.6
Marketing Specialists	4.8	4.2	1.8
General Research	3.4	2.2	0.4
IT Managers	2.8	1.9	0.8
Business Analysis	2.1	1.6	1.1
Network and Systems Support	2.0	1.6	1.3
Project and Program Managers	2.0	1.7	1.4
Engineering Managers	1.9	1.7	0.4
Business Intelligence	1.7	1.3	0.4
Human Resources Specialists	1.7	0.9	2.1
Mechanical and Related Engineers	1.6	3.2	0.8
Accounting Professionals	1.4	0.3	1.3
General Managers	1.2	0.6	0.6
Financial Analysis	1.2	0.8	0.8
Electrical, Electronic, and Related Engineering	1.1	2.6	0.7
Operations Managers	1.1	0.7	1.2
Sales Managers	0.9	1.1	1.2

Note: The table shows, for the United States, the occupational distribution of online vacancies requiring AI skills, distinguishing AI vacancies posted by the top ten AI employers ("Top AI") from those posted by other AI employers ("Other AI"). The top ten AI employers are the ten firms in each industry that posted the largest share of AI vacancies. The table displays only the top 20 occupations based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies in a specific occupation relative to their total number of AI vacancies across occupations, hence the shares across all occupations (not only the top ten displayed here) sum up to 100%. The table also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI") that are for the same specific occupation. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

Table A D.2. Top 20 technical skills in AI job postings by top AI employers (2022)

Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies requiring technical skills, United States

Technical skill	Top AI	Other AI	Non-AI
Python (Programming Language)	43.6	46.3	1.3
Computer Science	40.0	39.1	3.0
Amazon Web Services	25.2	20.6	1.0
Data Science	24.8	27.6	0.0
SQL (Programming Language)	24.7	26.0	1.7
Data Analysis	24.5	22.9	2.7
Automation	21.0	20.1	2.3
Agile Methodology	21.0	20.7	2.6
Software Engineering	20.9	18.3	1.2
Java (Programming Language)	20.2	17.5	1.0
R (Programming Language)	18.6	18.4	0.0
Microsoft Azure	16.1	12.7	0.4
Algorithms	15.8	18.1	0.0
Software Development	15.2	16.1	1.2
Big Data	15.0	13.5	0.0
Scalability	14.0	13.2	0.2
Statistics	13.7	12.9	0.0
C++ (Programming Language)	11.6	13.4	0.0
Apache Hadoop	10.0	7.2	0.0
Business Intelligence	9.3	5.0	0.0

Note: The table shows, for the United States, the percentage of AI online vacancies mentioning a specific technical skill, distinguishing AI vacancies posted by the top ten AI employers ("Top AI") from those posted by other AI employers ("Other AI"). The top ten AI employers are the ten firms in each industry that posted the largest share of AI vacancies. The table displays only the top 20 technical skills based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies requiring a specific skill relative to their total number of AI vacancies, hence the shares across all skills can exceed 100%. The table also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that mention the same specific skill. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

Table A D.3. Top 20 socio-emotional and foundational skills in AI job postings by top AI employers (2022)

Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies requiring socio-emotional and foundational skills, United States

Socio-emotional and foundational skill	Top AI	Other AI	Non-AI
Communications	46.4	44.8	38.0
Leadership	35.0	26.7	17.5
Management	33.3	26.6	25.7
Research	26.6	25.5	7.8
Problem-Solving	25.1	21.4	12.9
Innovation	24.1	18.8	3.8
Operations	23.1	20.8	17.9
Mathematics	21.3	19.0	4.1
Writing	16.8	17.1	11.8
Presentations	15.5	14.3	6.2
Planning	14.6	13.6	11.1
Customer Service	14.1	12.4	28.9
Sales	13.7	11.6	17.8
Mentorship	12.1	8.7	3.2
Interpersonal Communications	10.8	8.7	8.8
Consulting	10.5	5.4	1.5
Verbal Communication Skills	10.3	11.3	7.3
Self-Motivation	10.2	11.5	7.3
Decision-Making	9.4	8.1	4.4

Note: The table shows, for the United States, the percentage of AI online vacancies mentioning a specific socio-emotional and foundational skill, distinguishing AI vacancies posted by the top ten AI employers ("Top AI") from those posted by other AI employers ("Other AI"). The top ten AI employers are the ten firms in each industry that posted the largest share of AI vacancies. The table displays only the top 20 socio-emotional and foundational skills based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies requiring a specific skill relative to their total number of AI vacancies, hence the shares across all skills can exceed 100%. The table also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that mention the same specific skill. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

Table A D.4. Top 20 technical skills in AI job postings by top AI employers across industries (2022)

Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies requiring specific skills, United States

Technical skill	Top AI	Other AI	Non-AI
Python (Programming Language)	45.3	44.9	1.5
Amazon Web Services	42.9	19.2	1.2
Computer Science	41.0	38.8	3.1
Software Engineering	27.9	18.6	1.3
Java (Programming Language)	27.5	16.8	1.3
Agile Methodology	27.5	19.2	2.7
SQL (Programming Language)	26.2	25.1	2.1
Data Science	25.8	26.8	0.3
Microsoft Azure	23.6	12.6	0.9
Automation	22.4	19.8	2.4
Software Development	22.3	15.4	1.4
Data Analysis	20.1	23.8	2.8
Big Data	19.4	13.8	0.2
R (Programming Language)	18.5	18.3	0.4
Scalability	17.3	13.2	1.0
Data Engineering	17.1	9.4	0.2
Algorithms	15.5	18.0	0.3
C++ (Programming Language)	15.4	13.7	0.5
Business Intelligence	15.1	7.2	0.6
Emerging Technologies	13.6	4.6	0.4

Note: The table shows, for the United States, the percentage of AI online vacancies mentioning a specific technical skill, distinguishing AI vacancies posted by the top ten AI employers ("Top AI") from those posted by other AI employers ("Other AI"). The top ten AI employers are the ten firms that posted the largest share of AI vacancies across industries. The table displays only the top 20 technical skills based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies requiring a specific skill relative to their total number of AI vacancies, hence the shares across all skills can exceed 100%. The table also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that mention the same specific skill. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' own compilation based on Lightcast™ (December 2022).

Table A D.5. Top 20 socio-emotional and foundational skills in AI job postings by top AI employers across industries (2022)

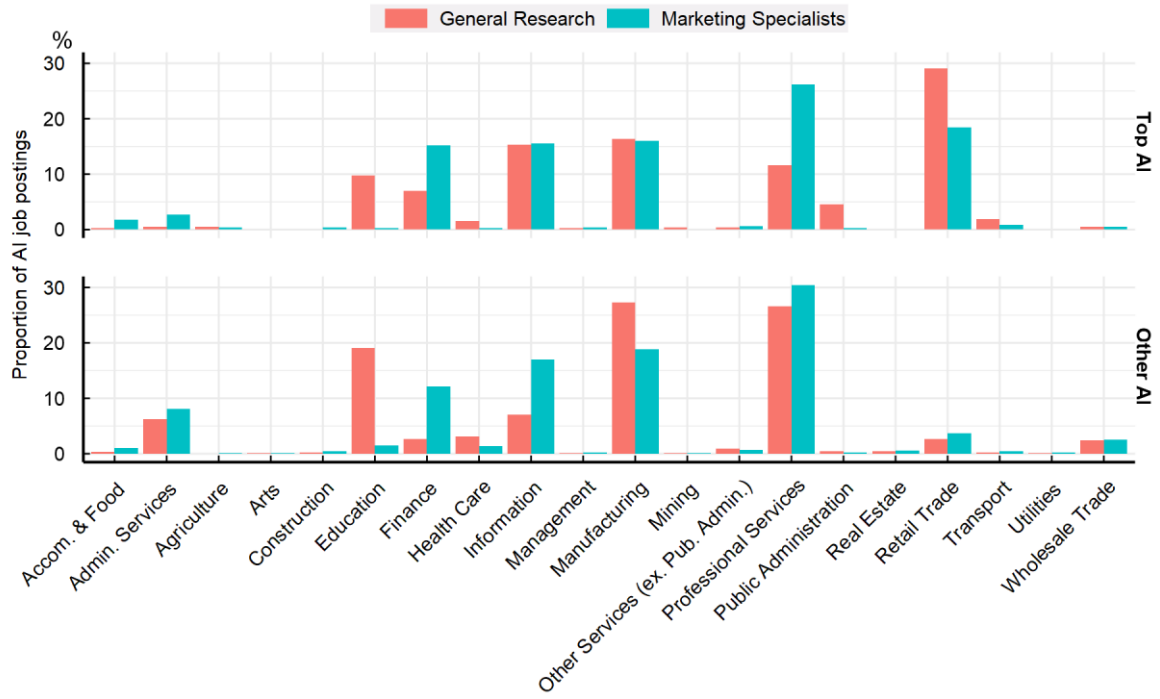
Percentage of AI online vacancies by top AI vs. other AI employers and percentage of non-AI online vacancies requiring specific skills, United States

Socio-emotional and foundational skill	Top AI	Other AI	Non-AI
Communications	41.8	45.1	36.7
Leadership	37.0	27.9	16.0
Management	31.4	28.4	24.3
Problem-Solving	30.3	21.3	12.0
Innovation	26.0	20.2	4.7
Mathematics	23.0	19.4	4.2
Operations	22.8	21.0	16.7
Writing	21.1	15.6	10.9
Research	20.3	27.1	7.8
Mentorship	16.0	8.8	3.4
Sales	15.7	12.1	16.9
Consulting	15.4	6.4	2.2
Customer Service	15.2	12.5	27.9
Planning	12.5	14.1	11.4
Presentations	12.5	13.2	6.7
Verbal Communication Skills	12.0	10.4	6.8
Troubleshooting	8.2	10.8	5.8
Self-Motivation	8.1	11.6	7.3
Forecasting	7.7	8.3	2.2

Note: The table shows, for the United States, the percentage of AI online vacancies mentioning a specific socio-emotional and foundational skill, distinguishing AI vacancies posted by the top ten AI employers ("Top AI") from those posted by other AI employers ("Other AI"). The top ten AI employers are the ten firms that posted the largest share of AI vacancies across industries. The table displays only the top 20 socio-emotional and foundational skills based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies requiring a specific skill relative to their total number of AI vacancies, hence the shares across all skills can exceed 100%. The table also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that mention the same specific skill. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' own compilation based on Lightcast™ (December 2022).

Figure A D.1. Top two non-STEM occupations in AI job postings by AI employers (2022)

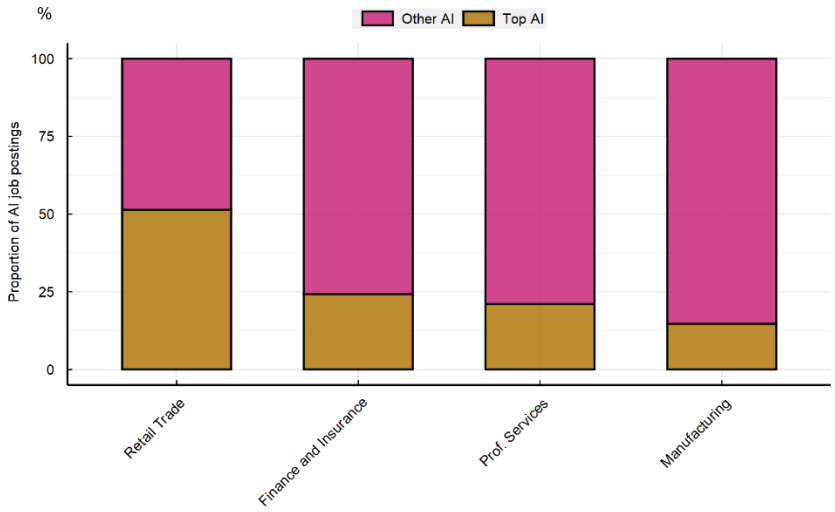
Percentage of AI online vacancies by top AI vs. other AI employers across industries, by occupation, United States



Note: The Figure shows, for the United States, the distribution across industries of online vacancies requiring AI skills for the top two non-STEM occupations, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", top Panel) from those posted by other AI employers ("Other AI", bottom Panel). The top ten AI employers are the ten firms in each industry that posted the largest share of AI vacancies. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies in a specific industry and occupation relative to their total number of AI vacancies across industries in the respective occupation, hence the shares for each occupation sum up to 100% across all industries. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

Figure A D.2. Share of US top ten AI and other AI employers, by industry (2022)

Percentage of online vacancies requiring AI skills posted by top ten AI and other AI employers, by top AI employers' industries, United States

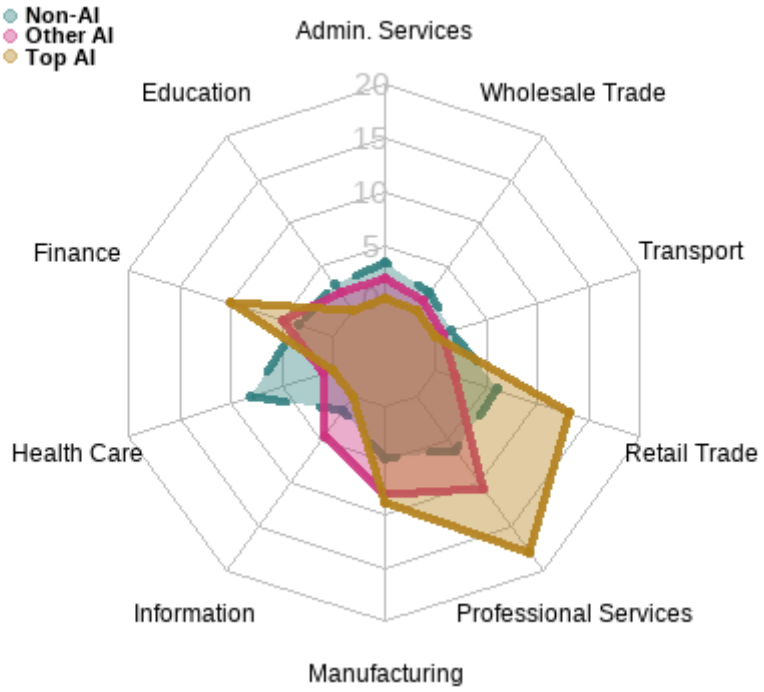


Note: The Figure shows, for the United States, the percentage of AI online vacancies by industry, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", mustard) from those posted by other AI employers ("Other AI", pink). The top ten AI employers are the ten firms that posted the largest share of AI vacancies across industries. The Figure displays only the four industries in which the top ten AI employers operate. For both, the top ten AI and other AI employers, the share is defined as their total number of online vacancies requiring AI skills (posted by the top ten AI vis-à-vis other AI employers) relative to the total number of AI online vacancies posted by both AI employers in a given industry. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills). Industries are sorted in descending order by the percentage of vacancies requiring AI skills posted by the top ten AI employers

Source: Authors' elaboration based on Lightcast™ (December 2022).

Figure A D.3. Distribution of different US employer types across industries (2022)

Percentage of online vacancies across industries, by employer type, United States



Note: The Figure shows, for the United States, the distribution across industries of online vacancies requiring AI skills, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", mustard) from those posted by other AI employers ("Other AI", pink). The top ten AI employers are the ten firms that posted the largest share of AI vacancies across industries. The Figure displays only the top 10 occupations based on AI vacancies posted by the other (not top) AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies in a specific industry relative to their total number of AI vacancies across industries, hence the shares across all industries (not only the top ten displayed here) sum up to 100%. The Figure also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that are in the same specific industry. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).

Figure A D.4. Distribution of different US employer types across occupations (2022)

Percentage of online vacancies across occupations, by employer type, United States

Note: The Figure shows, for the United States, the occupational distribution of online vacancies requiring AI skills, distinguishing AI vacancies posted by the top ten AI employers ("Top AI", mustard) from those posted by other AI employers ("Other AI", pink). The top ten AI employers are the ten firms that posted the largest share of AI vacancies across industries. The Figure displays only the top 10 occupations based on AI vacancies posted by the top ten AI employers. For both, the top ten AI and other AI employers, the share is defined as their total number of AI vacancies in a specific occupation relative to their total number of AI vacancies across occupations, hence the shares across all occupations (not only the top ten displayed here) sum up to 100%. The Figure also presents the percentage of the remaining online vacancies not requiring AI skills ("Non-AI", turquoise) that are for the same specific occupation. Vacancies requiring AI skills are vacancies in which at least two generic AI skills or at least one AI-specific skill were required (see Section 2.2 on generic and specific skills).
Source: Authors' elaboration based on Lightcast™ (December 2022).