ECONOMIC GRAPH

AI Talent in the European Labour Market

November 2019

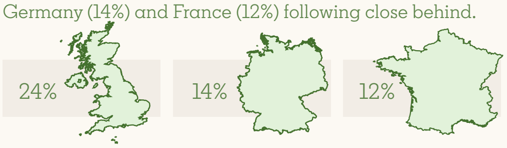
Executive Summary

Artificial Intelligence (AI) is a hotly debated topic, particularly in the context of its impact on the labour market and the workforce. These vital discussions are all too often based on assumptions and desktop projections rather than on concrete, objective data. Using data generated by LinkedIn's Economic Graph,[1] this report outlines new, evidence-based insights into the dynamic between AI and the labour market. This novel assessment of AI talent in Europe also uncovers emerging trends that can help inform policymaking in this area.

This report examines the relative distribution and concentration of AI talent and skills across the EU Member States, territories, and demographies. We define AI talent to encompass individuals who have both statistical modeling and big data computational skills, both of which are necessary to build and execute the algorithms that power AI technologies.

Large, well-established companies are most likely to be first adopters of AI in the EU -- a contrast to what we see in the U.S. market. And it follows that championing industries within Member States are the first to benefit from the diffusion: automotive companies in Germany, finance firms in the UK, and telecommunications firms and automotive in Sweden, are already seeing significant gains from investing in AI technologies.

Just three countries are home to half of all the EU's AI talent. The highest proportion (24%) can be found in the UK, with Germany (14%) and France (12%) following close behind.



Europe is lagging internationally.

The U.S. employs twice as many AI-skilled individuals than the EU, despite its total labour force being just half the size.

2x
AI-skilled people employed in the U.S.

Our analysis reveals that AI talent is spread unequally across Member States, industrial sectors, and demographic groups. Just three countries are home to half of all the EU's AI talent: the highest proportion (24%) can be found in the UK, followed by Germany (14%) and France (12%). The report also reveals that Europe is lagging behind the United States. The U.S. employs twice as many AI-skilled individuals than the EU, despite its total labour force being just half the size.

When looking at AI talent from an industry lens, we see that two-thirds of AI-skilled individuals work in the technology (ICT) sector or within academia. AI knowledge and technologies have not yet diffused to many segments of the European economy, either – we see that other industries are underrepresented when it comes to AI talent. We also find that AI talent distribution is uneven across gender, educational, and demographic lines.

In order to both transform the EU into an AI leader and simultaneously equalize the distribution of AI talent across socioeconomic and geographic spheres, policymakers must take action to establish and nurture AI ecosystems.

Industrial AI ecosystems would foster greater overlap between fundamental and applied research, and would diffuse AI skills across various fields of study, curricula, and levels of education -- including non-formal education. Monitoring how AI skills are acquired across the EU and establishing benchmarks between countries would also help to determine whether existing disparities can be linked to existing EU policies – or the absence of such policies. Without this kind of approach, AI could well become a new driver of inequality in Europe, which risks undermining the key tenets of the European project.

[1] While the LinkedIn data represents a good sample, we do not claim statistical representatitveness, since some biases may exist in the data due to LinkedIn's varying presence across countries, gender and industrial sectors. However, the analysis of LinkedIn data spots interesting trends that can help detect current gaps and guide policy-makers in the design of future policies.

1. Methodology Notes

On data limitation

This analysis represents the world seen through the lens of LinkedIn data, drawn from the anonymized and aggregated profile information of LinkedIn's 645+ million members around the world. As such, it is influenced by how members choose to use the platform, which can vary based on professional, social, and regional culture, as well as overall site availability and accessibility. These variances were not accounted for in the analysis.

Although LinkedIn's membership covers around 50 percent of Europe's active labour force, its members are not evenly distributed across the EU. While the results are therefore not statistically representative,the digital and tech workforce tends to be well represented within our membership, even in countries where LinkedIn's overall market share is smaller.

On AI talent identification

The methodology used in this analysis uses a two-step approach. First, all LinkedIn member profiles are filtered by a set of AI keywords. A machine learning model is then applied to further refine this population. This methodology is stricter in its requirements to result in "AI" assignation for a profile than the previous one. As such, those identified as "AI talent" are very likely to possess the needed skills and experience to design and create AI technologies and applications. The trade-off is that it may not capture all kinds of AI talent, especially those whose profiles contains weak AI signals. The benefit of this methodology is that we can have a high degree of confidence that members identified are truly AI professionals. The model showed a precision of 74% when evaluated with manually labelled profiles.

For more detailed information on the methodology used in this report you can refer to the full methodology notes in the appendix as well as Thomas Roca, 2019, "Identifying AI talent among LinkedIn members, A machine learning approach," available here.

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Introduction

The debate around AI-induced automation and its likely impact on jobs and the labour market is often deeply contentious and polarising, and it is rarely based on strong empirical evidence. Policymakers, academics, and business leaders have yet to achieve consensus on answering some fundamental questions, such as: how fast is AI diffusing in industry and services? Is AI already impacting the job market? Where are AI skills coming from and going to?

To date, two perspectives have dominated the debate around AI in the labour market AI advocates present it as an opportunity for businesses to increase productivity, foster innovation, access new markets, and free up human workers currently performing mundane or dangerous tasks to take on more human-centric, self-actualizing careers. Detractors see AI as a disruptive technology likely to lead to massive job losses and increased job polarization.

Academic research has tried to quantify the impact of AI on the labor market,[2] but has been limited by datasets that lack the level of granularity or timeliness needed to understand this rapidly emerging technology. Even estimates of the AI worker population are often acknowledged as working assumptions, based on the methodology used to construct those numbers and biased data sources. Data is similarly scarce when it comes to AI workers and implementation of AI systems within companies.

The European Union and governments across Europe are currently devising their own AI strategy, and would greatly benefit from objective data and insights about AI skills needed, AI diffusion progress and hindrance.

LinkedIn can provide unique insights to inform these strategies. LinkedIn's data is derived not only from AI professionals – their skills, distribution by industry, and geographic location – but also from AI job openings. By studying LinkedIn's Economic Graph data, we can measure supply and demand of talent trends in real-time, providing a comprehensive baseline of insights that can better inform AI diffusion in the economy as we track trends over time.

This research aims to provide new evidence and indicators that will contribute to discussion on the impact of AI on the European labour market. This paper explores four areas:

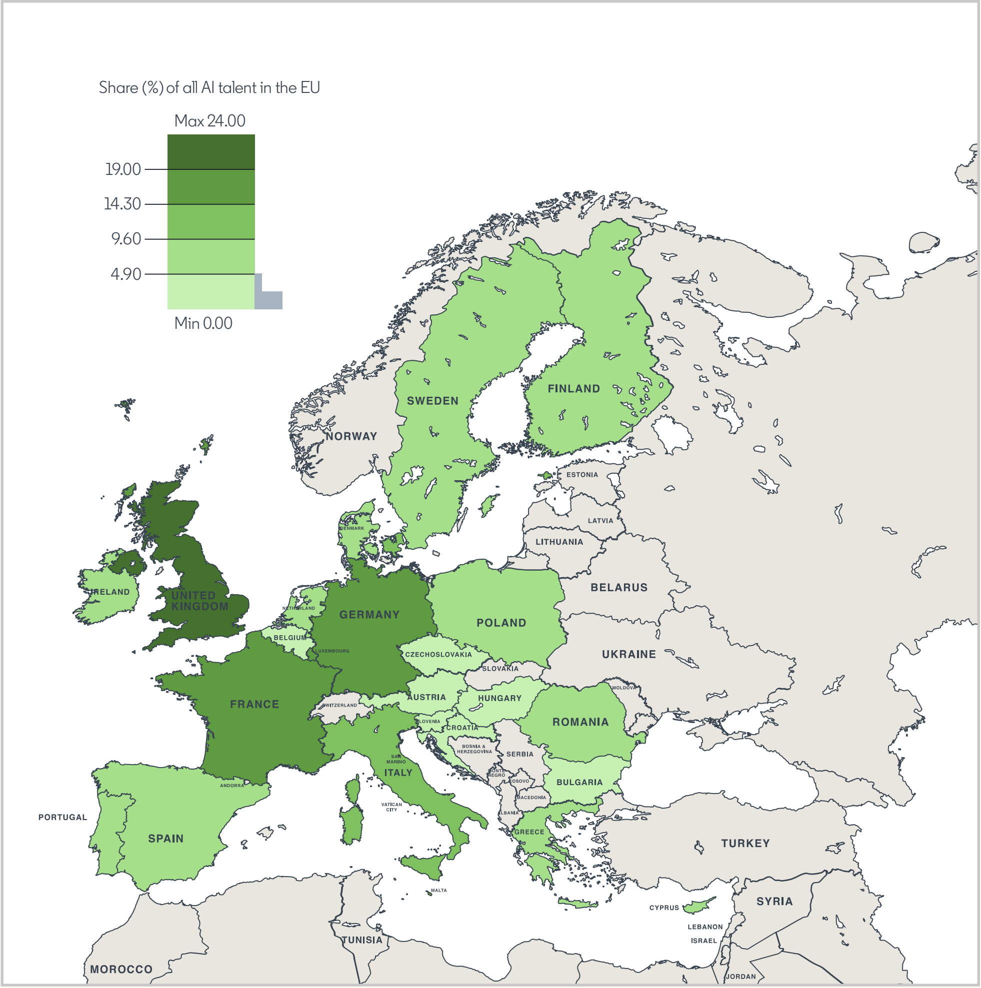
- Mapping the state of AI in the European Union, highlighting similarities and differences across EU Member States.
- Comparing the characteristics of AI talent across EU countries.
- Sharing interpretations for the variations we notice across countries.
- Contributing policy recommendations that can help transform the EU into an AI champion and simultaneously diversify the distribution of AI talent across socioeconomic and geographic spheres.

[2] Carl Benedict Frey and Micheal A. Osborne, 2013, "The future of employment: how susceptible are jobs to computerization?"; T. Gregory Arntz, M. and U. Zierahn., 2013, "The risk of automation for jobs in OECD countries: A comparative analysis."

Geographic Trends

The presence of AI workers varies significantly across EU Member States.[3] Most AI talent is concentrated in Western Europe, and AI skills are a rarer resource in Central and Eastern Europe. The geographical divide within Western Europe is itself stark. Half of all Europe's AI workers are based in just three countries: the United Kingdom (UK), France, and Germany. The UK leads by a significant margin, with nearly a quarter (24%) of all Europe's AI talent even though its active population only accounts for 13,4% of Europe's total workforce.

Figure 1. AI talent distribution in the European Union



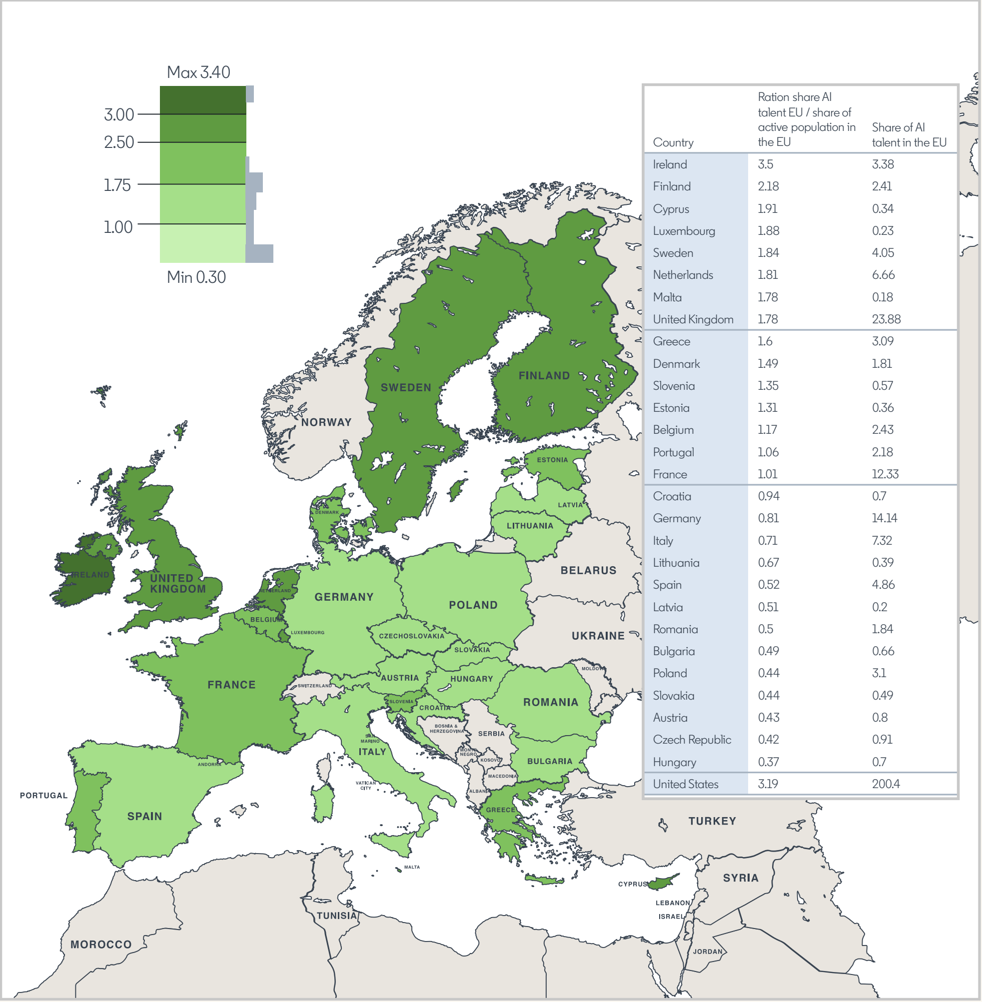
[3] Previous LinkedIn research on the prevalence of AI skills across the world can be found here: https://economicgraph.linkedin.com/blog/how-artificial-intelligence-is-already-impacting-todays-jobs

2. AI intensity trends explained

Ireland's high ratio of AI talent may be attributed to the fact that many leading multinational technology companies have established their European headquarters in the country, in addition to establishing data analytics, machine learning, and data centers. This has given rise to a research-led approach to building AI talent, fostered through the creation of various university AI centers. The close partnership between universities and industry during the development of this approach has been demonstrated by initiatives such as the AI Awards.

More generally, AI talent has very low unemployment rates so countries with low active population rates – for example, due to high unemployment -- may have more favorable rankings in this list than countries with high active populations.

Figure 2. AI intensity in the European Union*



Country	Ration share AI talent EU / share of active population in the EU	Share of AI talent in the EU
Ireland	3.5	3.38
Finland	2.18	2.41
Cyprus	1.91	0.34
Luxembourg	1.88	0.23
Sweden	1.84	4.05
Netherlands	1.81	6.66
Malta	1.78	0.18
United Kingdom	1.78	23.88
Greece	1.6	3.09
Denmark	1.49	1.81
Slovenia	1.35	0.57
Estonia	1.31	0.36
Belgium	1.17	2.43
Portugal	1.06	2.18
France	1.01	12.33
Croatia	0.94	0.7
Germany	0.81	14.14
Italy	0.71	7.32
Lithuania	0.67	0.39
Spain	0.52	4.86
Latvia	0.51	0.2
Romania	0.5	1.84
Bulgaria	0.49	0.66
Poland	0.44	3.1
Slovakia	0.44	0.49
Austria	0.43	0.8
Czech Republic	0.42	0.91
Hungary	0.37	0.7
United States	3.19	200.4

The distribution of AI talent is generally correlated with population size: countries with the largest populations have the largest AI talent pools. To understand how capable or not countries are of developing or attracting AI talent, we first look at a ratio we call AI intensity: the number of AI workers compared to the size of the active population in each country.

Mapping AI intensity confirms the East-West divide among AI talent in the EU. But it also suggests that six countries – Ireland, Finland, Cyprus, Luxembourg, Sweden, and the Netherlands – are leading the EU in attracting or developing AI talent. Ireland stands out, with a ratio far above the others in this group. This may well be explained by the strong presence of technology companies in the country (see Box 2). Other surprising findings: Slovenia is the only Eastern and Central European country that does not fall into the yellow category; and Greece, Malta, and Cyprus outperform their Mediterranean peers (Italy, Portugal, and Spain).

* The table in Figure 2 indicates the ratio of AI talent to the active population and compares it with the share of AI talent in the EU. Countries are listed according to their ratio in declining order, grouped into three categories (high, medium and low). Each category is assigned a corresponding color: the countries with a high ratio (above 1.8) are in dark green, countries with a medium ratio (1-1.75) are in light green, and countries with a low ratio (below 1) are in yellow. For comparative purposes, the table also includes the U.S., which has an AI talent pool twice the size of the EU's, and the second highest AI intensity after Ireland. Note that a country with a score equal to 1 has an AI talent pool corresponding to its demographic weight in European active labour force, and country with a score higher than one is attracting more AI talent relative to other Member States.

Industry Trends

We gain a greater understanding of how prevalent AI is across the European economy by looking at the companies where AI talent can currently be found.

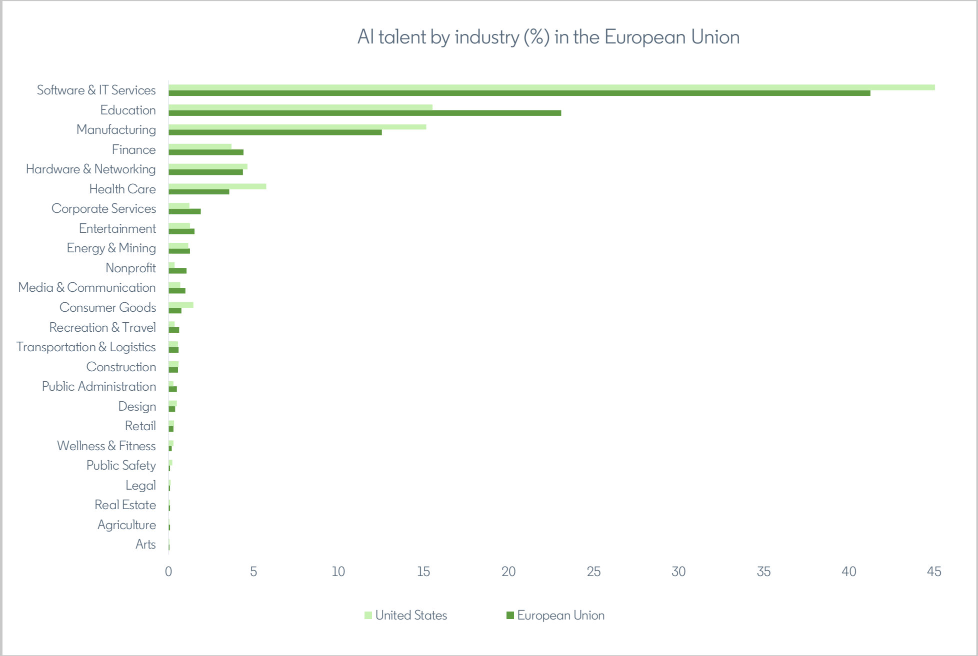
Previous LinkedIn research has shown that AI technologies are more pervasive across industries than many people realize.[4] Not all individuals with AI skills who are working in a given sector are necessarily working on AI tasks that are specific to that sector alone, and their skills could be deployed in virtually any sector that generates large amounts of data – from marketing to finance or real estate.

But while AI is not limited to any specific sector, the majority (77%) of the EU's AI talent is found in the technology, education, and manufacturing sectors. This mirrors what we find in the U.S., where 76% of AI talent can be found in the same three industries. Beyond technology, education, and manufacturing, a significant portion of AI talent and skills are also found in: finance, hardware and networking, and healthcare.

Given that the successful deployment of AI requires in-house expertise to design, adapt, monitor, and maintain sector and business-specific AI applications, higher concentrations of AI talent in a given industry are an indicator that it has mastered the ability to strategically deploy AI technologies faster than others.

Figure 3. AI talent distribution by industry in the EU

Source: LinkedIn Economic Graph



There are several notable sub-sectors within the three industries that represent the largest share of AI workers. Within the broader technology industry, information technology & services and computer software have particularly strong shares of AI workers (18% and 20%, respectively).

[4] https://economicgraph.linkedin.com/blog/how-artificial-intelligence-is-already-impacting-todays-jobs

When we look at the broader education industry, sub-sectors that capture the most AI talent are *research* and *higher education* (17% and 5% respectively). AI talent distribution is spread more evenly across the manufacturing industry's sub-sectors: automotive (3%), mechanical or industrial engineering (2%), industrial automation (1.8%), aviation and aerospace (2%), defense and space (0.819%), and renewables and environment (0.45%) sectors all hover between 0.5% and 3%.

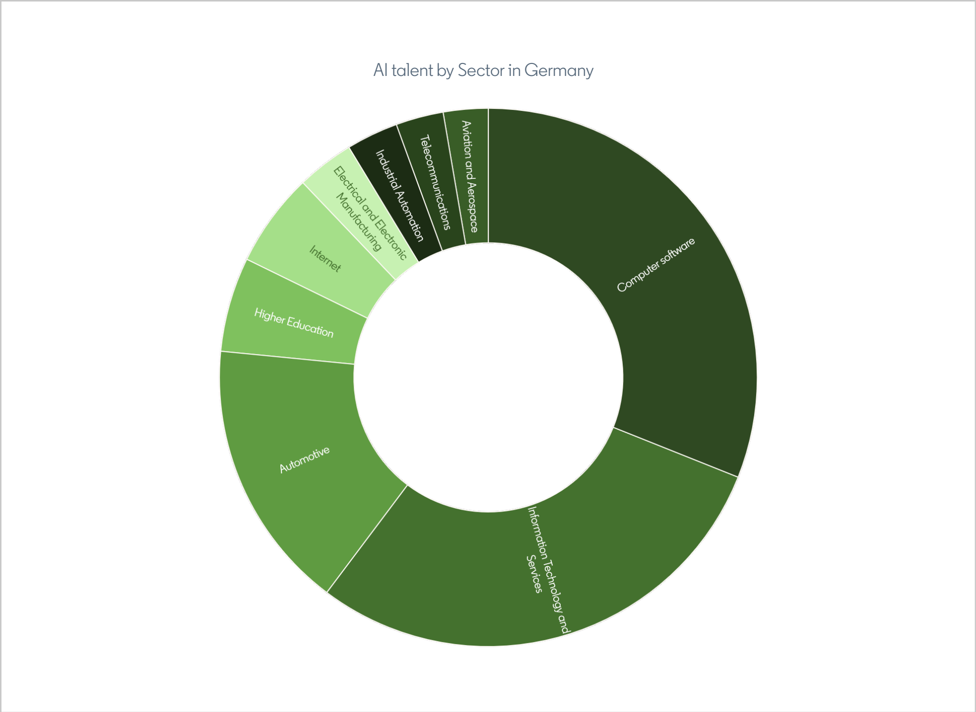
It is notable that AI talent remains concentrated in certain pioneering industries, and not yet diffused more broadly across the economy. LinkedIn data on skills penetration across the globe reveals that frontier and advanced digital skills first cluster in the information and communication technologies sector (ICT) before becoming more deeply penetrated in other industries, presumably as the technology diffuses and firms find productive ways to deploy the technology.

AI is the next step of digital transformation, so we expect it will follow the digital skills trend and diffuse into other industries as those industries find more commercially viable ways to implement and deploy AI technologies across firms with varying levels of productivity. Establishing a pool of in-house AI talent is the best way to make the most of AI systems, since in-house staff can apply their understanding of specific business needs, become embedded in the information system and data quality, and ultimately help improve their organization's productivity and offerings.

Looking at the country-level across Europe, AI talent is most concentrated in well-established industries and sub-sectors. Germany leads Europe with AI in manufacturing, and the automotive industry accounts for half of all AI talent in German manufacturing. The same trend follows with finance in the UK, manufacturing in Italy and Sweden, healthcare in Belgium, and telecommunication in Finland.

Figure 4. AI talent distribution by industry in Germany

Source: LinkedIn 2018



3. United Kingdom, a different story?

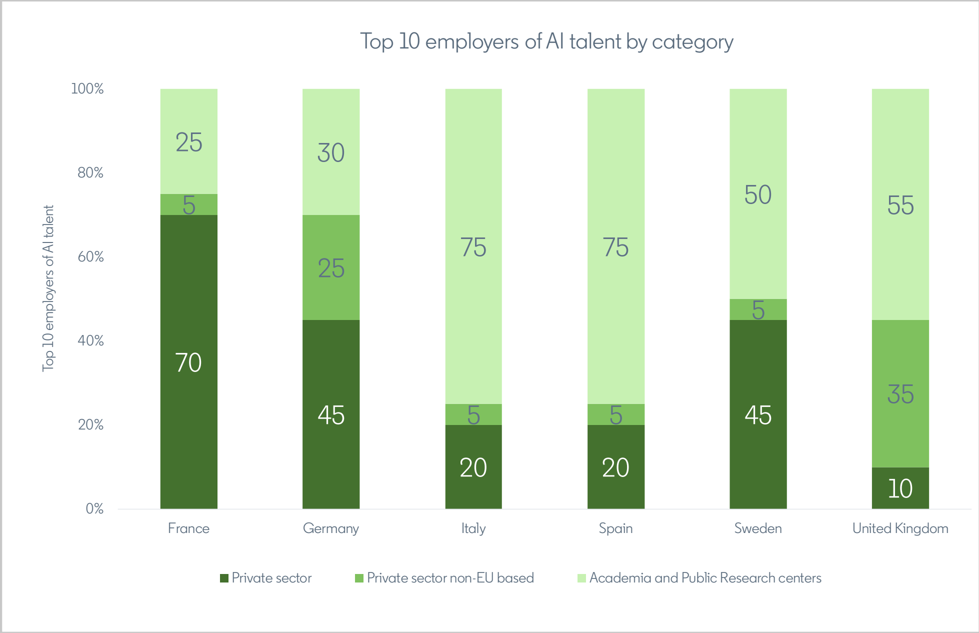
AI research in the UK is the most advanced of all EU Member States, giving the country a competitive advantage when it comes to attracting leading companies to its shores. This is reinforced by the quality of the research being produced by the universities of Oxford, Cambridge, and London (Imperial College, University College London). British universities receive considerable support from technology companies, a practice seen by policymakers as a way to prevent brain drain. Microsoft, for instance, strongly supports AI research at the University of Cambridge.[6]

Contrary to what we see in the U.S. market – where the AI marketplace is dominated by new entrants and *digital natives*[5] – most of the top organizations employing AI talent in the EU are large, well-established firms. This is likely because AI enables productivity and efficiency based on data generated during production processes. There are very few companies whose primary activity is producing AI applications or providing AI services, and those that do exist are usually small (e.g., targeted advertising, insurance, etc.).

Figure 5 gathers the top ten employers of AI talent from a sample of six European countries. In contrast to what we see in the U.S., the leading companies using AI in Europe are well-established. Additional research into AI intensity at the company level, comparing the ratio of AI talent to the total workforce, could shed additional light into why EU employees with AI skills tend to work in different kinds of firms.

Figure 5. Top 10 employers of AI talent from a sample of six European countries

Source: LinkedIn 2018



Among the top ten employers for those countries, academia and research centers dominate – especially in countries where AI intensity is the lowest. This finding is consistent with the industry analysis. Italy and Spain in particular reflect this reality and highlight a North-South divide. Among the top ten AI employers for those countries, foreign companies are only present in the United Kingdom, primarily due to the presence of the global technology companies' European headquarters and research centers. The UK deviates from the wider European pattern when it comes to academic research. Although academia is over-represented in the top ten UK AI employers, the underlying reason likely differs from that of countries with low AI diffusion (see Box 3).

In Spain and Italy, the concentration of AI talent in academia is a symptom of the fact that AI has not yet diffused into the private sector. A deeper analysis of the barriers to private sector adoption could help shed light on possible interventions to spread adoption, whether economic policies and incentives or education and re-training programs.

[5] M. Prensky, 2001, "Companies born in the in the era of ubiquitous technology, including computers and the internet," available at link.

[6] See, for e.g., "Multi-million pound initiative from Microsoft to support AI research at Cambridge," University of Cambridge News Release (Oct. 31, 2018), available at https://www.cam.ac.uk/research/news/multi-million-pound-initiative-from-microsoft-to-support-ai-research-at-cambridge.

France and Germany are more balanced, with strong research leaders (e.g. Inria in France, home to one of the top AI libraries "Scikit-Learn") and strong private sector companies (e.g. Thales, Amadeus, Orange, Airbus) in key industries.

Within countries illustrated in Figure 5, there are only two European digital natives among the companies with high concentrations of AI talent: Zalando (Germany) and Spotify (Sweden).

Demographic Trends

Diversity is a key asset in any industry, and especially in AI where developers from varying backgrounds, ages, and experience play a vital role in limiting biases in AI systems.[7] LinkedIn findings indicate that the typical profile of an AI worker in Europe is a young, highly-qualified male working in Western Europe, which raises concerns about the extent and depth of talent diversity among EU countries.

Gender Gap

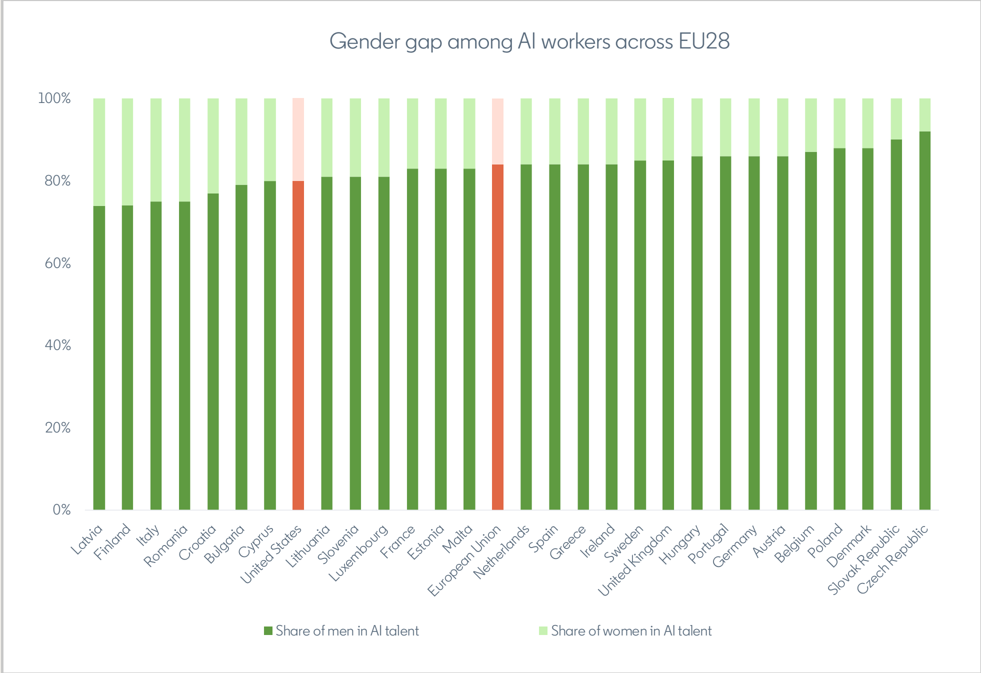
LinkedIn research (in partnership with the World Economic Forum[8]) reveals the AI talent pool is as prone to the gender gap as other STEM disciplines. Only around 16% of all AI workers in the EU are women. This is comparable to the U.S., where less than 20% of AI workers we identified are women. And despite some variations across Europe, the share of women in the AI workforce never exceeds 30% in any EU Member State.

This finding holds without any significant relationship to female labour force participation writ large. With the exception of Finland, the amount of women in AI is not quantifiably higher in countries with a high level of female participation in the labour market (i.e., Nordic countries, Germany).

Interestingly, some countries with a lower participation of women in the labour market have a relatively strong presence of women in the AI workforce. In Italy, Romania, and Croatia, we see approximately 25% of women in AI despite the employment rate of women was respectively at 52.5%, 60.2% and 58.3% in 2017.[9]

Figure 6. Gender gap among AI talent in the EU

Source: LinkedIn Economic Graph. NB. Results within LinkedIn Population, which may not be gender balanced to begin with.



[7] "Artificial Intelligence's White Guy Problem", Kate Crawford, The New York Times https://www.nytimes.com/2016/06/26/opinion/sunday/artificial-intelligences-white-guy-problem.html

[8] https://economicgraph.linkedin.com/blog/growing-but-not-gaining-are-ai-skills-holding-women-back-in-the-workplace

[9] International Labour Organization, ILOSTAT database

4. Methodology focus: how gender is inferred on LinkedIn

LinkedIn infers gender based on a member's first name. Members for whom we cannot infer a gender value with confidence have been removed from the analysis.

5. Country focus: the puzzling case of Italy

Italy has the lowest female participation rate in the EU labour force, so we expected the gender gap in AI to be one of the largest. Our data shows that it is actually one of the smallest gaps, just after Latvia and Finland. One possible explanation put forward in literature[12] related to women in STEM, is that strong role models play a key role in increasing women's participation in scientific disciplines. To that end, there are a number of noteworthy Italian female role models pioneering AI research including Elisabetta Abate, Maria Gini and Francesca Rossi, Barbara Caputo, and Maria Luigia.

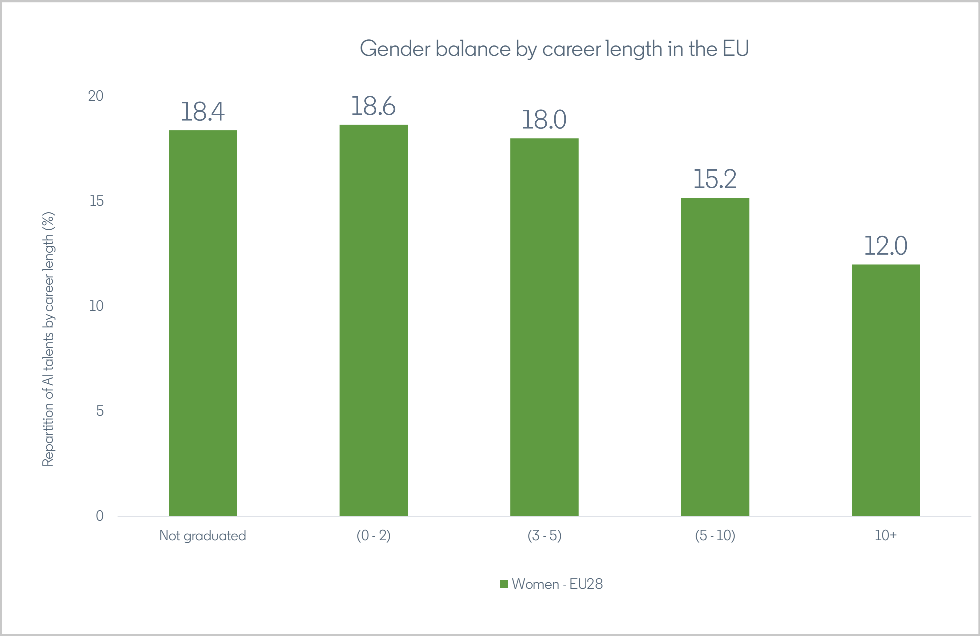
When looking at gender gap by career length,[10] we see that the gender gap is narrower among younger generations in most EU member states: women currently represent almost 20% of new entrants in the AI field, while women who have worked in the field for ten years represent only 12% of the AI workforce.[11]

To understand whether this narrowing is caused by more women entering AI-related occupations in recent years or by women leaving AI-related occupations as they age, we would need to generate longitudinal data with LinkedIn or government data.

The low level of female AI talent is a pressing issue. Diverse representation among emerging technology workers is crucial for the sector, and especially important for AI products given the potential for bias against members of diverse social, economic, or political groups.

Figure 7. Gender balance among AI talent by career length

Source: LinkedIn Economic Graph. NB. Results within LinkedIn Population, which may not be gender balanced to begin with.



[10] The average is calculated as the time since graduation.

[11] The average is calculated on the basis of the 44 countries covered by the LinkedIn population.

[12] "Closing the STEM GAP, Why STEM classes and careers still lack girls and what can we do about it" Microsoft Philanthropies link

6. Methodology focus: career length

We inferred career length as the distance between graduation year and the date the data was collected. Thus, it refers more to general work-life span rather than to the number of years spent in a specific job. Given AI workers are very specialized workers and less prone to career shifts, and that the demand is high for such professionals so the time to find a job after graduation is short, we assume that distance between graduation and date data was collected is a reasonable indicator for years of professional experience in the AI field.

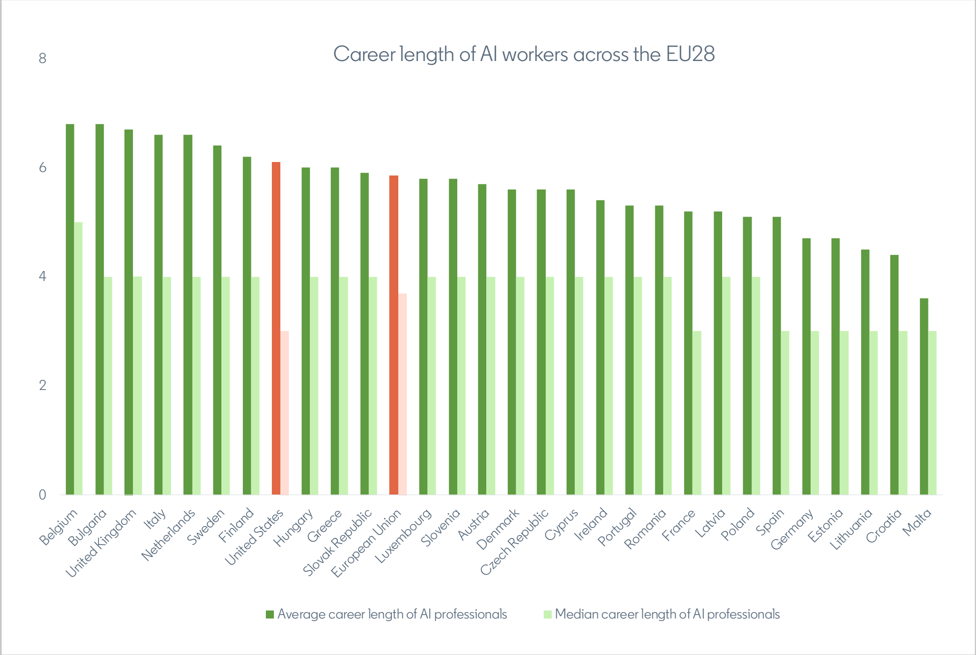
Tenure

Most of the AI labour force graduated recently, so have shorter career lengths than the average professional working in another computer-related industry. Although we do not have statistics with perfect similarity for other industries, the U.S. Bureau of Labor Statistics provides information about median age by occupation.[13] For the computer systems design and related services, the median age is 40.6 years, corresponding to a career length of around 16 years.[14]

With respect to AI workers, the median career length in Europe is 3.69 years, which is slightly higher than the U.S. average of 3 years, but significantly lower than the median for workers in the ICT sector, which is itself a relatively young profession.

Figure 8. Career length among AI talent in the EU*

Source: LinkedIn Economic Graph.



While AI is not a new field, advances in computing power and availability of data have led to a recent acceleration in AI research and the development of commercial AI applications. It therefore comes as no surprise that the average career duration of the AI workers is low.

But variation across EU countries can reveal early pioneers in this space – mostly in the research and academic field -- such as Sweden and Belgium, where the median career length is the highest in Europe (5 years). National universities in these countries have the capacity to teach advanced technologies and pioneer computer science and AI research, like the Katholieke Universiteit (KU) Leuven in Belgium, for example.

But for this pioneering research to make its way into industry, countries need a dynamic private sector that has already undergone digital transformation and strong incentives for innovative companies to settle there. A primary example of this process is Ireland and the UK. Early adopters and pioneering countries that do not have or foster a dynamic private sector won't be able to transform into an AI leader.

* The distance between average and median is a good indicator of statistical dispersion in a population. This can help better understand the structure of the AI ecosystem.

[13] See: Bureau of Labour Statistics: Employed persons by detailed industry and age. https://www.bls.gov/cps/cpsaat18b.htm

[14] Based on the average age of graduation (24) for a Bachelor's degree in the US, Bureau of Labor Statistics

More experienced professionals who can mentor, coach and guide the professional development of more junior talent will help the development and diffusion of AI-related applications and technologies. Tenured workers tend to have more domain expertise than younger workers, and junior workers benefit from learning that expertise from them.

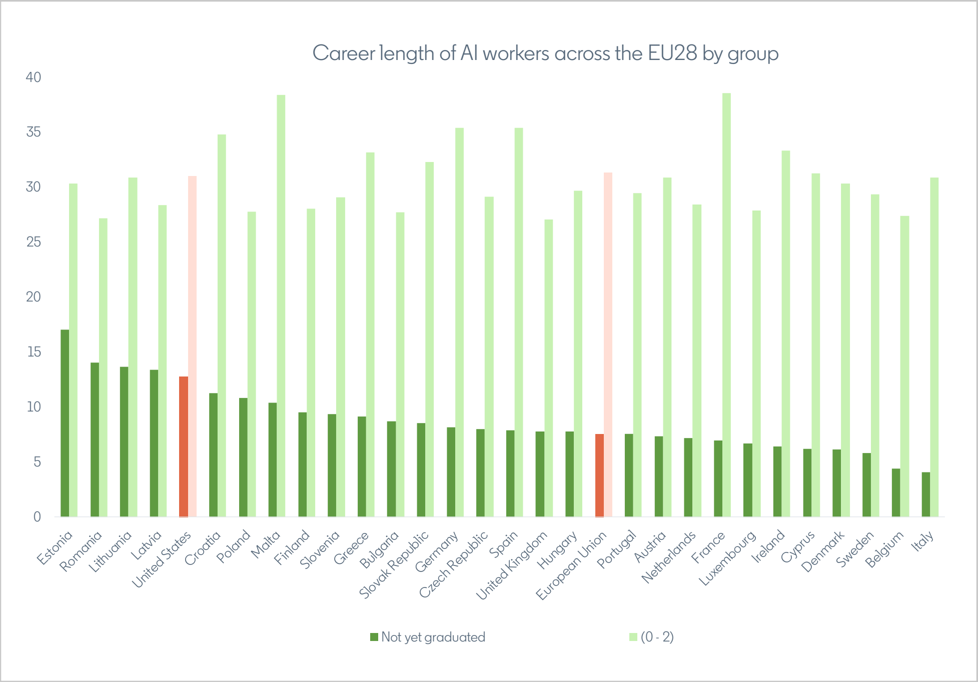
For that reason, countries with less diversity in career length levels may have more trouble developing AI for industry- or domain-specific applications. Belgium and Sweden's AI talent pools both have a high average and median career length. However, Belgium lacks a pool of young AI talent relative to Sweden, suggesting that it may fall behind in AI development in the coming years, as the upcoming pool of AI talent resides elsewhere.

Several factors contribute to an imbalance between the AI workers with long vs. short career lengths. One is that career length levels are high in research centers and universities where students learn AI skills, but that they do not stay in the country for work.

It is noteworthy that several Eastern European countries have the largest share of young AI talent relative to their proportion of total AI talent. This suggests there is an opportunity for these countries to gain traction by investing in economic opportunities for young AI workers at home.

Figure 9. Career length among AI talent in the EU

Source: LinkedIn Economic Graph.



Level of Education

AI workers in Europe have, on average, a higher level of education than those in the U.S. The majority of AI workers in Europe (56%) hold either a master's degree or a doctorate, compared to just over a third of AI workers in the U.S. (34%) holding the same. The majority of AI workers in the U.S. (62%) hold only a bachelor's degree.

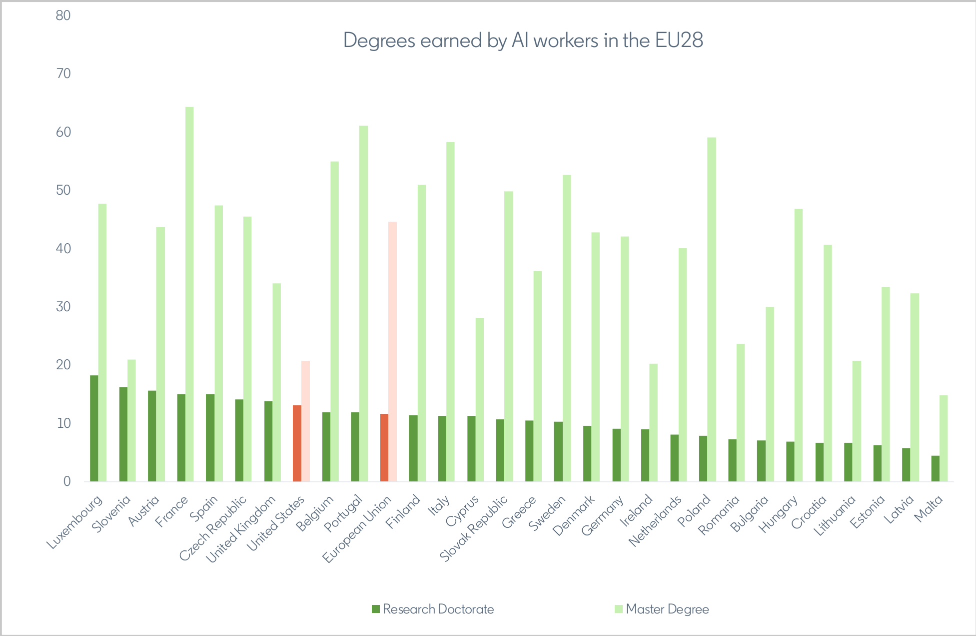
Although there is wide variance among EU countries, only four have higher percentages of AI workers with Bachelors' degrees than the U.S.: Malta, Romania, Lithuania, and Ireland. The large variance is likely due to factors such as heterogeneity of education and training systems that result in different skill sets; differential opportunity costs of acquiring additional education; and the flexibility of labour markets and their ability to match workers with jobs.

Cross-country variation may also originate from cultural expectations about the desired level of postsecondary education. In France, reaching a master's level is standard practice for many post-secondary students, whereas in Ireland, obtaining a bachelor's degree is seen as a sufficient level of education. Another possible factor could be the financial cost of formal education and the high demand for AI talent in the labour market. Considering the financial investment required in some countries to pursue a master's or PhD degree, students may find it more worthwhile to immediately enter the workforce and gain on-the-job training, or to use free or part-time online trainings to advance their skill sets.

Formal academic education is not the only way to acquire AI skills. It is now possible – and even desirable, given the rapid pace of technological change – to develop or continue to hone such skills after entering the labour market. Due to the wide variation between countries, it is unclear whether there is an optimal educational pathway to develop AI talent, and indeed this seems unlikely. Country-level analyses of the available education and training option would be needed to optimize the school-to-work transition for AI talent.

Figure 10. Degrees earned by AI talent

Source: LinkedIn Economic Graph.

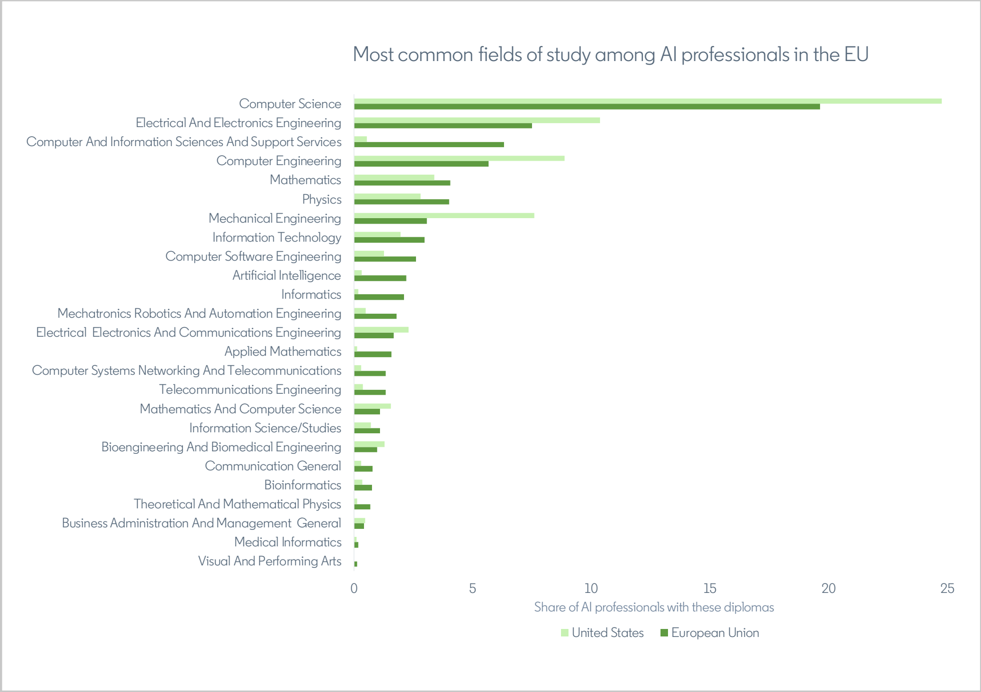


Field of Study

The fields of study that tend to produce workers with AI skills have not yet spread beyond studies related to ICT. More than one third of AI talent we identified (39.1%) comes from four fields of study, all related to ICT: computer science, electrical and electronics engineering, computer and information science, and computer engineering. The frontrunner among these, computer science (19.6%), is ideal for producing AI talent because it combines analytical and statistical education with big data computational skills. Only one of the humanities – economics – is among the top 30 fields studied by AI-skilled individuals, likely due to its emphasis in statistical modeling and econometrics. The subsequent two humanities degrees, linguistics and psychology, rank only 31st and 41st. AI talent sources in the EU are generally more diverse in terms of field of study when compared with the U.S.

Figure 11. Most common fields of study among AI professionals

Source: LinkedIn Economic Graph.



Mobility Trends

Retaining high-quality talent at home and also attracting high-quality talent from abroad are core components of countries' and cities' talent development strategies, especially for niche or highly specialized, skilled occupations like AI.

An economy's ability to retain talent after investing in educating that talent can help boost the net social gains to education, but attracting skilled talent can also be a core component of a talent development strategy – especially in the short term while longer-term investments in educating and training domestic talent are underway.

At the EU-region level, measuring AI talent migration helps paint a picture of the likely geographic divergence or convergence of AI-related human capital -- and which states are most likely to take advantage of AI-related economic opportunities. High levels of migration are also a signal that individuals cannot find good work opportunities in their country of education, indicating that countries may need to invest more in private sector demand for AI-related skills.

When looking at the universities attended by AI-skilled individuals, we see an interesting trend: AI talent only has a 42% mobility rate post-school. The majority of AI professionals (58%) studied in a university located in the same country as their subsequent place of employment.

The AI labour force is highly mobile. Our data shows AI talent has a slight preference for moving outside the EU rather than moving from one Member State to another. When studying in a different country than the one they are currently working in, AI workers tend to choose non-EU countries for their studies (21% vs 20% for EU countries).

In the best-case scenario, a high retention rate signals an effective school-to-work transition and the ability of economies to provide attractive opportunities to AI workers. However, retention rates could also be high because skills developed in school are mismatched with those needed in other countries where AI opportunity is greatest. High retention rates could also signal that there are mobility barriers preventing AI workers from moving to areas of highest opportunity.

Countries with centers of excellence in AI education will likely have their retention rates pushed down by the outsized foreign demand for workers educated in those centers of excellence. In this case, it is more important that enough graduates are retained to meet the demands of the private sector in that country, rather than maximizing the retention rate overall. Looking at the retention rate will not reveal which conditions apply in any given scenario, but the retention rate does provide a starting point for country-specific analysis to determine the appropriate action. They can also be used as a benchmark, baseline, or target indicator for country-level strategies aimed at developing AI economies.

The labour market for AI talent is inherently international: nearly half (42%) of AI talent in the EU studied at a university not located in the same country they are currently working in. This may be due in part to the relatively young nature of the AI talent pool, but it is also likely attributable to the fact that not all economies offer the same opportunities for AI workers to deploy their skills. As AI ecosystems take hold and mature, opportunities for AI workers will likely improve and set a positive feedback cycle in motion, which is why it is important that countries looking to gain a foothold in AI technologies provide AI graduates with attractive economic in-country opportunities, help them transition efficiently from school to work, and improve access to amenities that contribute to a good quality of life locally.

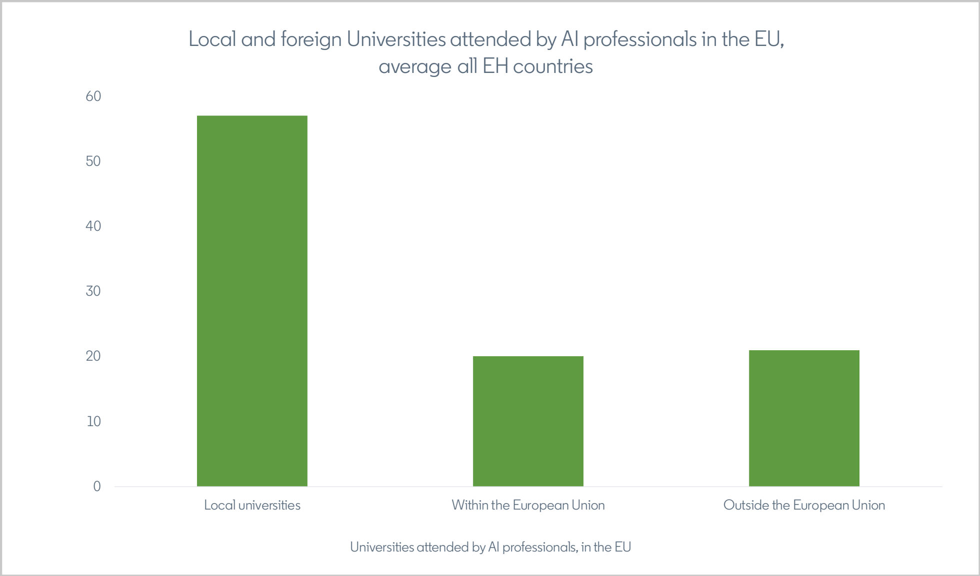
7. Methodology focus: mobility of AI talent

At LinkedIn we do not collect data on members' citizenship. For this research, we approach mobility broadly, observing the country in which the degree of any particular member was earned. We identify the country from the university name. With this method we cannot tell the citizenship of a given member, but we can observe whether they earned a degree in a different country to that which they are currently working in.

As noted above, our data does not provide information on whether a worker has citizenship from a different country than the one they currently work in, nor does it provide information on whether they studied abroad. In other words, it is difficult to disentangle student mobility from worker mobility because the retention and mobility rates tell us less about the share of non-citizens versus citizens in any given AI labour market, and more about the ability of a given labour market to retain the AI talent that it gains or trains.

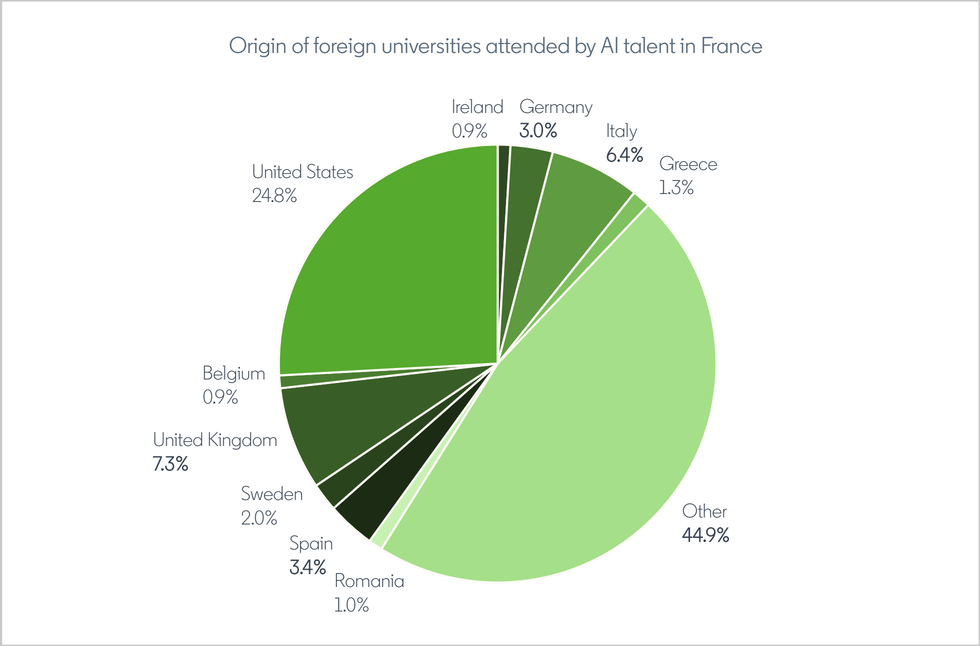
Figure 12. Local or foreign universities

Source: LinkedIn Economic Graph 2018



Most AI talent is educated at UK universities, followed by France, Germany, and Italy. This mirrors the countries that also have the most AI professionals in the EU. But looking outside of the EU, the U.S. is the top choice for AI talent.

Figure 13. Origin of foreign universities attended by AI talent



Labour Market Trends

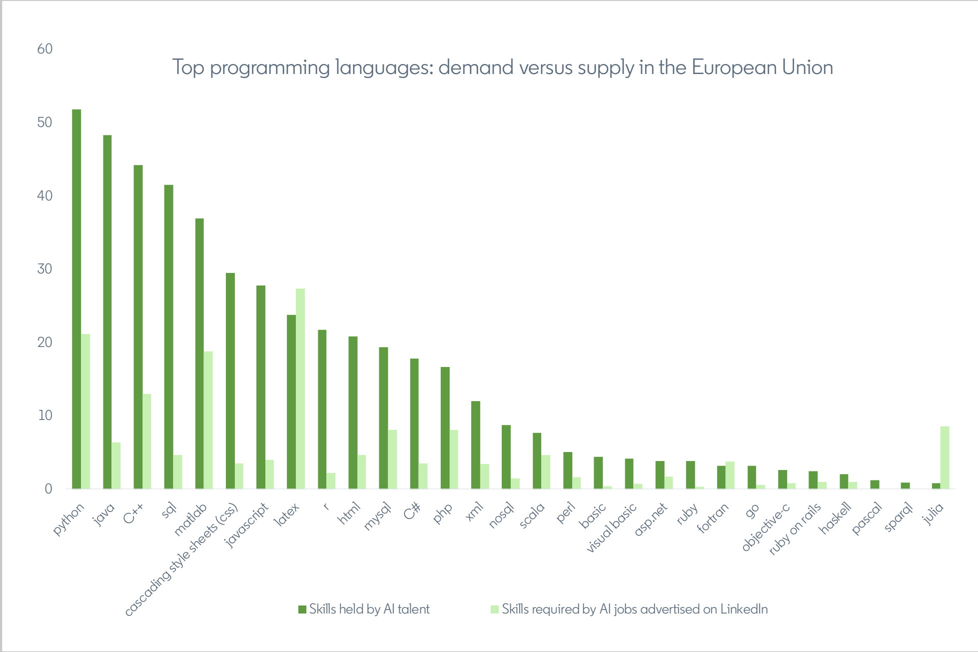
Beyond the EU-aggregate demand for and supply of AI skills, LinkedIn's data allow us to compare the demand for and supply of specific skills across EU Member States. For instance, LinkedIn data reveals that mastering Matlab is a key asset in the Belgian labour market. More than 12.5% of AI jobs advertised on LinkedIn require this skill, which exceeds the supply Belgium can provide for this specific tool. LinkedIn data also suggests that there are many AI workers mastering Matlab in other EU countries, like Germany.

The skill set of AI workers

AI workers tend to be highly specialized, so we looked at four categories of skills related to AI -- programming languages, AI-related libraries of code, data science libraries, and soft skills – to understand the concentration of these technical skills among AI talent.

Figure 14. Top skills held by AI talent: programming languages

Source: LinkedIn Economic Graph



Three AI libraries are required by more than 13% of the jobs advertised on LinkedIn, yet they have a supply below 3%. This skills gap contrasts what we see with other programming languages, which have high reporting rates across the most commonly demanded languages.*

* This difference might be explained by the suggestion of implied skills once one has already listed a specific skill. For example, looking at data-science skills, Pandas and Numpy are the data structure framework used by Python programming language. An AI professional working with Python has no choice but to master Pandas and Numpy, potentially making it redundant to specifically call out their mastery of such skills alongside their proficiency in Python.

Figure 15. Top skills reported by AI talent: artificial intelligence libraries

Source: LinkedIn Economic Graph

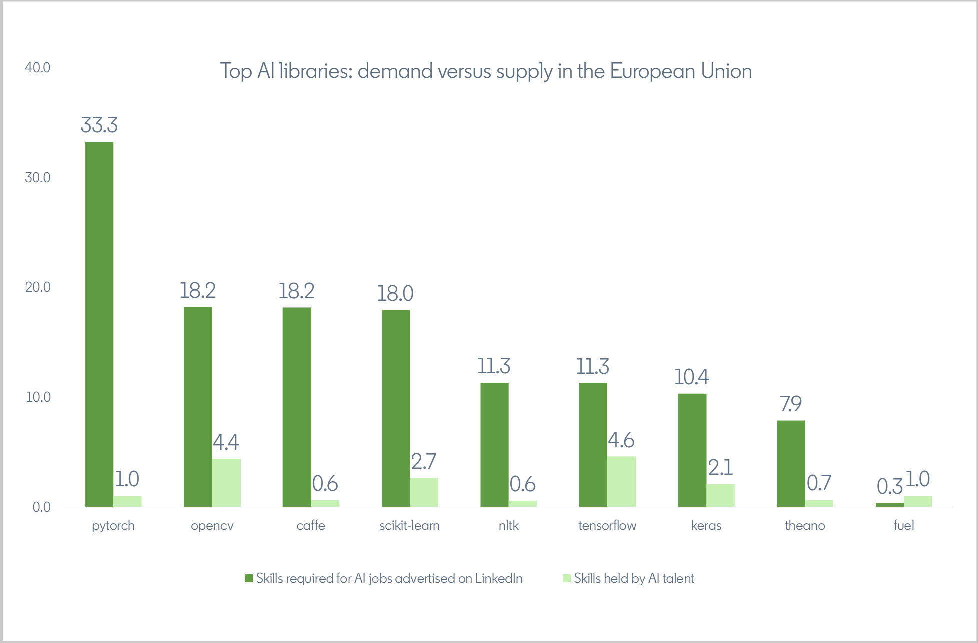
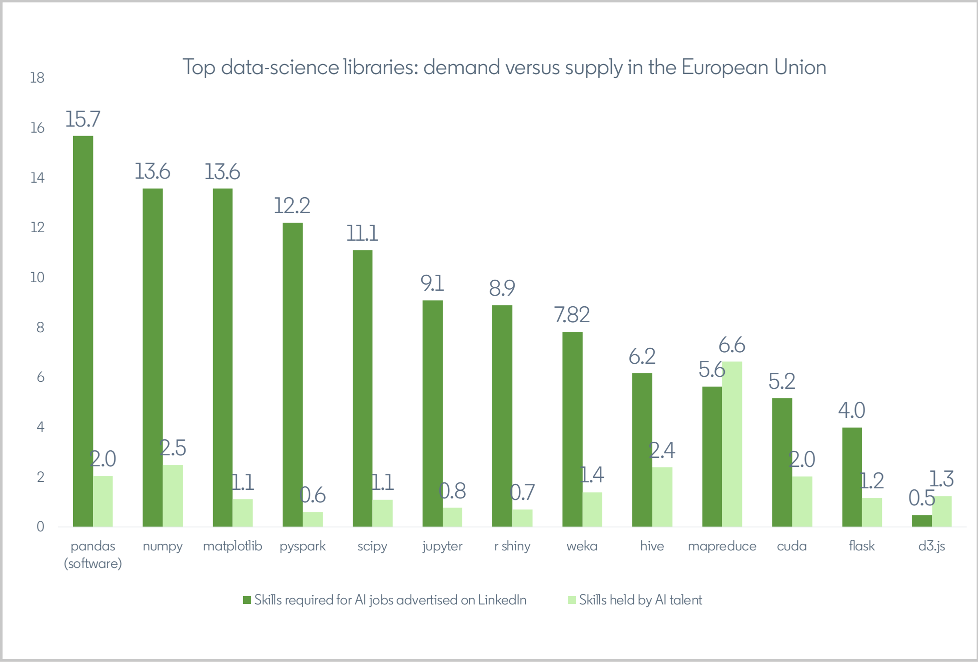


Figure 16. Top skills reported by AI talent: data-science libraries

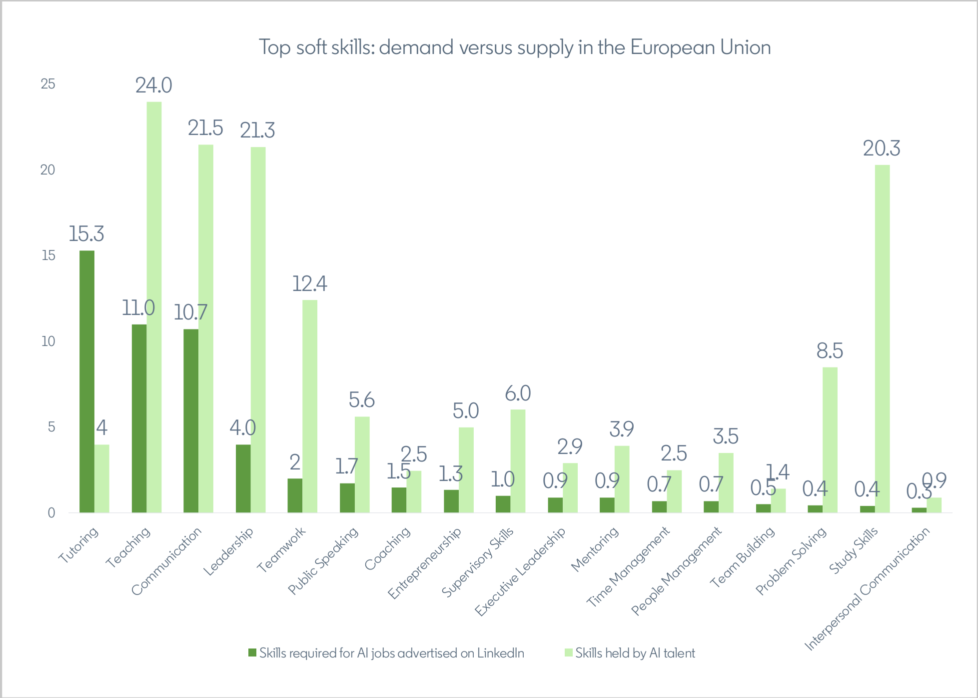
Source: LinkedIn Economic Graph



In contrast to what we see in other industries, where soft skills are in high demand, few AI related jobs posted on our platform explicitly mention soft skills as key requirements. But nearly a quarter of AI workers chose to list their soft skills – 24% report that they have teaching skills and 22% report good communication skills. There appears to be low demand for soft skills based on job postings, where recruiters tend to favor hard, technical skills. Jobs and tasks involving AI are still very much specialized, and AI-related tasks do not necessarily involve frequent interaction with non-technical counterparts that would require soft skills. AI skills are also in such high demand that the lack of softer skills such as collaboration and teamwork are less of a concern for employers at this point. This is, however, likely to change with the diffusion of AI across sectors.

Figure 17. Top skills reported by AI talent: soft skills

Source: LinkedIn Economic Graph



What Lies Ahead: Discussion and Policy Recommendations

Based on these insights from LinkedIn's Economic Graph, policymakers should consider these key takeaways:

- The distribution of AI talent within and between countries is uneven. Most AI talent is found in Western Europe and in urban areas. There is also a strong gender and age disparity.
- Compared with the U.S., Europe is lagging behind. The EU has only half the US talent pool although it has twice its active population.
- AI has not yet spread across industrial sectors. Software and IT services, together with education, capture most of the AI workforce.
- The skills needed to develop or implement AI systems remain scarce and limited to a well-educated segment of the labour force.
- The ability to train, attract, and retain AI workers is likely to become a new differentiator between EU Member States. Countries and territories with a low presence of AI workers and a low level of AI deployment across industries are likely to face innovation and competitiveness challenges unless they act quickly to gain a foothold in this rapidly evolving environment.
- By retraining its workforce with the necessary skills, the EU could potentially double its AI talent pool.

Adopt EU-wide best practices

The EU is falling behind the U.S., and levels of AI talent vary significantly between Member States. To better understand and address the root causes of AI intensity disparity across the EU, European policymakers should consider whether existing policies – or a lack of them – are a factor. Those policies can then be adjusted or, if they don't exist yet, implemented in order to level the playing field for Member States that may be underperforming.

AI skills may be better embedded in the educational systems of certain countries. Based on the variation in AI workers' seniority, we see that AI skills have been taught earlier than in others and that the standard and degree of specialization of teaching for AI skills varies between universities. One way to assess Member States' ability to prepare their workforce for AI jobs could be to compare the performance of national universities by, for instance, examining the number of articles published in academic journals.

Another factor that may explain the variance in AI skills education may relate to the presence – or absence – of certain industrial sectors and companies working with AI. Industrial ecosystems play a significant role in strengthening tertiary education programs and bringing research to market. Furthermore, university-industry collaboration can help create technology incubation programs, develop innovation capacities, and boost student employment prospects as well as national competitiveness.

The prevalence of AI workers in some countries can also be explained by socioeconomic factors. Certain countries are more effective at attracting AI workers due to the level of wages, the in-country presence of multinational corporations, or working conditions. Because their skills are in high demand, AI workers can choose to live and work in places based on their preferred living and working conditions.

Prepare for diffusion into new industries, increased migration

The EU has barely scratched the surface when it comes to the diffusion of AI across all sectors of the European economy, and there is significant potential in industries such as finance, health, entertainment, transportation, and logistics.

The low level of talent relative to the U.S. and low rates of AI talent diffusion into non-ICT industries suggests that there is much that can be done to help more EU countries in developing and diffusing AI into the rest of the economy. Moreover, political developments like Brexit will have a large impact on the growth of this emerging economic segment. At least in the short run, the EU would mechanically lose a quarter of its AI workforce and access to AI leading universities for Europeans students may become more difficult.

The high rate of migration among AI workers suggests that those with AI skills will work where they are most wanted. This can be both a benefit and a burden for countries looking to build a pipeline of AI talent. By incentivizing companies that can attract AI talent, these countries can build a competitive advantage; however, that advantage is easily lost. Europe's AI dominance in AI is not yet established, meaning that countries will need to make sustained investments in order to create self-sustaining AI clusters.

Make strategic investments in Eastern Europe

AI talent is clustered mostly in three Western European countries: the UK, France, and Germany, and left unchecked, could exacerbate inequalities within the EU. Eastern European countries produce AI graduates, while the most qualified AI talent leaves the region to work in Western Europe where their skills are in higher demand and command higher salaries.

European policies can encourage a more even development of AI skills across the continent and prevent widening geographical divides. Eastern Europe has a relatively large supply of young AI talent either still in school or with less than two years of experience, so its AI workforce has the potential to grow and develop. This presents an opportunity to actively recruit more senior-level employees to coach and develop younger peers.

While Eastern European countries tend to have above-average student retention rates, this may be because graduates are not adequately trained in the skills demanded by employers and that only the most capable AI graduates migrate. Indicators suggest that while some Eastern European countries (Estonia, Slovenia) have invested in developing AI talent, most need to act quickly and consistently to narrow the gap.

Eastern European countries with younger AI talent should strive to create stable business environments for large companies that employ and attract AI workers, while also working to recruit and retain older workers from other areas who can guide and mentor the next generation. Investing in the livability of its major cities would also help increase their appeal for European AI talent.

Help companies and clusters upgrade

Based on the sectoral concentration of AI talent, large, well-established companies are most likely to be first adopters of AI.

And it follows that championing industries within Member States are the first to benefit from the diffusion: automotive companies in Germany, finance firms in the UK, and telecommunications firms and automotive in Sweden, are already seeing significant gains from investing in AI technologies.

For middle size companies, investing in AI can be incredibly expensive. Information systems and database legacies, for example, can hamper the development of data-driven improvement such as the one permitted by AI. Opportunity costs also kick in when other existing technologies need to be deployed first to remain competitive.

Digital native companies have a different approach to data-driven decision making, as their information systems were initially designed to leverage the vast amount of data generated through digital technologies.

Company culture also plays a strong role when adopting AI. Data-driven mindsets are fundamental to implement and leverage such new applications effectively.

Helping companies in a sector cluster make other technological investments will likely increase the rate of diffusion of AI technologies, as more companies reach peak productivity. AI investments, and the resulting talent attraction and retention, will also be most intense in sectors where global leaders are well established. But this is mitigated by company size, since companies dealing with large amounts of data are the most likely to benefit from in-house AI capabilities.

Close the gender gap

Technology shapes society, so the diversity, inclusion and representation of those who build new technology is critical. Diversity ensures that teams are acutely aware of how what they are creating could impact different groups of people in different ways, for better or for worse.

This is especially important for AI products, given their automated nature and potential to create or exacerbate bias. To ensure that the AI talent pipeline – and the products it develops – reflects the varied reality of the world we live in, investments in technology and AI education for women and members of ethnically and geographically diverse groups must be made.

The rate at which the gender gap in other fields is narrowing could be an important benchmark for closing the same gap in the AI talent, which is currently a 1:4 ratio of women to men. Comparing countries' rates of convergence would help identify where the gender gap is closing faster and possibly inform policy recommendations for closing the AI gender gap. The immediate next step would be to see whether there are identifiable differences in the educational and professional backgrounds of women versus men in AI, and women in AI versus women in closely related fields. This could uncover areas where targeted interventions could increase the entry of women into AI fields.

To close the AI gender gap, digital literacy and technology skills should also be incorporated as part of all curricula. To achieve this, policymakers should consider funding inclusive education strategies to increase diverse representation among AI talent.

Align curriculum and training to industry standards

Based on what we know about the labour market, institutions may be incentivizing educational investments in some countries more than others. This possibility exists alongside the trend in competitive labour markets for students to acquire more education than workers in less competitive labour markets .

Beyond the lower opportunity cost in the EU, another reason that some markets have higher educational attainment may be that universities do not provide the right AI skills to Bachelor's-level students, and that university curricula in many EU Member States are not geared towards workforce preparation in the same way that U.S. colleges are.

The high levels of education in some countries also suggest that the entry of AI talent into the economy may be delayed. Aligning curricula and employer needs is also needed, along with an assessment of other hurdles facing AI workers in economies where their education level is higher than average.

Labour market institutions also lack effective channels for students and graduates to highlight their AI skills within the labour market. Hiring and firing rigidities mean that employers are reluctant to hire workers and need strong signals about non-AI skills, such as willingness to work hard, diligence, ability to follow directions and follow through on tasks, which they may feel can be better signaled with an advanced degree. The regions and countries with rates of undergraduate AI workers most similar to the United States are: Eastern Europe, Malta and Ireland. These countries also lead in digital government and economy initiatives, and have the highest percentage of young AI graduates. To untangle these issues would require a deeper future analysis, potentially combined with an analysis of AI demand in each labour market.

There is no single, dominant education or training model. Each country needs to think carefully about how they design their AI talent pipeline, balancing the value of further human capital development with the need to ensure people with the right skills are working in the right jobs.

The European Commission has touted the possibility of using digital learning and massive online courses (MOOCs) to supplement gaps in knowledge and help workers engage in lifelong learning. Country-specific strategy documents should assess these offerings and expand their availability as part of an AI talent development strategy. Lifelong learning and digital platforms such as Coursera and LinkedIn Learning can also offer flexible alternatives to formal education.

Upskill “near AI” talent to develop human capital

To compete globally on AI, the EU urgently needs to invest in AI talent in a targeted way. This can be achieved by identifying a pool of “near AI” talent and incentivizing those workers to upskill towards becoming AI talent. This paper’s methodology assigns a confidence score to members, and only those who have a confidence score equal to or greater than 0.95 are considered to be AI talent. By targeting upskilling initiatives at individuals with confidence scores between 0.5 and 0.95, what we are defining as “near AI” talent, the EU could potentially double its stock of AI talent in a short period of time.

Initiatives could include: incentives for employers to develop apprenticeships or training programs for “near AI” employees, online training and courses designed to supplement individual skill gaps, and targeting major sources of AI talent studying for other relevant university courses, such as mathematics or economics.

Policymakers and employers must also create pathways for non-near AI talent to eventually upskill to AI talent, for instance creating a learning pathway from business operations analyst into data scientist, and then eventually into an AI worker. This will widen the pipeline of future near-AI talent, avoid draining the pool of existing near-AI talent, and create a path for talented individuals from under presented groups currently less likely to be at near-AI talent, but with the potential to get there.

Conclusion

Europe must tackle the dual challenge of becoming an AI champion while making sure that AI skills do not exacerbate social divisions or increase inequalities. Significant work has already been devoted to AI, but more action is needed:

- **The EU and its Member States must increase their investment in AI,** not least by ensuring that the development and deployment of AI systems are part of an ecosystem allowing fundamental and applied research to nurture each other. Establishing this ecosystem in partnership with universities, research centers and industry, and between large company and SMEs, is vital to become a global champion and hub for AI that attracts and retains the best talent. To this end, EU-level investment must be increased and supported with concrete initiatives, as part of the EU's regional policy and its smart specialization strategy to develop such AI ecosystems.

- **To mitigate any societal challenges that biased AI systems might raise, the EU must ensure equitable distribution of AI skills.** EU initiatives introducing these AI skills must be introduced across various fields of study, curricula, and levels of education. EU initiatives in this area could be very impactful. For instance, monitoring how AI skills are acquired across the EU and establishing benchmarks between countries could help address the skills divide. While a certain degree of specialization is necessary, AI professionals should also master transversal and soft skills, as these will become more important as AI diffuses across the economy.

Data from LinkedIn's Economic Graph can help fill in the blanks around AI in the economy, by analyzing the distribution of AI talent and the demand for AI-specific skills across the EU. Our findings highlight significant disparities that, left unchecked, could exacerbate existing inequalities. Public policies have a strategic role to play in mitigating such disparities and addressing their root causes. The EU should play an important role in this effort, since increased inequality and divergence could undermine Europe's economic, social and territorial cohesion, and have a marked impact on countries' competitiveness and the functioning of the single market.

Turning the EU into an AI champion and ensuring an equal distribution of AI talent are two sides of the same coin. They are interconnected and should be part of the same strategy. In that respect, how the EU performs globally is important. While the U.S. outperforms the EU when it comes to its ability to train and retain AI talent, the European AI ecosystem is proving more inclined to cooperation than competition. Europe's ability to leverage and contribute to the open source AI ecosystem will be key for establishing local and global champions, while ensuring this technology remains accessible to everyone, fosters innovation in the EU, and contributes to solving societal challenges.

As we have discovered, the existing body of research on AI lacks robust data needed to advance the debate and better prepare the EU for the tremendous changes AI will have on its economy and labour force. More must be done to enrich the research and gain a greater level of granular understanding as regards the distribution and profile of AI workers, allowing policymakers to design better public policies adjusted to the specific needs and challenges of each territory.

Methodological Note: AI talent identification

The methodology used in this report to identify AI talent builds on previous efforts to identify AI professionals: workers whose main activity is to develop or implement Artificial Intelligence technologies.

Previous methodologies were rule-based, determined by whether a member reported an AI skill in the skills section of their profile. However, this identification method led to the inclusion of professionals who market and sell AI technologies in our talent pool. To provide a more precise picture of just the AI talent pool, the methodology used in this analysis uses a two-step approach. In the first step, all LinkedIn member profiles are filtered by a set of AI keywords. A machine learning model is then applied to filter further this population.

This methodology is stricter in its requirements to result in "AI" assignation for a profile than the previous one. As such, those identified as "AI talent" are more likely to possess the required skills and experience to design and create AI technologies and applications. The trade-off is that it may not capture all kinds of AI workers or those whose profiles contains weak AI signals.

The benefit of this methodology is that we can be more confident than before that the members identified are truly skilled in AI. Overall, the model showed a precision rate of 74% when evaluated with manually labelled profiles. For more detailed information on the methodology used in this report, refer to "Identifying AI talent among LinkedIn members, A machine learning approach", Roca, T. 2019.

Analyzing the demand and supply for AI skills does raise methodological challenges. Chief amongst these is the fact that measuring demand through job postings allows us to measure the flow of demand – i.e. how demand is changing right now – while measuring the supply of AI skills through member profiles merely provides an indication of the total accumulated skill set of the reporting members. As such, skills mentioned in job postings tend to reflect the current needs of the market, while those displayed by members may be considered more as a record of their career. It is therefore difficult to know if mismatches are accurately represented or are the result of a rapidly evolving field with quickly changing skill needs.

Nevertheless, the size and prevalence of the gaps between the skills called for in EU job postings and those reported by the AI talent in our sample indicate a mismatch between AI training and the skills demanded of AI workers. For example, the difference between the use of Pytorch and other tools could be due to the fact that Pytorch is a more accessible and usable tool for AI talent (since it allows using less parameters to be tweaked i.e. less customization of machine learning models). Rather than focusing on the difference of prevalence, we suggest focusing on relative rankings: AI professionals favor highlighting skills in TensorFlow, OpenCv and Scikit-learn, whereas the market seems to require PyTorch and caffe, above OpenCv and Scikit-learn.

Improving our identification strategies and methodologies to provide high quality insights is a priority. Ongoing efforts will be reflected in the future updates of the AI talent series.

What is LinkedIn's Economic Graph?

LinkedIn's Economic Graph is a digital representation of the global economy based on over 660+ million members, 30 million companies, 20 million open jobs, 35 thousand skills, and 90 thousand schools. In short: it's all the data on LinkedIn.

By mapping every member, company, job, skill, and school, we're able to spot trends like talent migration, hiring rates, and in-demand skills by region. These insights help us connect our members to better opportunities in new ways. And by partnering with governments and organizations around the world, we help them create economic opportunity for the global workforce.

To learn more about LinkedIn's Economic Graph, visit https://economicgraph.linkedin.com/.

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