



blockchain skills for Europe

D3.2.1:

Annual Blockchain Skills Forecasts

May 2022



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Partner Number	Participant organisation name	Short name	Country
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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
7	IOTA Stiftung	IOTA	DE
8	Universitat Politècnica de Catalunya	UPC	ES
9	Duale Hochschule Baden-Württemberg	DHBW	DE
10	Associazione CIMEA	CIMEA	IT
11	INTRASOFT International S.A.	INTRASOFT	LU
12	Institute of the Republic of Slovenia for Vocational Education and Training	CPI	SI
13	European DIGITAL SME Alliance	DIGITAL SME	BE
14	University of Tartu	UT	EE
15	Univerza V Ljubljani	UL	SI
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17	Italia4Blockchain	ITALIA4BLOCKCHAIN	IT
18	Autoritatea Națională pentru Calificări	ANC	RO
19	Akkreditierungs ,Certifizierungs- und Qualitätssicherungs- Institut e.V.	ACQUIN	DE
20	EXELIA	EXELIA	GR
21	INDUSTRIA Technology Ltd	INDUSTRIA	BG
22	Crypto4all	C4A	FR
23	Economic and Social Research Institute	ESRI	IE



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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
E&T	Education and Training
ICT	Information and Communications Technology
ILO	International Labour Organization
ISCO	International Standard Classification of Occupations
IT	Information Technology
MOOC	Massive Open Online Courses
VET	Vocational Education and Training



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1 Introduction

Blockchain is now accepted internationally as both an emerging technology and emerging skill set. This is reflected in the European Commission's blockchain strategy.¹ As the technology is still developing from the concept to application stage, its labour market impact remains relatively limited. For example, in a search of LinkedIn job advertisements (November 2021), our study found that blockchain job postings accounted for just 0.35% of total jobs advertised. To date, the principal use of blockchain technologies has been in the realm of cryptocurrencies. However, the last number of years have seen a rapid expansion in the application of blockchain technologies beyond the financial services sector and it is generally expected that the demand for blockchain skills is likely to grow rapidly as the technology continues to develop and adoption spreads across sectors.

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.

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 2020 to 2026 period. The study also uses data from Eurostat and a survey of CHAISE partners to estimate the supply of both ICT and blockchain specific graduates 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

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



industry experts and key stakeholder consultations, that are designed to ensure that that country level forecasts fall within an expected range.

From an anonymous survey of sectoral experts, the majority (90%) of respondents agree that the forecasting methodology is appropriate, and that the forecasting results are accurate. Interviews with sector participants also indicate that the current methodological framework is appropriate for blockchain skills forecasting. However, due to the rapid changes in the blockchain sector and evolution of blockchain related roles, as well as lack of information on blockchain E&T provision and activities, precisely estimating the future demand and supply of blockchain skills is a complex exercise.

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 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.

2 Methodology

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 2020/21 to 2026. The methods of data analysis used in this study are based on the previous academic literature on forecasting employment and occupational outcomes. Due to the unique nature of analysing blockchain labour market outcomes this report utilises



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previous literature from blockchain related fields such as information communication technology, economics, and finance. The data gathering process and methods of forecasting blockchain skills demand and supply are discussed in detail below.

2.2 Forecasting Blockchain Skills Demand

A number of 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 in order to map important real-time labour market information about the current job market to specific occupational categories. Mezzanzanica and Mercorio (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 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.

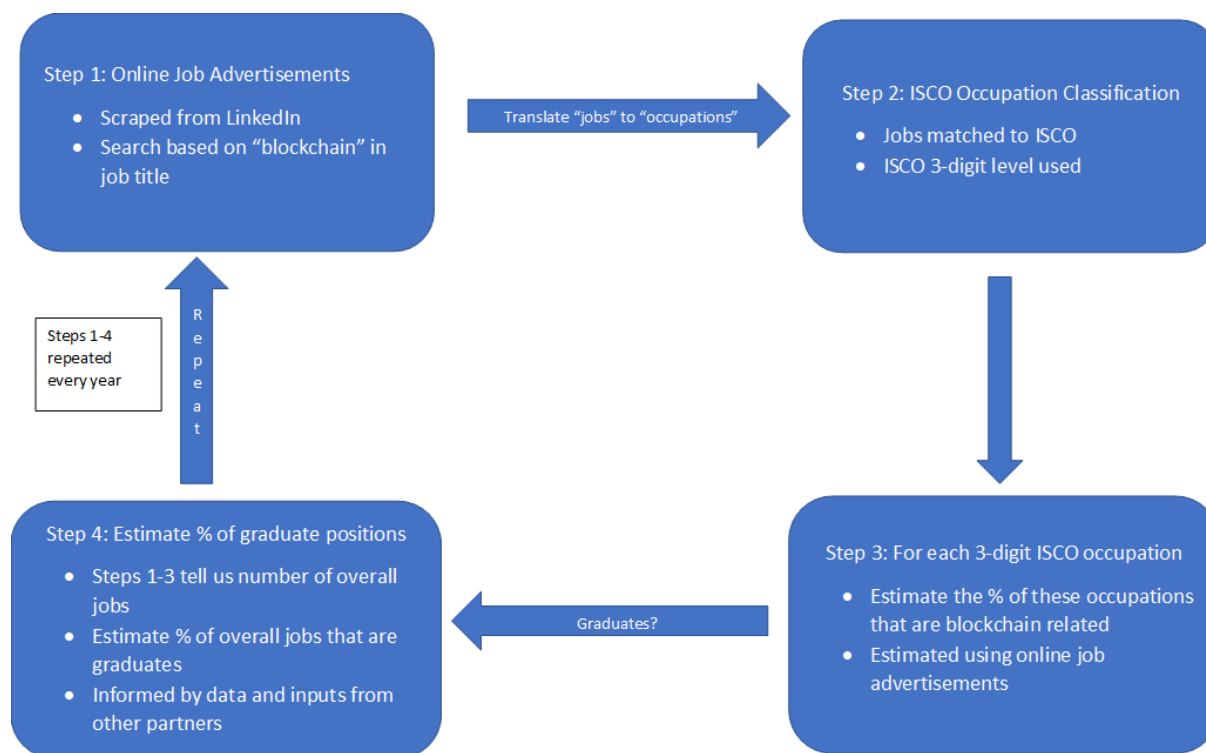


Figure 1: Job Forecasting Methodology

The challenge in forecasting demand for blockchain skills is that there are currently no blockchain specific job categories in the existing occupation taxonomies used in current survey data. Therefore, in order 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



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blockchain jobs across all European countries². 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.

In order to get a better idea about the size of the blockchain labour market in Europe, Table 1 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. Evidently the blockchain market is relatively small as approximately 0.34% of all jobs advertised on LinkedIn in Europe relate to blockchain.

² 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.



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Table 1: Number of Blockchain Jobs by European Country Advertised on LinkedIn on 04/11/2021 (Search input: "blockchain")

Country	Blockchain Jobs (LinkedIn)	Total Jobs (LinkedIn)	% of Total Jobs
Austria	142	37,203	0.38%
Belgium	216	63,217	0.34%
Bulgaria	350	8,171	4.28%
Croatia	102	2,298	4.44%
Cyprus	50	1,279	3.91%
Czechia	197	36,852	0.53%
Denmark	155	15,357	1.01%
Estonia	53	2,081	2.55%
Finland	86	8,910	0.97%
France	1,088	697,752	0.16%
Germany	2,624	1,007,673	0.26%
Greece	85	6,607	1.29%
Hungary	261	14,277	1.83%
Ireland	352	38,246	0.92%
Italy	650	173,254	0.38%
Latvia	14	1,588	0.88%
Lithuania	65	4,093	1.59%
Luxembourg	109	6,571	1.66%
Netherlands	731	475,026	0.15%
Poland	1,111	112,459	0.99%
Portugal	277	66,868	0.41%
Romania	647	24,871	2.60%
Slovakia	158	3,875	4.08%
Slovenia	22	1,292	1.70%
Spain	585	64,093	0.91%
Sweden	132	52,376	0.25%
Total	10,262	2,926,289	0.35%



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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-27³ countries totalling 6,906 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.⁴ 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 88% of all blockchain related jobs were mapped to one of the ISCO categories identified above. The remaining 12% 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.

³ Scraped online job advertisements for Malta are unavailable due to a different region overlap (region in the US named similarly).

⁴ Keywords and mapping criteria available on request. Consultations were held with the following CHAISE partners: INTRASOFT, C4A, IOTA, FUJITSU.



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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 online 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.

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 30% in Luxemburg to 65% in Cyprus, with the average across all countries closer to 50%.⁵ 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.

⁵ 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 7, Column 3 and a more detailed table can be provided on request from the authors.



2.3 Forecasting Blockchain Skills Supply

Blockchain skills supply is estimated by identifying the number of graduates from blockchain specific higher education courses. However, accurate and reliable information on the number of graduates from blockchain specific courses is not available across Europe. Therefore, this study utilises graduate data from blockchain related fields of study to forecast blockchain skills supply from 2020 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 degree 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 2020 to 2026 for each member state using linear trends based on data sourced from 2015 to 2019.

A small sample of CHAISE partners supplied estimates of blockchain-specific graduates for their home countries (Belgium, France, Ireland, and Slovenia) most completely for 2020. This allowed for an estimation of the share of blockchain specific graduates as a share of total ICT graduates for these countries in this year, which ranged from the lowest in France (0.65%) to the highest in Slovenia (2.54%). The average of these estimates of blockchain-specific graduates was 1.5% and was used to estimate the number of blockchain specific graduates 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 specific supply based on their understanding of their country's education system.

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. First, 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. Second, 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 3). Third, unavailable information on the number of blockchain specific graduates for most EU countries means that blockchain supply



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forecasts for countries that are missing this information are based on average EU estimates of blockchain specific graduates rather than country specific data. Fourth, unlike demand side forecasts, supply forecasts do not incorporate macroeconomic and demographic changes in their projections. Although data issues are important to acknowledge this study is the first to 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 the delivery of a blockchain skills strategy that will help future proof the sector against forms of skills mismatch.

3 Results

3.1 Occupational Forecasts

Blockchain skills demand forecasts are based on CEDEFOP occupational forecasts presented in Table 2. 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 2 indicate the change in employment in each occupational category for each of EU-27 member states from 2021 to 2026.⁶ Absolute change in the numbers of persons employed in these occupations is utilised in the blockchain skills forecasting.

⁶ Our results excluding Malta due to data constraints.



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Table 2: 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 2: 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 3, 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, 9,899 new blockchain jobs in France and only 1,720 new blockchain jobs in Germany. The main reason for this is a relatively greater proportion of blockchain jobs in *Software and Applications Developers and Analysts* 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 4 below.

Although demand for blockchain skills (Table 3) 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 648 jobs. However, this decrease in demand is largely 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 28,092, between 2021 and 2026. This is largely driven by growth in *Software and Applications Developers and Analysts* occupations which contains the most blockchain related jobs, which is approximately 40% of total forecasted blockchain jobs. Blockchain demand in occupations with minor blockchain representation is presented by the '*Other ISCO Categories*'. It accounts for approximately 13% of the total forecasted additional blockchain jobs and is included in the analysis for a complete representation of the blockchain labour market in Europe.



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Table 3: Forecasted Blockchain Demand by Blockchain-Relevant ISCO occupations, 2021-2026

	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
Country	Total Demand	Blockchain Demand	Total Demand	Blockchain Demand	Total Demand	Blockchain Demand	Total Demand	Blockchain Demand	Total Demand	Blockchain Demand	Blockchain Demand	
Austria	1,587	71	372	31	1,086	83	-189	-5	3,739	0	18	197
Belgium	10,525	453	2,798	67	1,271	27	6,536	699	5,824	47	194	1,486
Bulgaria*	2,086	111	522	27	-552	-83	434	89	128	5	12	160
Croatia	3,028	42	854	63	23	2	-565	-46	1,598	0	7	68
Cyprus	1,067	4	119	0	461	41	1,330	85	1,363	0	22	153
Czechia	2,986	54	1,049	37	-153	-12	4,797	667	1,978	0	52	797
Denmark	8,152	456	1,007	8	664	25	1,612	113	2,326	47	71	720
Estonia	1,721	71	544	40	-41	-8	1,082	262	-50	-14	63	414
Finland	7,079	142	700	11	21	1	-408	-50	-326	0	8	111
France	38,774	5,855	2,475	109	11,591	1,055	30,501	580	9,922	516	1,785	9,899
Germany	52,600	789	10,019	371	-1,283	-54	30,236	363	13,647	27	224	1,720
Greece	715	17	71	1	302	8	44	0	3,433	0	2	27
Hungary	4,590	147	1,613	29	1,264	88	1,368	155	4,664	0	67	486
Ireland	-	-	-	280	89	7	14,236	498	1,906	21	40	846
Italy	13,259	557	3,960	182	-964	-31	9,326	765	17,346	87	265	1,825
Latvia	762	11	599	0	82	2	2,035	120	882	0	17	151



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Cont'd Table 3: Forecasted Blockchain Demand by Blockchain-Relevant ISCO occupations, 2021-2026												
	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
Country	Total Demand	Blockchain Demand	Total Demand	Blockchain Demand	Total Demand	Blockchain Demand	Total Demand	Blockchain Demand	Total Demand	Blockchain Demand	Blockchain Demand	
Lithuania	2,031	89	956	85	-373	-7	108	7	664	30	12	216
Luxembourg	1,444	7	508	0	42	3	380	14	2,784	50	13	87
Netherlands	14,394	302	3,826	138	2,774	92	-10,605	-1,135	4,831	14	-59	-648
Poland*	19,294	888	4,823	87	-48	-2	25,220	2,648	2,189	0	471	4,091
Portugal	8,991	396	999	18	574	53	2,019	271	3,706	159	90	986
Romania	672	32	100	9	13	1	455	10	19,407	0	2	54
Slovakia	418	48	160	21	76	3	2,006	92	528	0	7	171
Slovenia	798	45	212	18	126	10	1456	73	473	5	8	158
Spain	12,935	530	5,030	106	1,278	40	10,707	1,017	11,413	228	192	2,113
Sweden	9,447	161	1,538	49	577	12	18,079	1,446	3,519	0	133	1,801
Total	219,355	11,278	44,854	1,786	18,899	1,352	152,200	8,738	117,893	1,222	3,716	28,092

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 1. The Blockchain demand for each country is estimated by applying the percentage of 3-digit ISCO occupations (Table 3) 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: 80%; ISCO252: 20%; ISCO 133: 10%; ISCO 121: 58%; 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 4: 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	4.5%	7.6%	8.2%	2.7%	0.0%
Belgium	4.3%	2.1%	2.4%	10.7%	0.8%
Bulgaria	5.3%	15.0%	5.1%	20.4%	3.8%
Croatia	1.4%	8.0%	5.1%	8.1%	0.0%
Cyprus	0.4%	8.9%	0.0%	6.4%	0.0%
Czechia	1.8%	7.9%	3.5%	6.4%	0.0%
Denmark	5.6%	3.7%	0.8%	7.0%	2.0%
Estonia	4.1%	19.1%	7.4%	24.2%	28.6%
Finland	2.0%	2.9%	1.6%	12.3%	0.0%
France	15.1%	9.1%	4.4%	1.9%	5.2%
Germany	1.5%	4.2%	3.7%	1.2%	0.2%
Greece	2.4%	2.5%	0.9%	0.0%	0.0%
Hungary	3.2%	7.0%	1.8%	11.3%	0.0%
Ireland	4.3%	5.2%	9.4%	3.2%	3.2%
Italy	4.2%	3.2%	4.6%	8.2%	0.5%
Latvia	1.5%	2.5%	0.0%	5.9%	0.0%
Lithuania	4.4%	2.0%	8.9%	6.4%	4.5%
Luxembourg	0.5%	6.6%	0.0%	3.8%	1.8%



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Cont'd Table 4: 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	2.1%	3.3%	3.6%	10.7%	0.3%
Poland	4.6%	4.1%	1.8%	10.5%	0.0%
Portugal	4.4%	9.2%	1.8%	13.4%	4.3%
Romania	4.7%	8.8%	9.2%	2.3%	0.0%
Slovakia	11.6%	3.8%	13.2%	4.6%	0.0%
Slovenia	5.7%	7.8%	8.5%	5.0%	1.0%
Spain	4.1%	3.1%	2.1%	9.5%	2.0%
Sweden	1.7%	2.0%	3.2%	8.0%	0.0%

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".



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3.3 Blockchain Skills Supply

The total number of ICT graduates per year from 2015 to 2019 for each European country is presented in Table 5. 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 that may be blockchain-specific graduates, and therefore, blockchain skills supply. Evidently, the number of ICT graduates across Europe has been increasing on average at 5.8% per year from 2015 to 2019 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-specific graduate supply in Europe the CHAISE consortium is consulted to provide national statistics on the number of blockchain-specific graduates. To forecast blockchain skills the proportion of ICT graduates that are coming from blockchain-specific courses is estimated. Therefore, we find that on average 1.5% of ICT graduates in Europe are coming from blockchain-specific courses. The number of ICT graduates over the examination period and the proportion of blockchain-specific graduates in 2020 are used to estimate the change in blockchain labour market and skills supply from 2020 to 2026.



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Table 5: Total ICT Graduates by Country, 2015-2019

Country	2015	2016	2017	2018	2019
Austria	2,471	2,522	2,396	2,622	2,721
Belgium	1,229	1,847	2,146	2,454	2,445
Bulgaria	1,957	1,733	2,127	2,055	2,084
Croatia	-	1,666	1,876	1,383	1,461
Cyprus	225	204	229	229	289
Czechia	3,848	3,648	3,964	3,758	3,662
Denmark	2,696	3,224	3,252	3,244	3,405
Estonia	516	652	713	604	718
Finland	3,784	3,958	3,538	4,065	4,342
France	19,515	19,827	18,658	21,538	23,049
Germany	24,755	25,332	26,731	27,456	29,513
Greece	2,131	2,606	3,109	3,374	3,491
Hungary	1,455	2,813	2,523	2,754	2,852
Ireland	4,449	4,851	5,275	6,251	6,271
Italy	-	3,211	3,328	4,549	5,103
Latvia	550	527	523	512	463
Lithuania	587	601	760	818	921
Luxembourg	84	88	75	94	78
Malta	242	240	271	270	270
Netherlands	3,101	3,463	3,730	4,311	4,789
Poland	15,744	15,214	18,259	17,911	17,270
Portugal	862	806	942	1,070	1,163
Romania	7,142	5,992	6,750	7,349	7,879
Slovakia	1,734	1,753	1,653	1,718	1,562
Slovenia	-	-	952	978	1,029
Spain	7,662	7,456	7,876	7,173	7,365
Sweden	2,075	2,088	2,139	2,199	2,340
Total	108,814	116,118	123,795	130,739	136,535

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 2020 to 2026 are presented in Table 6. ICT graduate forecasts are based on the number of graduates from 2015 to 2019 in Table 5. We forecast that the number of ICT graduates across Europe will grow on an average at 3.7% per year from 2020 to 2026. Therefore, the total forecasted ICT graduate supply in Europe over the sample period is 1,118,072. We estimate that approximately 1.5% of ICT graduates in Europe are from blockchain specific courses. This is estimated as an average of total ICT graduates that are blockchain-specific graduates in the following countries in which this information was provided by consortium partners: Belgium (2.04%), France (0.65%), Ireland (0.66%), and Slovenia (2.54%). Country specific data is applied in the forecasting analysis for which this information is available (i.e. for Belgium, France, Ireland and Slovenia) and the European average calculated as 1.5% is applied to all other countries. Therefore, forecasted total blockchain graduate supply in Europe over the period from 2020 to 2026 is 14,972.

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-specific graduates, over the sample period are Italy (9.4% p.a.), Belgium (8.4% p.a.), Lithuania (7.3% p.a.), Greece (7.3% p.a.), Hungary (7% p.a.), and the Netherlands (6.9% p.a). A minority of countries, namely Croatia, Czech Republic, Latvia, Luxembourg, 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 blockchain-specific graduates in Europe.



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Table 6: Forecasted ICT and Blockchain Graduates by Country, 2020-2026

Country	2020	2021	2022	2023	2024	2025	2026	Total Forecasted ICT Graduates: 2020 - 2026	Forecasted Blockchain Graduate Supply
Austria	2,726	2,786	2,846	2,906	2,966	3,026	3,086	20,342	305
Belgium	2,936	3,240	3,544	3,848	4,152	4,455	4,759	26,934	549
Bulgaria	2,164	2,222	2,279	2,337	2,394	2,452	2,510	16,358	245
Croatia	1,320	1,209	1,098	987	876	766	655	6,911	104
Cyprus	281	296	312	327	342	358	373	2,289	34
Czechia	3,697	3,671	3,645	3,619	3,593	3,566	3,540	25,331	380
Denmark	3,596	3,739	3,883	4,027	4,171	4,315	4,458	28,189	423
Estonia	747	783	819	854	890	925	961	5,979	90
Finland	4,304	4,427	4,549	4,671	4,794	4,916	5,038	32,699	490
France	23,151	24,029	24,907	25,785	26,663	27,541	28,419	180,495	1,173
Germany	30,249	31,413	32,577	33,741	34,905	36,069	37,233	236,187	3,543
Greece	3,989	4,337	4,686	5,035	5,384	5,733	6,081	35,245	529
Hungary	3,300	3,573	3,847	4,120	4,394	4,667	4,941	28,842	433
Ireland	6,933	7,437	7,941	8,446	8,950	9,455	9,959	59,121	390
Italy	5,772	6,462	7,151	7,841	8,531	9,221	9,910	54,888	823
Latvia	458	439	421	402	383	364	345	2,812	42
Lithuania	1,003	1,091	1,180	1,268	1,357	1,445	1,534	8,878	133
Luxembourg	82	81	81	80	80	79	78	561	8
Malta	284	293	302	310	319	327	336	2,171	33



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Cont'd Table 6: Forecasted ICT and Blockchain Graduates by Country, 2020-2026

Country	2020	2021	2022	2023	2024	2025	2026	Total Forecasted ICT Graduates: 2020 - 2026	Forecasted Blockchain Graduate Supply
Netherlands	5,146	5,568	5,991	6,413	6,836	7,258	7,680	44,892	673
Poland	18,604	19,179	19,754	20,329	20,904	21,479	22,054	142,303	2,135
Portugal	1,228	1,315	1,402	1,488	1,575	1,661	1,748	10,417	156
Romania	7,872	8,155	8,438	8,721	9,004	9,287	9,570	61,047	916
Slovakia	1,570	1,532	1,495	1,457	1,419	1,381	1,343	10,197	153
Slovenia	1,063	1,102	1,140	1,179	1,217	1,256	1,294	8,251	210
Spain	7,243	7,156	7,068	6,980	6,893	6,805	6,717	48,862	733
Sweden	2,361	2,425	2,489	2,553	2,617	2,681	2,745	17,871	268
Total	142,079	147,960	153,845	159,724	165,609	171,488	177,367	1,118,072	14,972

Notes: Total forecasted ICT graduates are estimated by applying a linear trend to total ICT graduates from 2015 to 2019 in Table 5. Estimated Blockchain skills supply for each country is the share of blockchain-specific graduates of total ICT graduates. The share of blockchain-specific graduates on average is 1.5% of total ICT graduates, which is applied to countries that did not provide specific blockchain graduate data. The average proportion of blockchain-specific graduates is estimated as a simple average based on the information provided by the following CHAISE partners: Belgium (2.04%), France (0.65%), Ireland (0.66%), and Slovenia (2.54%).



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3.5 Comparing Demand and Supply Forecasts

Finally, 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 7. We find that on average across all European states 49.5% of advertised blockchain related jobs are for new higher education graduates. By applying the percentage of graduate jobs to forecasted total blockchain demand for each country we estimate the number of forecasted blockchain new entrant demand. The total forecasted blockchain new entrant demand in Europe from 2021 to 2026 is 12,966. In terms of the graduate supply, we already know from Table 5 that 1,118,072 higher education students are expected to graduate from the ICT field of study, and we estimate that 14,972 of the new graduates will come from blockchain specific courses between 2020 and 2026. Although the results in Table 7 indicate that total forecasted blockchain new entrant demand is broadly in line with total graduate supply, a minor surplus of blockchain graduates is projected over the sample period but with no major labour market disruptions in the blockchain sector across Europe. It should also be noted that many ICT graduates from non-specific blockchain courses will be able to fill blockchain specific roles. 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 7 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 Belgium, Czechia, Denmark, Ireland, Italy, Lithuania, Poland, and Spain. Shortages of blockchain skills are expected at the national level in Cyprus, France, and Sweden. Conversely, surplus of blockchain skills is forecasted in Finland, Germany, Greece, Netherlands, Romania, and Slovenia. Figures 2 to 5 below present a direct comparison between blockchain graduate demand and blockchain graduate supply by regional groups across Europe.



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Table 7: 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	197	47.30%	93	20,342	305
Belgium	1,486	38.10%	566	26,934	549
Bulgaria	160	43.00%	69	16,358	245
Croatia	68	50.90%	35	6,911	104
Cyprus	153	65.20%	99	2,289	34
Czechia	797	60.00%	478	25,331	380
Denmark	720	52.30%	376	28,189	423
Estonia	414	45.90%	190	5,979	90
Finland	111	39.90%	44	32,699	490
France	9,899	36.20%	3,583	180,495	1,173
Germany	1,720	48.10%	827	236,187	3,543
Greece	27	56.40%	15	35,245	529
Hungary	486	59.60%	290	28,842	433
Ireland	846	43.90%	371	59,121	390
Italy	1,825	56.40%	1,029	54,888	823
Latvia	151	50.00%	75	2,812	42
Lithuania	216	63.40%	137	8,878	133
Luxembourg	87	30.10%	26	561	8
Malta*	-	-	-	2,171	33
Netherlands	-648	39.20%	-254	44,892	673
Poland	4,091	58.80%	2,406	142,303	2,135
Portugal	986	40.30%	397	10,417	156
Romania	54	61.60%	33	61,047	916
Slovakia	171	71.20%	122	10,197	153
Slovenia	158	31.30%	50	8,251	210
Spain	2,113	40.20%	849	48,862	733
Sweden	1,801	58.60%	1,055	17,871	268
Total	28,092	49.53%	12,966	1,118,072	14,972

Notes: Total Blockchain Demand (#) comes from Table 3 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. Total ICT Graduate Supply and Blockchain Graduate Supply comes from Table 6 on *Forecasted ICT and Blockchain Graduates by Country, 2020-2026*. (*) Malta is not included in data scraping exercise due to difficulties in region differentiation.



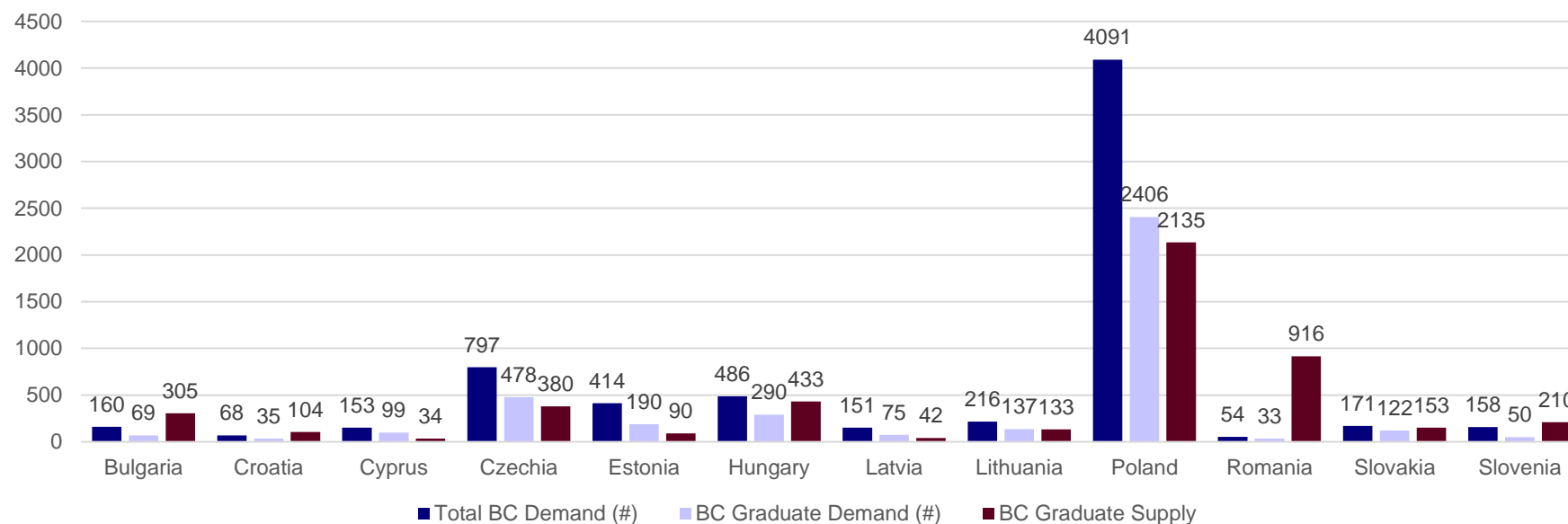
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Figure 2: Blockchain Skills Demand and Supply Forecasts 2020-2026, Eastern EU Countries



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Figure 3: Blockchain Skills Demand and Supply Forecasts 2020-2026, Peripheral EU Countries

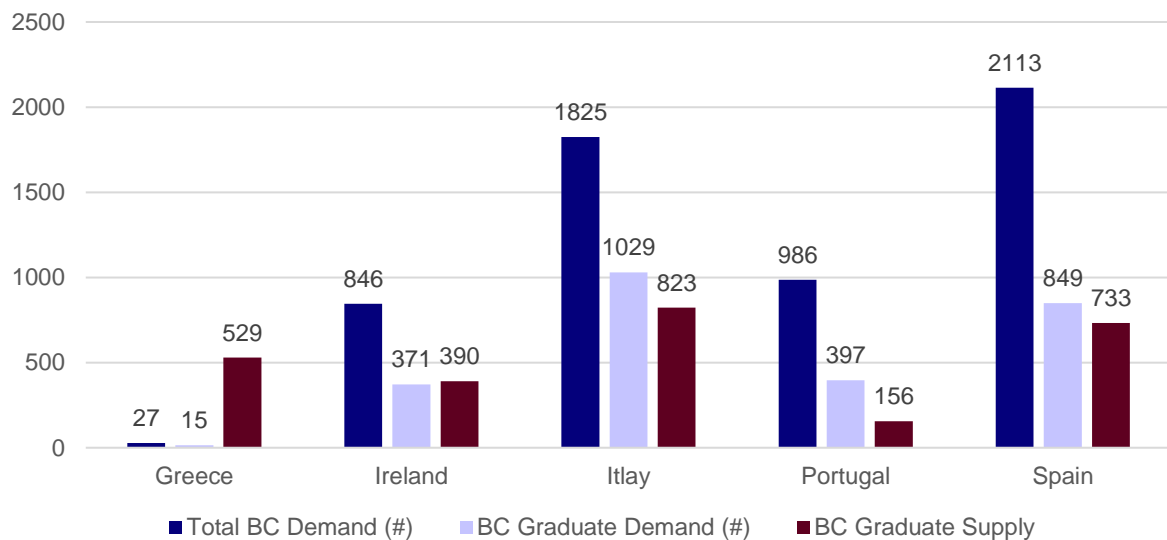
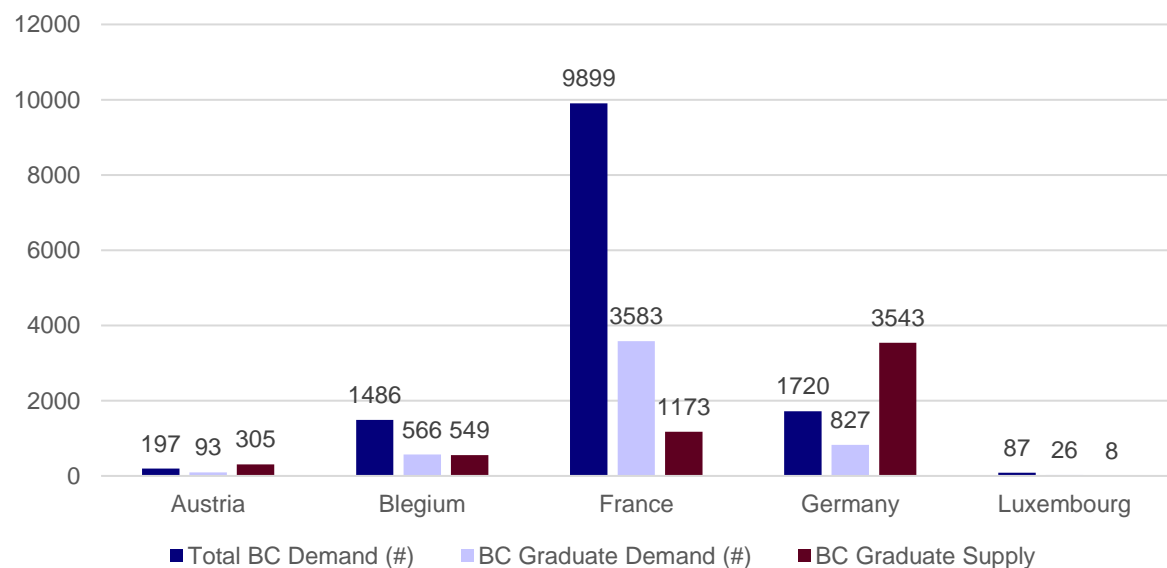


Figure 4: Blockchain Skills Demand and Supply Forecasts 2020-2026, Central EU Countries



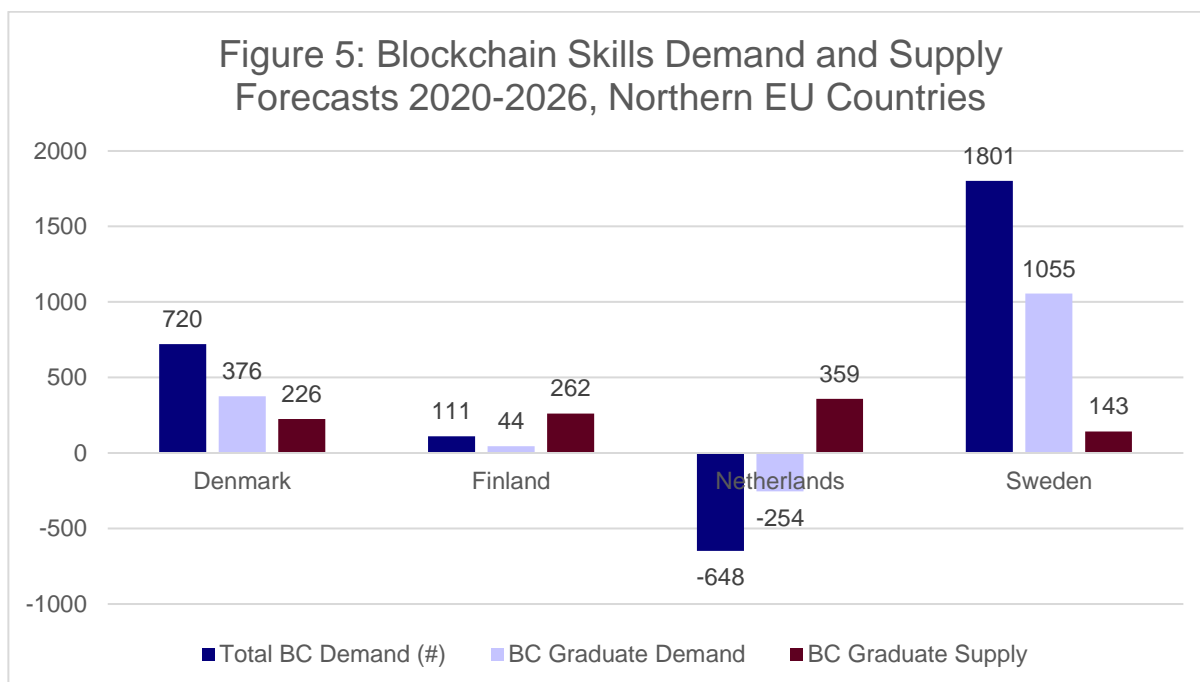
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Figure 5: Blockchain Skills Demand and Supply Forecasts 2020-2026, Northern EU Countries



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 IOTA, INTRASOFT, FUJITSU, 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 communities, and challenges and opportunities. The findings provide additional insights into the future of the blockchain sector and blockchain skill needs.



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4.1.1 Blockchain regulatory and policy developments

In terms of blockchain regulatory and policy developments, appropriate regulation could be a significant accelerator for the adoption of the blockchain technology. As a result, there has been an emergence of regulation of the use of blockchain technology in a variety of areas, such as cryptocurrencies. A variety of policies, regulations, and practices have been established at a European level and in individual member states. Further, many other countries are closely monitoring blockchain developments and following the recommendations and pathways for blockchain regulation set out by the EU and leading national blockchain ecosystems.

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.

4.1.3 Blockchain Ecosystem and Community Networks

High investment in research and development activities, increased growth of the IT sector and utilisation of blockchain solutions across industries such as retail, ecommerce and many others are causing significant market growth around the world. Further, blockchain stakeholders are coming together to share ideas, present blockchain use cases while promoting the growth in the blockchain sector and collaboration between public and private representatives across Europe. Among the many national and international community networks the following organisations in Europe are significant drivers of blockchain knowledge generation and information distribution: The EU Blockchain Observatory and Forum; INATBA; The European Blockchain Partnership; European Blockchain Services Infrastructure; The Blockchain4Europe.



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4.1.4 Challenges and Opportunities

The main opportunities include the adaptation of blockchain technology into a variety of sectors and industries. The blockchain market is mainly driven by the rising adoption of blockchain for supply chain management, and by banking and financial institutions. However, increasing investment and research by Small & Medium Enterprises is expected to drive the growth of the technology across the world in the future. Government and public institution interest regarding the utilisation of blockchain technology is going to advance the demand for blockchain technology in future. The low operational cost of blockchain technology is another driving factor of the technology. Many corporations and businesses are experimenting with blockchain technology and are running a variety of pilot projects that are likely to switch to a large-scale implementation soon.

The main challenges currently faced by the blockchain sector in Europe include the lack of standardisation of blockchain development operations, and the lack of regulation. The open access of blockchain poses threats to data privacy and security. Due to cryptocurrencies being associated with money laundering, and illegal drug, arms and other illegal item trade there are serious doubts about the use of blockchain technology for legal and legitimate business. A common misconception is that blockchain's energy consumption is similar to that of cryptocurrency mining. For example, Bitcoin's high energy consumption is almost exclusively inherent to the Bitcoin network due to its architectural and governance design. In general, high-energy consumption is not intrinsic to blockchain technology.

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 16 E&T professionals from Austria, Germany, Greece and Italy. Interviewees were professors or lecturers, heads of departments, and researchers. Interview questions were centered 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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Although there are not many blockchain courses available across Europe the interest in this area is emerging at the university level. Due to the rapid adaptation of blockchain technology in the financial services sector existing education providers move towards implementation of this technology in finance related teaching. Soon, the provision of blockchain training will depend on the wider sector and industry interest in this technology. Recently, organisations beginning to implement blockchain technology are looking for 1-to-3-day workshops with real world blockchain applications and examples. Interviewees also state that E&T providers should be closely collaborating with the industry. Real world applications and examples should be considered in any blockchain teaching to present the full potential of this technology and to apply existing knowledge in a meaningful way.

In terms of trends in blockchain student enrollments, there is an increased demand for blockchain courses at a master's level. However, government funded education providers often do not allocate more funding to blockchain teaching and the existing resources are scarce. As a result, the provision of blockchain teaching at a university level is lagging the demand for blockchain skills. Interviewees also state that there is greater demand for webinars and seminars which indicates increased demand for blockchain programmes. They state that interest in blockchain may be linked to the performance of cryptocurrencies.

Typical students enrolling in blockchain programmes and training come from engineering, software development, IT and management fields with personal interest or previous knowledge of the blockchain space. People with management background are interest in blockchain to communicate blockchain developments within their organisation and to work efficiently with colleagues that do have technical understanding of the blockchain technology. Many of the students enrolling in blockchain training and courses wish to establish tech companies, manage supply chains, participate in the cryptocurrency trade, or to upskill.

In terms of changes in VET and tertiary systems in the future, interviewees believe that any curriculum development around blockchain technology needs to be as open as possible. This means that new blockchain developments should be efficiently integrated in the delivery of course material. The link between education and industry may be strengthened by bringing in external experts from the industry to deliver classes or workshops. Interviewees also believe that integration of blockchain in computer science courses would increase the supply of necessary blockchain skills.



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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. An overview of CEDEFOP's research that may influence blockchain skills and labour market developments is examined below.

New digital technologies, such as blockchain, are changing economies by creating new jobs and automating existing jobs in most European countries. This in effect increases the demand for workers in more digitally intensive occupations, such as blockchain. CEDEFOP estimates that, in the EU by 2030, 8% of people will be employed in technology intensive jobs, and that 16% of EU adults may have outdated skills due to the pace of technological change (CEDEFOP, 2022a). This is already evident in 2020 as approximately 85% of jobs in the EU already demand at least some basic digital skills, and in 20% of online job advertisements digital skills were required in the initial application.

People who are employed in science, engineering and ICT occupations as professionals or associate professionals are considered as high-tech employees. EU-27 employment in high-tech roles in 2030 is estimated to be approximately 9% of all employment, with Greece being lower at 5% and Finland being the highest at 14% of the population employed in high-tech jobs (CEDEFOP, 2022b). Employment growth in high-tech roles is expected to be 11% (on average) in the EU-27 countries from 2020 to 2030, with lowest growth in Bulgaria (-10%) and the highest growth in Luxembourg (30%) (CEDEFOP, 2021).

McGuinness et al. (2019) highlight that only 16% of EU employees who are affected by technological changes, think that their skills will become obsolete in the near future, and that 5% are afraid of technological unemployment. Digitalisation also transforms the nature of the employment relationship, for example, via the rise of platform work or telework. Occupational level trends during the Covid-19 pandemic confirm that some labour market segments were more sensitive to the impact of the pandemic,



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as opposed to others which proved to be relatively resilient. High skilled occupations in STEM, but also learning, culture, and social occupations had net job growth in 2019-2020 (CEDEFOP, 2022c). Many jobs were lost in hospitality, sales, and personal services occupations, and employment in production and construction were also negatively affected and declined sharply.

CEDEFOP also suggests that overreliance on traditional employment and occupational forecasting methods using historical data only is no longer sufficient. Instead, innovative approaches and transparent quality standards are now required. Therefore, CEDEFOP's guide to understanding technological change and skill needs builds on previous conventional and automated skills assessment and anticipation methods. Their guide suggests the use of big data and AI-driven analyses to apply automated knowledge extraction and machine-based techniques to source information on technologies and skills from mostly unstructured online sources to provide a more accurate estimation of the labour market in the future.

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.

During the second year of the project, the CHAISE consortium gathered 120 online job vacancies from 13 EU countries. The sample includes job ads directly listed on LinkedIn from December 2021 to February 2022. The ads have passed a screening process before analysis 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



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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.

Our findings indicate that the ICT sector is found to be the largest employer for blockchain professionals, accounting for over a half of all job advertisements. Other Blockchain intensive industries are financial services and gaming. There is a uniform distribution of online job advertisements across the three main blockchain occupational profiles, namely blockchain architect, blockchain developer and blockchain manager. Over a third of jobs appear to be open to new, or inexperienced, labour market entrants with either no, or between 0-3 years of experience. In about 60% of cases, the employer did not specify a minimum educational requirement or stated that no formal degree was required.

In terms of blockchain skills, technical skills mostly mentioned in blockchain related online job ads were “coding”, “blockchain solutions design”, and “decentralised application development”. Business skills most frequently mentioned in blockchain related online job ads were “use cases development”, “product management” and “product development”. The most popular transversal skills requested by employers are “cooperation”, “self-determination and autonomy”, and “communication”. 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 (2020/2021), are “develop decentralised applications”, “smart contract development”, “data/network security”, “distributed network engineering skills” and “protocol engineering”. In contrast, less demand is recorded for “frontend/backend development” in 2021/2022. Business skills that are increasing in demand from the previous year are “use cases development”, “product management skills”, “finance and controlling skills”, and “marketing skills”. Recruiters are requiring less “systems & networked thinking, analytical competence, problem solving”, and “initiative and performance competence (self-motivation, engagement, persistence)”. Transversal skills that have received greater attention from recruiters are: “self-determination & autonomy”, “design-thinking competence, versatility & perspective taking”, “self-efficacy & self-confidence” and “learning literacy & metacognitive skills”.



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5 Verification of Results

Forecasting results were verified by experts in the blockchain sector via online survey and expert interviews. 123 survey participants, with a good understanding of blockchain and Distributed Ledger Technology (DLT), in the following roles completed the survey: blockchain experts, sector representatives, academics, researchers, and IT professionals. Further, in total 56 sectoral experts across the Europe participated in the interviews to validate and provide feedback on the forecasting framework and results.

Survey results indicate that over 90% of respondents agree that blockchain related jobs are accurately mapped to ISCO categories, and 77% of respondents agree that LinkedIn is the most appropriate source of blockchain related jobs data. In terms of blockchain demand forecasts, 49% of respondents think that the forecasts are 'accurate' (Figure 6), and 71% of respondents think that graduate demand forecasts are 'accurate' (Figure 7).

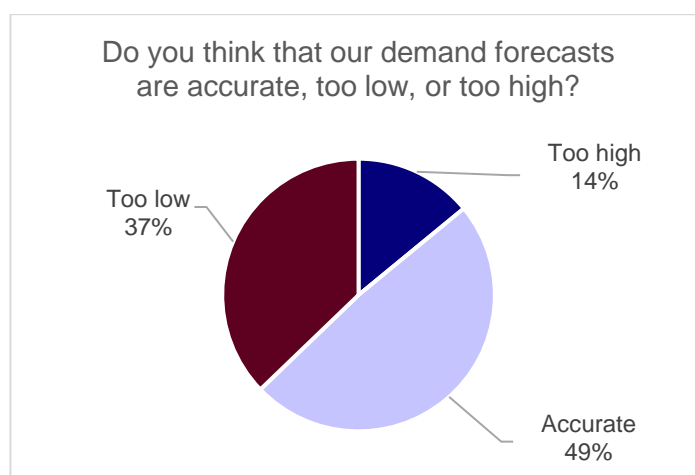


Figure 6: Demand Forecast Accuracy



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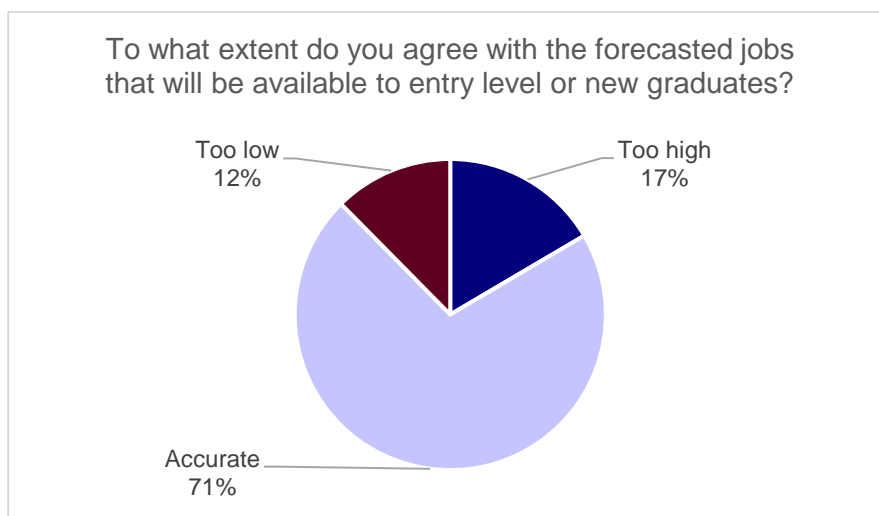


Figure 7: Graduate Demand Forecast Accuracy

Survey respondents also agree that most of new graduates from tertiary education with blockchain skills will come from the ICT and computer science fields of study, 94% of respondents agree with this observation (Figure 8). In terms of blockchain supply forecasts, 59% of respondents think that the forecasts are 'accurate', 21% think that the forecasts are 'too low' and 20% think that the forecasts are 'too high' (Figure 9).

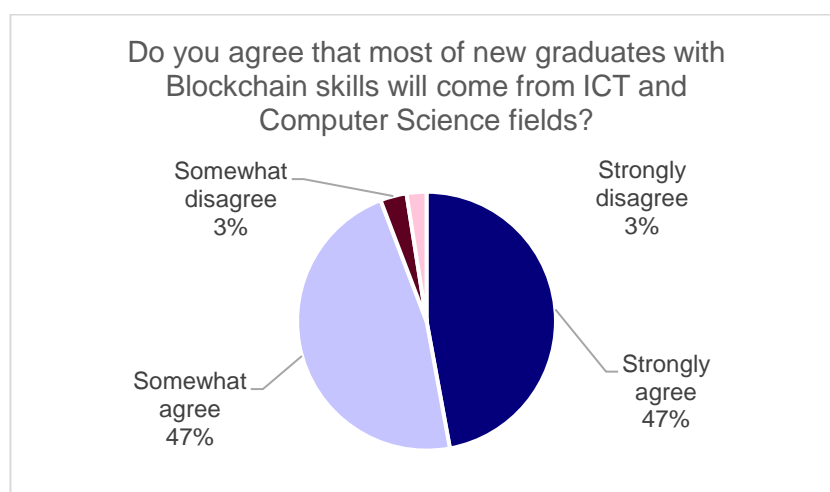


Figure 8: Blockchain Skills Supply from ICT and Computer Science



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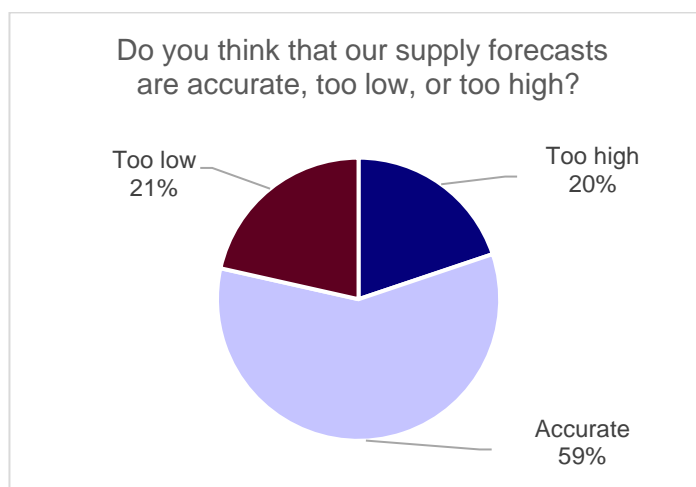


Figure 9: Supply Forecast Accuracy

Interviews with sectoral participants provide additional insights into the forecasting methodology and results. In general, they believe that the methodology and results are appropriate and reliable. However, they also state that the blockchain sector is still developing and changing and there may be additional sector specific skill needs that need to be considered in future forecasting activities. Interviewees agree that forecasted blockchain skill demand and supply seems to be trending in the right direction. Some interviewees also state that demand forecasts may be conservative or understated due to significant expansion of blockchain adoptability in a variety of different sectors. Interviewees also highlighted that due to the lack of blockchain specific courses across Europe it is difficult to forecast the number of blockchain skills supply. They also emphasise the industry demand for blockchain workers puts pressure on E&T providers, and therefore, many institutions are considering incorporating blockchain in their programmes. Therefore, the average proportion of ICT graduates that are blockchain specific graduates may change significantly in the short term and will need to be incorporated in future forecasting activities.

Based on the interviews with sectoral experts, reviews by the CHAISE consortium, and internal evaluation of the results, the forecasting results for graduate supply are adjusted to include up-to-date information on ICT graduate supply. Supply forecasts for countries that provide blockchain-specific graduate information are estimated and the average of these is applied to all other countries. This is in



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comparison to the preliminary supply forecasting results, where the average proportion of blockchain specific graduate information is applied to all EU countries.

6 Conclusion

The study outlines a novel dynamic methodological framework for forecasting the demand for blockchain skills across EU countries and matching this against educational supply. The forecasts are designed to be a key input into any national, or EU level, skills strategies designed to ensure that the growth of blockchain employment is not restricted as a consequence of skill mismatches. The results from the study confirm that the demand for blockchain workers, expressed as a proportion of new jobs, remains quite small in most EU countries, and ranged from 0.25% in Sweden to 4.4 % in Croatia in 2021. We find that the vast majority of emerging blockchain jobs (81%) are concentrated in just three detailed occupational groups (Software and Applications Developers and Analysts; Information and Communications Technology Services Managers; Business Services and Administration Managers), suggesting that skill requirements for companies engaging in blockchain will remain heavily concentrated in the areas of ICT and computer science. Our results indicate that the demand for blockchain professionals is likely to remain modest over the 2020 to 2026 period, with the highest rates of job growth expected in France (9,899), Poland (4,091), Spain (2,113) Italy (1,825), Sweden (1,801) and Germany (1,720). 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 the vast majority of countries. The supply of general ICT graduates greatly outweighs the demand for blockchain professionals in most countries examined, 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 in most member states.



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