

chaise

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| 2 | International Association of Trusted Blockchain Applications | INATBA | BE |
| 3 | Fujitsu Technology Solutions NV | FUJITSU | BE |
| 4 | Ministry of Education and Religious Affairs | YPEPTH | GR |
| 5 | ECQA GmbH | ECQA | AT |
| 6 | DIGITALEUROPE AISBL | DIGITALEUROPE | BE |
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| 21 | INDUSTRIA Technology Ltd | INDUSTRIA | BG |
| 22 | Crypto4all | C4A | FR |
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Abbreviations

| | |
|---------|---|
| AI | Artificial Intelligence |
| BC | Blockchain |
| CEDEFOP | (Translated) European Centre for the Development of Vocational Training |
| DLT | Distributed Ledger Technology |
| ESCO | European Skills, Competences, Qualifications and Occupations |
| EU | European Union |
| EU-LFS | European Union Labour Force Survey |
| EQF | European Qualifications Framework |
| E&T | Education and Training |
| ICT | Information and Communications Technology |
| ILO | International Labour Organization |
| ISCO | International Standard Classification of Occupations |
| IT | Information Technology |
| MiCA | Markets in Crypto-Assets Regulation |
| MOOC | Massive Open Online Courses |
| VET | Vocational Education and Training |



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1 Introduction

The European Union aims to be a leader in development and applications of blockchain technology by supporting and guiding different blockchain stakeholders via appropriate policy, legal and regulatory framework, and funding.¹ Since blockchain is an advanced form of technology it requires specific expertise and experience in its development and applications. As adoptability of blockchain technology increases, it puts pressure on the current EU labour market to satisfy the demand for blockchain-related skills. Although to date the principal use of blockchain technologies has been around cryptocurrencies, there has been a rapid expansion in its application in other important areas, such as finance and banking, supply chain management, and healthcare technology. Therefore, the demand for blockchain skills is likely to grow as the technology continues to develop and adoption spreads across sectors. This report aims to estimate anticipated demand for blockchain skills as well as blockchain skills supply to provide evidence and address blockchain skills mismatches.

Firstly, a key concern is the lack of information on the current size of the blockchain labour market or the number of people working on blockchain development or applications in the EU. Therefore, we estimate that there were approximately 361,767 blockchain-related workers in the EU-26 in 2021 (Table 1). This equates to approximately 0.2% of all employment in the EU-26 in 2021. Table 1 below displays an estimated number of blockchain workers in each EU-26 country by blockchain-related occupation², which are Software and Applications Developer and Analyst; Database and Network Professional; Information and Communications Technology Services Manager; Business Services and Administration Manager; Legal Professional occupations.

A central problem in planning skills policy for any emerging technology are that (a) little is known of the type of jobs across which the skills are being demanded, (b) the jobs related to the technology have not been linked to the formal occupational framework that is used for forecasting purposes, and (c) the occupational distribution of the skill area is likely to become quickly outdated as the emerging technology is adopted across an expanding range of sectors and business operations.

¹ See <https://digital-strategy.ec.europa.eu/en/policies/blockchain-strategy>

² On identification of blockchain-related occupations, please see CHAISE blockchain skills forecasting model here: https://chaise-blockchainskills.eu/wp-content/uploads/2022/06/CHAISE_WP3_D3.1.1-Blockchain-Skills-Forecasting-Model.pdf



In response to these challenges, this report outlines a unique methodological framework that estimates the current demand for blockchain skills by using data scraping technologies. We locate blockchain related jobs within the occupational classification framework and produce forecasts for both total blockchain professionals and newly qualified blockchain graduates for the 2021 to 2026 period. The study also uses data from Eurostat and a survey of CHAISE partners to estimate the supply of both ICT graduates and graduates with blockchain exposure for each country for the period. The resulting forecasts will enable the EU, and individual member states, to assess the extent to which labour market imbalances are likely to occur in the short-term that could inhibit the development of the blockchain sector. In particular, the results of the study will be an important input into the development of a more strategic approach to the delivery of a blockchain skills strategy that will help future proof the sector against forms of skills mismatch. The methodology measuring, and forecasting, the demand and supply of blockchain skills is dynamic in nature and will be repeated annually to account for the evolving applications of the technology across economies. The methodology also includes several validation steps, involving industry experts and key stakeholder consultations, that are designed to ensure that that country level forecasts fall within an expected range.

Forecasting results were validated by 154 field experts who completed an online survey and 50 blockchain experts across the EU who were interviewed on the key findings from this report. In general, survey respondents and interviewees agree with blockchain skills demand and supply forecasting results. They also provided input on the current industry and sectoral demand for blockchain related skills. Interviews with field experts indicate that, as the adoption of blockchain technology grows the demand for non-technical, business-related, legal, and interdisciplinary skills increases. Although there continues to be a high degree of interest in blockchain technology the lack of workers with blockchain-related skill pose a major challenge for further blockchain developments.

As part of the CHAISE forecasting framework, additional information on sectoral developments, education, and training provision, and economic, societal and employment development trends was gathered. Industry experts within the CHAISE consortium expect the sector to experience further growth in the future and that there is an increased interest in blockchain activities and applications within different sectors and governments. Interviews with education and training providers suggest that provision of blockchain education and training is likely to improve due to the sectoral and industry demand for skills in this technology and growing public interest. Information on economic, societal and



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employment trends indicate that rapid expansion of new digital technologies across Europe will increase the demand for digital skills and growth in the high-tech work.



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Table 1: Estimated Blockchain Workers in 2021 by Relevant Occupation – EU-26

| | Software and Applications Developers and Analysts | Information and Communications Technology Services Managers | Database and Network Professionals | Business Services and Administration Managers | Legal Professionals | Other | Total |
|--------------|---|---|------------------------------------|---|---------------------|---------------|----------------|
| Country | (ISCO 251) | (ISCO 133) | (ISCO 252) | (ISCO 121) | (ISCO 261) | | |
| Austria | 3,518 | 1,055 | 1,603 | 825 | 125 | 575 | 7,702 |
| Belgium | 5,752 | 385 | 514 | 7,123 | 365 | 1,414 | 15,554 |
| Bulgaria | 2,151 | 788 | 518 | 4,250 | 1,191 | 890 | 9,787 |
| Croatia | 315 | 153 | 197 | 661 | 96 | 142 | 1,564 |
| Cyprus | 24 | 95 | 15 | 119 | 6 | 26 | 284 |
| Czechia | 1,317 | 788 | 1,347 | 4,142 | 321 | 791 | 8,706 |
| Denmark | 4,464 | 355 | 80 | 1,140 | 397 | 643 | 7,078 |
| Estonia | 606 | 949 | 443 | 1,051 | 1,555 | 460 | 5,065 |
| Finland | 2,069 | 55 | 155 | 731 | 122 | 313 | 3,446 |
| France | 78,417 | 4,479 | 5,847 | 6,162 | 11,242 | 10,615 | 116,760 |
| Germany | 12,287 | 2,187 | 4,903 | 3,109 | 581 | 2,307 | 25,373 |
| Greece | 872 | 46 | 70 | 65 | 12 | 107 | 1,172 |
| Hungary | 2,291 | 507 | 506 | 3,714 | 154 | 717 | 7,890 |
| Ireland | 1,618 | 254 | 884 | 1,171 | 485 | 441 | 4,855 |
| Italy | 6,475 | 872 | 2,413 | 1,085 | 1,228 | 1,207 | 13,281 |
| Latvia | 178 | 62 | 82 | 1,043 | 41 | 141 | 1,547 |
| Lithuania | 1,046 | 37 | 795 | 1,732 | 548 | 416 | 4,574 |
| Luxembourg | 46 | 26 | 22 | 160 | 163 | 42 | 460 |
| Netherlands | 6,846 | 859 | 3,303 | 9,602 | 229 | 2,084 | 22,925 |
| Poland | 12,494 | 779 | 917 | 19,652 | 352 | 3,419 | 37,613 |
| Portugal | 2,815 | 1,394 | 513 | 4,476 | 1,931 | 1,113 | 12,242 |
| Romania | 4,025 | 106 | 1,035 | 366 | 76 | 561 | 6,168 |
| Slovakia | 3,689 | 267 | 1,288 | 742 | 132 | 612 | 6,729 |
| Slovenia | 1,100 | 143 | 409 | 392 | 113 | 216 | 2,371 |
| Spain | 5,271 | 783 | 1,102 | 10,531 | 4,813 | 2,250 | 24,749 |
| Sweden | 3,712 | 283 | 1,120 | 7,241 | 255 | 1,261 | 13,872 |
| Total | 163,398 | 17,707 | 30,081 | 91,285 | 26,532 | 32,763 | 361,767 |

Notes: The number of blockchain workers in each EU country is estimated using 2021 EU-LFS information on the number of workers in blockchain-related occupations, namely Software and Applications Developers and Analysts, Information and Communications Technology Services Managers, Database and Network Professionals, Business Services and Administration Managers, and Legal Professionals, and our (CHAISE) estimates of proportions of those occupations that are blockchain-specific. We begin by gathering the total number of workers in these occupations for each country in 2021. Then, we apply our estimates of proportions of each occupation for each country that are blockchain-specific to derive the number of blockchain workers in each occupation. For more information on blockchain proportions please see [CHAISE WP3 methodology document](#) or the last year's [forecasting report](#). The total number of blockchain workers for each country and across the EU are estimated as a sum of blockchain workers across occupations. Further, we know that not all blockchain workers are in the five occupations listed above. Therefore, we add an additional 10% of the total blockchain workers from our key occupations to incorporate blockchain workers from occupations where blockchain is not yet a prominent feature.



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2 Methodology

In this section we outline sources of blockchain-related data and procedures for forecasting blockchain skills demand and supply. We use robust data from a variety of sources, and we utilize innovative tailor-made data scraping tool to obtain important information about blockchain-related jobs. On the methods of blockchain skills forecasting, we use standard occupational forecasting approaches to estimate future demand for blockchain skills, and we apply linear trends to historic blockchain-related graduate information to estimate future supply of blockchain skills. The rest of this section provides more detail on sources of data, methods of data analysis, and limitations.

2.1 Data

The data to forecast blockchain skills demand and supply comes from a number of sources. To forecast blockchain skills demand, information from online jobs advertisements, European Union Labour force Survey (EU-LFS), and CEDEFOP occupational forecasts are employed. To forecast blockchain skills supply, Eurostat and national European government department/agencies are contacted to provide graduate data for each EU member state. The demand and supply of blockchain skills is forecasted for EU member states where data is available from 2021 to 2026. The methods of data analysis used in this study are based on the previous academic literature on forecasting employment and occupational outcomes. The data gathering process and methods of forecasting blockchain skills demand and supply are discussed below.

2.2 Forecasting Blockchain Skills Demand

Recent studies attempt to identify new and emerging occupations that are yet to be recognised in the current occupational classification framework. A notable example is ILO (2020), in which AI algorithms are used to incorporate language that characterises occupations based on word-embeddings in job vacancies to understand the developments of emerging technologies and their placement in the current occupational framework. CEDEFOP (2018) have also utilised a similar approach to map important real-time labour market information about the current job market to specific occupational categories. Mezzanzanica and Mercurio (2019) state that specific word terms that link occupations to online job vacancies also link to the skills that are important in those occupations. In this way, it is possible to



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accurately map the current online jobs market information to occupational classification frameworks and identify the necessary skills.

We build on the approaches set out by ILO (2020), Mezzanzanica and Mercorio (2019), and CEDEFOP (2018) to map current blockchain related jobs advertised to the ISCO occupational classifications. However, when forecasting the demand for skills it is important to incorporate macroeconomic developments and employment projections in the changing dynamic of skills demand in various occupations (McGuinness et al., 2012). CEDEFOP employment and occupational forecasts capture skills needs, economic factors and developments in the future (Biagi et al., 2020). Therefore, we also incorporate CEDEFOP employment and occupational forecasts to account for different macroeconomic and labour market developments when forecasting blockchain skills demand.



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The methodology for forecasting blockchain skill demand is summarized in Figure 1 below.

Step 1: Collecting blockchain-related jobs data

- A unique tailored scraping tool is used to collect information on blockchain jobs advertised
- LinkedIn job advertisements are scraped using "blockchain" as a keyword (in job title of job description) to identify blockchain-related jobs

Step 2: Mapping blockchain-related jobs to ISCO classification

- Use appropriate keywords to map blockchain-related jobs to ISCO categories
- The core blockchain-related occupational categories are identified
- Use EU-LFS data to derive 3-digit ISCO categories from 2-digit ISCO categories where necessary

Step 3: Estimate the share of blockchain-related jobs in each ISCO classification

- The share of blockchain-related jobs as a proportion of total jobs are estimated for ISCO category
- LinkedIn job advertisements are used to estimate the proportion of each ISCO category that was blockchain-specific by identifying the percentage of each of core blockchain-related occupational categories, for example 'Software and Applications Developers and Analysts'

Step 4: Forecasting the demand for blockchain skills in each ISCO classification

- The share of blockchain jobs in each ISCO category is applied to the CEDEFOP forecasts to estimate the number of new blockchain jobs for each European country over the sample period
- Also, identify the share of blockchain jobs advertised at an entry level or graduate level

Figure 1 - Forecasting Blockchain Demand - Methodology



The challenge in forecasting demand for blockchain skills is that only recently blockchain specific job categories have been added to the existing occupation taxonomies. For the purposes of this report appropriate information on blockchain occupations from external sources is still lacking. Therefore, to forecast blockchain skills demand we utilised an approach set out in CEDEFOP (2018) to map blockchain related job advertisements to international standard classification of occupations. The mapping of blockchain related job advertisements to ISCO categories provided a sample of blockchain skills demand for forecasting analysis. In *Step 1*, the data on blockchain jobs was collected by employing a purpose made automated online job scraping software to extract online jobs information from a popular job advertisement website. The approach is similar to CEDEFOP (2018) who also used a web scraping technology to extract online jobs information.

After consulting a variety popular job advertisement site around Europe, LinkedIn was identified as the most reliable source for blockchain related jobs data, as it consistently produced high numbers of blockchain jobs across all European countries³. LinkedIn is also the world's largest and most developed professional network. Unlike other job advertisement sites considered, it also provided us with the seniority level for each job to derive valuable information on entry level or graduate jobs. We also believe that blockchain employment is largely in professional occupations and that LinkedIn is suited very well for professional jobs advertisements. Furthermore, our consideration of job advertisement sites and the source of data has been reviewed by the CHAISE consortium and over 40 external blockchain sector experts (during six virtual expert consultations held by the ESRI) who agreed that LinkedIn is the most appropriate data gathering source for blockchain jobs.

To get a better idea about the size of the blockchain labour market in Europe, Table 2 shows the number of blockchain related and total jobs advertised on LinkedIn, and the proportion of total jobs that are blockchain related jobs for each EU member state. The table indicates the size of the blockchain labour market and the demand for blockchain skills in the first year of blockchain skills demand forecasting (2021) and in the latest period of blockchain skills demand forecasting, which is 2022. The blockchain market has declined from approximately 0.34% of all LinkedIn jobs listing blockchain skills in 2021 to 0.24% in 2022.

³ While it is recognised that LinkedIn job advertisements may not be representative of the entire European labour market, the consortium, and expert partners, assume that it provides an adequate representation of current blockchain jobs at a country level within the EU, or at least the most adequate information that exists.



Table 2: Blockchain and Jobs Market Information from LinkedIn

| Country | 2021 Jobs | | | 2022 Jobs | | |
|--------------|----------------------------|-----------------------|-----------------|----------------------------|-----------------------|-----------------|
| | Blockchain Jobs (LinkedIn) | Total Jobs (LinkedIn) | % of Total Jobs | Blockchain Jobs (LinkedIn) | Total Jobs (LinkedIn) | % of Total Jobs |
| Austria | 142 | 37,203 | 0.38% | 72 | 47,898 | 0.15% |
| Belgium | 216 | 63,217 | 0.34% | 132 | 87,578 | 0.15% |
| Bulgaria | 350 | 8,171 | 4.28% | 69 | 6,775 | 1.02% |
| Croatia | 102 | 2,298 | 4.44% | 43 | 2,175 | 1.98% |
| Cyprus | 50 | 1,279 | 3.91% | 23 | 1,903 | 1.21% |
| Czechia | 197 | 36,852 | 0.53% | 44 | 34,389 | 0.13% |
| Denmark | 155 | 15,357 | 1.01% | 35 | 16,169 | 0.22% |
| Estonia | 53 | 2,081 | 2.55% | 43 | 2,109 | 2.04% |
| Finland | 86 | 8,910 | 0.97% | 22 | 10,673 | 0.21% |
| France | 1,088 | 697,752 | 0.16% | 1,587 | 949,096 | 0.17% |
| Germany | 2,624 | 1,007,673 | 0.26% | 2,249 | 1,033,475 | 0.22% |
| Greece | 85 | 6,607 | 1.29% | 46 | 9,746 | 0.47% |
| Hungary | 261 | 14,277 | 1.83% | 66 | 13,865 | 0.48% |
| Ireland | 352 | 38,246 | 0.92% | 244 | 35,815 | 0.68% |
| Italy | 650 | 173,254 | 0.38% | 577 | 147,610 | 0.39% |
| Latvia | 14 | 1,588 | 0.88% | 11 | 1,783 | 0.62% |
| Lithuania | 65 | 4,093 | 1.59% | 41 | 4,366 | 0.94% |
| Luxembourg | 109 | 6,571 | 1.66% | 52 | 7,947 | 0.65% |
| Netherlands | 731 | 475,026 | 0.15% | 433 | 335,930 | 0.13% |
| Poland | 1,111 | 112,459 | 0.99% | 427 | 101,907 | 0.42% |
| Portugal | 277 | 66,868 | 0.41% | 139 | 26,664 | 0.52% |
| Romania | 647 | 24,871 | 2.60% | 377 | 25,930 | 1.45% |
| Slovakia | 158 | 3,875 | 4.08% | 158 | 5,008 | 3.15% |
| Slovenia | 22 | 1,292 | 1.70% | 37 | 1,230 | 3.00% |
| Spain | 585 | 64,093 | 0.91% | 564 | 96,319 | 0.59% |
| Sweden | 132 | 52,376 | 0.25% | 46 | 97,906 | 0.05% |
| Total | 10,262 | 2,926,289 | 0.35% | 7,537 | 3,104,266 | 0.24% |



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The search criteria in LinkedIn is based on the keyword “blockchain” appearing in the job title and/or the detailed job advertisement. LinkedIn online jobs advertisements were collected for each of the EU-27⁴ countries totalling 6,103 job advertisements across the countries. These jobs are classified as blockchain-related jobs. Then, in *Step 2*, blockchain related jobs are translated into occupations (ISCO) based on the job title, job description, and keywords. Important ISCO categories and keywords used to link blockchain jobs to specific ISCO occupations were verified by CHAISE partners.⁵ Further, each CHAISE partner reviewed the mapping of blockchain jobs to ISCO categories for their home country for robustness. The following 3-digit ISCO categories emerged as the key occupations in blockchain:

- Software and Applications Developers and Analysts (ISCO 251)
- Database and Network Professionals (ISCO 252)
- Information and Communications Technology Services Managers (ISCO 133)
- Business Services and Administration Managers (ISCO 121)
- Legal Professionals (ISCO 261)

Approximately 93% of all blockchain related jobs were mapped to one of the ISCO categories identified above. The remaining 7% of blockchain related jobs were represented by the ‘other’ category since their overall representation by a specific ISCO was relatively insignificant. However, all blockchain jobs, including ‘other’, were used in the forecasting analysis.

We utilised CEDEFOP occupational forecasts for each European member state to identify, in absolute terms, by how much employment in each blockchain related ISCO category is likely to change from 2021 to 2026. Since CEDEFOP occupational forecasts incorporate important information on future employment, education, and labour force trends, as well as European and global economic developments, they are a valuable source of data to forecast blockchain labour market trends in Europe. Similarly, Biagi et al. (2020) have previously utilised CEDEFOP employment forecasts in their labour market analysis.

⁴ Scraped online job advertisements for Malta are unavailable due to a different region overlap (region in the US named similarly).

⁵ Keywords and mapping criteria available on request. Consultations were held with the following CHAISE partners: INTRASOFT, C4A, IOTA, FUJITSU.



CEDEFOP occupational forecasts are available at 2-digit ISCO level. However, this study examines demand for blockchain skills at a 3-digit ISCO level. In order to apply CEDEFOP forecasts to our data the EU Labour Force Survey data was used for each country to derive 3-digit ISCO proportions from the 2-digit ISCO categories and apply them to the CEDEFOP forecasts. The results identified the proportion of CEDEFOP occupational forecasts in each of the blockchain related occupations at a 3-digit ISCO level.

Furthermore, we must also consider that not every job within an ISCO 3-digit classification relates to blockchain. In *Step 3*, to identify the proportion of each of ISCO categories that are blockchain jobs it was necessary to estimate the percentage of each of 'software and applications developers and analysts', 'database and network professionals', 'information and communications technology services managers', 'business services and administration managers', and 'legal professionals' occupations advertised on LinkedIn that are blockchain jobs. Thus, for each of these key 3-digit occupation identified, we estimated the share of blockchain-related jobs as a proportion of total jobs for each occupation using LinkedIn. It is important to note that LinkedIn search output may yield different results if inverted commas are used around the keywords. Inverted commas around the search term will yield results related to the specific search criteria, while search results with no inverted commas produces all jobs related to the search criteria, which may or may not encompass the searched keyword in the job title or description. Further tests indicated that a more accurate representation of jobs in each occupational category may be achieved without using inverted commas in LinkedIn job search and was applied in the analysis.

To forecast blockchain skills demand between 2021 and 2026 across Europe, the percentage of blockchain jobs in each ISCO category was applied to the CEDEFOP forecasts at a 3-digit ISCO level to estimate the number of new blockchain jobs for each country over the next 6-year period. Although most blockchain jobs fall into one of the five ISCO categories identified previously some jobs were not allocated to these five specific ISCO categories. These jobs were classified as 'other'. We incorporated these 'other' jobs in the final forecasting model to obtain a more accurate estimation by inflating our forecasts by the appropriate percentage for each country. In *Step 4*, from the scraping of online jobs advertisements, we were also able to identify the proportion of all blockchain jobs that were advertised at an entry level or graduate level. The proportion of blockchain jobs classified as 'entry or graduate' level ranged from 23% in Ireland to 68% in Romania, with the average across all countries closer to



45%.⁶ This enabled us to also estimate the proportion of total forecasted blockchain jobs that may be at the graduate level. The final blockchain skills demand forecasts are presented for each European country for which relevant data was available and at specific occupational categories.

2.3 Forecasting Blockchain Skills Supply

Blockchain skills supply is estimated by identifying the number of graduates with some blockchain exposure in higher education courses. However, accurate and reliable information on the number of graduates with blockchain skills is not available across Europe. Therefore, this study utilises graduate data from blockchain related fields of study to forecast blockchain skills supply from 2021 to 2026 for EU-27 member states. CHAISE partner input and information from Eurostat was used to produce estimates for new labour market entrants from blockchain related E&T programmes. From expert consultations and CHAISE partner feedback, the Information and Communication Technology (ICT) field contained the most blockchain relevant degree programmes. Therefore, we forecast ICT graduates from 2021 to 2026 for each member state using linear trends based on data sourced from 2015 to 2020.

A sample of CHAISE partners supplied estimates of graduates with at least some exposure to blockchain learning for their home countries (Austria, Belgium, Estonia, France, Germany, Ireland, Italy, Slovenia, and Spain) most completely for 2021. This allowed for an estimation of the share of blockchain graduates as a share of total ICT graduates for these countries in this year, which ranged from the lowest in Austria (0.48%) to the highest in Belgium (5.45%). The average of these estimates of blockchain graduates was 2.57% and was used to estimate the number of graduates with blockchain exposure for all other countries for which blockchain graduate data was unavailable. These supply-side forecasts provide a framework that will also allow individual member states to estimate blockchain skills supply based on their understanding of their country's education system.

⁶ Entry level positions were estimated as all jobs which stated 'entry level' in the job advert posting on LinkedIn and 75% of those positions who either did not specify the education level i.e. 'not applicable' or where the information was missing. Please see Table 9, Column 3 and a more detailed table can be provided on request from the authors.



2.4 Data Limitations

Although this study utilised a unique method of forecasting blockchain skills supply and demand it encountered data issues that need to be acknowledged. In terms of blockchain skills demand, data for the analysis comes from online job vacancies advertised on LinkedIn. In general, online job vacancies suffer from the following limitations: they are a sample of total jobs demand as not all jobs are advertised on LinkedIn; across Europe there are different methods of advertising jobs, and there are many different online job vacancy providers; information contained within job advertisements may differ depending on occupational requirements and employer demands. Next, the mapping of blockchain jobs to ISCO categories involves a mixture of automated and manual mapping processes based on keywords that may misallocate some jobs to different ISCO categories. Detailed analysis of online job vacancies is inherently subject to human or systematic errors even when most up-to-date data technique are used (CEDEFOP, 2019). It is also important to acknowledge that missing CEDEFOP forecasts and EU-LFS occupational data for a small number of countries means that such forecasts rely on additional assumptions and estimates (further documented in footnotes on Table 4).

In terms of blockchain skills supply, unavailable information on the number of blockchain specific graduates for most EU countries means that blockchain supply forecasts for countries that are missing this information are based on average EU estimates of blockchain graduates rather than country specific data. Further, due to the lack of EU-wide information on the number of graduates from blockchain courses, we estimate the number of graduates with some blockchain exposure through modules or classes in the forecasting analysis. Unlike demand side forecasts, supply forecasts do not incorporate macroeconomic and demographic changes in their projections. Supply side forecasts do not specifically consider blockchain skills supply from vocational education and training providers, due to the lack of data availability across the EU-27 countries. However, VET experts are interviewed as part of skills intelligence gathering activities and forecasting results validation process to provide further input on blockchain skills supply.

Although data issues are important to acknowledge this our second attempt document both the measurement and forecast blockchain skills demand and supply in Europe. The resulting forecasts will facilitate the EU, and individual member states, to review and assess the extent to which labour market imbalances are likely to occur in the short-term that could inhibit the development of the blockchain sector. In particular, the results of the study will inform the development of a more strategic approach to



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the delivery of a blockchain skills strategy that will help future proof the sector against forms of skills mismatch.

Having outlined the sources of data, methods of data analysis, and limitations associated with forecasting blockchain skills demand and supply we present the key results from in the next section.



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3 Results

In this section we present the key results on forecasting blockchain skills demand and supply. We begin by presenting results on CEDEFOP occupational forecasts, followed by blockchain demand forecasts, historic data on blockchain-related graduate supply, and finally blockchain skills supply forecasts from 2021 to 2026. In this section we focus on the latest forecasting results using data from 2022, but we also refer to forecasting results from the last year of forecasting activities which used blockchain-related information from 2021. We make comparisons to previous year of forecasting to identify any changes in the current blockchain labour market.

3.1 Occupational Forecasts

Blockchain skills demand forecasts are based on CEDEFOP occupational forecasts presented in Table 3. The four key 2-digit ISCO categories containing most blockchain jobs are Information and Communications Technology Professionals (ISCO 25), Production and Specialised Services Managers (ISCO 13), Administrative and Commercial Managers (ISCO 12), and Legal, Social and Cultural Professionals (ISCO 26). Other ISCO categories contain a relatively insignificant number of blockchain related jobs and are therefore excluded from the detailed analysis. CEDEFOP's 2-digit ISCO forecasts in Table 3 indicate the change in employment in each occupational category for each of EU-26 member states from 2021 to 2026.⁷ Absolute change in the numbers of persons employed in these occupations is utilised in the blockchain skills forecasting.

⁷ Our results excluding Malta due to data constraints.



Table 3: Total Demand for Blockchain-Related ISCO Occupations by Country

| Country | Information and Communications Technology Professionals (ISCO 25) | | Production and Specialised Services Managers (ISCO 13) | | Administrative and Commercial Managers (ISCO 12) | | Legal, Social and Cultural Professionals (ISCO 26) | |
|-------------|---|--------------------|--|--------------------|--|--------------------|--|--------------------|
| | (CEDEFOP annual %) | (Absolute numbers) | (CEDEFOP annual %) | (Absolute numbers) | (CEDEFOP annual %) | (Absolute numbers) | (CEDEFOP annual %) | (Absolute numbers) |
| Austria | 0.50% | 1,959 | 1.50% | 5,716 | -0.10% | -461 | 1.90% | 12,062 |
| Belgium | 2.30% | 13,323 | 1.10% | 6,355 | 2.00% | 13,338 | 2.20% | 22,399 |
| Bulgaria | 1.30% | 2,608 | -1.70% | -5,524 | 0.40% | 749 | 0.10% | 442 |
| Croatia | 3.30% | 3,882 | 0.40% | 762 | -0.90% | -796 | 1.60% | 5,686 |
| Cyprus | 4.30% | 1,186 | 5.20% | 2,196 | 8.10% | 2,714 | 3.50% | 2,524 |
| Czechia | 1.00% | 4,035 | -1.10% | -5,108 | 1.50% | 6,230 | 1.10% | 7,327 |
| Denmark | 2.20% | 9,159 | 4.40% | 7,383 | 1.90% | 2,041 | 2.10% | 10,114 |
| Estonia | 2.60% | 2,265 | -0.10% | -275 | 2.60% | 2,352 | -0.20% | -198 |
| Finland | 1.60% | 7,779 | 1.50% | 265 | -1.50% | -869 | -0.50% | -2,037 |
| France | 1.90% | 41,249 | 1.10% | 57,956 | 1.30% | 46,214 | 1.00% | 38,161 |
| Germany | 1.50% | 62,619 | -0.50% | -12,834 | 1.50% | 45,128 | 1.10% | 71,828 |
| Greece | 0.60% | 786 | 1.60% | 2,741 | 0.80% | 491 | 1.30% | 8,582 |
| Hungary | 1.70% | 6,203 | 2.30% | 11,492 | 0.80% | 1,983 | 2.30% | 14,575 |
| Ireland | N/A | 4,059 | 0.50% | 1,486 | 4.60% | 16,748 | 2.30% | 5,955 |
| Italy | 1.60% | 17,219 | -0.70% | -10,710 | 6.40% | 23,315 | 1.20% | 38,546 |
| Latvia | 1.50% | 1,361 | 0.70% | 819 | 1.70% | 2,261 | 1.90% | 2,151 |
| Lithuania | 3.00% | 2,987 | -2.00% | -3,726 | 0.10% | 168 | 1.60% | 2,768 |
| Luxembourg | 2.70% | 1,952 | 5.10% | 832 | 2.30% | 481 | 3.70% | 7,954 |
| Netherlands | 1.10% | 18,220 | 2.10% | 19,815 | -3.10% | -18,938 | 1.20% | 24,153 |
| Poland | 1.90% | 24,117 | N/A | -476 | 2.40% | 43,483 | 0.40% | 7,547 |



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| Cont'd Table 3: Total Demand for Blockchain-Related ISCO Occupations by Country | | | | | | | | |
|---|---|--------------------|--|--------------------|--|--------------------|--|--------------------|
| Country | Information and Communications Technology Professionals (ISCO 25) | | Production and Specialised Services Managers (ISCO 13) | | Administrative and Commercial Managers (ISCO 12) | | Legal, Social and Cultural Professionals (ISCO 26) | |
| | (CEDEFOP annual %) | (Absolute numbers) | (CEDEFOP annual %) | (Absolute numbers) | (CEDEFOP annual %) | (Absolute numbers) | (CEDEFOP annual %) | (Absolute numbers) |
| Portugal | 3.30% | 9,990 | 1.60% | 9,559 | 1.90% | 3,606 | 1.80% | 11,581 |
| Romania | 0.20% | 772 | 0.30% | 655 | 1.50% | 1,109 | 3.50% | 71,877 |
| Slovakia | 0.40% | 572 | 0.50% | 1,084 | 2.60% | 3,934 | 0.90% | 2,640 |
| Slovenia | 1.40% | 1,010 | 1.30% | 2,635 | 3.00% | 4,696 | 1.20% | 2,055 |
| Spain | 1.90% | 17,965 | 1.30% | 18,250 | 1.80% | 20,995 | 0.90% | 30,035 |
| Sweden | 1.30% | 10,985 | 1.00% | 6,408 | 4.00% | 25,464 | 1.80% | 18,520 |

Notes: Annual percentage change and absolute numbers in 2-digit ISCO categories were derived from CEDEFOP occupational forecasts from 2021 to 2026, available at <https://www.cedefop.europa.eu/en/tools/skills-forecast>. CEDEFOP occupational forecasts for "Information and Communications Technology Professionals (ISCO 25)" were not available for Ireland, and "Production and Specialised Services Managers (ISCO 13)" were not available for Poland. For Ireland, we use EU average CEDEFOP forecast for ISCO 25 to estimate the proportion of total Irish employment in ISCO 25



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3.2 Blockchain Skills Demand Forecast

In Table 4, blockchain skills demand forecasts are presented across Europe. For each of the key blockchain related occupations total demand represents the change in employment in a specific occupation over the period, 2021 to 2026. Blockchain demand reflects the size of an occupational change that is likely to be blockchain specific. The demand for blockchain skills for each country depends on the proportion of blockchain jobs in a specific occupational category in that country. Therefore, greater proportion of blockchain jobs in a specific occupational category means that the demand for blockchain skills will change by a more significant amount. This also explains disparities in blockchain skills demand between different countries. For example, although France and Germany are similar in population size, relative to the rest of Europe, their forecasted additional blockchain jobs differ significantly, 10,470 new blockchain jobs in France and only 3,879 new blockchain jobs in Germany. The main reason for this is a relatively greater proportion of blockchain jobs in *Business Services and Administration Managers* and *Information and Communications Technology Service Managers* occupations in France than in Germany. Therefore, more additional blockchain jobs are forecasted in France than in Germany. The proportion of blockchain jobs to specific ISCO categories for each country are presented in Table 5 below.

Although demand for blockchain skills (Table 4) is increasing at the European level, specific countries and in specific occupations total demand and blockchain specific demand may be decreasing. For example, total forecasted blockchain demand in the Netherlands is forecasted to decrease by 70 jobs. However, this decrease in demand is driven by a reduction in total demand, as forecasted by CEDEFOP, for *Business Services and Administration Managers* occupations while in other occupations blockchain demand is expected to increase. Similarly, in other countries a reduction in specific occupations, based on CEDEFOP occupational forecasts, reduce the demand for blockchain specific jobs. On aggregate, the total forecasted demand for blockchain-related jobs across Europe is 29,383, between 2021 and 2026. This is largely driven by growth in *Business Services and Administration Managers* occupations which contains the most blockchain related jobs. Blockchain demand in occupations with minor blockchain representation is presented by the '*Other ISCO Categories*'. It accounts for approximately 7% of the total forecasted additional blockchain jobs and is included in the analysis for a complete representation of the blockchain labour market in Europe.



Table 4: Forecasted Blockchain Demand by Blockchain-Relevant ISCO occupations, 2021-2026

| Country | Software and Applications Developers and Analysts (ISCO 251) | | Database and Network Professionals (ISCO 252) | | Information and Communications Technology Service Managers (ISCO 133) | | Business Services and Administration Managers (ISCO 121) | | Legal Professionals (ISCO 261) | | Other ISCO Categories | Total Forecasted Additional Blockchain Jobs 2021-2026 |
|-----------|--|-------------------|---|-------------------|---|-------------------|--|-------------------|--------------------------------|-------------------|-----------------------|---|
| | Total Demand | Blockchain Demand | Total Demand | Blockchain Demand | Total Demand | Blockchain Demand | Total Demand | Blockchain Demand | Total Demand | Blockchain Demand | | |
| Austria | 1,528 | 22 | 431 | 5 | 1,086 | 40 | -189 | -12 | 3,619 | 154 | 36 | 245 |
| Belgium | 11,325 | 137 | 1,998 | 30 | 1,271 | 29 | 5,602 | 188 | 6,496 | 51 | 5 | 440 |
| Bulgaria* | 2,008 | 33 | 600 | 14 | -718 | -112 | 457 | 55 | 128 | 48 | 2 | 41 |
| Croatia | 3,377 | 76 | 505 | 9 | 69 | 11 | -390 | -68 | 1,535 | 0 | 3 | 32 |
| Cyprus | 747 | 29 | 439 | 53 | 813 | 60 | 1,493 | 498 | 1,161 | 0 | 115 | 755 |
| Czechia | 2,703 | 17 | 1,332 | 16 | -1,686 | -48 | 4,859 | 558 | 2,491 | 0 | 11 | 553 |
| Denmark | 8,243 | 387 | 916 | 22 | 738 | 52 | 1,408 | 815 | 2,225 | 0 | 201 | 1,477 |
| Estonia | 1,631 | 45 | 634 | 27 | -77 | -25 | 1,388 | 463 | -53 | -31 | 10 | 489 |
| Finland | 7,079 | 36 | 700 | 3 | 24 | 1 | -408 | -52 | -326 | -9 | 0 | -22 |
| France | 28,049 | 291 | 13,200 | 395 | 18,546 | 2,304 | 24,493 | 6,421 | 8,395 | 157 | 903 | 10,470 |
| Germany | 53,852 | 313 | 8,767 | 138 | -1,412 | -34 | 27,528 | 2,718 | 12,929 | 416 | 329 | 3,879 |
| Greece | 668 | 3 | 118 | 1 | 164 | 8 | 226 | 32 | 3,347 | 0 | 4 | 47 |
| Hungary | 4,156 | 35 | 2,047 | 26 | 690 | 17 | 1,705 | 181 | 4,518 | 0 | 35 | 293 |
| Ireland | | | | 43 | 89 | 4 | 16,078 | 835 | 1,548 | 56 | 16 | 955 |
| Italy | 12,914 | 216 | 4,305 | 290 | -857 | -99 | 10,025 | 1,465 | 17,346 | 173 | 56 | 2,101 |
| Latvia | 762 | 3 | 599 | 9 | 74 | 2 | 1,967 | 358 | 538 | 0 | 0 | 372 |



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Cont'd Table 4: Forecasted Blockchain Demand by Blockchain-Relevant ISCO occupations, 2021-2026

| Country | Software and Applications Developers and Analysts (ISCO 251) | | Database and Network Professionals (ISCO 252) | | Information and Communications Technology Service Managers (ISCO 133) | | Business Services and Administration Managers (ISCO 121) | | Legal Professionals (ISCO 261) | | Other ISCO Categories Blockchain Demand | Total Forecasted Additional Blockchain Jobs 2021-2026 |
|--------------|---|-------------------|--|-------------------|--|-------------------|---|-------------------|-----------------------------------|-------------------|--|--|
| | Total Demand | Blockchain Demand | Total Demand | Blockchain Demand | Total Demand | Blockchain Demand | Total Demand | Blockchain Demand | Total Demand | Blockchain Demand | | |
| Lithuania | 2,121 | 40 | 866 | 19 | -186 | -17 | 109 | 36 | 637 | 0 | 2 | 81 |
| Luxembourg | 1,405 | 45 | 547 | 6 | 133 | 6 | 399 | 10 | 2,943 | 76 | 22 | 166 |
| Netherlands | 14,029 | 121 | 4,191 | 57 | 2,774 | 264 | -10,416 | -545 | 4,348 | 41 | -8 | -70 |
| Poland* | 20,499 | 147 | 3,618 | 15 | -24 | -2 | 31,308 | 1,204 | 2,868 | 120 | 99 | 1,584 |
| Portugal | 7,293 | 58 | 2,697 | 20 | 574 | 46 | 1,983 | 79 | 3,358 | 438 | 0 | 640 |
| Romania | 664 | 21 | 108 | 2 | 13 | 2 | 466 | 17 | 24,438 | 0 | 1 | 43 |
| Slovakia | 435 | 27 | 137 | 18 | 87 | 13 | 2,124 | 595 | 396 | 25 | 23 | 700 |
| Slovenia | 778 | 36 | 232 | 17 | 343 | 181 | 2,865 | 955 | 596 | 0 | 0 | 1,189 |
| Spain | 12,576 | 191 | 5,390 | 139 | 1,095 | 96 | 11,547 | 1,191 | 12,014 | 311 | 187 | 2,115 |
| Sweden | 9,337 | 29 | 1,648 | 14 | 577 | 14 | 18,334 | 604 | 3,519 | 53 | 94 | 807 |
| Total | 208,181 | 2,358 | 56,022 | 1,386 | 24,199 | 2,815 | 154,962 | 18,600 | 121,014 | 2,079 | 2,143 | 29,383 |

Notes: Total demand for each 3-digit ISCO category is estimated by finding their proportions from EU-LFS for each country and applying them to absolute changes in 2-digit ISCO categories from CEDEFOP forecasts in Table 3. The Blockchain demand for each country is estimated by applying the percentage of 3-digit ISCO occupations (Table 5) that are Blockchain jobs to 'Total Demand' figures. The final column lists total forecasted Blockchain jobs from 2021 to 2026 for each country. For Ireland, 3-digit ISCO 25 employment data from EU-LFS was also unavailable but we use EU average CEDEFOP forecast and estimate average of ISCO 25 that are Blockchain jobs. (*) For Bulgaria and Poland 3-digit ISCO employment data from EU-LFS was also unavailable. Therefore, we estimate the average proportion of 3-digit ISCO across Europe in each of 2-digit ISCO categories (ISCO 251: 77%; ISCO252: 23%; ISCO 133: 13%; ISCO 121: 61%; ISCO 261: 29%) and apply it to CEDEFOP occupational forecast data and estimate the forecasted additional blockchain jobs in these countries.



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Table 5: Proportion of Jobs in each ISCO Category that are Blockchain Jobs - Europe

| | Software and Applications Developers and Analysts | Information and Communications Technology Services Managers | Database and Network Professionals | Business Services and Administration Managers | Legal Professionals |
|------------|---|---|------------------------------------|---|---------------------|
| Country | (ISCO 251) | (ISCO 133) | (ISCO 252) | (ISCO 121) | (ISCO 261) |
| Austria | 1.42% | 3.72% | 1.17% | 6.12% | 4.26% |
| Belgium | 1.21% | 2.26% | 1.50% | 3.36% | 0.79% |
| Bulgaria | 1.66% | 15.57% | 2.41% | 12.00% | [37.50%]* |
| Croatia | 2.24% | 16.67% | 1.82% | 17.39% | 0.00% |
| Cyprus | 3.86% | 7.41% | 12.12% | [33.33%]* | 0.00% |
| Czechia | 0.63% | 2.84% | 1.18% | 11.48% | 0.00% |
| Denmark | 4.70% | 7.08% | 2.39% | [57.89%]* | 0.00% |
| Estonia | 2.75% | [32.26%] | 4.26% | [33.33%]* | [57.14%]* |
| Finland | 0.51% | 2.31% | 0.43% | 12.82% | 2.86% |
| France | 1.04% | 12.42% | 2.99% | [26.21%]* | 1.87% |
| Germany | 0.58% | 2.42% | 1.57% | 9.87% | 3.21% |
| Greece | 0.39% | 4.82% | 0.46% | 14.29% | 0.00% |
| Hungary | 0.84% | 2.51% | 1.25% | 10.59% | 0.00% |
| Ireland | 1.43% | 4.87% | 0.53% | 5.19% | 3.64% |
| Italy | 1.67% | 11.50% | 6.73% | 14.62% | 1.00% |
| Latvia | 0.40% | 3.23% | 1.52% | 18.18% | 0.00% |
| Lithuania | 1.90% | 8.89% | 2.22% | [33.33%]* | 0.00% |
| Luxembourg | 3.22% | 4.55% | 1.18% | 2.47% | 2.59% |



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| Cont'd Table 5: Proportion of Jobs in Each ISCO Category That are Blockchain Jobs - Europe | | | | | |
|--|---|---|------------------------------------|---|---------------------|
| | Software and Applications Developers and Analysts | Information and Communications Technology Services Managers | Database and Network Professionals | Business Services and Administration Managers | Legal Professionals |
| Country | (ISCO 251) | (ISCO 133) | (ISCO 252) | (ISCO 121) | (ISCO 261) |
| Netherlands | 0.86% | 9.53% | 1.36% | 5.23% | 0.93% |
| Poland | 0.72% | 7.64% | 0.40% | 3.85% | 4.20% |
| Portugal | 0.79% | 7.98% | 0.73% | 3.97% | 13.04% |
| Romania | 3.20% | 14.01% | 1.71% | 3.73% | 0.00% |
| Slovakia | 6.14% | 14.46% | 13.24% | [28.00%]* | 6.25% |
| Slovenia | 4.62% | [52.94%]* | 7.14% | [33.33%]* | 0.00% |
| Spain | 1.52% | 8.74% | 2.58% | 10.31% | 2.59% |
| Sweden | 0.31% | 2.41% | 0.86% | 3.30% | 1.49% |
| Average | 1.87% | 10.12% | 2.84% | 15.93% | 5.51% |

Notes: The proportion of jobs in each ISCO category that are blockchain jobs was estimated by dividing the number blockchain jobs in a specific ISCO category by the total number of jobs in that ISCO category. This was estimated for each ISCO category and for each European state. The following keywords were used to derive the total number of jobs in each ISCO category from LinkedIn: ISCO 251: “software developer” and “analyst software”; ISCO 252: “database and network”; ISCO 133: “IT manager”; ISCO 121: “business services manager”; ISCO 261: “lawyer”. (*) indicates that blockchain proportions may be overestimated due to relatively few ISCO related jobs advertised on LinkedIn or more blockchain jobs mapped to a specific occupation. This effect is more severe for countries with fewer job offerings on LinkedIn. Our data scraping tool enables us to collect blockchain jobs data on up to 1,000 observations per country.



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Estimation of the proportions of jobs in each ISCO category that are blockchain-related is repeated on annual basis during the continuation of the CHAISE project. Therefore, it is possible to compare the current estimation (2022) of blockchain proportions to last year's proportion estimates (2021). By doing so, we can identify notable changes in the composition of the blockchain labour market and identify potential reasons for changes in blockchain skills demand forecasts year-on-year. Table 6 below indicates that the proportions of ISCO jobs that are blockchain-related have changed for most EU-26 countries. On average, the proportion of blockchain-related employment has increase in *Information and Communications Technology Services Managers, Business Services and Administration Managers, and Legal Professionals* occupations. We also observe a significant decrease in the proportions of blockchain-related employment in *Software and Applications Developers and Analysts, and Database and Network Professional* occupations, which have been previously identified as key areas of blockchain-related employment. This may be due to the recent turbulence in the technology sector⁸, which has resulted in layoffs and halted hiring of new staff in roles largely linked to blockchain technology.⁹ We also observe volatility in the crypto-market space, which relies on blockchain technology, leading to reduced demand for software developers, engineers, and database and network professionals with blockchain skills.¹⁰

⁸ See <https://www.forbes.com/sites/qai/2023/01/19/why-were-tech-stocks-down-in-2022-and-how-long-will-the-slump-last/?sh=6e32bd627f116>

⁹ See <https://www.nbcnews.com/tech/tech-news/another-tech-bubble-bursts-2022-brutal-silicon-valley-workers-rcna56435>

¹⁰ See <https://www.forbes.com/sites/jackkelly/2022/07/06/the-new-era-of-layoffs-hiring-freezes-stock-and-crypto-market-crashes/?sh=74b6187896df>



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Table 6: Comparison of Proportion of Jobs in each ISCO Category that are Blockchain Related

| Country | ISCO 251: Software and Applications Developers and Analysts | | ISCO 133: Information and Communications Technology Services Managers | | ISCO 252: Database and Network Professionals | | ISCO 121: Business Services and Administration Managers | | ISCO 261 Legal Professionals | | Other | |
|----------|---|-------|---|--------|---|--------|--|--------|---------------------------------|--------|--------|--------|
| | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| Austria | 4.50% | 1.42% | 7.60% | 3.72% | 8.20% | 1.17% | 2.70% | 6.12% | 0.00% | 4.26% | 10.16% | 16.90% |
| Belgium | 4.30% | 1.21% | 2.10% | 2.26% | 2.40% | 1.50% | 10.70% | 3.36% | 0.80% | 0.79% | 14.92% | 1.20% |
| Bulgaria | 5.30% | 1.66% | 15.00% | 15.57% | 5.10% | 2.41% | 20.40% | 12.00% | 3.80% | 37.50% | 8.03% | 5.10% |
| Croatia | 1.40% | 2.24% | 8.00% | 16.67% | 5.10% | 1.82% | 8.10% | 17.39% | 0.00% | 0.00% | 10.71% | 11.63% |
| Cyprus | 0.40% | 3.86% | 8.90% | 7.41% | 0.00% | 12.12% | 6.40% | 33.33% | 0.00% | 0.00% | 26.83% | 17.95% |
| Czechia | 1.80% | 0.63% | 7.90% | 2.84% | 3.50% | 1.18% | 6.40% | 11.48% | 0.00% | 0.00% | 6.82% | 2.00% |
| Denmark | 5.60% | 4.70% | 3.70% | 7.08% | 0.80% | 2.39% | 7.00% | 57.89% | 2.00% | 0.00% | 10.66% | 15.71% |
| Estonia | 4.10% | 2.75% | 19.10% | 32.26% | 7.40% | 4.26% | 24.20% | 33.33% | 28.60% | 57.14% | 17.74% | 2.00% |
| Finland | 2.00% | 0.51% | 2.90% | 2.31% | 1.60% | 0.43% | 12.30% | 12.82% | 0.00% | 2.86% | 7.89% | 0.00% |
| France | 15.10% | 1.04% | 9.10% | 12.42% | 4.40% | 2.99% | 1.90% | 26.21% | 5.20% | 1.87% | 31.60% | 9.43% |
| Germany | 1.50% | 0.58% | 4.20% | 2.42% | 3.70% | 1.57% | 1.20% | 9.87% | 0.20% | 3.21% | 14.68% | 9.26% |
| Greece | 2.40% | 0.39% | 2.50% | 4.82% | 0.90% | 0.46% | 0.00% | 14.29% | 0.00% | 0.00% | 7.89% | 8.11% |
| Hungary | 3.20% | 0.84% | 7.00% | 2.51% | 1.80% | 1.25% | 11.30% | 10.59% | 0.00% | 0.00% | 16.40% | 13.43% |
| Ireland | 4.30% | 1.43% | 5.20% | 4.87% | 9.40% | 0.53% | 3.20% | 5.19% | 3.20% | 3.64% | 4.67% | 1.74% |
| Italy | 4.20% | 1.67% | 3.20% | 11.50% | 4.60% | 6.73% | 8.20% | 14.62% | 0.50% | 1.00% | 26.89% | 2.73% |
| Latvia | 1.50% | 0.40% | 2.50% | 3.23% | 0.00% | 1.52% | 5.90% | 18.18% | 0.00% | 0.00% | 12.50% | 0.00% |



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Cont'd Table 6: Comparison of Proportion of Jobs in each ISCO Category that are Blockchain Jobs

| Country | ISCO 251: Software and Applications Developers and Analysts | | ISCO 133: Information and Communications Technology Services Managers | | ISCO 252: Database and Network Professionals | | ISCO 121: Business Services and Administration Managers | | ISCO 261 Legal Professionals | | Other | |
|----------------|---|--------------|---|---------------|---|--------------|--|---------------|---------------------------------|--------------|---------------|--------------|
| | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| Lithuania | 4.40% | 1.90% | 2.00% | 8.89% | 8.90% | 2.22% | 6.40% | 33.33% | 4.50% | 0.00% | 6.15% | 1.96% |
| Luxembourg | 0.50% | 3.22% | 6.60% | 4.55% | 0.00% | 1.18% | 3.80% | 2.47% | 1.80% | 2.59% | 21.62% | 15.63% |
| Netherlands | 2.10% | 0.86% | 3.30% | 9.53% | 3.60% | 1.36% | 10.70% | 5.23% | 0.30% | 0.93% | 9.84% | 12.90% |
| Poland | 4.60% | 0.72% | 4.10% | 7.64% | 1.80% | 0.40% | 10.50% | 3.85% | 0.00% | 4.20% | 12.87% | 6.70% |
| Portugal | 4.40% | 0.79% | 9.20% | 7.98% | 1.80% | 0.73% | 13.40% | 3.97% | 4.30% | 13.04% | 10.04% | 0.00% |
| Romania | 4.70% | 3.20% | 8.80% | 14.01% | 9.20% | 1.71% | 2.30% | 3.73% | 0.00% | 0.00% | 2.67% | 2.43% |
| Slovakia | 11.60% | 6.14% | 3.80% | 14.46% | 13.20% | 13.24% | 4.60% | 28.00% | 0.00% | 6.25% | 3.64% | 3.40% |
| Slovenia | 5.70% | 4.62% | 7.80% | 52.94% | 8.50% | 7.14% | 5.00% | 33.33% | 1.00% | 0.00% | 5.41% | 0.00% |
| Spain | 4.10% | 1.52% | 3.10% | 8.74% | 2.10% | 2.58% | 9.50% | 10.31% | 2.00% | 2.59% | 9.66% | 9.72% |
| Sweden | 1.70% | 0.31% | 2.00% | 2.41% | 3.20% | 0.86% | 8.00% | 3.30% | 0.00% | 1.49% | 8.11% | 13.11% |
| Average | 4.05% | 1.87% | 6.14% | 10.12% | 4.28% | 2.84% | 7.85% | 15.93% | 2.24% | 5.51% | 12.25% | 7.04% |



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3.3 Blockchain Skills Supply

The total number of ICT graduates per year from 2015 to 2020 for each European country is presented in Table 7. Since most blockchain employment comes from the ICT field of study we utilise the number of graduates from this field to estimate the proportion of ICT graduates with exposure to blockchain learning, and therefore, blockchain skills supply. Evidently, the number of ICT graduates across Europe has been increasing on average at 6.8% per year from 2015 to 2020 which is reflecting the continuous expansion of the ICT sector at a European level. This suggests that the blockchain sector across Europe was also growing at that time. However, the extent of growth in the blockchain sector and applicable skills supply is unknown due to the lack of appropriate data on blockchain-specific graduates.

In order to estimate blockchain graduate supply in Europe the CHAISE consortium is consulted to provide national statistics on the number of blockchain graduates from blockchain-specific courses or graduates with at least some exposure to blockchain content. To forecast blockchain skills the proportion of ICT graduates that are coming from blockchain-related courses is estimated. Therefore, we find that on average 2.57% of ICT graduates in Europe are coming with some exposure with blockchain learning. The number of ICT graduates over the examination period and the proportion of graduates with exposure to blockchain learning in 2021 are used to estimate the change in blockchain labour market and skills supply from 2021 to 2026.



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Table 7: Total ICT Graduates by Country, 2015-2020

| Country | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|--------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Austria | 2,555 | 2,574 | 2,435 | 2,549 | 2,704 | 2,717 |
| Belgium | 1,229 | 1,847 | 2,146 | 2,454 | 2,445 | 2,728 |
| Bulgaria | 1,957 | 1,733 | 2,127 | 2,055 | 2,084 | 2,147 |
| Croatia | - | 1,666 | 1,876 | 1,383 | 1,461 | 1,603 |
| Cyprus | 225 | 204 | 229 | 229 | 289 | 258 |
| Czechia | 3,848 | 3,648 | 3,964 | 3,758 | 3,662 | 3,630 |
| Denmark | 2,696 | 3,224 | 3,252 | 3,244 | 3,405 | 3,650 |
| Estonia | 516 | 652 | 713 | 604 | 718 | 766 |
| Finland | 3,784 | 3,958 | 3,538 | 4,065 | 4,342 | 4,762 |
| France | 18,359 | 18,801 | 19,442 | 20,459 | 20,994 | 29,810 |
| Germany | 24,755 | 25,332 | 26,731 | 27,456 | 29,513 | 29,305 |
| Greece | 1,984 | 2,211 | 1,998 | 2,174 | 2,393 | 2,427 |
| Hungary | 1,455 | 2,813 | 2,523 | 2,754 | 2,852 | 5,338 |
| Ireland | 4,449 | 4,851 | 5,275 | 6,251 | 6,271 | 7,154 |
| Italy | - | 3,211 | 3,328 | 4,549 | 5,103 | 5,657 |
| Latvia | 550 | 527 | 523 | 512 | 463 | 550 |
| Lithuania | 587 | 601 | 760 | 818 | 921 | 974 |
| Luxembourg | 84 | 88 | 75 | 94 | 78 | 109 |
| Malta | 242 | 240 | 271 | 270 | 270 | 276 |
| Netherlands | 3,101 | 3,463 | 3,730 | 4,311 | 4,789 | 5,329 |
| Poland | 15,744 | 15,214 | 18,259 | 17,911 | 17,270 | 15,379 |
| Portugal | 862 | 806 | 942 | 1,070 | 1,163 | 1,399 |
| Romania | 8,460 | 8,572 | 9,379 | 9,905 | 10,758 | 11,688 |
| Slovakia | 1,734 | 1,753 | 1,653 | 1,718 | 1,562 | 1,670 |
| Slovenia | - | - | 952 | 978 | 1,029 | 962 |
| Spain | 7,662 | 7,456 | 7,876 | 7,173 | 7,365 | 8,402 |
| Sweden | 2,075 | 2,088 | 2,139 | 2,199 | 2,340 | 2,729 |
| Total | 108,913 | 117,533 | 126,136 | 130,943 | 136,244 | 151,419 |

Note: Data for total ICT graduates comes from CHAISE partner submissions and Eurostat (https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=educ_uoe_grad02&lang=en).



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3.4 Blockchain Skills Supply Forecast

Forecasts of ICT graduates and blockchain graduates for each European country from 2021 to 2026 are presented in Table 8. ICT graduate forecasts are based on the number of graduates from 2015 to 2020 in Table 7. We forecast that the number of ICT graduates across Europe will grow on an average at 3.8% per year from 2021 to 2026. Therefore, the total forecasted ICT graduate supply in Europe over the sample period is 1,029,417. We estimate that approximately 2.57% of ICT graduates in Europe are from blockchain specific courses or were exposed to blockchain learning. This is estimated as an average of total ICT graduates that are blockchain-graduates in the following countries in which this information was provided by consortium partners: Austria (0.48%), Belgium (5.45%), Estonia (2.26%), France (3.77%), Germany (0.99%), Ireland (2.31%), Italy (3.56%), Slovenia (3.60%) and Spain (0.76%). Last year's forecasting results indicated that on average approximately 1.5% of ICT graduates in Europe are from blockchain specific courses, but this information was provided by only four CHAISE partners. Current forecasting results incorporate more complete and up-to-date information on graduates with blockchain exposure, and therefore provide a more accurate forecasting of blockchain skills supply.

In terms of blockchain graduate proportions, country specific data is applied in the forecasting analysis for which this information is available (i.e. for Austria, Belgium, Estonia, France, Germany, Ireland, Italy, Slovenia and Spain) and the European average calculated as 2.57% is applied to all other countries. Therefore, forecasted total blockchain graduate supply in Europe over the period from 2021 to 2026 is 25,557. This is almost doubled when compared to our last year's forecasted supply of 14,972. The main reason for the increase in forecasted supply from our last year's estimates is a higher and more accurate picture about graduates with blockchain exposure in the current year of forecasting.

Countries with a larger population or greater number of ICT graduates are likely to contribute more to the supply of blockchain skills in Europe. The countries that are forecasted on average to experience a significant growth in the number of ICT graduates, and therefore blockchain graduates, over the sample period are Italy (9.4% p.a.), Belgium (8.6% p.a.), Lithuania (7.4% p.a.), the Netherlands (6.8% p.a.), Hungary (6.6% p.a.), Ireland (6.2% p.a), and Portugal (6.0% p.a). A minority of countries, namely Croatia, Czech Republic, Latvia, Slovakia, and Spain, are forecasted to experience a relatively insignificant negative trend in the number of ICT graduates. However, all EU-27 member states are forecasted to add to the total supply of graduates with blockchain exposure in Europe.



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Table 8: Forecasted ICT and Graduates with Blockchain Exposure by Country, 2021-2026

| Country | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | Total Forecasted ICT Graduates: 2021 - 2026 | Forecasted Blockchain Graduate Supply |
|------------|--------|--------|--------|--------|--------|--------|---|---------------------------------------|
| Austria | 2,720 | 2,758 | 2,795 | 2,833 | 2,871 | 2,908 | 16,886 | 81 |
| Belgium | 3,101 | 3,375 | 3,650 | 3,924 | 4,198 | 4,472 | 22,720 | 1,238 |
| Bulgaria | 2,210 | 2,265 | 2,321 | 2,376 | 2,431 | 2,486 | 14,089 | 362 |
| Croatia | 1,436 | 1,381 | 1,327 | 1,273 | 1,219 | 1,165 | 7,802 | 200 |
| Cyprus | 281 | 293 | 305 | 317 | 329 | 341 | 1,866 | 48 |
| Czechia | 3,626 | 3,590 | 3,555 | 3,519 | 3,483 | 3,447 | 21,220 | 603 |
| Denmark | 3,776 | 3,927 | 4,079 | 4,230 | 4,382 | 4,534 | 24,928 | 708 |
| Estonia | 795 | 834 | 872 | 910 | 948 | 987 | 5,346 | 121 |
| Finland | 4,732 | 4,919 | 5,107 | 5,295 | 5,482 | 5,670 | 31,206 | 802 |
| France | 27,796 | 29,649 | 31,502 | 33,355 | 35,207 | 37,060 | 194,569 | 7,335 |
| Germany | 30,784 | 31,813 | 32,842 | 33,871 | 34,900 | 35,929 | 200,139 | 1,981 |
| Greece | 2,492 | 2,575 | 2,659 | 2,743 | 2,827 | 2,911 | 16,208 | 417 |
| Hungary | 4,932 | 5,497 | 6,061 | 6,626 | 7,191 | 7,755 | 38,063 | 978 |
| Ireland | 7,585 | 8,121 | 8,657 | 9,193 | 9,729 | 10,265 | 53,548 | 1,237 |
| Italy | 6,370 | 7,036 | 7,703 | 8,370 | 9,037 | 9,703 | 48,219 | 1,717 |
| Latvia | 501 | 495 | 489 | 483 | 477 | 472 | 2,916 | 75 |
| Lithuania | 1,072 | 1,157 | 1,241 | 1,325 | 1,410 | 1,494 | 7,698 | 198 |
| Luxembourg | 99 | 103 | 106 | 109 | 112 | 116 | 645 | 17 |
| Malta | 287 | 295 | 302 | 310 | 317 | 324 | 1,835 | 47 |



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Cont'd Table 8: Forecasted ICT and Graduates with Blockchain Exposure by Country, 2021-2026

| Country | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | Total Forecasted ICT Graduates: 2021 - 2026 | Forecasted Blockchain Graduate Supply |
|--------------|----------------|----------------|----------------|----------------|----------------|----------------|---|---------------------------------------|
| Netherlands | 5,690 | 6,139 | 6,587 | 7,036 | 7,485 | 7,933 | 40,871 | 1,050 |
| Poland | 17,029 | 17,143 | 17,257 | 17,371 | 17,486 | 17,600 | 103,886 | 2,670 |
| Portugal | 1,429 | 1,540 | 1,651 | 1,762 | 1,873 | 1,984 | 10,237 | 263 |
| Romania | 12,116 | 12,780 | 13,443 | 14,107 | 14,770 | 15,434 | 82,650 | 2,124 |
| Slovakia | 1,599 | 1,575 | 1,552 | 1,528 | 1,504 | 1,481 | 9,238 | 237 |
| Slovenia | 1,001 | 1,009 | 1,017 | 1,025 | 1,033 | 1,041 | 6,125 | 220 |
| Spain | 7,928 | 8,006 | 8,084 | 8,162 | 8,239 | 8,317 | 48,736 | 370 |
| Sweden | 2,670 | 2,787 | 2,904 | 3,020 | 3,137 | 3,254 | 17,773 | 457 |
| Total | 154,057 | 161,062 | 168,067 | 175,072 | 182,077 | 189,083 | 1,029,417 | 25,557 |

Notes: Total forecasted ICT graduates are estimated by applying a linear trend to total ICT graduates from 2015 to 2020 in Table 7. Estimated Blockchain skills supply for each country is the share of blockchain graduates of total ICT graduates. The share of blockchain graduates on average is 2.57% of total ICT graduates, which is applied to countries that did not provide blockchain graduate data. The average proportion of blockchain graduates is estimated as a simple average based on the information provided by the following CHAISE partners: Austria (0.48%), Belgium (5.45%), Estonia (2.26%), France (3.77%), Germany (0.99%), Ireland (2.31%), Italy (3.56%), Slovenia (3.60%) and Spain (0.76%).



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3.5 Comparing Demand and Supply Forecasts

In order to make comparisons between forecasted blockchain graduate demand and supply the proportion of blockchain related jobs that are advertised at an 'entry-level' is estimated and presented for each country in Table 9. We find that on average across all European states 45.2% of advertised blockchain related jobs are at entry level and for new higher education graduates. The total forecasted blockchain new entrant demand in Europe from 2021 to 2026 is 13,278. In terms of the graduate supply (Table 8), 1,029,417 higher education students are expected to graduate from the ICT field of study, and we estimate that 25,557 of the new graduates will have some blockchain learning exposure between 2021 and 2026. The results in Table 9 indicate that total forecasted blockchain graduate supply will greatly outweigh the demand for new entrants to the blockchain sector in Europe. It should also be noted that many of the ICT graduates without exposure to blockchain modules will have some knowledge and skills to perhaps enter blockchain vacancies where on-the-job training would be provided. The resulting forecasts will enable individual member states to assess the extent to which labour market imbalances are likely to occur in the short-term and provide important input into the development of a more strategic approach to the delivery of a blockchain skills strategy.

The results in Table 9 shows that on aggregate graduate supply is likely to satisfy graduate demand in Europe during the sample period, albeit with some variation across countries. For most countries in Europe forecasted graduate demand and supply does not match, and therefore, some level of blockchain skills surplus or shortage is expected. For example, forecasted demand and supply is broadly in line for Austria, Germany, Portugal, and Sweden. Shortages of blockchain skills are expected at the national level in Cyprus, Estonia, Latvia, Luxembourg, Slovakia, Slovenia, and Spain. Conversely, large surplus of blockchain skills is forecasted in Belgium, Bulgaria, Croatia, Finland, Hungary, Ireland, the Netherlands, and Poland. Figures 3 to 6 below present a direct comparison between blockchain graduate demand and blockchain graduate supply by regional groups across Europe.



Table 9: Forecast Summary for Demand and Supply, 2021-2026

| Country | Total Blockchain Demand (#) | Blockchain Graduate Demand (%) | Blockchain Graduate Demand (#) | Total ICT Graduate Supply | Blockchain Graduate Supply |
|--------------|-----------------------------|--------------------------------|--------------------------------|---------------------------|----------------------------|
| Austria | 245 | 41.30% | 101 | 16,886 | 81 |
| Belgium | 440 | 28.10% | 124 | 22,720 | 1,238 |
| Bulgaria | 41 | 37.80% | 15 | 14,089 | 362 |
| Croatia | 32 | 67.20% | 21 | 7,802 | 200 |
| Cyprus | 755 | 41.00% | 309 | 1,866 | 48 |
| Czechia* | 553 | 45.19% | 0 | 21,220 | 603 |
| Denmark | 1,477 | 33.50% | 495 | 24,928 | 708 |
| Estonia | 489 | 48.00% | 234 | 5,346 | 121 |
| Finland | -22 | 60.70% | -13 | 31,206 | 802 |
| France | 10,470 | 28.80% | 3,015 | 194,569 | 7,335 |
| Germany | 3,879 | 42.10% | 1,633 | 200,139 | 1,981 |
| Greece | 47 | 54.10% | 25 | 16,208 | 417 |
| Hungary | 293 | 52.10% | 153 | 38,063 | 978 |
| Ireland | 955 | 23.30% | 222 | 53,548 | 1,237 |
| Italy | 2,101 | 45.10% | 947 | 48,219 | 1,717 |
| Latvia | 372 | 57.10% | 212 | 2,916 | 75 |
| Lithuania | 81 | 53.90% | 44 | 7,698 | 198 |
| Luxembourg | 166 | 39.10% | 65 | 645 | 17 |
| Malta** | - | - | - | 1,835 | 47 |
| Netherlands* | -70 | 45.19% | -31 | 40,871 | 1,050 |
| Poland | 1,584 | 33.30% | 528 | 103,886 | 2,670 |
| Portugal | 640 | 39.00% | 250 | 10,237 | 263 |
| Romania | 43 | 68.00% | 29 | 82,650 | 2,124 |
| Slovakia | 700 | 64.00% | 448 | 9,238 | 237 |
| Slovenia | 1,189 | 48.20% | 573 | 6,125 | 220 |
| Spain | 2,115 | 31.40% | 664 | 48,736 | 370 |
| Sweden | 807 | 47.50% | 383 | 17,773 | 457 |
| Total | 29,383 | 45.19% | 13,278 | 1,029,417 | 25,557 |

Notes: Total Blockchain Demand (#) comes from Table 4 on *Forecasting Blockchain Demand by Blockchain-Relevant ISCO occupations, 2021-2026*. Blockchain Graduate Demand (%) is the percentage of Total Blockchain Demand that is for Entry-level positions. (*) Blockchain Graduate Demand was not available for Czechia and the Netherlands. Therefore, we use average Blockchain Graduate Demand percentage for Czechia and the Netherlands. Total ICT Graduate Supply and Blockchain Graduate Supply comes from Table 8 on *Forecasted ICT and Blockchain Graduates by Country, 2021-2026*. (**) Malta is not included in data scraping exercise due to difficulties in region differentiation.



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Figure 2 compares total forecasted blockchain skills demand and supply from 2021 to 2026 using data from the current year of forecasting (2022) and the previous year of forecasting (2021) across all EU-27 countries. Table 10 shows country-specific breakdown of total forecasted blockchain demand and supply using information from 2021 and 2022. In total (Figure 2), the results indicate that there has been a marginal increase in forecasted blockchain skills demand during the sample period from 28,092 new jobs, as per 2021 forecasts, to 29,383 new jobs, as per 2022 forecasts. Although, the proportion of blockchain jobs advertised at the entry-level or for new graduates has decreased slightly from our last year's estimate of 49.5% to 45.2% in 2022, the most recent forecasts indicate an increase in total forecasted blockchain graduate demand from 12,966, using 2021 data, to 13,278, using 2022 data. In terms of blockchain graduate supply, the most recent forecasts indicate a significant increase in total forecasted blockchain graduate supply from 14,972, using last year's data, to 25,557 in the current year of forecasting, during the sample period from 2021 to 2026. This change in forecasted blockchain skills supply is largely due to greater proportion of blockchain-specific graduates and graduates with some blockchain exposure in the current year of forecasting, which is also available for more European countries, and therefore, improving the accuracy of results. Overall, we observe a blockchain skills shortage in both years of blockchain skills forecasting when comparing total blockchain demand and blockchain graduate supply.



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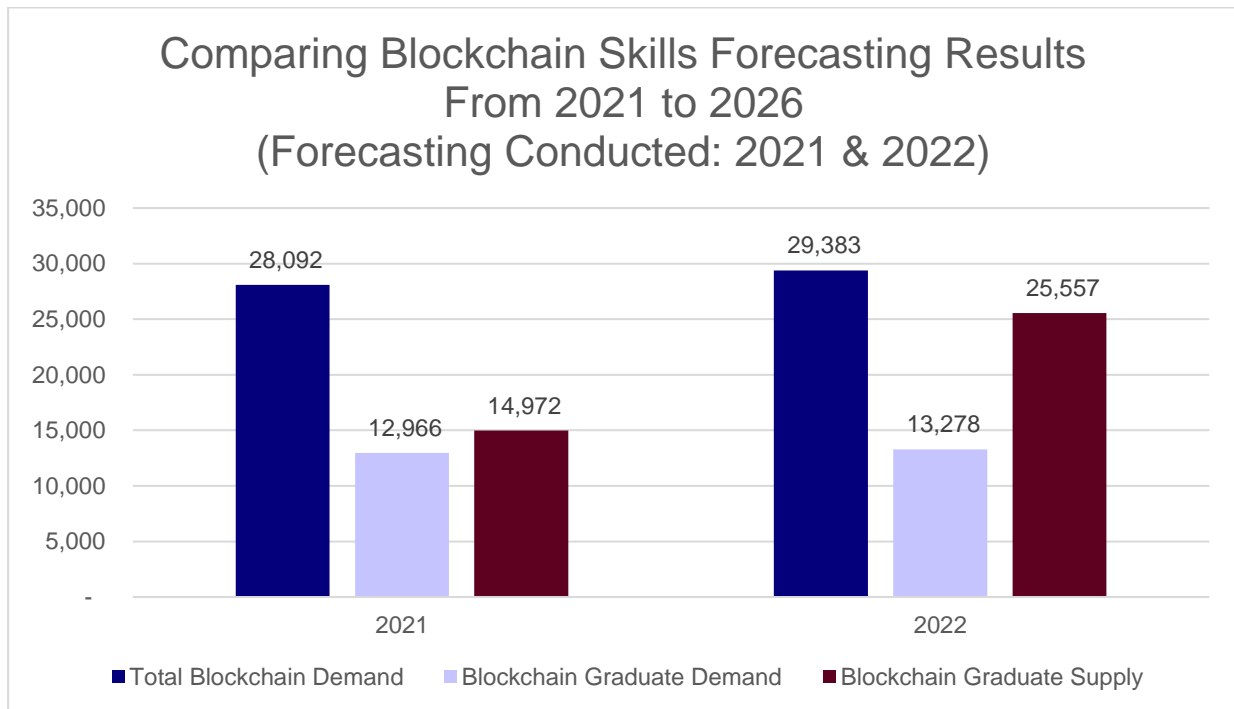


Figure 2 - Comparing Blockchain Skills Forecasting Results From 2021 to 2026



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Table 10: Comparing Forecasted Blockchain Skills Demand and Supply: 2021 - 2026

| Country | Total Blockchain Demand | | Blockchain Graduate Supply | |
|--------------|----------------------------|----------------------------------|----------------------------|----------------------------------|
| | Annual Forecasts From 2021 | Updated Annual Forecasts in 2022 | Annual Forecasts From 2021 | Updated Annual Forecasts in 2022 |
| Austria | 197 | 245 | 305 | 81 |
| Belgium | 1,486 | 440 | 549 | 1,238 |
| Bulgaria | 160 | 41 | 245 | 362 |
| Croatia | 68 | 32 | 104 | 200 |
| Cyprus | 153 | 755 | 34 | 48 |
| Czechia | 797 | 553 | 380 | 603 |
| Denmark | 720 | 1,477 | 423 | 708 |
| Estonia | 414 | 489 | 90 | 121 |
| Finland | 111 | -22 | 490 | 802 |
| France | 9,899 | 10,470 | 1,173 | 7,335 |
| Germany | 1,720 | 3,879 | 3,543 | 1,981 |
| Greece | 27 | 47 | 529 | 417 |
| Hungary | 486 | 293 | 433 | 978 |
| Ireland | 846 | 955 | 390 | 1,237 |
| Italy | 1,825 | 2,101 | 823 | 1,717 |
| Latvia | 151 | 372 | 42 | 75 |
| Lithuania | 216 | 81 | 133 | 198 |
| Luxembourg | 87 | 166 | 8 | 17 |
| Malta* | - | - | 33 | 47 |
| Netherlands | -648 | -70 | 673 | 1,050 |
| Poland | 4,091 | 1,584 | 2,135 | 2,670 |
| Portugal | 986 | 640 | 156 | 263 |
| Romania | 54 | 43 | 916 | 2,124 |
| Slovakia | 171 | 700 | 153 | 237 |
| Slovenia | 158 | 1,189 | 210 | 220 |
| Spain | 2,113 | 2,115 | 733 | 370 |
| Sweden | 1,801 | 807 | 268 | 457 |
| Total | 28,092 | 29,383 | 14,972 | 25,557 |



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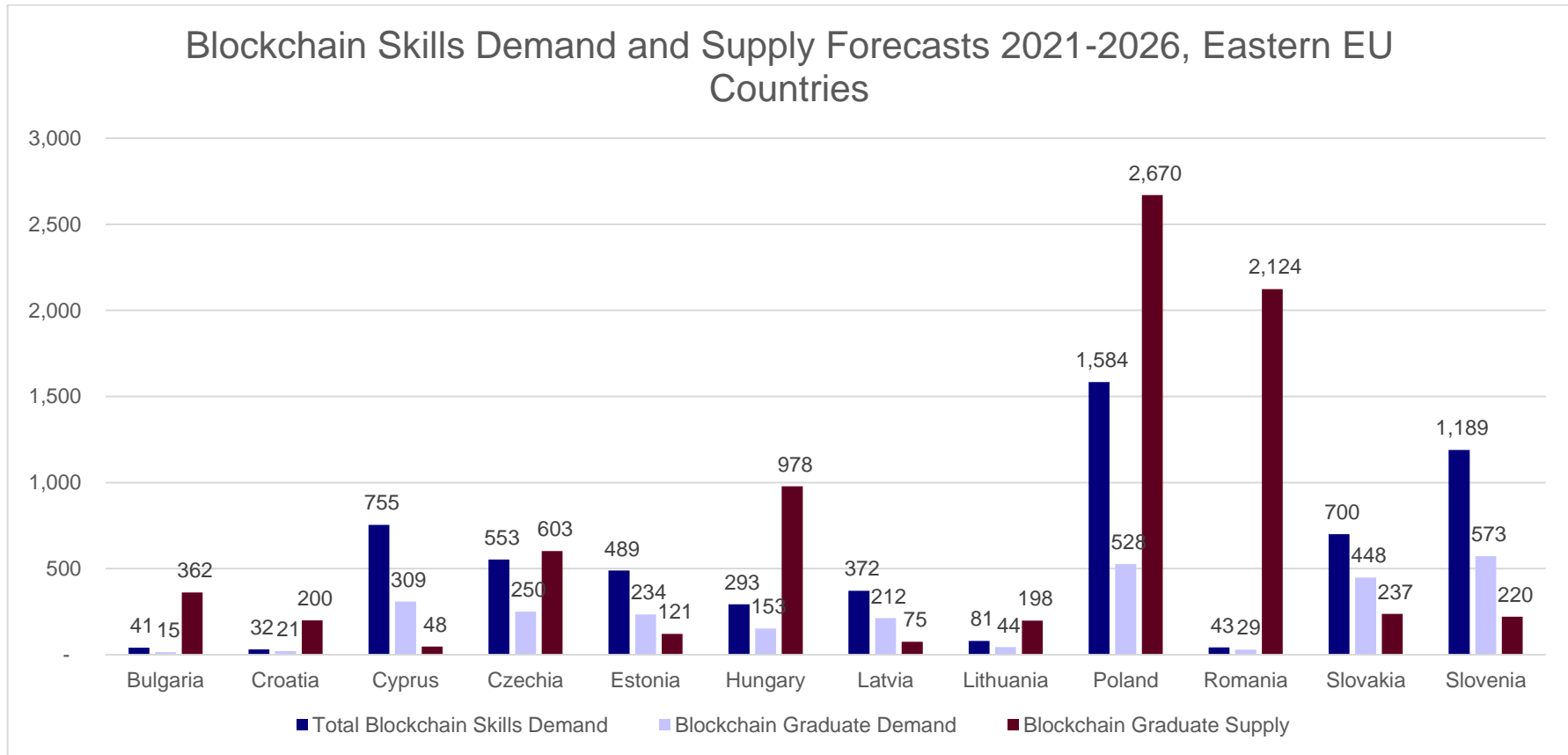


Figure 3 - Blockchain Skills Demand and Supply Forecasts 2021-2026, Eastern EU Countries



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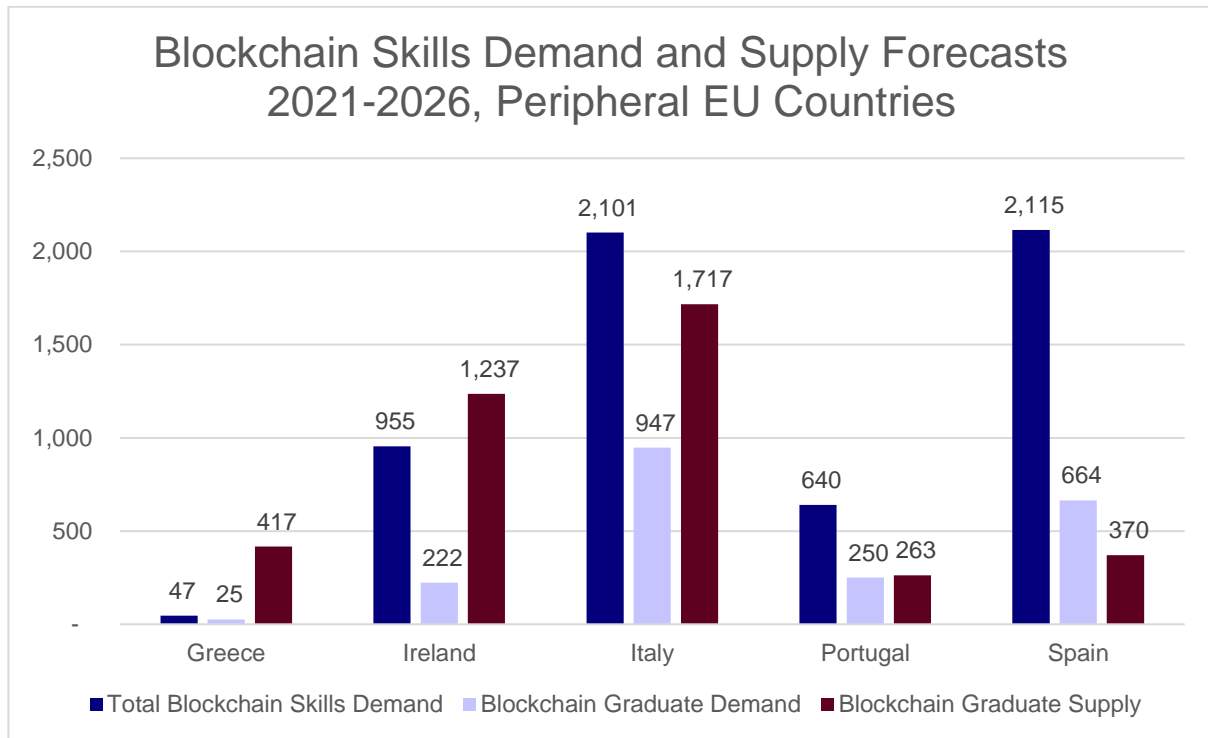


Figure 4 - Blockchain Skills Demand and Supply Forecasts 2021-2026, Peripheral EU Countries



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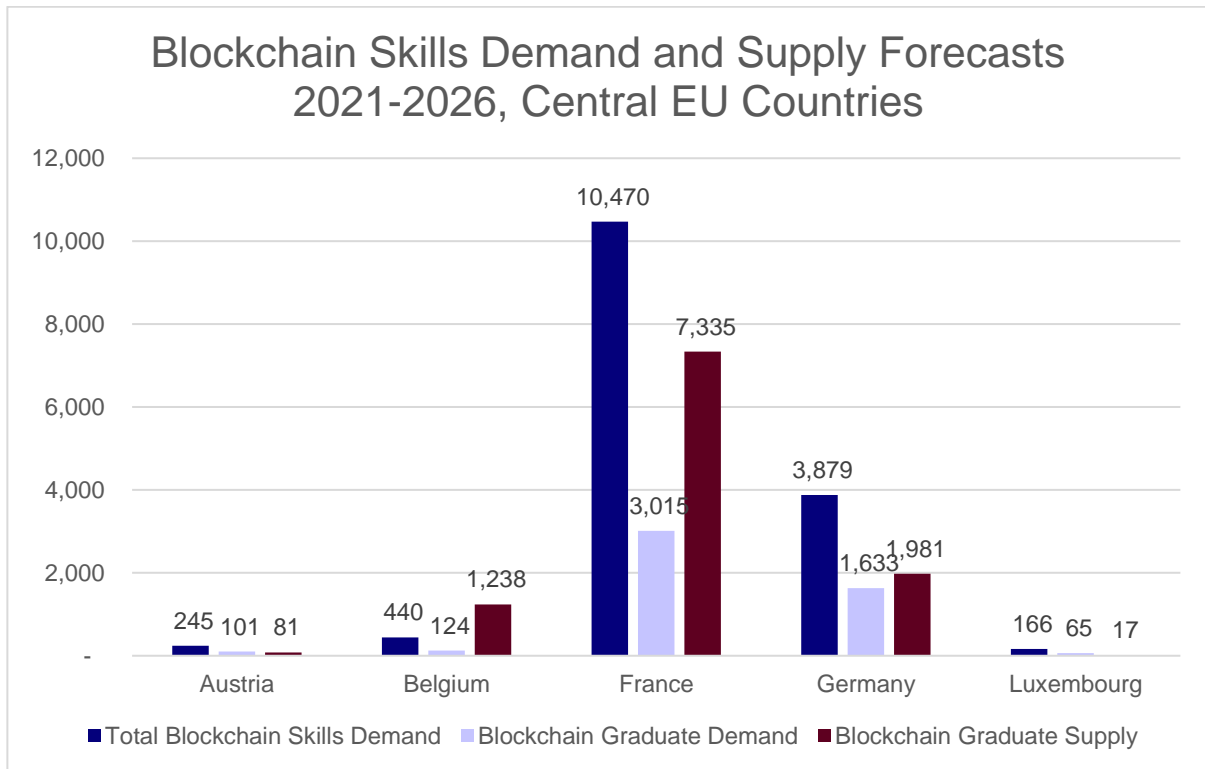


Figure 5 - Blockchain Skills Demand and Supply Forecasts 2021-2026, Central EU Countries

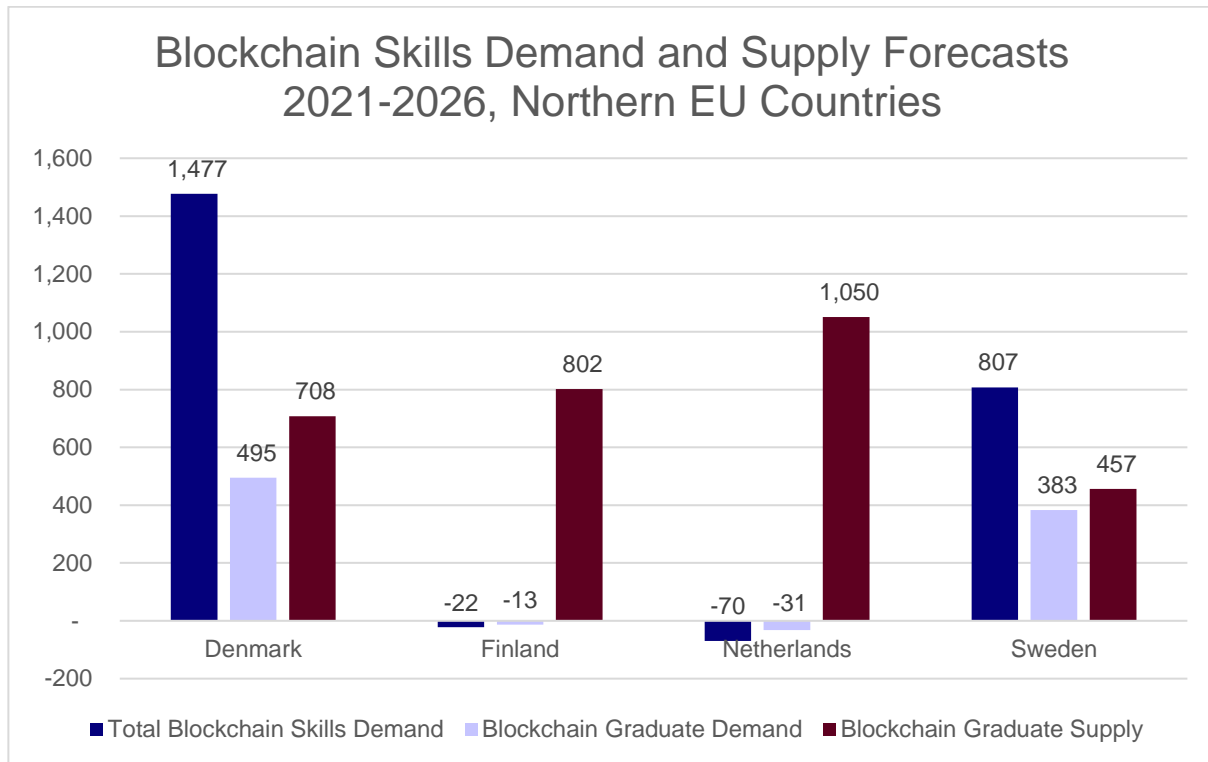


Figure 6 - Blockchain Skills Demand and Supply Forecasts 2021-2026, Northern EU Countries



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In conclusion, we estimate a minor blockchain skills shortage from 2021 to 2026 as 29,383 new blockchain-related jobs are expected to be created during this period in comparison to 25,557 blockchain graduates that will be available. However, we also find that approximately 46% of blockchain jobs or 13,278 jobs will be available to new entrants to the labour market. Therefore, blockchain graduate supply is expected to greatly exceed blockchain graduate demand. From the two rounds of forecasting blockchain skills demand and supply, we anticipate a consistent demand for blockchain skills and blockchain graduates, while we estimate a significant increase in blockchain graduate supply in the current year of forecasting when compared to the first round of forecasting. Significantly greater forecasted blockchain graduate supply than blockchain graduate demand may be due to the loss of ICT and technology jobs more widely, and greater demand for workers at mid-to-senior roles which are consistent with the maturity of the blockchain sector in Europe. Further, firms are looking for more senior staff who may be less exposed to education and training in blockchain and, therefore, require reskilling or upskilling.



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4 Intelligence Gathering Activities

Findings from intelligence gathering activities provide important information to both supplement the forecasting model and to inform the future development of the forecasting framework. Intelligence gathering activities include the latest developments and future trends in the blockchain sector, E&T provision and changes in the educational systems, and economic, societal and employment trends across Europe. Developments in the blockchain labour market are also examined via relevant online job vacancies to identify core skill requirements, tasks and roles that are in demand, tasks and roles that are likely to disappear, and emerging and future knowledge and skills requirements.

4.1 Sectoral Development Trends

The key findings on sectoral developments come from blockchain experts from Netcompany-INTRASOFT, IOTA, FUJITSU, and Crypto4All within the CHAISE consortium. Their analysis of sectoral developments and connections to future blockchain skill needs are based on an examination of policy developments, E&T initiatives, blockchain ecosystem, and challenges and opportunities. The findings provide additional insights into the future of the blockchain sector and blockchain skill needs.

4.1.1 Blockchain regulatory and policy developments

EU member states are taking major steps towards harmonising the legal, regulatory and policy frameworks on crypto assets. In late-2020, the European Commission published a proposal for a regulation of the European Parliament and of the council on Markets in Crypto-Assets (MiCA). This proposal is part of the Digital Finance package to enable and support the potential of digital finance, increase innovation and competition while minimizing associated risks. Proposal on MiCA framework has moved to the next phase for further considerations and discussions between the European Parliament, European Council, and the European Commission.

In addition to the MiCA proposal, the Digital Finance package includes a proposal for a pilot scheme on DLT market infrastructures, a proposal for digital operational resilience, and a proposal to clarify or amend of certain EU financial services rules. EU's strategy is to ensure that the EU financial services regulatory framework is innovation friendly and that it does not pose obstacles to the application of new



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technologies in this area. The MiCA proposal, together with the proposal on a DLT pilot regime presents the first concrete action within this area. Finally, as showcased in the ‘European Financial Stability and Integration Review’ 2022, the European Commission is aware of the potential of decentralised finance (DeFi) and its associated innovations for streamlining the financial sector and offering efficient, robust and transparent services.

4.1.2 Blockchain Education & Training Initiatives

Blockchain technology is currently used in more than 20 different sectors and industries, which requires a variety of blockchain related skills. Therefore, any blockchain related education and training should be built to address the needs of a specific sector. Although there are not many blockchain courses provided by VET and tertiary education providers across Europe, online video channels, such as Whiteboard Crypto and other Massive Open Online Courses (MOOCs), fill the gap in blockchain knowledge by offering learning content on a variety of blockchain topics. There is also a rise in demand for soft skills in the blockchain labour market. Recruiters emphasise the demand for a balanced set of hard and soft skills for organisations to thrive.

4.1.3 Blockchain Ecosystem

There are a number of organisations, associations and initiatives that exist in Europe and beyond, which allow experts, academics, researchers, business people, etc, to come together to share their knowledge and experience in the area of blockchain. Their role can be either that of knowledge generators or that of multipliers of information. Some examples include: The EU Blockchain Observatory and Forum; INATABA; The European Blockchain Partnership; European Blockchain Services Infrastructure; The Blockchain4Europe. Such ecosystems and community networks facilitate further expansion in the blockchain startup and business scene. As a result, we observe a continuous growth in the number of companies implementing blockchain technology in their business practices across most EU member states.



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4.1.4 Challenges and Opportunities

Blockchain is one of the key technologies currently experiencing high adoptability in several different industries and sectors with several applications that improve many aspects related to transparency, traceability and interoperability through decentralised applications. Continued investment in research of blockchain technology by the Small & Medium Enterprises in order to develop and deploy the technology in their organisation is expected to drive the growth of the technology. Government interest in utilisation of blockchain technology is most likely to propel the technology's demand over the forecasted period. Further, the growing demand for blockchain technology among the healthcare and life sciences, transportation and logistics, and retail and eCommerce sectors are anticipated to drive the market growth. Low operational cost of blockchain technology is another driving factor of the technology.

Some of the main challenges experienced by blockchain companies include high transaction fees, lack of process standardisation, threats to privacy and security, lack of regulation, crime and money laundering. Energy consumption used in blockchain application is another major concern. However, most of the energy consumption comes from cryptocurrency mining, which is often perceived as blockchain technology. General misconceptions, miseducation, and general uncertainty about blockchain technology are also perceived as significant challenges for future blockchain utilisation.

4.2 Changes in Education and Training Provision

Interviews with education and training professionals provide an in-depth understanding of trends in training provision, student enrolments, and qualifications related to blockchain, as well as changes in vocational education training and tertiary systems in Europe. Interviews were conducted by the following CHAISE partners: ACQUIN, ECQA, CIMEA, and YPEPTH. The analysis was based on interviews with 6 E&T professionals from Austria, Germany, Greece and Italy. Interviewees were professors or lecturers, heads of departments, and researchers. Interview questions were centred around trends in blockchain training provision, trends in student enrolment in blockchain training programmes, and changes in VET and tertiary systems. The findings from this section provides additional insights into the future of the blockchain training and education provision.



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In terms of trends in blockchain training provision, due to the rapid adaptation of blockchain technology in the financial services sector existing education providers are increasingly incorporating blockchain teaching into finance related courses. Blockchain training and mode of delivery is likely to depend on the wider sector and industry interest in blockchain. There are currently few but growing number of courses, classes, modules, webinars, or seminars that satisfy the demand for blockchain skills in Europe. Workshops are often considered by blockchain companies when upskilling or reskilling their staff. There is considerable work underway throughout Europe to update existing higher education courses to lay foundations of future competencies around blockchain. Some of the key blockchain training needs or requests from companies include education and training on use cases of blockchain, interdisciplinary knowledge, and compliance. The key challenges identified in implementing blockchain education and training include high costs, lack of technically trained staff, qualified lecturers, and regulatory landscape to facilitate blockchain utilization.

In terms of trends in blockchain student enrollments, some interviewees observed as much as 30% increased demand for blockchain courses at a master's level year-on-year. Interviewees expect the demand for blockchain education and training to rise in the near future and they also highlight the demand for high-quality courses and training provision. Typical student profiles enrolling in blockchain training programmes include engineers, software developers, IT professionals, managers, people working in finance, entrepreneurs, businesspeople, and individuals working in social science related fields. Persons enrolling on blockchain education and training while working are most likely going to stay in their organisation and position or join organisations looking to adopt blockchain technology. When asked about the challenges reported by students when enrolling in blockchain training programmes, the interviewees state that, some E&T providers select applicants due to limited spaces or resources, lack of prior blockchain knowledge or general understanding, and fast paced nature of courses. In terms of E&T delivery, E&T provision comes in different forms, such as classroom-based teaching, virtual teaching only, or hybrid. Interviewees state that each form of delivery yields their own positives and negatives, and that providers aim to provide the best training quality depending on the mode of delivery.

In terms of changes in VET and tertiary systems, there is a greater demand for blockchain qualifications which is changing the E&T landscape in this space. Growing number of companies are looking for less technology focused skills and more user centric approaches to blockchain implementation and management. Therefore, E&T providers are encouraged to work with industry partners and to update syllabus that reflects industry needs. Due to E&T and industry collaboration, recent blockchain training



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provision is focusing on Hype Cycles, interdisciplinary knowledge and approaches, sectoral collaboration, continuous IT education, and further development of technology and digital skills. The key drivers for these changes include favorable policy frameworks, investment policies, digitalisation and technology advancement. Blockchain related E&T provision outside of the computer science domain is predominantly incorporated in business-related courses. Interviewees state that some of the initiatives currently driving blockchain VET and tertiary education offerings in Europe include online resources, CHAISE project, the Blockchain Council, the Hyperledger Project, and the Enterprise Ethereum Alliance.

4.3 Economic, Societal and Employment Developments

Although CEDEFOP has not published blockchain specific information on economic, societal and employment trends their research on automation, innovation, digital technologies, and labour market outcomes provides insights into the future of the blockchain sector. In the context of blockchain, CEDEFOP research is important due to their analysis of societal change, future labour market trends, and economic and societal megatrends that influence policy developments across Europe. Therefore, DIGITALEUROPE (a CHAISE consortium partner) interviewed a CEDEFOP expert to gather information on blockchain skills and labour market developments and the key takeaways are summarized below.

4.3.1 Economic and Employment Development

On employment trends, the expert notes a larger number of blockchain experts in technological roles, such as developers, than in other fields, such as legal professionals and business or administration roles related to blockchain. They further state that, there is a growing need for people who can combine their expertise in business related fields, such as marketing, sales, and communications, with blockchain technology. Such people do not necessarily need an in-depth understanding of blockchain technology but rather they need to be trained to implement and use existing blockchain solutions in their core business activities.

The expert believes that, when it comes to reskilling and capacity building around blockchain there is no need for very detailed and long-term trainings. They further state that, IT companies and emerging technology start-ups are used to reskilling people on a regular basis for their internal purposes. The reskilling and continuous learning are already a reality of an IT professional, as they need to constantly



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learn new tools. A higher number of short and tailored made learning programmes could help to provide a range of opportunities for people who need very specific training.

4.3.2 Societal Developments

On societal developments, the CEDEFOP expert thinks that the societal impact of blockchain is currently very limited due to the lack of knowledge and confidence around this technology. They indicate that, the state could play an important role here by providing transparent administrative services based on the blockchain technology, which in turn could help to get people using it and building trust. By leveraging the gain from simplifying the legal process around blockchain, people could experience the benefits and incentives for wider adoption of the technology. These would in turn translate into higher positive societal impact.

4.3.3 Education

In terms of educational outcomes, the interviewee states that, although blockchain technology is not a completely new technology there is still a lack of understanding in the general population around its use. There is a clear need for a solution which would make it clear and understandable for people. Such solution could be prepared by governments or by public-private initiatives. Public-private cooperation is especially needed because very specific skills and profiles are developed in-house by companies and their knowledge as to the future needs and developments cannot be overestimated.

There is also a need for easy explanations of blockchain as a technology for the public and its possible applications without a specific technological knowledge. The interviewee states that, for example, marketing start-ups very often use blockchain in mapping and matching client profiles. This task does not require a highly technical knowledge but rather capacity to use tools prepared by developers and adapt them to business goals following market and not technological logic. The CEDEFOP expert emphasised several times that there is a need for short and specific education programmes developed in cooperation with business to educate, upskill or reskill people about blockchain. Without such training the gap between the number of highly specialized IT professionals with blockchain skills and those in more business-oriented professions will widen.



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4.4 Blockchain Labour Market Developments

Our forecasting approach is to act as an early warning information mechanism to meet and mitigate possible labour market imbalances and support E&T and labour market actors in making evidence-based decisions. Therefore, this forecasting mechanism relies on annual labour market data that serves as an input in the production of skills forecasts. Part of this process involves the collection of yearly evidence on blockchain relevant online job vacancies with the aim to detect labour market developments and identify changes in skills requirements, as compared to the previous year, for the three main blockchain occupational profiles: namely Blockchain Architect, Blockchain Developer and Blockchain Manager. The rationale is that job vacancy analysis can help to obtain a more accurate picture of the rapidly evolving labour market, identify the most in-demand skills sought after by employers and to better understand market dynamics. EXELIA (a CHAISE consortium partner) conducted the analysis of blockchain relevant online job vacancies and provided additional information on the blockchain labour market in the EU.

During the third year of the project, the partnership gathered 98 online job vacancies from 11 EU countries. The sample includes job ads directly listed on LinkedIn from January 2022 to February 2023. The ads have passed a screening process before analysis in order to identify and remove non-related, duplicated or incomplete job ads. Skills required by job ads were then categorised using the European Skills, Competences, Qualifications and Occupations (ESCO) skills taxonomy, and have been classified into three broad areas: a) Technical Skills, b) Business Skills, and c) Soft Skills. The evidence and conclusions drawn from job vacancies analysis enrich the existing skills intelligence in the blockchain field and will feed the creation and publication of annual forecasting results with quantitative and qualitative projections for blockchain skill supply and demand, new knowledge and skill needs, workplace requirements, and key trends in training provision.

The findings indicate that 67% of recruiters are blockchain service providers and 28% of recruiters are blockchain service users, while 5% were not specified. The ICT sector is the largest employer for blockchain professionals, accounting for over a half of all job advertisements. Other Blockchain intensive industries are financial services and gaming. Approximately 37% of jobs are for blockchain managers, 36% of jobs are for blockchain developers, and 27% of jobs are advertised for blockchain architects. Approximately 46% of blockchain jobs advertised are for entry-level positions or the seniority level is not specified, 28% of jobs are for mid-level or mid-senior-level positions, and 26% of blockchain jobs



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advertised are for senior-level positions. In about 65% of cases, the employer did not specify a minimum educational requirement or stated that no formal degree is required. At least a postgraduate qualification is required in 44% of blockchain-related job advertisements. In terms of work experience, 56% of job ads require up to three years of work experience or no previous experience. 35% of job ads require at least three years of work experience while 9% of ads require at least five years of work experience.

In terms of blockchain skills, technical skills mostly mentioned in blockchain related online job ads are “Coding” and “Blockchain Solutions Design”. Technical skills such as “Development of Decentralized Applications”, “Data Analysis”, “Smart Contract Development”, “Frontend/Backend Development”, “Cryptography” and “Protocol engineering” are also in high demand. Business skills most frequently mentioned in blockchain related online job ads are “Use Cases Development”, “Product Management” and “Product Development”. The most popular transversal skills requested by employers are “Team-working and Emotional intelligence”, “Systems, networked thinking and problem solving”, “Communication” and “Self-management and self-responsibility”. Employers are looking for a combination of technical and non-technical skills in a successful blockchain employee.

Technical skills that are rising in importance, as compared to the previous year (2021/2022), are “develop decentralised applications”, “smart contract development”, “data/network security”, “distributed network engineering skills” and “protocol engineering”. “Frontend/Backend Development”, “Cryptography”, “Cloud and Infrastructure”, “Protocol engineering”, and “UX Design”. In contrast, less demand is registered for “coding” and “Development of Decentralised Applications” in 2022/2023. Business skills that are increasing in demand from the previous year are “Use Cases development”, “Product Development Skills”, and “Legal / Compliance Skills”. Recruiters appear to pay less attention to “Product Management Skills”, “Business Development skills” and “Business Analysis skills”. Recruiters are requiring less Product Management Skills”, “Business Development skills” and “Business Analysis skills”. Transversal skills that have received greater attention from recruiters are: “Communication”, “Cooperation competence & Team-working ability & emotional/ Social intelligence”, “Critical thinking & Self-Reflection”, “Initiative and performance competence (Self-motivation, engagement, persistence)”, “Innovation & Creativity”, “Future mind-set & willingness to change & continuous improvement”, and “Ambiguity competence (dealing with uncertainty, acting in different roles)”.



4.5 Academic and Training Programme Analysis

To further understand the future of blockchain skills supply we analyse the current state of blockchain-related education and training provision. The CHAISE consortium has identified 121 E&T services across a sample of EU countries from which we analyse the types of E&T services, certification, mode of course delivery and learning, duration of programmes, and their status and disciplines. EXELIA (a CHAISE consortium partner) analysed E&T provision in the context of the full sample and the three main blockchain occupations, namely Blockchain Manager, Blockchain Architect, and Blockchain Developer.

4.5.1 E&T Provision

There are 53 (44% of the total sample) blockchain courses offered at EQF 1-4 level, 36 (30% of the total sample) courses offered at EQF 7-8 level, and 32 (26% of the total sample) courses offered at EQF 5-6 level. Approximately 43% of all blockchain courses come from Computer Science & Informatics discipline, 13% come from Business discipline, 11% come from Finance discipline, while combined 18% of blockchain courses come from Engineering, Social Sciences, Personal Development, Interdisciplinary, and other. 15% of courses did not specify discipline of E&T provision. In terms of the types of certifications offered by E&T providers, most offer a certificate of completion (32%) while 23% offer a master's degree. A combined 24% of courses offer bachelor's degree, VET or professional diploma, certificate of continuing education, certificate of attendance, while 21% of courses offer 'other' type of certification. In 51% of cases blockchain teaching is delivered via an online course, and 29% of cases through a higher education authority. The mode of E&T delivery varies between the courses. 36% of courses are delivered via distance learning, 17% are delivered via blended approach or classroom and online delivery, 14% are delivered via combined classroom, VET and apprenticeship, 12% are delivered via classroom only, and 21% of courses used 'other' modes of delivery. In terms of course duration, 50% of E&T courses run for a day or a few days, 22% of courses run for 1-2 years, 19% of courses run for a month or a few months. Most E&T programmes are subject specific (48%), another 28% are sector-specific, and 24% of courses have a general orientation. Overall, 61% of E&T courses are run by private organisations while the remaining 39% of courses are run by public organisations.



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4.5.2 Blockchain Developers

The findings indicate that 60 (50% of the total sample) blockchain courses are aimed towards Blockchain Developers, and that 53% of them are offered at the EQF 1-4 level, 25% are offered at the EQF 5-6 level, and 22% at the EQF 7-8 level. Discipline of study is mostly (62% of courses offered to Blockchain Developers) in Computer Science & Informatics. 33% of certifications achieved in these courses are for a certificate of completion, and 20% are for a master's degree. These courses are most often delivered in a higher education setting (23%) or via online resources (57%) and learning typically takes place via distance learning (35%) or a combined classroom-based VET and apprenticeship learning modes (23%). 53% of E&T courses for Blockchain Developers come in the form of a single day or a few days long course. Persons enrolled in a higher education setting are most likely going to spend 2-4 semesters or 1-2 years to achieve certification. In terms of programme orientation, 55% of Blockchain Developer courses are subject specific while 23% general and 22% of courses are sector specific. 62% of Blockchain Developer courses are offered by a private institution and 38% of courses are offered by a public institution.

4.5.3 Blockchain Managers

The findings indicate that 52 (43% of the total sample) blockchain courses are aimed towards Blockchain Managers. Approximately 38% of the E&T provision for Blockchain Managers is at the EQF 7-8 level, 33% of courses are offered at the EQF 1-4 level, and 29% are offered at the EQF 5-6 level. In terms of the discipline of study of Blockchain Managers, 25% are Business courses, 23% are Finance courses and 17% are Computer Science & Informatics courses. Approximately 31% of E&T courses aimed towards Blockchain Managers offer a certificate of completion while 27% of courses are at a master's degree level. Further, 46% of the courses for Blockchain Managers are delivered online only, while another 37% of courses are offered in a higher education setting. In terms of the mode of learning, 38% of E&T courses are based on distance learning, 25% are classroom based, and 19% have a blended learning approach. Approximately 40% of E&T courses for Blockchain Managers are conducted over a day or a few days, 27% of courses are conducted over 1-2 years, and another 25% of courses are conducted over a month or a few months. 38% of courses for Blockchain Managers are subject specific, 37% are sector specific, and 25% are general. In terms of programme status, approximately 62% of E&T courses for Blockchain Managers are offered by private organisations while 38% are offered by public organisations.



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4.5.4 Blockchain Architect

The findings indicate that only 9 (7% of the total sample) blockchain E&T courses aimed towards Blockchain Architects. 44% of E&T programmes offered to Blockchain Architects come from EQF 1-4 level, 33% are offered at the EQF 7-8 level, and 22% are offered at the EQF 5-6 level. In terms of the discipline of study, 67% of courses for Blockchain Architects come from Computer Science & Informatics and another 11% come from engineering and interdisciplinary areas, each. Types of certifications typically offered to Blockchain Architects include, 33% of courses offering a certificate of completion, 22% offer a certificate of attendance, 22% offer a master's degree, and 11% bachelor's degree. 44% of E&T is delivered via online courses, 33% through workshops, and 22% through higher education setting. Learning mode is largely in a form of blended delivery or distance learning, both 33% of courses offered to Blockchain Architects, 22% of courses have a combined classroom learning, and 11% purely classroom based. In terms of the duration of training, 78% of E&T courses for Blockchain Architects take place over a day or a few days, while 11% of courses take place over 1-2 years or 2 or more years, each. 56% of courses for Blockchain Architects are subject specific, 22% are sector specific, and another 22% are general. These courses are largely offered by private institutions, 56%, while the remaining 44% of courses are offered by public organisations.

4.6 Conclusion to Intelligence Gathering Activities

Intelligence gathering activities indicate that the blockchain sector is still growing as government, E&T, and societal interest in this technology continues to rise. As blockchain continues to be adopted in a variety of different sectors and industries it requires a diverse set of technical, business, and transversal skills. As a result, the demand for appropriate non-technical skills, such as finance, sales, marketing, legal, and regulatory skills have become extremely important. Although blockchain-related education and training is increasing, there remains a lack of appropriate interdisciplinary skills often sought after by employers. Blockchain-related teaching is largely available at VET and higher education levels. However, we observe a general recommendation towards micro credential courses in order for the blockchain sector to grow and evolve more rapidly. Long term modules are easier to implement, especially across disciplines and different areas of study, than to establish new courses. Wider awareness and knowledge of blockchain technology and its applications is likely to accelerate its adoption.



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5 Verification of Results

To validate forecasting results, an online survey on the key findings was disseminated, national blockchain experts interviewed, and a CHAISE Expert Advisory Board meeting conducted. The survey was administered, and expert interviews conducted in March/April 2023. The Expert Advisory Board meeting took place in June 2023. General feedback from validation activities indicated that the forecasts blockchain demand and supply presented in this report reflect the current views and experiences of blockchain stakeholders in the EU. The key findings and feedback from the verification of forecasting results are presented below.

5.1 Interviews of National Blockchain Experts

To validate forecasting results, 50 blockchain field experts across the EU were interviewed in April 2023. The interviews were conducted individually by CHAISE consortium partners in their respective countries of origin on either one-to-one basis or round-table interviews including three to four field experts per partner. Each interview included a presentation of forecasting results followed by a detailed discussion of the key findings. The following analysis of blockchain expert feedback and comments is summarised below in five subsections, namely Methodology, Results, Skill Shortages, Opportunities and Challenges, and Policy Suggestions.

5.1.1 Methodology

Most interviewees thought that the CHAISE methodology of forecasting blockchain skills demand and supply is appropriate and effective. In terms of data collection activities, blockchain experts mostly agree with the mapping of blockchain jobs to the five key occupational categories. They also state that additional occupational categories may need to be considered due to the increased adoption of blockchain technology in other areas. In general, interviewees agree that LinkedIn is an appropriate source of general jobs information. However, they emphasise that other online jobs websites focusing on blockchain-specific vacancies may provide additional information on the types of blockchain jobs and relevant skill but unfortunately these portals do not provide information in a systematic way for all EU countries included in this study. In terms of the method of forecasting blockchain skills demand, experts



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indicate that CEDEFOP forecasts may be volatile over time because they are adjusted and updated less frequently. It is expected that the CEDEFOP forecast will be updated in late 2023 and these updates can be incorporated in the next set of forecasts. Similarly, particularly during 2023, blockchain related sectors, such as ICT, are currently experiencing significant turbulence and high levels of job turnover. Therefore, it becomes harder to identify 'new' blockchain jobs.

5.1.2 Results

Most Interviewees think that the forecasting results accurately predict future labour market developments in the EU. However, they also indicate that due to the high volatility in sectors primarily using blockchain technology future demand for blockchain workers is less clear. Experts indicate that blockchain-related occupations under review (ISCO 252; ISCO 251; ISCO 133) may potentially experience an extensive outsourcing of workers to non-EU countries soon, which is likely to affect the provision of blockchain jobs. At the same time interviewees across Europe observe a steady growth nationally in the blockchain start-up scene. They state that many of the start-up companies are relatively small and continuously looking new staff and, therefore, young graduates could be particularly suited to their business needs. Large and medium enterprises working with blockchain are searching for more experienced people and they are less likely to facilitate education and training of inexperienced blockchain workers.

In general, interviewees indicate that there is a growing demand for business and/or transversal skills, such as managerial, business competencies and communication skills, compared to technical skills. Demand for people with blockchain governance skills or legal and regulatory experience are also expected to be in high demand. Interviewees agree with the high proportion of forecasted blockchain workers at an entry-level. They indicate that most of the existing people working in ICT are not familiar with blockchain technology, and as the blockchain market continues to grow there will be greater demand for more junior staff. In terms of forecasting blockchain skills supply, tertiary education institutions have increased the adaptability of blockchain teaching in fields of study across computer science and engineering, business, and economics, law and policy, and mathematics and statistics. They are expected to contribute to the overall blockchain graduate supply in the future.



5.1.3 Skill Shortages

In terms of blockchain skill developments, interviewees highlight that the current ICT and blockchain labour market in the EU appears to be very volatile. This is partially due to external factors leading to increased layoffs of people with ICT and blockchain-related skills, but it may also be due to shortages of appropriate blockchain skills. Interviewees state that blockchain technology is still relatively new and complex, and that there are not enough trained professionals with the necessary skills to develop and implement blockchain solutions. At the same time, there is a greater demand for experienced people with managerial and business competencies. Similarly, with the legal and regulation issues surrounding blockchain-related products, the blockchain sector is looking for more professionals with regulatory and legal knowledge and expertise.

To address blockchain skills shortages, interviewees note that the number of blockchain E&T courses have increased over the last year. They state that there is interest from higher education institutions to implement blockchain-related teaching into existing programmes and to create new blockchain-specific courses, however, there is a greater emphasis on short-term courses and micro-credentials. In general, interviewees agree that there appears to be a disconnect between blockchain companies and education providers. Although relevant blockchain skills have been identified by the blockchain sector, education providers are unsure how to incorporate education and training of necessary skills into existing courses. Interviewees emphasise that companies and E&T providers need to work together to increase the supply of appropriate blockchain skills.

5.1.4 Opportunities and Challenges

In terms of blockchain-related opportunities, there continues to be a high degree of interest in blockchain technology. Interviewees state that more people want to set up blockchain related enterprises but have no prior business experience, knowledge, or funding support. Trends involving information availability, democratisation, and collaboration are driving the adoption of blockchain technology. Further incorporation of blockchain-related teaching in other fields of study, such as economics and law, indicate that the different sectors and fields are interested in this technology. Regulation of blockchain, such as MiCA, may make the European blockchain market stronger as it will provide more certainty and, therefore, nudge business into establishing themselves in Europe.



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In terms of challenges for the blockchain sector, interviewees indicate that the main difficulties will be finding qualified personnel and very high costs of adopting blockchain technology, which are particularly significant barriers for start-ups, micro and small businesses. Therefore, blockchain utilisation is more likely to grow in traditional institutional sectors, and less likely to growth in the start-up scene. These challenges are particularly exacerbated by the general slowdown in the development of blockchain technology due to ICT sector turbulence.

Some interviewees indicate that there is a reluctance to set-up full-time three-year degree courses as they are associated with greater investment and risk. A challenge is also to monitor and consider the fast-paced change in blockchain development and applications when developing blockchain-related E&T programmes. Interviewees state that one of the biggest issues going forward is policy and regulation around blockchain development and implementation, as governments around the world are trying to regulate blockchain technology while in some cases they do have the necessary depth of knowledge and understanding related to the technology required. This will cause further uncertainty for blockchain businesses and investors. Misconception around blockchain and its use is seen as one of the major challenges for wider adoption.

5.1.5 Policy Suggestions

The regulatory environment for blockchain technology is evolving in the EU. However, there is still uncertainty around how governments will approach blockchain regulation. Interviewees suggest that this regulatory uncertainty can create barriers to entry for businesses and hinder the overall growth of the blockchain sector. Although, the political influence on further blockchain development and adoptability is high, in most cases policy makers and public administrators have very little understanding or competencies around blockchain technology and its applications. Therefore, all relevant stakeholders should be involved in discussions regarding blockchain-related regulations and policy developments.

5.2 Blockchain Skills Survey Analysis

To gather additional insights on blockchain skill developments and to review forecasting results, 154 blockchain field experts were surveyed in April 2023. The survey was disseminated by CHAISE consortium members to blockchain experts working with blockchain, such as managers, developers,



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consultants, education and training providers, sectoral representatives, and business, finance, and legal professionals. The survey contained twelve questions on the validity of the CHAISE forecasting methodology, results, blockchain skill developments, and some personal characteristics of respondents. The survey results are analysed below.

5.2.1 Forecasting Results

Approximately 62% of respondents agree and 18% strongly agree with the mapping of blockchain jobs to 3-digit ISCO categories (Figure 7). Therefore, they consider that most of blockchain-related employment can be placed in the following occupational categories: Software and Applications Developers and Analysts, Information and Communications Technology Services Managers, and Business Services and Administration Managers. Only 4% of respondents disagree and 2% strongly disagree with our mapping of blockchain jobs to the ISCO categories while 14% neither agree nor disagree.

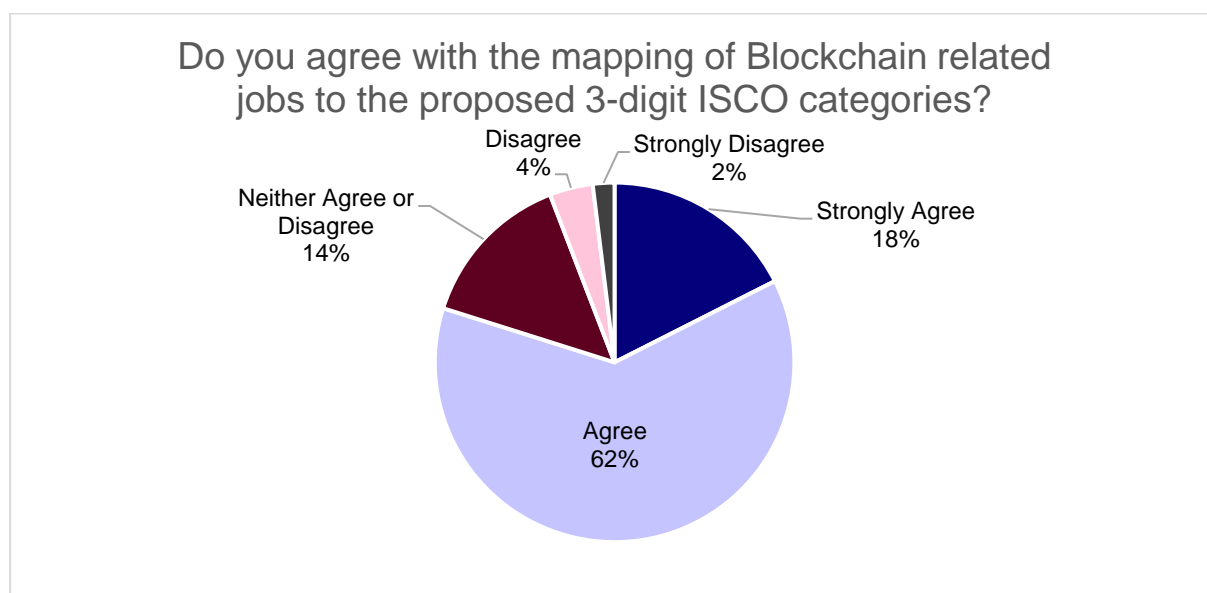


Figure 7 - Survey results from the mapping of blockchain jobs to occupational categories

Note: The complete question was, “From the mapping of Blockchain jobs to occupational categories we find that the majority of Blockchain jobs can be placed in the following three ISCO categories: Software and Applications Developers and Analysts (58.5% of EU Blockchain jobs); Information and Communications Technology Services Managers (20.9% of EU Blockchain jobs); and Business Services and Administration Managers (6.8% of EU Blockchain jobs). Do you agree with the mapping of Blockchain related jobs to the proposed 3-digit ISCO categories?”



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Approximately 46% of survey respondents think that our blockchain demand forecasts are accurate (Figure 8). Another 31% think that demand forecasts are too low and 23% think that they are too high. When comparing survey results to the previous year of forecasting blockchain skills demand, we find that respondent views did not change by much. Last year, approximately 49% of survey respondent thought that the results were accurate, 37% thought that they were too low, and 14% thought that they were too high. The recent contraction in the ICT sector may explain why survey respondents do not expect the demand for blockchain skills to grow and, therefore, they think that our forecasts overestimate blockchain skills demand.

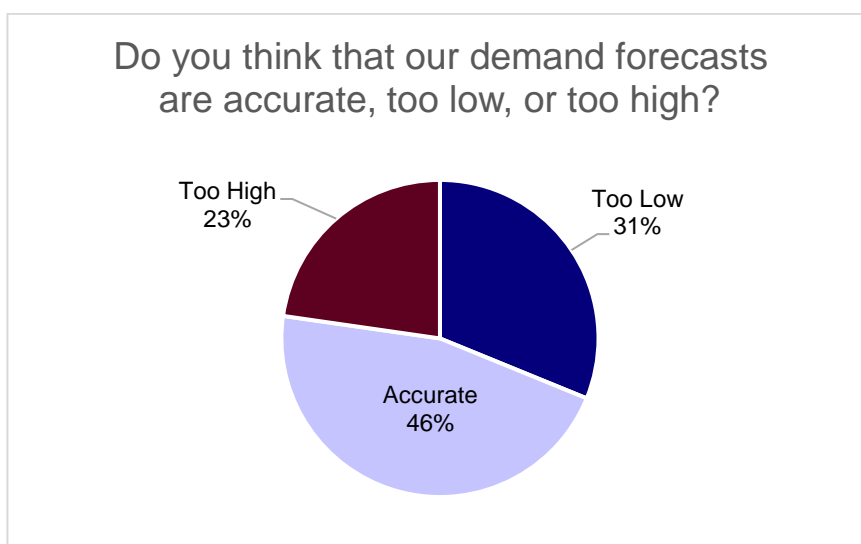


Figure 8 - Survey results from demand forecasts

Note: The complete question was, “Our preliminary Blockchain skills demand forecasting results indicate approximately 29,000 new blockchain jobs will be created from 2021 to 2026 period across Europe. Do you think these forecasts are accurate, too low, or too high?”

In terms of blockchain graduate demand in Figure 9, 56% of respondents agree with the forecasts, 25% think that they are too high and 19% think that they are too low. In general, survey respondents agree that the EU blockchain labour market is expected to grow by approximately 29,000 workers from 2021 to 2026 of which approximately 13,000 are expected to be new entrants to the EU blockchain labour market. Last year, approximately 71% of survey respondents thought that our blockchain graduate



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demand forecasts were accurate, 17% thought that they were too high, and 12% thought that they were too low. The increase in respondents who thought that our results this year were too high may be due to greater labour market demand for more experienced staff. Increase in respondents who thought that our forecasted graduate demand results are too low can be attributed to more start-ups or small and medium enterprises this year adopting blockchain technology that require at least basic blockchain skills.

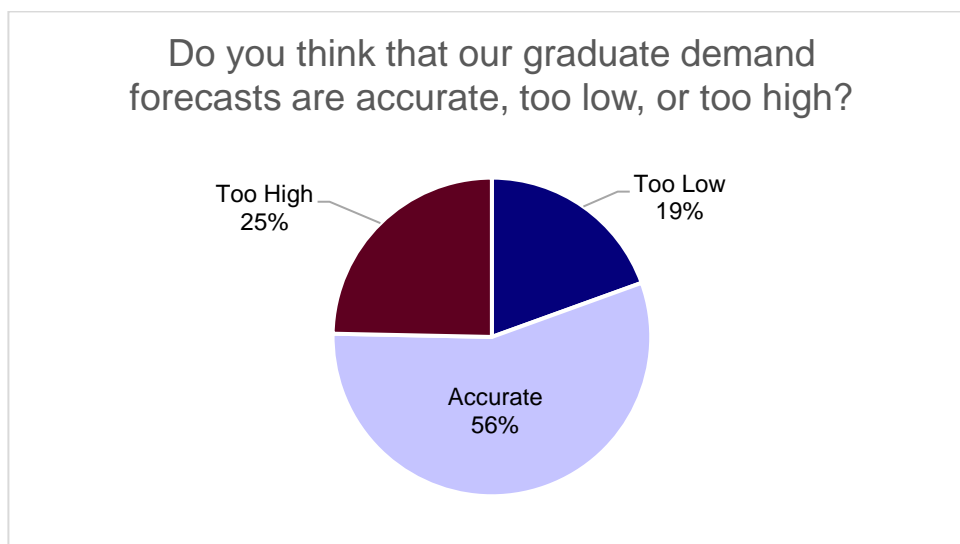


Figure 9 - Survey results from graduate demand forecasts

Note: The complete question was, “The forecasting results suggest that approximately 45% or 13,000 of new Blockchain jobs from 2021 to 2026 will be entry level or offered to new graduates. To what extent do you agree with proportion that will be available to entry level or new graduates?”

In terms of blockchain skills supply, approximately 49% survey respondents agree and 32% mostly agree that most of the new graduates from tertiary education with blockchain exposure will come from the ICT or Computer Science fields of study (Figure 10). Another 12% of respondents neither agree nor disagree with our findings, while 7% disagree but no one strongly disagrees with blockchain skills supply results. It is important to acknowledge that the incorporation of blockchain skills education and training is growing in different fields of study, and that in the future blockchain graduates are likely to come from other areas, such as business, finance, and law.



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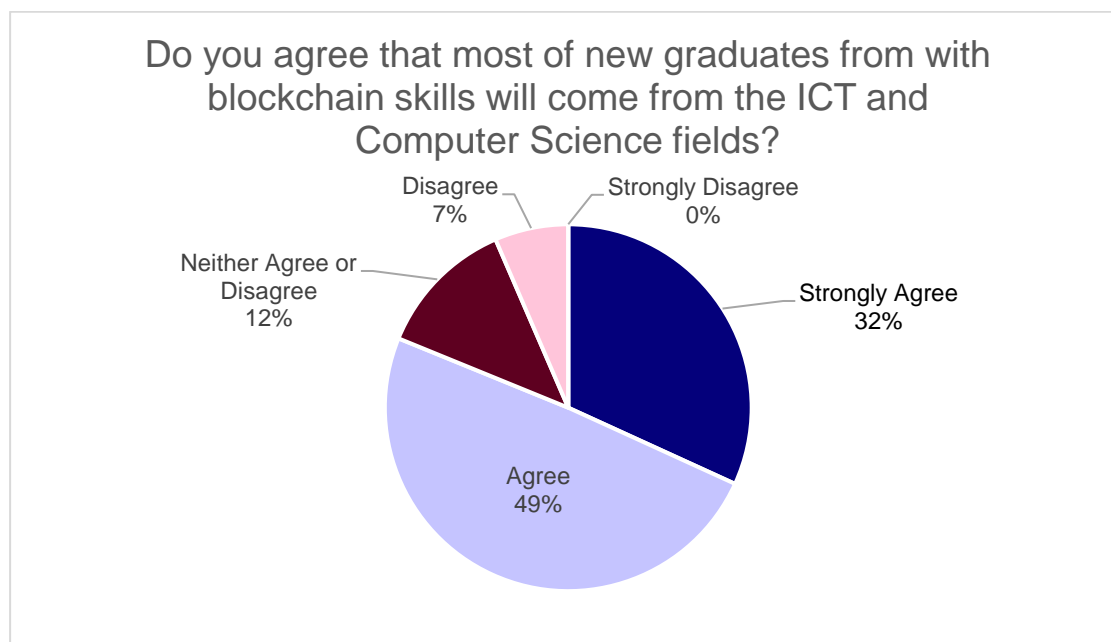


Figure 10 - Survey results from blockchain skills supply

Note: The complete question was, "To what extent do you agree that most of new graduates from tertiary (higher) education with Blockchain skills come from the Information Communications Technology (ICT) and Computer Science fields?"

In terms of forecasting blockchain skills supply, approximately 48% of survey respondents agree with our forecasting results (Figure 11). Another 34% think that they are too high and 18% think that they are too low. Last year's survey of our blockchain supply forecasts suggested that 59% thought that our forecasts were accurate, 21% thought that they were too low, while 20% of respondents thought that they were too high. We observe a significant increase in the number of respondents who think that our supply forecasts this year are too high. The main reason for this increase in forecasted blockchain skills supply is that we estimate that there are more courses and modules offering blockchain teaching this year than last year. As the adaptation of blockchain increases across the EU more VET and higher education courses become available to satisfy the demand for blockchain skills.



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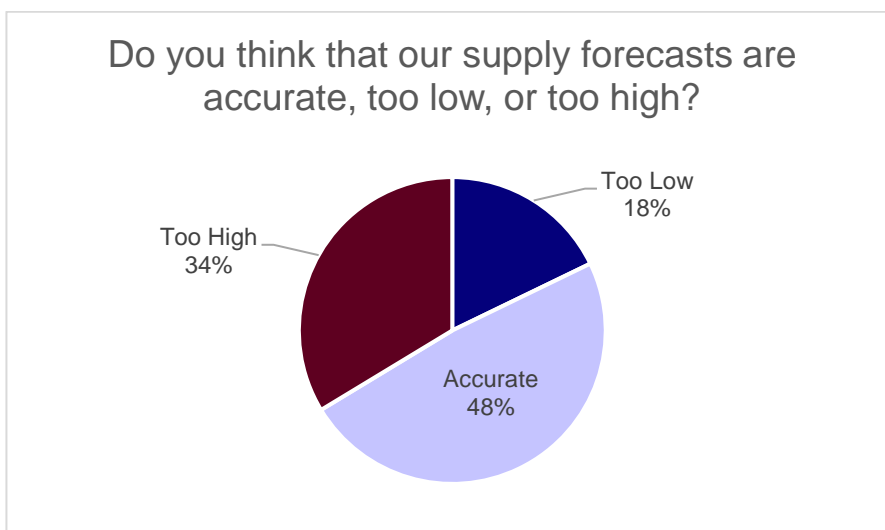


Figure 11 - Survey results from supply forecasts

Note: The complete question was, "Preliminary Blockchain skills supply forecasting results indicate that approximately 25,500 new Blockchain graduates will be available from 2021 to 2026 across Europe. Do you think these forecasts are accurate, too low, or too high?"

Survey participants were also asked about their views on the compositional change in the blockchain labour market in terms of blockchain-related occupations. In comparison to the previous year of blockchain skills forecasting, we estimate an increase in proportion of blockchain-related employment in ICT Services Managers (ISCO 133), Business Services and Administration Managers (ISCO 121), and Legal Professionals (ISCO 261) occupations, and a decrease in Software and Applications Developers and Analysts (ISCO 251), and Database and Network Professional (ISCO 252) occupations. We asked respondents if this is in line with what they currently observe in the industry. Approximately 51% of survey respondents agree and 9% strongly agree with our findings, while 28% neither agree nor disagree, and 12% disagree with our observations (Figure 12).



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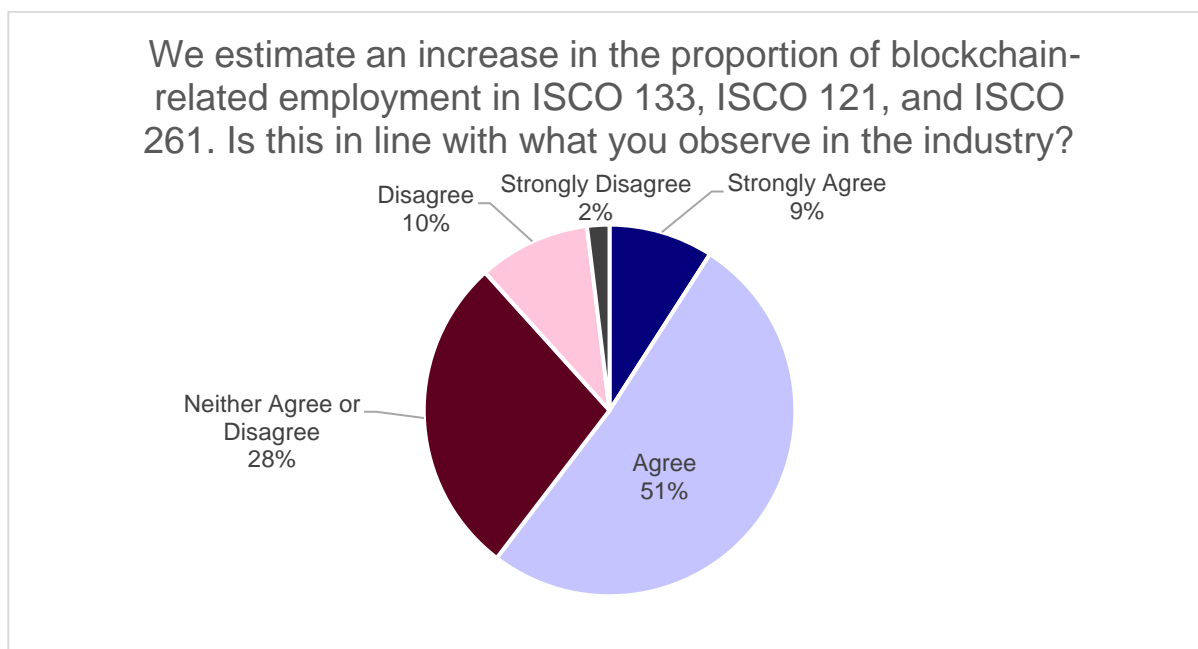


Figure 12 - Survey results from compositional change in blockchain employment

Note: The complete question was, “We observe a compositional change in the forecasted Blockchain labour market from 2021 to 2026 when compared to the last year’s forecasts. We estimate an increase the proportion of Blockchain-related employment in ICT Services Managers, Business Services and Administration Managers, and Legal Professionals occupations, and a decrease in Software and Applications Developers and Analysts, and Database and Network Professional occupations. Is this in line with what you observe in the industry?”

5.2.2 Skill Developments

Survey participants were asked to identify what they think are the most important blockchain skills from a list of the most relevant blockchain skills currently sought after by employers. Blockchain skills were grouped in the following categories: technical skills, professional or business skills, and transversal skills. In Table 11 we show the top five most important skills identified by survey participants in each category.



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Table 11: Most Important Blockchain Skills

| Top Skills | Technical Skills | Professional/Business Skills | Transversal Skills |
|------------|---|------------------------------|---|
| Top 1 | Blockchain Solutions Design | Use Cases Development | Critical thinking & Self-Reflection |
| Top 2 | Smart Contract Development | Business Analysis | Systems & Networked thinking |
| Top 3 | Cryptography Development | Product Development | Self-Management/Organization/Regulation & Self-Responsibility |
| Top 4 | Coding (C++, Python, Java) | Legal & Compliance | Design-Thinking Competence |
| Top 5 | Development of Decentralised Applications | Business Development | Decision Competence & Responsibility-Taking |

Note: Survey respondents were asked, "To your knowledge, what are the most important technical, professional/business, and transversal skills needed for Blockchain roles? Please select up to five skills from the following list."

In terms of technical skills, Blockchain Solutions Design was identified as the most important technical skill currently in demand, followed by Smart Contract Development, Cryptography Development, Coding, and Development of Decentralised Applications (Table 11). Last year's survey results showed a similar interest in these technical skills. The results suggest that blockchain skills related to implementation and application of blockchain technology in an institutional setting continue to be in strong demand.

Professional or business skills most sought after in the industry are Use Cases Development, Business Analysis, Product Development, Legal and Compliance, and Business Development (Table 11). Skills in appropriate use of blockchain technology and legal, regulatory and compliance elements of blockchain adaptation appear to be the most important business skills. The survey findings on blockchain business skills are similar to last year's results, but Legal & Compliance skills are particularly in demand this year. In terms of transversal skills, Critical Thinking and Self-Reflection is the most important skill identified by survey participants, followed by Systems and Networked Thinking, Self-Management/Organization/Regulation and Self-Responsibility, Design-Thinking Competence, and Decision Competence and Responsibility-Taking. Greater emphasis is placed on critical decision making and effective communication in the context of blockchain development and applications. This extends from our last year's findings where respondents valued cooperation, self-determination and autonomy, and communication skills the most.



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5.3 Expert Advisory Board Feedback

CHAISE Expert Advisory Board meeting took place in June 2023 to verify forecasting results and to provide additional feedback for consideration during the project. Overall, the board was satisfied with the procedures and results over the latest reporting period of blockchain skills forecasting. No major adjustments to the methodology, forecasting results, intelligence gathering activities, or verification of results procedures were identified. The board requested more specific definitions of key variables in this report, as well as expression of interest regarding use case developments around blockchain technology that may be considered in future developments of this project. Therefore, we provide greater clarity when defining blockchain skills supply in the methodology section as well as throughout this report. A library of Use Cases of Blockchain in the EU may be added to the forecasting report in the upcoming reporting period.

5.4 Conclusion to Verification of Results

Forecasting results presented in this report were validated by 50 blockchain field experts through individual or round-table interviews, 154 survey participants, and 17 members of the CHAISE Expert Advisory Board. Overall, blockchain experts thought that the forecasting results were reasonably accurate and resemble their experiences in the labour market. They provided additional insights that will be also considered in the next round of forecasting. As the blockchain space continues to change, skill requirements for blockchain related roles are also likely to change.



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6 Conclusion

We utilise a novel and dynamic methodological framework to forecast the demand for blockchain skills across the EU from 2021 to 2026 and match this against our forecasted blockchain skills supply. The main goals of this report are to provide key input into any national and EU level skills strategy design and to provide up-to-date information on the changes in blockchain employment to address any skill mismatches. The results in this report come from the second year of blockchain skills forecasting, and in terms of demand for blockchain workers, they indicate that the demand for blockchain workers, expressed as a proportion of new jobs, remains small in most EU countries. We find that on average 0.24% of new jobs are blockchain related, ranging from 0.05% in Sweden to 3.15% in Slovakia. Further, we find that 90% of emerging blockchain jobs are concentrated in just four occupational groups, namely Software and Applications Developers and Analysts, Database and Network Professionals, Information and Communications Technology Services Managers, and Business Services and Administration Managers. Therefore, skill requirements for companies engaging in blockchain will remain heavily concentrated in the areas of ICT and computer science. However, a growing number of companies from business services and finance areas are recruiting individuals with blockchain skills. In terms of the overall blockchain labour market, we estimate that there were 361,767 blockchain-related workers in the EU in 2021.

In terms of the forecasting results in the second year of estimation, we anticipate that in total across the EU the demand for blockchain skills will grow by 29,383 individuals between 2021 and 2026. Over the sample period we project the highest rates of job growth in France (10,470), Germany (3,879), Spain (2,115), and Italy (2,101). Total forecasted blockchain skills supply during the same sample period is expected to be 25,557. The forecasts suggests that while there is a gap between the demand for new blockchain graduates and the supply from universities, these imbalances are not substantial in most countries. Overall, the estimated supply of graduates with some exposure to blockchain course content outweighs the demand for blockchain graduates. Further, general ICT graduates in most countries examined greatly outweighs the demand for blockchain professionals, suggesting that there will be a sufficient graduate stock from which blockchain companies can recruit. However, there may well be substantial training costs associated with blockchain companies recruiting from the general ICT graduate population, and these may act as a constraint on growth. The study suggests that there is a need to expand specialist blockchain training courses at mid to senior level in most member states.



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Additional insights from the intelligence gathering activities on sectoral, labour market, and education and training developments indicate that interest in blockchain technology is growing in the EU. For example, in late-2020, the European Commission published a proposal for a regulation of the European Parliament and of the council on Markets in Crypto-Assets (MiCA) to enable and support the potential of digital finance, innovation and competition while minimizing associated risks. Therefore, blockchain technology is currently experiencing high adoptability in different industries and sectors, such as finance and marketing. Continued investment in research of blockchain technology by the Small & Medium Enterprises is also expected to drive the growth of the technology.

As blockchain continues to be adopted in a variety of different sectors and industries it requires a diverse set of technical, business, and transversal skills. As a result, the demand for appropriate non-technical skills, such as finance, sales, marketing, legal, and regulatory skills have become extremely important. Although blockchain-related education and training is increasing, there remains a lack of appropriate interdisciplinary skills often sought after by employers. Blockchain-related teaching is largely available at a VET and higher education levels. However, the focus has shifted to micro credentials as the blockchain sector continues to expand. Wider knowledge of blockchain technology and its applications is likely to accelerate its adoption.

Blockchain skills forecasting and intelligence gathering results presented in this report were also validated by blockchain field experts in the EU who confirmed that the results were reasonably accurate and resemble their experiences in the labour market. In general, blockchain field experts indicate that the blockchain space in Europe continues to change and skill requirements for blockchain related roles are also likely to change. They also suggest that the regulatory environment for blockchain technology is evolving in the EU, however, there is still uncertainty around how governments will approach blockchain regulation. Given that the political influence on further blockchain development and adoptability is high, in most cases policy makers and public administrators have very little understanding or competencies around blockchain technology and its applications. Blockchain field experts state that all blockchain-relevant stakeholders should be involved in discussions regarding blockchain-related regulations and policy developments.



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