RESEARCH SERIES
NUMBER 191
SEPTEMBER 2024

SKILL REQUIREMENTS FOR EMERGING TECHNOLOGIES IN IRELAND

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AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

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RESEARCH SERIES

NUMBER 191

Available to download from www.esri.ie

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Whitaker Square, Sir John Rogerson's Quay, Dublin 2

ISBN 978-0-7070-0553-9
https://doi.org/10.26504/rs191

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ACKNOWLEDGEMENTS

The work carried out in this report was funded by the Department of Further and Higher Education, Research, Innovation and Science (DFHERIS) as part of the Joint Research Programme on Irish Skills Requirements. We would like to thank all the individuals within DFHERIS who provided assistance during the project, particularly William Beausang, Emma Kinsella, Karolina Murphy, John McGeown and Megan O'Dowd. Valuable contributions were made by members of the Research Programme Steering Committee: Marcus Breathnach, Sorcha Carthy, Nora Condon, Paul Healy, Joan McNaboe, Mary Ryan and Emer Smyth. We are extremely grateful to the members of the Research Programme Steering Committee for their ongoing support and feedback on the research. We would also like to thank all the individuals who participated in our consultation workshops for employers on skill requirements for emerging technologies in Ireland. Sincere thanks to Mauro Pelucchi and Simone Perego from Lightcast, and their team, and to Miguel Conner from Barcelona School of Economics for the additional support and feedback they provided to us. We would also like to thank the Higher Education Authority (HEA) and Quality and Qualifications Ireland (QQI) for proving access to the data used in the study, and those who assisted in this regard, including Sorcha Carthy, Janice Lau, Roisín Morris-Drennan, Arancha Oviedo and David Sheils. We also thank Luke Brosnan and Lorcan Kelly, Research Assistants at the ESRI, who helped to organise the workshop consultation with emerging technologies employers. We would like to express our gratitude to the participants of the BSA-DIGIT-CERIC event, 'Digital Transformations of Work and Employment in the Professions', of the 12th Annual NERI Labour Market Conference and of the 9th International Ioannina Meeting of Applied Economics and Finance, for their invaluable feedback and constructive suggestions. Finally, we would like to thank anonymous internal and external reviewers for their feedback on the present study.

This report has been accepted for publication by the Institute, which does not itself take institutional policy positions. All ESRI Research Series reports are peer reviewed prior to publication. The author(s) are solely responsible for the content and the views expressed

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ABBREVIATIONS

AI	Artificial intelligence
AIGO	Expert Group on Artificial Intelligence at the OECD
Cedefop	European Centre for the Development of Vocational Training
CHAISE	A sector skills alliance financed by the EU's Erasmus+ programme
DETE	Department of Enterprise, Trade and Employment
DFHERIS	Department of Further and Higher Education, Research, Innovation and Science
ENISA	European Union Agency for Cybersecurity
ESRI	Economic and Social Research Institute
EU27	27 Member States of the European Union
FET	Further education and training
HEA	Higher Education Authority
HEI	Higher education institution
ICT	Information and communications technology
ISCO	International Standard Classification of Occupations
LFS	Labour Force Survey
OECD	Organisation for Economic Co-operation and Development
QQI	Quality and Qualifications Ireland
ILO	International Labour Organization
SQL	Structured Query Language
NUTS	Nomenclature of territorial units for statistics
STEM	Science, technology, engineering and mathematics
TU	Technological university
UNESCO	United Nations Education, Scientific and Cultural Organization

EXECUTIVE SUMMARY

This research was funded by the Irish Department of Further and Higher Education, Research, Innovation and Science (DFHERIS). It focuses on labour market demand and supply for automation-, artificial intelligence (AI)- and blockchain-related jobs in Ireland. These were identified as the areas of emerging technologies of most strategic importance to the Irish labour market, in terms of potential future employment growth, and aligned with DFHERIS's most immediate skill development policy. The analysis provides valuable evidence that can serve as a key input into any national skills strategy and any education programme reform that seeks to ensure that the growth of employment in emerging technologies will not be restricted as a consequence of skill mismatches.

The research adopts a mixed-methods approach, combining the use of job advertisement data, course provision information, occupational forecasts and consultations with employers, to provide a comprehensive outlook of the labour market for key emerging technologies in Ireland. A key contribution is its development of a methodological tool that is highly replicable. This tool should therefore be used periodically to monitor variations in technologically driven labour demand, so that government policy in this area can be fully informed of, and reactive to, changing labour market conditions.

We find that most emerging technology vacancies appear to be filled relatively quickly. In the limited incidences where recruitment difficulties appear to exist, they are more likely to occur in automation posts, particularly for entry-level positions.

Our labour market forecasting exercise for the medium-term horizon shows that the labour market demand for new entrants in automation, AI and blockchain jobs in Ireland is currently being met by supply projections. The results confirm that the university sector is meeting employer demands for new graduates in the three emerging technology areas.

We provide an in-depth analysis of the skills currently required by employers in emerging technology jobs, using job advertisement data. Our detailed analysis demonstrates that while employers place much emphasis on technical competencies, there is a significant demand for workers to also be equipped with transversal and business skills. We found that approximately 50–60 per cent of skills required by employers are technical, 20–30 per cent are transversal, and 20 per cent are business.

With respect to technical competencies, there is a good degree of overlap in terms of employer requirements for AI and blockchain jobs, while technical requirements for automation jobs tend to be more specific. There is a very high degree of overlap in the transversal and business skills required by employers across the three emerging technology areas.

In our consultation workshop with employers from emerging technology areas, employers highlighted that the labour market requirements arising from the impending regulatory environment, following the recently approved European Artificial Intelligence Act for example, are likely to be substantial. Participants stressed that policy needs to be developed to assist organisations in implementing change that will occur at a national level across a whole range of dimensions related to AI.

While employers were happy with our methodological approach and forecasting exercise, they stressed that high levels of uncertainty regarding the development and adoption of AI could result in levels of demand exceeding those predicted by our research.

CHAPTER 1

Introduction

1.1 INTRODUCTION

In a rapidly changing world that is experiencing global megatrends, such as the digital and the green transitions, both economies and their labour markets need to anticipate change at a sharper pace in order to strengthen adaptive capacity and competitiveness. The fast rate of technological change implies that conventional labour market anticipation approaches, which rely on historical datasets, are no longer sufficient to meet planning requirements. In Ireland, a highly-skilled labour force has allowed for strong economic growth over the last few decades; however, as new challenges appear on the horizon, the country's ability to exploit emerging technologies and other innovations will depend on there being an adequately skilled labour force. Therefore, an in-depth understanding of the skills and attributes that are needed to support innovation, digitalisation and climate transition, and how these can best be developed through the skills and education system, is needed (OECD, 2023a). Emerging technologies are giving rise to changes in labour market needs. New methodological approaches are required in order to identify the nature of these changing labour market patterns, using contemporaneous data sources such as job advertisements data, so that early warning systems be developed to inform policy. This research is funded by the Irish Department of Further and Higher Education, Research, Innovation and Science (DFHERIS). It aims to provide valuable evidence that can be utilised as a key input in the development of any national skills strategy and any education programme reform that seeks to ensure that the growth of employment in emerging technologies will not be hampered as a consequence of skills mismatch.

Our analysis focuses on automation-, artificial intelligence (AI)- and blockchain-related jobs. AI and automation were identified as areas of emerging technology with the greatest employment implications for Ireland; they are also aligned with DFHERIS's most immediate skill development policy.[1] Additionally, blockchain is included to extend the analysis, building upon prior Economic and Social Research (ESRI) related research.[2] The research develops a methodological template that can be adopted, and modified, to identify changing labour market requirements arising from technological change and, for instance, continued AI adoption and development.

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1 For further information, see: https://www.gov.ie/en/publication/69fd2-irelands-national-skills-strategy-2025-irelands-future/.

2 Blockchain was previously examined by the ESRI team as part of the CHAISE project (European Commission Erasmus+), for Ireland relative to all European countries. See McGuinness et al., 2022, 2023b, 2024.

The key contributions of this research concern skill requirements for emerging technology jobs in Ireland. The study comprises five strands:

(i) in-depth analysis of job advertisement trends in order to investigate the areas of emerging technology with significant labour market implications for Ireland;

(ii) examination of the extent to which potential skill shortages are dominant in a particular emerging technology area and identification of job characteristics potentially associated with potential skill shortages;

(iii) detailed skill requirement analysis for technical, transversal and business skills in areas of emerging technology demand;

(iv) demand and supply forecasts for emerging technology jobs; and

(v) expert consultations to verify our findings and unpack the perception of emerging technology employers.

Our mixed-methods approach combines two main complementary elements. Firstly, data are used from a range of sources to identify labour market demand and supply levels for emerging technologies, including job advertisements portals, course provision information and occupational forecasts. Specifically, on the labour demand side, we use four principal data sources: (i) a tailored Python scraping tool for LinkedIn data;[3] (ii) Lightcast data;[4] (iii) Cedefop occupational forecasts;[5] and (iv) Irish Labour Force Survey (LFS) data. On the supply side, we utilise data from the Higher Education Authority (HEA), SOLAS and Quality and Qualifications Ireland (QQI) on the number of graduates in emerging technology-related courses.

Alongside the quantitative analysis, employer consultations are used to verify the results of the research and unpack how Ireland can respond most effectively to the challenges and opportunities facing us now and into the future. Consultation with employers took the form of qualitative in-depth focus groups. This strand of the research has a particular focus on skills and talent in emerging technologies as key drivers of productivity, innovation and growth.

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3 As the three job areas selected for assessment are primarily professional in nature, LinkedIn was assessed as the job portal likely to capture data on most relevant job postings.

4 Lightcast is a private labour market and employment analytics company that scrapes and aggregates millions of job advertisements worldwide on a daily basis, drawing from more than 65,000 sources, including job boards, company websites and other sources. Lightcast data provide real-time labour market demand information, facilitated by advanced natural-language processing technology and other AI tools, along with dedicated in-house experts. Their tools extract more than 70 different elements from every job posting.

5 Cedefop is the EU agency that supports the development of European vocational education and training (VET) policies and contributes to their implementation. Cedefop provides the so-called 'Skill Forecast', which represents quantitative projections of future trends in employment by sector of economic activity and occupational group in the 27 European Countries (see https://www.cedefop.europa.eu/en/tools/skills-forecast).

Together, these two aspects of this study yield rich insights into the challenges for, and good practice in, the provision of skill requirements for emerging technologies in the current labour market context.

A measure of *potential skill shortage* is derived to identify vacancies that are potentially 'hard to fill', with substantially higher than average durations and substantially lower than average number of applications. We use an in-house bespoke LinkedIn scraped sample of job advertisements related to automation, AI and blockchain in Ireland that incorporates such information. We find that most of the vacancies appear to be filled relatively quickly, and there is no evidence that the incidence of potential skill shortages is higher in any of the emerging technology areas. However, where recruitment difficulties do exist, they are more common in automation posts, particularly for entry-level positions.

This report also aims to both inform policymakers in the education fields and to bridge the gap between employers' expectations on skill requirements acquired by graduates within the education process and employees' skills profiles, in a fast-paced, changing and technology-driven labour market. This is particularly important considering the 2023 European Year of Skills initiatives, which promote a mindset of reskilling and upskilling for workers navigating the digital transition. Job advertisement data from Lightcast (previously Burning Glass Technologies) are used to carry out an in-depth analysis of the key skills most commonly required by employers in the emerging technology areas under study. Our detailed analysis demonstrates that while employers place much emphasis on technical competencies, there is also a significant demand for transversal and business skills. The demand for transversal competencies is particularly high among jobs in automation. With respect to technical competencies, there is a good deal of overlap in the employer requirements for AI and blockchain, while the technical requirements for automation jobs tend to be more specific. There is a very high degree of overlap in the transversal and business competencies required by employers across the three emerging technology areas. The most demanded business skills are common to AI, automation and blockchain. In the analysis, we provide a detailed breakdown of the specific skill requirements for emerging technology jobs from Lightcast data, and a further disaggregation of competencies by entry, mid-senior and senior levels of seniority within our in-house scraped LinkedIn sample.

Finally, we mapped automation, AI and blockchain jobs to the International Standard Classification of Occupations (ISCO) system. We used Lightcast data to provide demand and supply forecasts for the relevant occupations by employing occupational forecasts made by the European Centre for the Development of Vocational Training (Cedefop).

Our labour market forecasting exercise for the medium-term horizon confirmed that the labour market demand for new entrants in automation, AI and blockchain is currently being met by supply projections.

The key objective of our analysis is to benchmark levels of labour demand and supply generated by the third level education sector in Ireland, in order to assess the adequacy of the educational supply provision in emerging technology areas. However, it is important to note that supply level can be impacted by both inward and outward migration. These factors lie outside the research agreement for the current study.

An important aspect of the study was our consultation workshop with employers in emerging technology areas, who were brought together in a focus group setting. This provided validation for our results, but also highlighted risk factors and development that have high importance from a policy perspective. Employers emphasised that the labour market requirements arising from the forthcoming regulatory environment, such as the European Artificial Intelligence Act, are likely to be substantial. Participants stressed that policy needs to be developed to assist organisations in implementing change that will occur at a national level across a whole range of dimensions related to AI. The increases in regulatory requirements will require organisations to scale up their capabilities and will drive the demand for people who can implement change within organisations and interact with the regulators. Furthermore, the application of the new regulations will require changes in the skill sets of everyone who works in the impacted fields. While employers were happy with our methodological approach and forecasts, they underscored the fact that high levels of uncertainty regarding the development and adoption of AI could result in levels of demand exceeding that predicted by our research: demand levels in these emerging technology areas can be somewhat volatile and reactive to external factors and it should not be assumed that future employment growth is inevitable.

Finally, it is worth highlighting that a key value of the present research study is its development of a methodological tool that is highly replicable and which, as such, should be implemented periodically to monitor variations in technologically driven labour demand. In this way, policy can be fully informed of, and reactive to, changing labour market conditions.

The report is structured as follows. Chapter 2 begins with a summary of literature on technological change and the world of work. Chapter 3 outlines methodologies used to examine skill shortages and skill requirements, and to forecast demand and supply for emerging technology jobs, while also introducing the key data sources used. Chapter 4 examines the nature of potential skill shortages. Chapter 5 focuses on the type of skills required (technical, business and transversal) by employers for automation, AI and blockchain jobs. Chapter 6 presents the demand and supply

forecasts from 2021 to 2025 and 2025 to 2030. Chapter 7 examines employers' perceptions of jobs that require skills in emerging technologies, in order to validate our findings and to further investigate this issue via qualitative data. This chapter also addresses stakeholders' perspectives regarding future skill requirements, education and skills development, and perceived future changes within industries and organisations. Chapter 8 concludes with a summary of our findings.

CHAPTER 2

Literature review

The way technological change and innovation shapes and affects labour market demand and supply has been under study by economists and sociologists for decades. The introduction of information and communication technologies (ICT) and automation within production processes was theorised as 'skill-biased technological change', because it appeared to be complementary to high-skilled workers, while substituting low-skilled workers (Katz and Author, 1999; Acemoglu, 2002; Violante, 2008). Subsequently, Autor et al. (2003) laid the foundations for a new theoretical approach: by introducing the notion of tasks (routine and non-routine, manual and cognitive tasks), technological change was theorised as 'routine-biased'. According to this conception, technological change substituted middle-skilled occupations that involved routine tasks, rather than occupations that involve a lower degree of non-routine tasks; i.e., low-skilled occupations and high-skilled occupations. This was seen to lead to job polarisation, and indeed earlier waves of technological innovation certainly did have a disproportionate impact on mid-skilled occupations, with many such jobs 'hollowed out' as a consequence of automation (Autor, 2024).

Nowadays, much emphasis is placed on new emerging technologies that have been recently introduced in workplaces, such as artificial intelligence (AI), new forms of automation and blockchain. These technologies can potentially be used for industrial purposes across several sectors.

AI, automation and blockchain are the key technologies we investigate in this report. We are aware that definitions of these terms can vary. However, in order to build common ground, we briefly summarise definitions from experts, policymakers and the academic literature. These are the definitions we adopted in this study.

(i) A wide body of literature seeks to define the concept of **automation**. Automation technologies have historically been conceived as those machines, information and communications technology (ICT) and robotisation technologies deployed in workplaces, mainly in the manufacturing and industry sector, that can replace labour input for some types of tasks in production and distribution processes. In the current digital age, new forms of automation involve the use of algorithmic control of machinery and digital sensors, a system of internet connectivity across devices (i.e., 'Internet of Things') and an ever-increasing computing power, which together largely expand the range of tasks that machines are able carry out (Eurofound, 2018; Fernandez-Macias et. al., 2021).

Some examples of jobs that require a high level of automation-related skills are: automation engineer, automation technician, automation project manager, electrical engineer, biotechnician, chemical process engineer, construction architect, IT system engineer and data centre manager.

(ii) For **artificial intelligence** (AI), we refer to the definition deliberated within the Recommendation of the Council on Artificial Intelligence, adopted by the OECD Council in 2019, which was supported by research and deliberations from the Expert Group on Artificial Intelligence at the OECD (AIGO).[6]

> *Artificial intelligence is: 'a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments. It uses machine and/or human-based inputs to perceive real and/or virtual environments; abstract such perceptions into models (in an automated manner e.g. with machine learning (ML) or manually); and use model inference to formulate options for information or action. AI systems are designed to operate with varying levels of autonomy.*
> (OECD, 2019)

A very similar definition has been provided by the European Commission within the new European Artificial Intelligence Act. Some examples of jobs that require a high-level of AI skills are: machine learning and AI engineer, machine learning and AI researcher, AI developer, data analyst, software engineer, business analyst and product manager.

(iii) For **blockchain**, we adopt definitions from two different sources:

- From the European Union Agency for Cybersecurity (ENISA):

  Blockchain is a public ledger consisting of all transactions taken place across a peer-to-peer network. It is a data structure consisting of linked blocks of data, e.g. confirmed financial transactions with each block pointing/referring to the previous one forming a chain in linear and chronological order.[7]

- From the European Commission's blockchain strategy:

  Blockchain technology allows people and organisations who may not know or trust each other to collectively agree on and permanently record information without a third-party authority. By creating trust in data in ways that were not possible before, blockchain has the potential to revolutionise how we share information and carry out

6 For additional information, see: OECD, Recommendation of the Council on Artificial Intelligence, OECD/LEGAL/0449 (https://legalinstruments.oecd.org/en/instruments/oecd-legal-0449).

7 For further information, see: https://www.enisa.europa.eu/topics/incident-response/glossary/blockchain.

transactions online.[8]

Some examples of jobs that require a high level of blockchain expertise are: blockchain developer, blockchain architect, software engineer, product manager, security architect and blockchain researcher.

There is a substantial body of literature on the labour market impacts of new technologies; Frey and Osborne's work in this regard is often cited (2013, 2017). These studies predicted that close to a half of all jobs in advanced economies would become susceptible to replacement by machines. Nevertheless, subsequent studies that accounted for task heterogeneity within occupations have shown that the proportion of occupations at high risk of automation was between 9 and 14 per cent (Pouliakas, 2018; Nedelkoska and Quintini, 2018; Arntz et al., 2016). These projections are still very high, but much lower than what was initially predicted. A good deal of the recent literature has focused on the potential impacts of technology on the composition of job tasks. Fossen and Sorgner (2019) found that computerisation risk is associated with lower wages, whereas AI complements workers' skills and increases wages. Graetz and Michaels (2018) showed that increased use of industrial robots substantially improves labour productivity and wages. McGuinness et. al. (2023a) report that technological change in the workplace disproportionately impacts high-skilled workers and tends to reinforce existing inequalities.

A new, emerging field of literature examines the labour market implications of AI, which are thought by many to be significant. AI is capable of automating non-routine cognitive tasks, as it can perform tasks such as information ordering, memorisation, perceptual speed and deductive reasoning. As a result, for the first time ever, high-skilled occupations – the roles of so-called 'knowledge workers' (Gmyrek et al., 2023) – appear to be more exposed to the impact of technological change (OECD, 2023b). AI could have a displacement effect on some jobs, but will also increase the demand for other jobs, as a result of higher productivity effects (OECD, 2023b). New tasks and capabilities will likely emerge, resulting in the creation of new jobs, in particular for workers with skills that are complementary to AI (Autor, 2022). AI will substitute some existing work tasks and will change the way work is organised (OECD, 2023b).

The net effect of emerging technologies on job creation and job displacement is hard to predict. The literature on the labour market impact of emerging technologies is under-developed, and to a large extent speculative, due to an absence of datasets that specifically link adoption of new technologies with task

[8] For further information, see: https://digital-strategy.ec.europa.eu/en/policies/blockchain-strategy.

content and/or job loss (McGuinness et al., forthcoming). Nevertheless, a number of studies do exist, which provide some important insights.

Cazzaniga et al.'s study (2024) sought to elaborate on the occupational impact of adopting AI-driven technologies. To do this, they combined an AI exposure index at occupational level, which measured the degree of overlap between AI applications and human skills in each occupation (Felten et al., 2021), and an AI potential complementarity index, which signals a more likely/less likely degree of shielding from AI-driven job displacement (Pizzinelli et al., 2023). On the basis of their findings, Cazzaniga et al. (2024) argue that occupations with high AI exposure and low complementarity might face a higher likelihood of AI replacing key tasks, and even a decrease in labour demand. Occupations with high exposure and high complementarity might experience productivity growth from adopting AI technologies. However, any productivity gains will depend on workers having the adequate skills to exploit AI. Lastly, when the AI exposure level is low, complementarity is less important. Cazzaniga et al. (2024) find that professionals, managers and clerical workers all exhibit high AI exposure, but clerical workers exhibit low complementarity potential.

Interestingly, Autor (2024) suggests that by supporting decision-making processes with different ranges of information, AI might enable workers equipped with basic skills to perform higher level tasks that up to now have only been carried out by higher skilled workers. Autor (2024) argues that this might even help to restore the middle class in the US labour market, which in recent decades has been hollowed out due to automation and globalisation.

A relatively new aspect of data analysis in these fields is to use real time labour market data, often scraped from job portals, to provide insights on both the scale of demand for new technologies and the associated mix of competencies sought by employers. Job portal data, as opposed to that from labour force and occupational surveys, are real-time labour market demand data that can provide timely information on the number of job openings, sectors and occupations where jobs are created or destroyed, and employers' changing skill requirements (Sostero and Fernandez-Macias, 2021).[9] Real-time labour market information can enable governments to respond to moments of rapid change; for instance, by signalling changing jobs and skill requirements, it can help policymakers in implementing proactive skills policies (Cedefop et al., 2021; Cardenas and Warhurst, 2022). Nonetheless, as opposed to surveys, job advertisements might have representativeness issues: nowadays, a very significant proportion of all job

[9] In the present study, we focus on three areas of labour market demand for emerging technologies in Ireland:AI, automation and blockchain. Our aim is to examine occupations related to these areas and the skills requirements for these kinds of jobs. Therefore, our analysis is focused on analysing the demand for jobs that are complementary to emerging technologies. As the labour market demand reality related to technological change can rapidly change, we employ real-time job advertisement data.

positions are advertised online, but some labour market segments might be excluded, because some low-skilled jobs are less likely to be posted online. Moreover, not all job advertisements lead to actual recruitments. However, high-skilled jobs usually tend to be mostly advertised online; therefore, the representativeness issue for these job positions is less of a problem (Cedefop et al., 2021; Cardenas and Warhurst, 2022).

McGuinness et al. (2022, 2023b, 2024) used a scraping approach in their analysis of job advertisement data to identify blockchain-related jobs, which they then mapped into International Standard Classification of Occupations (ISCO) occupations at the two-digit level. Blockchain-related jobs appeared to be mainly located among professional and managerial occupations; however, the research also revealed the blockchain labour market to be somewhat volatile, with demand levels falling across most EU countries between 2022 and 2023. By using online job advertisement data from Lightcast for Canada, the United Kingdom (UK), the US and Singapore over 2012 to 2018, Squicciarini and Nachtigall (2021) identified occupations at the ISCO one-digit level that require workers to possess AI-related skills: the demand for AI competencies was mainly concentrated in the categories of 'professionals and technicians' and 'associated professionals'.

The model for forecasting demand and supply for AI, automation and blockchain jobs for Ireland developed in this study follows the same approach used by McGuinness et al. (2022, 2023b, 2024) to forecast demand and supply of blockchain-related jobs in the EU27 for 2021–2026, by employing the existing Cedefop occupational forecasting framework. Similarly, Biagi et al. (2020) have previously utilised Cedefop employment forecasts to forecast demand and supply for tertiary graduates in the EU27 Member States related to four ISCO occupational groups, for 2016 and 2030.

Finally, our work contributes to the development of a deeper understanding in the literature by identifying the specific competencies requested and required by employers in AI-, automation- and blockchain-related jobs. Our approach is complementary to recent Organisation for Economic Co-operation and Development (OECD) research (2022) that used information from Lightcast's online job advertisement data across ten countries – Belgium, Canada, France, Germany, Italy, the Netherlands, Singapore, Spain, the UK and the United States (US) – and applied machine learning techniques in order to identify the most relevant skills for several 'digital' occupations, classified as roles important in the digital transition or affected by digitalisation in various sectors.

Recently, Borgonovi et al. (2023) analysed Lightcast's job advertisement data from 2022 on postings requiring applicants to possess AI-related skills for 14 OECD countries, including selected English-speaking countries (Australia, Canada, New Zealand, the UK and the US) and selected European countries (Austria, Belgium,

France, Germany, Italy, the Netherlands, Spain, Sweden and Switzerland). By applying Lightcast's skills taxonomy, the authors identified technical clusters of skills most demanded by employers – machine learning and AI – but also found that non-technical and human/relational skills are highly in demand.

Recent Irish research, based on qualitative interviews with representatives from small, medium and large multinational (public and private) companies operating in Ireland, explored future skills needs for automation and AI jobs in Ireland (Bukartaite and Hooper, 2023). The authors found that for these types of jobs a combination of soft and hard skills is sought by employers, and that workers' positive attitude to lifelong learning is pivotal in such fast-changing labour market scenarios. Respondents within the study reported that Irish businesses lagged behind in the adoption of emerging technologies and in preparing their workforce for the forthcoming changes. The authors highlighted the importance of an integrated system, based on collaboration between employers, employees, the Irish Government and educational providers, in bridging the existing skills gaps in automation and AI jobs.

Globally, Ireland is well positioned regarding its AI 'readiness', ranking 20th out of 193 countries in Oxford Insight's *Government AI Readiness Index 2023* (Oxford Insights, 2023)[10]. The Irish Department of Enterprise, Trade and Employment (DETE) launched Ireland's AI strategy in 2021, which encompasses the Government's long-term commitment to keeping pace with developments in automation and AI (DETE, 2021). Importantly, according to Eurostat data, Ireland recorded the highest share of enterprises in Europe using AI in 2020, at around 23 per cent (Eurostat, 2021). Furthermore, forthcoming research has indicated that jobs in Ireland are among the most impacted by new technologies (including AI) in terms of both task replacement and task displacement in the EU (McGuinness et al., 2024 – forthcoming).

[10] The index draws on several indicators to measure how ready a given government is to implement AI in the delivery of public services to their citizens.

CHAPTER 3

Data and methodology

3.1 INTRODUCTION

This research study explores the demand, supply and skill requirements for emerging technologies in Ireland. Furthermore, it endeavours to bridge the gap between employer expectations and requirements and the actual education and skills acquired by graduates and employees in the fast-paced context of technological change.

In this section, we summarise the methodologies used within the research and outline the main characteristics of our data. We began our research by drawing up an agreed set of more than 20 keywords, a process that involved consultation with the Department of Further and Higher Education, Research, Innovation and Science (DFHERIS) and the monitoring of job portal websites. This list was used to identify areas of emerging technology most relevant to the Irish labour market (see Table 3.1). Following this process and consultations with the research steering group, the key topics for this study were identified: automation, artificial intelligence (AI) and blockchain.

We use a range of data sources to identify key aspects of the labour market in each area, both in terms of the balance between demand and supply, and the skills and competencies requested by employers. Each data source has its own advantages and drawbacks. For example, the Lightcast dataset has a very large comprehensive sample of job advertisements (i.e., approximately one million total job advertisements over 2023 for Ireland). As the data are quite representative for trends in the Irish labour market, seasonal trends in hiring are less of an issue. Lightcast tools extract over 70 different elements from every job posting and are categorised across several dimensions including, sector, occupation, location, company name and type of contract. The Lightcast data used in the report come from 2021; this year was selected so that the extracted data could be linked to the Cedefop forecast framework for the period 2021 onwards. However, this dataset does not include detailed information on the posting date of vacancies, the number of applications or the seniority of the position advertised. By contrast, our bespoke LinkedIn scraped data include this information, albeit for a smaller number of job postings for a snapshot of time in 2023, again focusing on emerging technologies.[11] As it presents a snapshot, our LinkedIn dataset contains job postings related to a short period in the year, and we acknowledge that seasonal trends in hiring across different industries might be more of an issue (Romanko and O'Mahony, 2022). By

[11] Data were scraped on the following dates: 29 May, 30 May, 15 June, 11 July, 1 August, 2 August and 5 October.

using both datasets, we aim to exploit the advantages of both while taking into account their limitations.

We exploit LinkedIn data in order to examine the extent to which potential skill shortages are predominant within specific emerging technology areas and identify which job characteristics are possibly correlated with potential skill shortages. Lightcast data are then utilised to provide a detailed analysis of the relative demand for technical, transversal and business skills using a term frequency method in Python to extract the number of times a skill appears across all job postings related to AI, automation and blockchain. Within this component of the work, we calculate the relative frequency and rank skills, from the most common to the least common required per each emerging technology area.

A further key aspect of our approach is the development of a novel dynamic methodological framework for forecasting the demand for emerging technology jobs, again using Lightcast data, and matching this against educational supply. The forecasting model is designed to provide key inputs into any national skills strategies designed to ensure that the growth of emerging technology employment is not restricted as a consequence of a skills mismatch. It is a fully dynamic model, which means that it can be updated to incorporate changes in occupation categories and data gathering techniques, as well as information on graduates, in order to capture forecasting estimates over time. The model builds on previous forecasting methodologies to provide a unique method to emerging technology skills demand and supply forecasting. The methodological approach is designed to be easily replicated and extended by government departments in Ireland.

3.2 MONITORING JOB PORTALS

In order to identify emerging technologies with a significant share of job vacancies, we conducted a comprehensive analysis of various job portals in Ireland over a four month period (February to May 2023).[12] The platforms included in our initial monitoring are LinkedIn, Indeed, Irishjobs.ie and Jobs.ie. Initially, we tracked a diverse set of keywords associated with skills pertinent to emerging technologies. Our approach involved extracting the absolute numbers of job advertisements and calculating the percentage of total jobs that mentioned these keywords. This allowed us to observe the distribution and changing trends in the job market over the initial phase of the project. An illustrative example of the extracted data from February 2023 is presented in Table 3.1.

Based on the insights derived from monitoring job advertisements across well-known portals, and in collaboration with DFHERIS and the steering group

12 The monitoring process occurred monthly, on the 15th of every month.

overseeing the skills research programme, we identified three areas of focus for this initial research project: automation; AI; and blockchain. The objective of this study is therefore to provide substantiated findings regarding the evolving job landscape and the corresponding skills required in these three domains.

TABLE 3.1 JOB POSTINGS RELATED TO KEYWORDS ON JOB PORTALS, NUMBERS AND SHARES

Keywords	LinkedIn		Indeed		Irish Jobs		Jobs.ie	
	#	%	#	%	#	%	#	%
Automation	2,000	5.6	3,311	4.7	746	7.2	150	3.2
SQL	1000	2.8	1950	2.8	424	4.1	44	0.9
Software development	1,000	2.8	1622	2.3	260	2.5	51	1.1
Python	1,000	2.8	1,607	2.3	286	2.8	26	0.6
Java	1,000	2.8	1,318	1.9	232	2.2	24	0.5
Coding	764	2.1	851	1.2	661	6.4	161	3.4
Linux	1,000	2.8	1,081	1.5	137	1.3	22	0.5
Data analysis	841	2.3	1,030	1.5	197	1.9	60	1.3
Software engineering	752	2.1	765	1.1	98	0.9	48	1.0
Data analytics	681	1.9	651	0.9	111	1.1	59	1.3
Digital marketing	495	1.4	572	0.8	63	0.6	74	1.6
Cyber security	343	1.0	694	1.0	93	0.9	12	0.3
C++	506	1.4	460	0.6	84	0.8	10	0.2
Machine learning	519	1.4	386	0.5	60	0.6	1	0.0
AI	272	0.8	222	0.3	61	0.6	15	0.3
Internet of Things (IoT)	226	0.6	280	0.4	31	0.3	25	0.5
Cloud computing	207	0.6	228	0.3	28	0.3	71	1.5
Big data	206	0.6	213	0.3	100	1.0	10	0.2
Robotics	161	0.4	274	0.4	76	0.7	10	0.2
Blockchain	250	0.7	145	0.2	6	0.1	5	0.1
Web development	135	0.4	174	0.2	30	0.3	4	0.1
5G	121	0.3	127	0.2	12	0.1	2	0.0
Augmented reality	31	0.1	36	0.1	1	0.0	0	0.0
Virtual reality	30	0.1	31	0.0	2	0.0	0	0.0
3D printing	6	0.0	32	0.0	3	0.0	0	0.0
TOTAL	36,000	100	70,823	100	10,377	100	4,702	100

Sources: Job portal websites: LinkedIn, Indeed, Irish Jobs, Jobs.ie.
Notes: Data refer to February 2023; absolute numbers of advertisements and the corresponding shares of total jobs advertisements from each website is shown.

For the analysis, AI and automation align with DFHERIS's most immediate skill development policy.[13] Blockchain is included to extend the analysis, in order to build on prior ESRI-related research; Blockchain was previously examined by the ESRI team as part of CHAISE (a sector skills alliance financed by the EU's Erasmus+ programme), for Ireland relative to all European countries.[14]

3.3 SKILL SHORTAGES

A key aspect of any labour market analysis is to assess the extent to which employers are being impacted by a lack of qualified candidates applying for job vacancies, typically referred to as skill shortages. In this study, this concerns the respective areas of emerging technologies. We employ an in-house scraped LinkedIn dataset to identify and model 'potential skill shortages' among automation, AI and blockchain jobs, with a novel methodology.

We first present the dataset, which consists of a sample of job advertisements published in each emerging technology area on Irish LinkedIn between May and October 2023.[15] In total, 1,859 relevant job postings were collected from that period. The information from the advertisements was cleaned and organised into relevant fields, including seniority level, location, contract type offered, sector of employment, job posting duration and whether a remote working option was specified.[16]

3.3.1 Vacancy characteristics from LinkedIn data

The distribution of the collected sample of job postings by employment area is shown in Table 3.2, providing an initial indication of the scale of relative labour demand across the three key emerging technology areas. Jobs in automation accounted for just over half of advertised posts in the three emerging technology areas, AI postings accounted for 30 per cent of jobs, and blockchain jobs accounted for the remaining approximately 17 per cent of vacancies.

13 For further information, see: https://www.gov.ie/en/publication/69fd2-irelands-national-skills-strategy-2025-irelands-future/.

14 See McGuinness et al. (2022, 2023b, 2024).

15 Data were collected on the following dates: 29 May, 30 May, 15 June, 11 July, 1 August, 2 August and 5 October.

16 It should be noted that LinkedIn is a professional level dataset – the jobs advertised there are predominantly high-skilled graduate level positions – so this sample may under-represent lower-skilled non-graduate positions.

TABLE 3.2 DISTRIBUTION OF LINKEDIN SAMPLE

Emerging technology	N	%
Automation	983	52.8
AI	565	30.4
Blockchain	311	16.7
Total	1,859	100

Source: LinkedIn data sample (authors' analysis).
Note: The data comprises a sample of job advertisements that was collected between May and October 2023.

In Table 3.3, we present job postings by seniority level, in order to identify the experience levels currently being sought by employers across each of the technology areas. On average, around 15 per cent of job advertisements do not specify a seniority level and it is reasonable to assume that such posts are predominantly for entry-level positions. Between 6 and 25 per cent of jobs are at entry level; however, the incidence of entry-level positions is substantially lower in the blockchain labour market compared to AI and automation.[17] Over 70 per cent of job vacancies in blockchain are for mid-level positions compared to 51 and 55 per cent in AI and automation, respectively. Between 7 and 8 per cent of advertised vacancies are for senior positions across all three labour markets.

TABLE 3.3 LEVEL OF EXPERTISE

Level of expertise	Automation	AI	Blockchain
Entry level	25.7	25.5	6.1
Mid-level	55.0	50.8	70.1
Senior level	7.5	8.5	8.4
Not stated	11.8	15.2	15.4
Total	100.0	100.0	100.0

Source: LinkedIn data sample (authors' analysis).
Note: The data comprise a sample of job advertisements that was collected between May and October 2023.

In Table 3.4, we examine the location of the sample of job advertisements by emerging technology: while over 60 per cent of AI and blockchain jobs were in Dublin, the distribution of automation positions was somewhat more dispersed, with 44 per cent located in Dublin. Between 13 and 15 per cent of automation and AI advertised jobs were located in Cork, compared to less than 2 per cent of blockchain jobs. Conversely, blockchain positions were more likely to be located outside of either Dublin or Cork (36 per cent of job advertisements) compared to both automation (30 per cent) and AI (26 per cent) vacancies.

[17] The figure is based on the assumption that advertisements in which the entry level is not stated are for entry-level positions.

TABLE 3.4 LOCATION OF EMPLOYER

Location	Automation	AI	Blockchain
Dublin	44.5	61.3	62.4
Cork	15.0	13.1	1.6
Elsewhere	30.5	25.6	36.0
Total	100.0	100.0	100.0

Source: LinkedIn data sample (authors' analysis).
Note: The data comprise a sample of job advertisements that was collected between May and October 2023.

LinkedIn data also provide information on the broad employer sector: we show the distribution of the sample of jobs across the four prevalent sectors (information and communications technology (ICT), software, manufacturing and financial services sectors) for each emerging technology area (see Table 3.5). Manufacturing and ICT employers account for over 50 per cent of vacancies in automation. Approximately three-quarters of blockchain employers were in the software and financial services sectors. AI employers tend to be more dispersed across sectors, with manufacturing accounting for over 30 per cent and the software sector accounting for over 16 per cent of vacancies.

TABLE 3.5 SECTOR OF EMPLOYER

Sector	Automation	AI	Blockchain
Financial services	6.7	6.0	35.4
ICT	16.3	10.3	6.4
Software	8.1	16.3	39.6
Manufacturing	37.6	30.6	11.2

Source: LinkedIn data sample (authors' analysis).
Note: The data comprise a sample of job advertisements that was collected between May and October 2023.

In terms of the contractual nature of the jobs being advertised, most were for full-time/permanent contracts; however, vacancies in automation were somewhat more likely be to fixed term or temporary in nature (see Table 3.6).

TABLE 3.6 CONTRACTUAL STATUS

Contractual status	Automation	AI	Blockchain
Full-time/Permanent	78.1	89.4	95.5
Contract	21.2	6.6	4.2
Other	0.7	4.0	0.3
Total	100.0	100.0	100.0

Source: LinkedIn data sample (authors' analysis).
Note: The data comprise a sample of job advertisements that was collected between May and October 2023.

Regarding other job characteristics, in Table 3.7 we show the percentage of job postings that specifically state that the position offers remote/hybrid working arrangements. It should be noted that jobs whose advertisements do not mention

remote working may actually come to do so. Between 10 and 17 per cent of vacancies are described as offering remote/hybrid arrangements, with the lowest incidence in blockchain and highest in AI.

TABLE 3.7 INCIDENCE OF REMOTE/HYBRID WORKING

	Automation	AI	Blockchain
Remote/hybrid	14.6	17.4	9.7

Source: LinkedIn data sample (authors' analysis).
Note: The data comprise a sample of job advertisements that was collected between May and October 2023.

In summary, through analysing our bespoke LinkedIn dataset, we found that jobs in automation accounted for just over half of all advertised posts in the three emerging areas, with AI posts accounting for 30 per cent of jobs and blockchain jobs accounting for the remaining approximately 17 per cent of vacancies. While over 60 per cent of blockchain and AI jobs were in Dublin, the distribution of automation positions were somewhat more dispersed, with 44 per cent located in Dublin. Over 70 per cent of job vacancies in blockchain were for mid-level positions compared to 51 and 55 per cent in AI and automation, respectively. Between 7 and 8 per cent of advertised vacancies were for senior positions across all three labour markets.

3.3.2 Modelling potential skill shortages

As previously explained, an important strength of our bespoke scraped LinkedIn dataset is that it provides information on the number of applications each job posting received through the LinkedIn portal; it also provides information on the date the vacancy has been advertised. Through the latter information and by considering the scraping date, we were able to compute the average job posting online duration.[18] This allowed us to develop a novel methodology to build a proxy for potential skill shortages. The average job posting duration is quite short across all the emerging technology areas (approximately ten days). The average number of applications was highest for blockchain positions (at 49 applications), with figures for automation and AI standing at 39 and 33, respectively (see Table 3.8).

TABLE 3.8 APPLICATION RESPONSE DATA

	Automation	AI	Blockchain
Average duration (days)	11.5	10.1	9.4
Average applications	39.2	33.0	49.0

Source: LinkedIn data sample (authors' analysis).
Note: The data comprise a sample of job advertisements that was collected between May and October 2023.

[18] It should be noted that a short posting duration may simply be determined by when the vacancy was posted online rather than an indication that the post was filled.

We derived a measure of *potential skill shortage* by identifying advertisements with:

- substantially higher than average durations; and
- substantially lower than average applications.

On this basis, potential skill shortages are identified as vacancies with over 30 days of duration and less than 10 applications. While we cannot be certain that all of these vacancies will be hard to fill, we can be confident that all hard-to-fill vacancies will lie within this sub-population.

A probit estimation strategy is then used to model the extent to which potential skill shortages are predominant in a particular emerging technology area and to identify which job characteristics are potentially correlated with potential skill shortages. The dependent variable, Pss_{it}, is a binary variable, indicating that an individual job posting is a potential skill shortage in time, t; X_{ijt} represents our explanatory variables (emerging technology area, job location, contract type, sector, expertise level and hybrid working arrangement), while ε_{it} is an error term capturing the unexplained elements of the model.

$$Pss_{it} = \beta_0 + \beta_j X_{ijt} + \varepsilon_{it} \quad (1)$$

3.4 SKILL REQUIREMENTS

This section explains the data and the methodology we used to analyse skill requirements for AI, automation and blockchain jobs in Ireland. The aim of our analysis is to examine the extent to which specific skills are required consistently by employers in emerging technology jobs, in order to inform curriculum developments for the DFHERIS.

We employ a large dataset from online job platforms and companies' websites collected by Lightcast for Ireland from 2018 to 2023, and in particular from 2021. Lightcast is a private labour market and employment analytics company that scrapes and aggregates millions of job advertisements worldwide on a daily basis, drawing from more than 65,000 sources, including job boards, company websites and other sources. Lightcast data provide real-time labour market demand information, facilitated by advanced natural-language processing technology and other AI tools, along with dedicated in-house experts. Their tools extract more than 70 different elements from every job posting.[19] Each job posting is unique, with all duplicates removed.

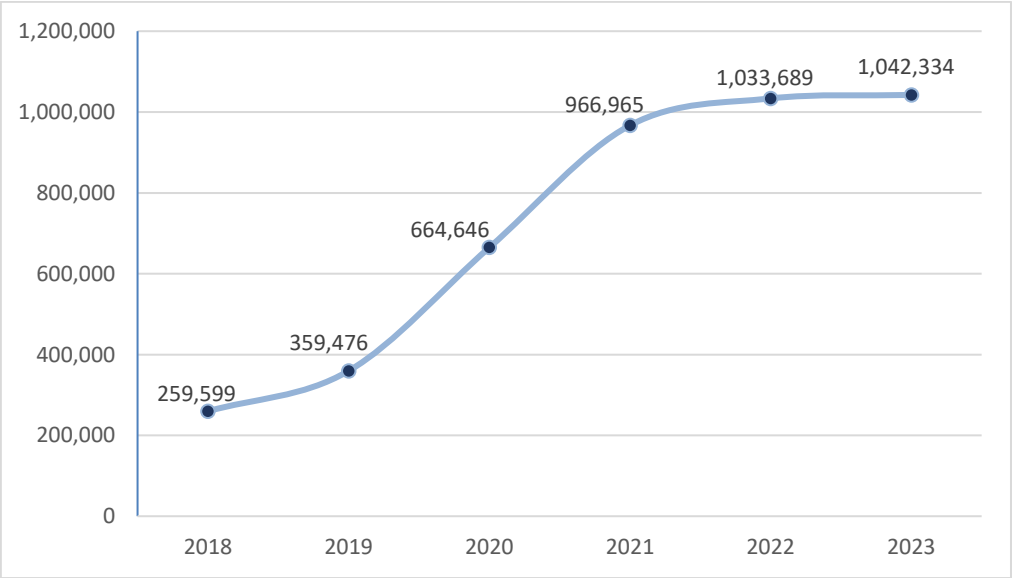
[19] For more information on Lightcast data, please see https://lightcast.io/about/data.

Each job posting collected is classified by Lightcast according to standard labour market variables/analytics, which allow for the data to be comparable (i.e., sector, region/location, occupation, company name, employment type, remote working arrangements, salary, etc.). Moreover, Lightcast provides a specific variable that codifies all the skills mentioned in each job posting's description through machine learning algorithms. We employ this variable and provide a detailed analysis of the relative demand for technical, transversal and business skills for AI, automation and blockchain jobs in Ireland, by using a term frequency method in Python and extracting the number of times a skill appears across all job postings related to the three areas of emerging technologies. We first present our Lightcast dataset briefly, before introducing our methodology.

3.4.1 Lightcast data

We show the evolution of online job postings from 2018 to 2023 in Ireland from Lightcast data (see Figure 3.1). The numbers were extracted in January 2024 and show that the volume of online job advertisements has significantly increased over recent years (from 259,599 in 2018 to 1,042,334 in 2023). This surge can be primarily attributed to the enhanced web-scraping capabilities of Lightcast over the years. As the Irish labour market experienced growth during this period, accompanied by increases in employment rates, it's plausible that heightened labour demand also contributed to the observed rise in job postings. However, we cannot fully disentangle the change that is attributable to increased labour demand versus better web-scraping technology.

FIGURE 3.1 ABSOLUTE NUMBER OF JOB POSTINGS IN IRELAND (LIGHTCAST, 2018–2023)



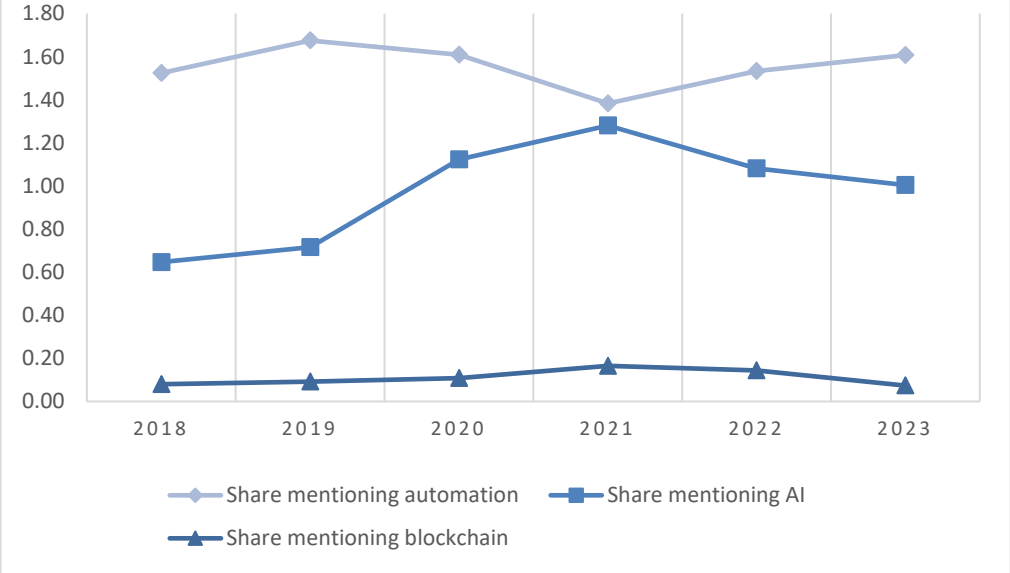
Source: Lightcast data.

Next, we conducted analysis of the progression of online job advertisements related to the emerging technologies areas under investigation, namely,

automation, AI and blockchain. Theses postings are extracted using the keywords search for 'automation', 'artificial intelligence' and 'blockchain', as identified by Lightcast's skills taxonomy. We then calculated the shares of total job postings related to these emerging technologies over time (see Figure 3.2).

The share of automation-related jobs experienced an increase, from 1.52 per cent in 2018 to 1.67 in 2019, followed by a decline to 1.38 per cent in 2021, and a subsequent increase to 1.61 in 2023. Simultaneously, the share of jobs associated with AI has increased, from 0.65 per cent in 2018 to 1.28 in 2021, before decreasing to 1.00 per cent in 2023. In contrast, the share of blockchain-related jobs has remained relatively low and stable, increasing from 0.08 per cent in 2018 to 0.17 in 2021, and then declining to 0.07 per cent in 2023.

FIGURE 3.2 SHARES JOB POSTINGS RELATED TO EMERGING TECHNOLOGIES (LIGHTCAST, 2018–2023), %



Source: Lightcast data.

3.4.1.1 Prevalent occupations including automation, AI and blockchain

To conduct descriptive analysis on jobs related to emerging technologies, we concentrated on Lightcast data from the year 2021. Here are the numbers of job advertisements associated with each technology:

- Automation: 13,360 job advertisements;
- AI: 12,528 job advertisements;
- Blockchain: 1,545 job advertisements.

These job advertisements provide the basis for our examination and understanding of the labour market dynamics in these technical areas.

As previously explained, Lightcast's job advertisements data are already categorised across several dimensions including, sector, occupation, location, company name and type of contract. Importantly, job titles are aligned to the International Standard Classification of Occupations (ISCO), facilitating the breakdown of the data to identify occupations related to our three areas of emerging technologies. This information is provided at ISCO two-digit level.

To pinpoint the most prevalent occupations within AI, automation and blockchain jobs, we selected the occupational groups with the highest relevant shares of job advertisements. Specifically, we focused on the occupations that accounted for 80 per cent of jobs within each emerging technology area in 2021. The remaining 20 per cent of jobs within each area were classified under the 'Other' category, as they were advertised across a broad range of less relevant occupational groups. This approach allows for a detailed understanding of the dominant occupations within each emerging technology sector.

Overall, the evidence from job advertisements shows that employment within automation, AI and blockchain predominantly involves high-educated/high-skilled occupations, and includes professional roles and technicians, as well as associate professionals and managers. However, there are also lower employment shares among certain low-educated/low-skilled occupations, such as plant and machine operators and craft and related trade workers. The top three occupations with the highest share of automation jobs are:

- Science and engineering professionals, accounting for 42.81 per cent of automation jobs;
- Science and engineering associate professionals, accounting for 10.27 per cent;
- Information and communications technology professionals, accounting for 6.89 per cent.

A more comprehensive breakdown of automation jobs by ISCO category is shown in Table 3.9.

TABLE 3.9 AUTOMATION JOBS BY ISCO TWO-DIGIT OCCUPATIONS

ISCO code	ISCO occupations	Freq.	%
21	Science and engineering professionals	5,719	42.81
31	Science and engineering associate professionals	1,372	10.27
25	ICT professionals	921	6.89
74	Electrical and electronic trades workers	862	6.45
12	Administrative and commercial managers	686	5.13
24	Business and administration professionals	446	3.34
71	Building and related trades workers, excluding electricians	433	3.24
13	Production and specialised services managers	322	2.41
		2,599	19.46
	Total	13,360	100.00

Source: Lightcast data, 2021.
Note: ISCO is one of the main classifications for which ILO is responsible.[20]

The leading occupations with the highest share of jobs mentioning AI are as follows:

- ICT professionals, accounting for 32.57 per cent of AI jobs;
- Science and engineering professionals, accounting for 11.95 per cent;
- Business and administration professionals, accounting for 11.53 per cent.

A more comprehensive breakdown of AI jobs by ISCO category is shown in Table 3.10.

TABLE 3.10 AI JOBS BY ISCO TWO-DIGIT OCCUPATIONS

ISCO code	ISCO occupations	Freq.	%
25	ICT professionals	4,080	32.57
21	Science and engineering professionals	1,497	11.95
24	Business and administration professionals	1,445	11.53
12	Administrative and commercial managers	939	7.5
26	Legal, social and cultural professionals	612	4.89
31	Science and engineering associate professionals	396	3.16
74	Electrical and electronic trades workers	359	2.87
42	Customer services clerks	320	2.55
33	Business and administration associate professionals	311	2.48
81	Stationary plant and machine operators	294	2.35
		2,275	18.15
	Total	12,528	100.00

Source: Lightcast data, 2021.

[20] For more information on ISCO classifications, please see https://www.ilo.org/public/english/bureau/stat/isco/.

The top three occupations with the highest share of jobs mentioning blockchain jobs are as follows:

- ICT professionals, accounting for 33.46 per cent of blockchain jobs;
- Business and administration professionals, accounting for 12.62 per cent;
- Science and engineering professionals, accounting for 10.55 per cent.

A more comprehensive breakdown of blockchain jobs by ISCO category is shown in Table 3.11.

TABLE 3.11 BLOCKCHAIN JOBS BY ISCO TWO-DIGIT OCCUPATIONS

ISCO code	ISCO occupations	Freq.	
25	ICT professionals	517	33.46
24	Business and administration professionals	195	12.62
21	Science and engineering professionals	163	10.55
12	Administrative and commercial managers	154	9.97
26	Legal, social and cultural professionals	100	6.47
13	Production and specialised services managers	51	3.3
74	Electrical and electronic trades workers	43	2.78
81	Stationary plant and machine operators	34	2.2
	Other occupations	288	18.65
	Total	1,545	100.00

Source: Lightcast data, 2021.

3.4.1.2 Regional distribution and top employers by emerging technology

The regional distribution of job advertisements by emerging technology, based on the NUTS (Nomenclature of territorial units for statistics) 2021 classification provided by Eurostat, is shown in Table 3.12. A significant proportion of the AI- and blockchain-related jobs are concentrated in the eastern and midland region. It is important to consider that Dublin, the capital city, is located within this region and accounts for a disproportionately large share of the population, encompassing almost 30 per cent of the total population in Ireland, which amounts to over five million people. In contrast, automation-related jobs postings appear to be more evenly distributed, although approximately half of them are still located in the eastern and midland region. This distribution pattern sheds light on the geographical concentration of emerging-technology-related job opportunities across different regions in Ireland.

TABLE 3.12 REGIONAL DISTRIBUTION OF JOB ADVERTISEMENTS BY EMERGING TECHNOLOGY IN IRELAND

NUTS2 region	Automation	AI	Blockchain
Eastern and midland	54.58	68.8	83.91
Northern and western	14.29	9.35	5.72
Southern	31.12	21.85	10.37
Total	100.00	100.00	100.00

Source: Lightcast data, 2021.
Note: The NUTS classification is a hierarchical system for dividing up the economic territory of the EU and UK.[21]

The Lightcast dataset also includes information on the companies that are advertising these jobs (see Table 3.13), enabling us to identify the top employers in each emerging technology area. The analysis reveals distinctive trends among the employers associated with different emerging technologies:

- Companies posting job advertisements related to automation are primarily concentrated in the pharmaceutical sector.
- Job postings related to AI predominantly come from big tech companies, with universities also featuring prominently as employers.
- Blockchain-related job postings are predominantly sourced from technology companies and consultancy firms.

These findings provide valuable insights into the sectors and types of organisations driving employment opportunities within each emerging technology sphere.

TABLE 3.13 TOP EMPLOYERS BY EMERGING TECHNOLOGY IN IRELAND

	Companies
Automation	Bristol-Myers Squibb, Pfizer, Google, Johnson & Johnson, LotusWorks, Morgan McKinley
AI	Amazon, Apple, Deloitte, Dublin City University, Google, IBM, Intel, Johnson & Johnson, Meta, Microsoft, National University of Ireland Galway, Qualcomm, UnitedHealth Group, University College Dublin
Blockchain	Ernst & Young, Deloitte, IBM, Accenture, Consensus Systems, Latoken, Coinbase, Citigroup, Crypto International Ltd., KPMG

Source: Lightcast data, 2021.
Note: Recruitment firms have been excluded from the analysis.

3.4.2 Skill requirement analysis methodology

The rationale of the emphasis within our analysis on examining the detailed competencies contained within job advertisements is summarised by the following quote:

[21] For more information on NUTS classifications, please see https://ec.europa.eu/eurostat/web/nuts/overview.

> *An understanding of what skills are in demand is necessary to bridge the gap between demand and supply: what employers are looking for isn't always the same as what educators are teaching or what training providers are offering. Without a common language, these gaps remain and grow wider. Skills create a common language to navigate that gap.* (Lightcast, 2023)

Job advertisement data disclose what type of skills employers are looking for. Lightcast data provide a well-established and developed open skills taxonomy, which we employ in our analysis. By applying machine learning algorithms to the job postings' descriptions, Lightcast codifies all the skills mentioned in each job posting as a unique variable. The taxonomy is unique, in the sense that a single skill related to a job posting appears only once even if it is mentioned multiple times. The taxonomy includes over 32,000 skills, with competencies, knowledge, specific software and soft skills included.

BOX 3.1 HOW DOES LIGHTCAST DEFINE THE SKILLS TAXONOMY?

Lightcast employs a big data approach to taxonomy development that allows for real-time updates as skills evolve and new ones emerge. As a new skill is identified, it is mapped and codified also in the historical data. Skills are identified through the following.

1. Algorithmic methods: Machine learning algorithms are used to identify potential new skills not yet classified.
2. Qualitative methods: Labour market analysts conduct research in emerging skills areas.
3. Partner requests: Companies/agents suggest new skills.

Using Python, we employ a term frequency method and extract the number of times a skill appears across all job postings related to AI, automation and blockchain. We firstly calculate the relative frequency, and then rank skills required within each emerging technology area, from the most common to the least common.

For each emerging technology area, we then map the most required skills into three categories: technical, business and transversal. We classify *technical* skills as the 'hard' skills, mostly specific to jobs in the field of the related technology (i.e., machine learning, computer science, electrical engineering). *Transversal* skills are 'soft' skills not specifically related to a particular job, task or academic discipline but valuable for effective action in any work, learning or life activity (i.e., communications, problem-solving, leadership). *Business* skills are business capabilities applicable to a variety of jobs in different businesses and industries (i.e., management, sales, business development).

This methodology was applied not only to the 2021 Lightcast dataset, but also to our in-house bespoke scraped LinkedIn dataset, as it was possible to code the same skill variable within our dataset. It was then possible to further disaggregate the competency requirement for entry-, mid- and senior-level vacancies. The competency requirements for entry-level position will be of greatest interest to policymakers involved in curriculum development.

3.5 FORECASTING DEMAND AND SUPPLY FOR EMERGING TECHNOLOGY JOBS

3.5.1 Demand for emerging technology jobs

3.5.1.1 Estimating the proportions of emerging technology jobs

In this section, we outline the methodology used to forecast labour demand and supply for automation, AI and blockchain jobs over a medium-term time horizon (four years) and a longer-term horizon (ten years). We use 2021 Lightcast online job advertisements for automation, AI and blockchain jobs, and employ a similar methodology used by McGuinness et al. (2022; 2023; 2024), details of which are shown below.

As outlined in Section 3.4.1.1, we mapped job advertisement data for Ireland related to automation, AI and blockchain to the dominant ISCO occupations relevant for each emerging technology area, by focusing on the occupations that accounted for 80 per cent of job advertisements within each emerging technology area in 2021. The remaining 20 per cent of jobs within each area were classified under the 'Other' category.

We then estimated the share of each emerging technology-related jobs in each ISCO occupation. First, we extracted from the Lightcast portal the total number of jobs advertised in 2021 for each ISCO category identified as most relevant for each emerging technology. Second, we estimated the proportion of jobs within each ISCO category for each emerging technology – automation, AI and blockchain. For example, 53,440 vacancies were posted in 2021 for ICT professionals, and among those 4,080 jobs required AI-related skills. This process allows us to incorporate relevant occupational employment shares, for each emerging technology area, into the Cedefop occupational forecasting model to generate demand estimates for AI, automation and blockchain jobs.

3.5.1.2 Cedefop occupational forecasts

As the final step for the demand forecasting methodology, we employ Cedefop skill forecast data.[22] The Cedefop forecasts were recently updated, in mid-2023, and we

[22] For further information, see https://www.cedefop.europa.eu/en/tools/skills-forecast.

use the most up-to-date information. Cedefop provides quantitative projections of future trends in employment by sector of economic activity and occupational group in the 27 EU Member States, by taking into account 2021 data as a baseline scenario and global macroeconomic indicators up until spring 2022.[23] The forecasts account for different macroeconomic and labour market developments, and capture skills needs, economic factors and developments in the future (Biagi et al., 2020). They thereby represent a guide for future trends in employment, and the numbers are to be considered estimates, rather than exact figures (SOLAS, 2023). The timeframe for the projections is 2021–2035, and the data can be broken down into these time periods: 2021–2025, 2025–2030 and 2030–2035.

Cedefop provides the annual rate of increase for each ISCO occupation (available at the two-digit level) and the absolute number of people that will be employed within that occupation at the end of the period by country. Each number identifies the total demand forecast for a specific occupation. We employ Cedefop's occupational forecasts for each occupation identified as relevant for AI, automation and blockchain jobs for two time periods: 2021–2025 and 2025–2030.

SOLAS (2023) reviewed Cedefop's forecasts for Ireland by comparing the 2021 Cedefop baseline figures with Labour Force Survey (LFS) data by Eurostat for both 2021 and 2022, to determine how closely they align. They identified several discrepancies for some sectors and some occupational groups, which was attributed to insufficient consideration being made of the fast growth experienced by some sectors during the COVID-19 crisis, and of the slower recovery experienced by some other sectors after the pandemic. For the purpose of this study, Cedefop's projections referring to two ISCO groups (ISCO-13 production and specialised services managers and ISCO-25 ICT professionals) have been revised accordingly in line with the findings of SOLAS.

According to SOLAS, Cedefop's baseline data for 2021 – the starting year of the forecast – comprise figures that do not align with the official Eurostat figures for the number of employed people in that year. Rather, they represent an underestimate. As per Eurostat's data, in 2022 the number of people employed in ISCO-13 and ISCO-25 already exceeded the number of people forecast to be employed by the end of 2025. In order to address the issue, we checked the figures from the Irish Quarterly Labour Force Survey (LFS). Data for 2021 reflect the impacts of COVID-19 on the labour market: in Q1 and Q2 2021, COVID restrictions were in place and figures were low. When in Q3 the restrictions eased, the Irish LFS reports a record increase in the number of people employed, as the recovery from the pandemic began. Consequently, there was an increase in employment in the two occupational groups considered. Q4 2021 reports lower figures compared to

[23] For the main macroeconomic assumptions underlying the Cedefop projections we refer to Cedefop's technical report: https://www.cedefop.europa.eu/files/2023_skills_forecast_technical_report.pdf.

Q3, similar to 2022 averages. In order to strip out the COVID-19 effects, we re-calculated forecasts for ISCO-13 and ISCO-25 by keeping the occupational growth rate used by Cedefop but using Q4 2021 figures from the Irish LFS as baseline data. However, the results of our recalculations in terms of projections for ISCO-13 and ISCO-25 were only slightly higher than the current Cedefop projections, with a negligible difference in magnitude.

3.5.2 Supply for emerging technology jobs

Emerging technology skills supply is estimated by identifying the number of graduates from automation-, AI- and blockchain-specific higher education courses. We utilise data from the Higher Education Authority (HEA), SOLAS and Quality and Qualifications Ireland (QQI) to forecast emerging technology skills supply over the next five years for Ireland. In terms of context, it is important to note that Eurostat figures show a substantial increase in the total number of ICT graduates, at a rate significantly above the EU average (Table 3.14).

TABLE 3.14 TOTAL ICT GRADUATES, IRELAND AND EU27 COUNTRY AVERAGE, 2015–2021

Country	2015	2016	2017	2018	2019	2020	2021	Increase 2015–2021
Ireland	4,449	4,851	5,275	6,251	6,271	7,154	7,008	57.5%
Total EU27	108,913	117,533	126,136	130,943	136,244	151,419	153,644	41.0%

Source: Eurostat.

We began by analysing data on graduates for 2017–2021, which we received from the Higher Education Authority (HEA). The HEA has the statutory responsibility, at central government level, for the effective governance and regulation of higher education institutions and the higher education system. The HEA provided specific data on graduates in 'emerging skills' areas; within this dataset, we were able to isolate and identify courses and numbers of graduates that related to 'artificial intelligence', 'automation' and 'blockchain', delivered by both HEA and non-HEA institutions. These are university courses that directly mention the 'emerging technologies' in their name. In this study, we employ only the most recent data from 2020 and 2021.

In addition, we utilise data from the state agency SOLAS on the further education and further education and training (FET) sector.[24] We also consulted with QQI, the state agency responsible for promoting the quality, integrity and reputation of Ireland's further and higher education system, and for awarding qualifications and

[24] SOLAS reported approximately 50 people per year completing course with an FET certificate or award in the 'automation' field, while they did not identify any further education and training courses (FET) on 'blockchain' or 'artificial intelligence'.

issuing certificates. QQI data on graduates from emerging technology courses by private providers at major class of awards is also included in our analysis.[25]

Table 3.15 shows data on the number of graduates from HEA courses, non-HEA institutions courses, SOLAS' FET courses and QQI awards in 2020 and 2021. In particular, we utilise: HEA and non-HEA institutions data for AI, automation and blockchain;[26] SOLAS data for FET related to automation; and QQI awards data for automation and AI.

[25] A number of graduates in automation and artificial intelligence has been recorded, but no courses have been identified in the blockchain field.

[26] In a previous study by the ESRI team on blockchain demand and supply forecasting in Ireland (as part of the CHAISE project), some educational providers were contacted directly and they provided data on numbers of graduates as well as students exposed to some blockchain courses/modules/micro credentials. Given the difference in the methodological approach, the numbers resulted from that analysis are somehow higher than the numbers reported in the present study, and the supply forecastings are consequently higher than those projected in the present study (a surplus of blockchain graduates is forecast over the next few years). For additional information, see: https://chaise-blockchainskills.eu/wp-content/uploads/2024/06/D3.2.1_CHAISE_WP3_Annual_blockchain-Skills_Forecasts_2024.pdf.

TABLE 3.15 NUMBER OF GRADUATES IN AI-, AUTOMATION- AND BLOCKCHAIN-RELATED COURSES IN IRELAND (2019/2020 AND 2020/2021)

AI	2019/2020	2020/2021
HEA courses	300	310
Non-HEA courses	90	25
QQI		10
Total	**390**	**345**

Automation	2019/2020	2020/2021
HEA courses	160	260
SOLAS – FET		50
QQI	119	100
Total	**279**	**410**

Blockchain	2019/2020	2020/2021
HEA courses	10	20
Non HEA courses	5	5
Total	**15**	**25**

Source: HEA data for AI, automation and blockchain (HEA and non-HEA institutions for 2020 and 2021); SOLAS data for FET (for 2020 and 2021 automation only); QQI awards data (for 2020 and 2021 – automation and AI).

In order to produce a forecast on the number of graduates in AI, automation and blockchain courses in Ireland in a medium-term horizon, we calculated the average number of graduates per year over 2020 and 2021 (see Table 3.16). We then multiplied the average figure by four (years) for the forecasting period 2021–2025 and by five (years) for the forecasting period 2025–2030. As we assume the supply will remain constant over the years and calculate linear projections, the forecast constitutes a lower bound estimate for the future number of graduates.

TABLE 3.16 GRADUATES AVERAGE PER YEAR IN AI-, AUTOMATION- AND BLOCKCHAIN-RELATED COURSES

Relevant courses	Average number of graduates per year (2020–2021)
AI	373
Automation	370
Blockchain	20

Sources: HEA, SOLAS, QQI awards (authors' calculations).

CHAPTER 4

Potential skills shortages

As outlined in Section 3.3.2, we used our in-house scraped LinkedIn dataset for Ireland on automation, artificial intelligence (AI) and blockchain jobs to derive a measure of potential skill shortage. This related to job advertisements with substantially higher-than-average durations and substantially lower-than-average applications. Potential skill shortages are identified in cases of vacancies with over 30 days of duration and less than 10 applications.

We estimate the lowest level of skill shortage to be in blockchain, at 3.9 per cent of vacancies, and the highest rate to be in automation, at 7.7 per cent of vacancies. Among AI vacancies, we estimate that 5.8 per cent are potentially 'hard to fill' (see Table 4.1).[27]

TABLE 4.1 POTENTIAL SKILL SHORTAGES IN EMERGING TECHNOLOGY JOBS

Application response	Automation	AI	Blockchain
% potential shortage*	7.7	5.8	3.9

Source: LinkedIn data sample (authors' analysis).
Note: Potential skill shortages are identified as vacancies with over 30 days of duration and less than 10 applications.

We employ our measure of potential skill shortage as a dummy variable in Probit models in order to: (i) investigate whether specific emerging technology recruitment areas experience difficulties in filling vacancies; and (ii) identify which job characteristics are more or less associated with 'hard to fill' vacancies.

Our dependent variable is binary, and indicates whether an individual job posting potentially represents a skill shortage. Our explanatory variables are: the emerging technology area; job location; contract type; sector; expertise level; and hybrid working arrangement (for the model explanation, see Section 3.3.2).

4.1 PROBIT MODEL FOR POTENTIAL SHORTAGES

Table 4.2 presents the results from the probit model that were estimated using the entire sample. There is no evidence that the incidence of potential skill shortages is statistically higher in any of the emerging technology areas. The model does, however, suggest that some particular vacancy characteristics are associated with an increased probability of potential skill shortages. Compared to vacancies where no seniority level was specified, jobs for entry-level positions were ten percentage

[27] In 2022, 6 per cent of European enterprises had hard-to-fill vacancies for jobs requiring ICT specialist skills, with Ireland standing just below the average, according to Eurostat data (Eurofound, 2023). However, it should be noted that the methodology used to measure hard-to-fill vacancies does not align with the approach adopted in the present report.

points more likely to be potential skill shortages, while mid-level and senior jobs were three percentage points more likely to be categorised as 'hard to fill'. Regarding the sector, potential skill shortages were four percentage points less likely to be found in the financial services and software sectors, compared to other sectors.

TABLE 4.2 MODELS FOR ADV DURATION >30 AND APPLICATIONS <10: PROBIT ME

Variables	Coefficients
Reference: Not stated	
Entry level	0.10*** (0.029)
Mid/senior level	0.03** (0.015)
Reference: Blockchain	
Automation	-0.00 (0.019)
AI	-0.01 (0.018)
Reference: Other area	
Dublin	-0.00 (0.012)
Cork	0.01 (0.018)
Reference: Other sector	
Financial services	-0.04*** (0.012)
ICT	-0.02 (0.015)
Software	-0.04*** (0.011)
Manufacturing	-0.00 (0.012)
Reference: Not stated	
Full-time/Permanent	0.01 (0.038)
Contract	-0.00 (0.042)
Remote\Hybrid	-0.01 (0.014)
Observations	1,859
Pseudo R2	0.062

Source: LinkedIn data sample (authors' analysis).
Notes: The data comprise a sample of job advertisements that was collected between May and October 2023. Standard errors in parentheses. Robustness checks have been carried out, both by adjusting the conditions for the skill shortage categories and by estimating the models using the Lightcast data (not all explanatory variables were common to both datasets). Our results are robust to these changes.

4.2 PROBIT MODEL FOR POTENTIAL SHORTAGES BY EMERGING TECHNOLOGY AREA

We then estimate the model separately for each emerging technology area, to assess the extent to which the potential drivers of skill shortage vary across emerging technology areas (see Table 4.3). Within automation, entry-level positions were 14 percentage points more likely to have a potential skill shortage. Conversely, vacancies offering remote working and in the information and communications technology (ICT), software, financial services and manufacturing sectors, compared to other sectors, had a lower likelihood of having a potential

skill shortage. Regarding AI vacancies, potential skill shortages were found to be lower in the software sector, while higher in manufacturing; vacancies offering remote working arrangements were also found to be at higher risk of a skill shortage (but the result was only statistically significant at the 10 per cent level). Finally, within blockchain jobs, there was evidence of potential shortages for vacancies offering both a full-time/permanent contract and a fixed-term contract, relative to those vacancies where no contract information was provided. The evidence for this was at a lower extent for positions located in Dublin.

TABLE 4.3 MODELS FOR POTENTIAL SHORTAGE BY EMERGING TECH AREA: PROBIT ME

Variables	Automation	AI	Blockchain
Reference: Not stated			
Entry level	0.14*** (0.042)	0.04 (0.041)	0.02 (0.057)
Mid/Senior level	0.03 (0.021)	0.04 (0.028)	-0.00 (0.024)
Reference: Other area			
Dublin	-0.01 (0.016)	-0.03 (0.024)	0.04* (0.019)
Cork	0.02 (0.023)	-0.03 (0.021)	0.36 (0.297)
Reference: Other sector			
Financial services	-0.04** (0.018)		-0.00 (0.022)
ICT	-0.04*** (0.015)	-0.01 (0.032)	0.11 (0.079)
Software	-0.05*** (0.013)	-0.04** (0.018)	0.00 (0.022)
Manufacturing	-0.04*** (0.014)	0.06** (0.027)	0.00 (0.029)
Reference: Not stated			
Full-time/Permanent	-0.08 (0.133)	-0.01 (0.056)	0.04** (0.015)
Contract	-0.06 (0.041)	0.03 (0.081)	0.98*** (0.004)
Remote/Hybrid	-0.05*** (0.013)	0.06* (0.035)	0.00 (0.029)
Observations	983	531	311
Pseudo R2	0.12	0.08	0.12

Source: LinkedIn data sample (authors' analysis).
Notes: The data comprise a sample of job advertisements that was collected between May and October 2023. Standard errors in parentheses. Stars indicate level of coefficient statistical significance: *** p<0.01, ** p<0.05, * p<0.1.

4.3 SUMMARY OF FINDINGS

This section exploits data scraped from LinkedIn to profile vacancies in emerging technologies and investigates the drivers of potential skill shortages. Constructing a measure of skill shortages within our bespoke LinkedIn dataset, we found that the lowest level of potential skill shortage is in blockchain, at 3.9 per cent of vacancies, the highest rate is found in automation, at 7.7 per cent of vacancies, while 5.8 per cent of AI vacancies are potentially hard to fill. The measure was used to implement a probit estimation strategy. Our models indicate that potential shortages were higher among entry-level vacancies and that this was particularly the case for posts in automation.

CHAPTER 5

Skill requirements analysis

5.1 INTRODUCTION

This chapter focuses on the type of skills required by employers for automation, artificial intelligence (AI) and blockchain jobs. Our aim is to examine the extent to which specific skills are required consistently by employers in emerging technology jobs. The analysis endeavours to bridge the gap between employer expectations and requirements and the actual education and skills acquired by graduates and employees, in the fast-paced context of technology. It also seeks to inform any curriculum developments made by the Department of Further and Higher Education, Research, Innovation and Science (DFHERIS). We present the skill requirement analysis from both the Lightcast data and our own scraped LinkedIn dataset. It is important to note that while we focus on emerging technologies here, a similar methodology can be used for other job skill requirements, such as examining 'green' jobs and skill requirements for the green transition.

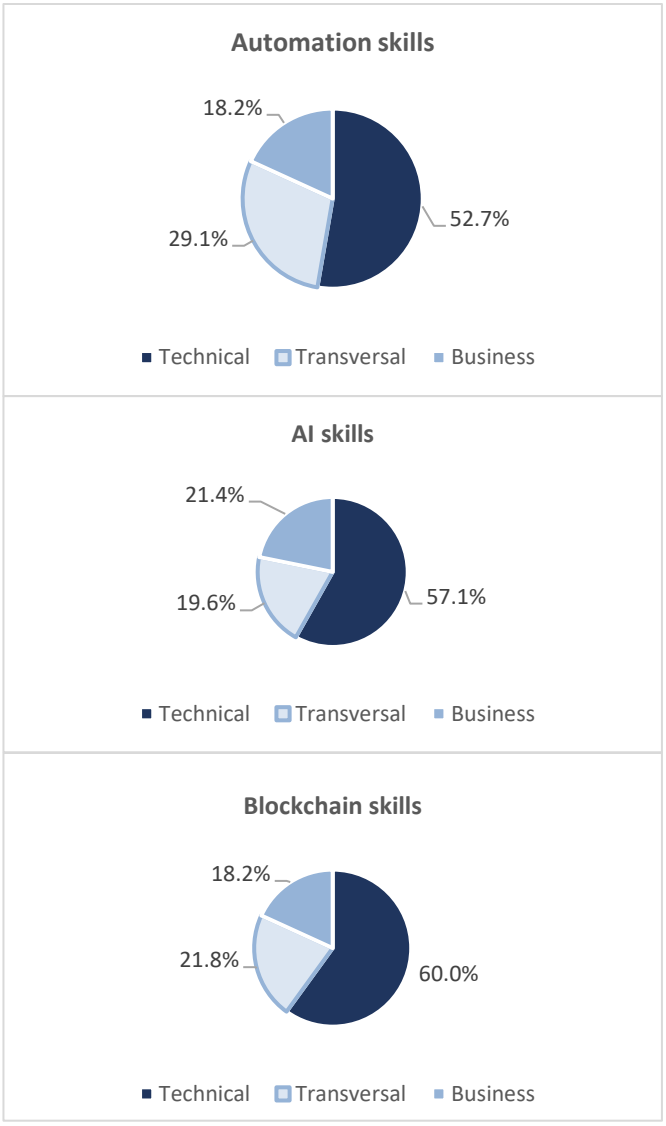
5.2 SKILL REQUIREMENTS FROM LIGHTCAST DATA

We employ the 2021 Lightcast job advertisement dataset for Ireland related to AI, automation and blockchain jobs. The dataset contains: 13,412 automation-related job postings; 12,525 AI-related job postings; and 1,591 blockchain-related job postings.[28] We extract the relative frequency of skills appearing across all the job postings, rank them from the most common to the least common skill required per each emerging technology area, and classify skills into technical, business and transversal skills.

By analysing the first 50 to 60 common skills that appeared in a range from 100 to 5–6 per cent of job postings per each emerging technology area, we found that approximately 50–60 per cent of skills required by employers are 'technical', 20–30 per cent are 'transversal', and 20 per cent are 'business' (see Figure 5.1). This means that, while a solid knowledge of technical skills is essential within emerging technology occupations, there is also high demand among companies for non-technical and relational skills. This is line with evidence from a similar skill requirement analysis of US jobs postings concerning AI-related jobs (Borgonovi et al., 2023). It is also in line with Irish research, which stresses the importance of a combination of soft skills and hard skills for workers in automation- and AI-related jobs, according to a qualitative study on employers in emerging technology areas (Bukartaite and Hooper, 2023).

[28] Please refer to Section 3.4.2 for the methodology applied.

FIGURE 5.1 SKILL REQUIREMENTS BY CATEGORY



Source: 2021 Lightcast data for Ireland (authors' analysis).

5.2.1 Technical skills

In this section, we present the technical skills most commonly required in each of the three areas of emerging technology jobs. We show the 10 skills most commonly mentioned in job postings along with their frequency of appearance (in a range from 100 to 10–15 per cent of job advertisements), and we investigate the degree of skills overlap across emerging technology areas.

Skills that are technology specific are presented in black shading, those skills common to two technologies are in orange shading, and those skills common to three technologies are in green shading. As is evident from Table 5.1, there is some

overlap between AI and blockchain technical skills,[29] but many skills are technology specific, particularly in the case of automation jobs. For instance, among AI jobs: 'machine learning' is mentioned in over 60 per cent of job postings; 'python' is required in almost 40 per cent of job advertisements; and 'computer science' in 33 per cent of jobs. Among automation jobs: 'control systems' is required in 34 per cent of job advertisements; 'programmable logic controllers' in 26 per cent of postings; and 'building automation' in 24 per cent of jobs. Among blockchain-related jobs: 'agile methodology' is mentioned in 31 per cent of job postings; 'Amazon web services' in 24 per cent of jobs; and Microsoft Azure in 21 per cent of jobs.[30]

TABLE 5.1 TECHNICAL SKILLS BY EMERGING TECHNOLOGY AREA

Automation		AI		Blockchain	
Skill	**Frequency**	**Skill**	**Frequency**	**Skill**	**Frequency**
Control systems	0.34	Machine learning	0.61	Agile methodology	0.31
Programmable logic controllers	0.26	Python (programming language)	0.38	Amazon web services	0.24
Building automation	0.24	Computer science	0.33	Microsoft azure	0.21
Pharmaceuticals	0.21	Data science	0.22	DevOps	0.20
Good manufacturing practices	0.19	Agile methodology	0.20	Java (programming language)	0.20
Supervisory control and data acquisition (SCADA)	0.18	SQL (programming language)	0.19	Kubernetes	0.19
Systems engineering	0.14	Data analysis	0.19	Computer science	0.18
Electrical engineering	0.12	Amazon web services	0.18	Software engineering	0.18
Commissioning	0.12	Software engineering	0.16	Software development	0.17
HVAC	0.10	Software development	0.15	Application programming interface (API)	0.17

Source: 2021 Lightcast data for Ireland (authors' analysis).
Notes: The dataset contains 13,412 automation-related job postings; 12,525 AI-related job postings; and 1,591 blockchain-related job postings. We present the skills that are technology specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

5.2.2 Transversal skills

In this section, we present the transversal skills most commonly required in each of the three areas of emerging technology jobs. As per the technical skills, we show the 10 skills most commonly mentioned in job postings with their frequency of appearance (in a range from 100 to 8–10 per cent of job advertisements). We then investigate the degree of skills overlap across emerging technology areas. As

29 We also expanded the analysis to the first 20 most common skills, and we found that the skills overlap between AI and blockchain increases.

30 As one might expect, AI, automation and blockchain appeared as the most required skill by employers in each corresponding emerging technology area. To avoid any redundancy, it was the authors' choice not to show them in the tables.

before, skills that are technology specific are presented in black shading, those skills common to two technologies are in orange shading and those skills common to three technologies are in green shading. Our analysis in Table 5.2 shows that there is a very high degree of transversal skills overlap between the three emerging technology areas, while very few skills are technology specific. For instance, 'communications' is mentioned in 43 per cent of automation-related jobs, in 42 per cent of AI-related jobs, and in 48 per cent of blockchain-related jobs. 'Problem-solving' is mentioned in 22 per cent of automation-related jobs, in 20 per cent of AI-related jobs, and in 22 per cent of blockchain-related jobs. 'Leadership' is mentioned in 14 per cent of automation-related jobs, in 17 per cent of AI-related jobs, and in 20 per cent of blockchain-related jobs.

TABLE 5.2 TRANSVERSAL SKILLS BY EMERGING TECHNOLOGY AREA

Automation		AI		Blockchain	
Skill	**Frequency**	**Skill**	**Frequency**	**Skill**	**Frequency**
Communications	0.43	Communications	0.42	Communications	0.48
Problem solving	0.22	Research	0.21	Problem solving	0.22
Troubleshooting (Problem solving)	0.21	Problem solving	0.20	Self-motivation	0.22
Planning	0.16	Innovation	0.19	Leadership	0.20
Leadership	0.14	Leadership	0.17	Innovation	0.19
Self-motivation	0.13	Writing	0.13	Consulting	0.15
Interpersonal communications	0.12	Detail oriented	0.12	Planning	0.15
Detail oriented	0.11	Planning	0.10	Detail oriented	0.15
Innovation	0.10	Presentations	0.10	Coaching	0.13
Investigation	0.08	Self-motivation	0.10	Writing	0.13

Source: 2021 Lightcast data for Ireland (authors' analysis).
Notes: The dataset contains 13,412 automation-related job postings; 12,525 AI-related job postings; and 1,591 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

5.2.3 Business skills

We present the business skills most commonly required in each of the three areas of emerging technology jobs (see Table 5.3). Again, we identify the 10 skills most commonly mentioned in job postings along with their frequency of appearance (in a range from 100 to 4–7 per cent of job advertisements). We then investigate the degree of skills overlap across emerging technology areas. Again, skills that are technology specific are presented in black shading, those skills common to two technologies are in orange shading, and those skills common to three technologies are in green shading.

There is evidence of a wide business skills overlap between AI, blockchain and automation. For instance, 'management' is required in 32 per cent of automation-related jobs, in 24 per cent of AI-related jobs, and in 22 per cent of blockchain-related jobs. 'Operations' is required in 25 per cent of automation-related jobs, in 16 per cent of AI-related jobs, and in 19 per cent of blockchain-related jobs.

Some business skills are common to AI and blockchain: for instance, 'marketing' appears in 9 per cent of job postings for each of these two fields. Several skills are technology specific, but generally less likely to be required by employers.

TABLE 5.3 BUSINESS SKILLS BY EMERGING TECHNOLOGY AREA

Automation		AI		Blockchain	
Skill	**Frequency**	**Skill**	**Frequency**	**Skill**	**Frequency**
Management	0.32	Management	0.24	Management	0.22
Operations	0.25	Customer service	0.16	Project management	0.19
Project management	0.25	Sales	0.16	Operations	0.19
Customer service	0.13	Operations	0.16	Sales	0.11
Sales	0.08	Project management	0.12	Marketing	0.09
Process improvement	0.06	Marketing	0.09	Customer service	0.08
Procurement	0.06	Business development	0.08	Customer relationship management	0.08
Training and development	0.05	Business intelligence	0.07	Workflow management	0.08
Time management	0.05	Product management	0.06	Stakeholder management	0.07
Change management	0.04	Workflow management	0.06	Business development	0.07

Source: 2021 Lightcast data for Ireland (authors' analysis).
Notes: The dataset contains 13,412 automation-related job postings; 12,525 AI-related job postings; and 1,591 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

5.3 SKILL REQUIREMENTS FROM LINKEDIN DATA

The same methodology for analysing skill requirements for emerging technology jobs is applied to our bespoke scraped LinkedIn dataset. We extract the relative frequency of skills appearing across all the job postings, and rank them from the most common to the least common skill required per each emerging technology area. We then map the skills into technical, business and transversal skills and also explore the degree of overlap between recruitment areas. Again, skills that are technology specific are presented in black shading, those skills common to two technologies are in orange shading, and those skills common to three technologies are in green shading. Unlike Lightcast data, LinkedIn job postings also provide data on the seniority level being sought by employers (i.e., entry, mid-senior or senior):

we can exploit this information and analyse skill requirements for emerging technology jobs by seniority level. One drawback of this is that the analysis for blockchain jobs at entry level, and all emerging technologies at the most senior levels, relies on a smaller number of observations – 19 for entry-level blockchain jobs; 17 for automation at senior level; 27 for AI at senior level; and 15 for blockchain at senior level.

5.3.1 Technical skills by seniority

Entry-, mid-senior- and senior-level technical skill requirements for automation, AI and blockchain are presented in Tables 5.4, 5.5 and 5.6, respectively. Technical skills appear to be highly demanded across all seniority levels and are mostly technology specific (black shading), particularly for entry-level positions. Specific skills appear required across all seniority levels (i.e., 'machine learning' for AI jobs and 'cryptocurrency' for blockchain jobs), while some skills are required for entry- and mid-senior-level jobs (i.e., 'test automation' for automation jobs). At mid-senior level, there is some skills overlap across all the technology jobs (green shading), while at senior level we find some overlap across two emerging technology areas (orange shading).

TABLE 5.4 TECHNICAL SKILLS BY EMERGING TECHNOLOGY AREA – ENTRY LEVEL

Automation N=254		AI N=146		Blockchain N=19	
Skills	**Frequency**	**Skills**	**Frequency**	**Skills**	**Frequency**
Test automation	0.24	Machine learning	0.49	Web 3.0	0.47
Systems engineering	0.19	Computer science	0.34	Javascript (programming language)	0.37
Pharmaceuticals	0.18	Python (programming language)	0.32	Scalability	0.32
Programmable logic controllers	0.15	SQL (programming language)	0.16	Ethereum	0.32
Good manufacturing practices	0.15	Data science	0.16	Cryptocurrency	0.26
Test planning	0.15	Data analysis	0.15	Cryptography	0.26
Continuous improvement process	0.13	Algorithms	0.14	Financial services	0.26
Agile methodology	0.13	Mathematics	0.14	Internet of Things (IoT)	0.21
Computer science	0.13	Software development	0.13	Typescript	0.21
Change control	0.12	Agile methodology	0.13	Software engineering	0.21

Source: LinkedIn data sample (authors' analysis).
Notes: At entry level, the dataset contains 254 automation-related job postings; 146 AI-related job postings; 19 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

TABLE 5.5 TECHNICAL SKILLS BY EMERGING TECHNOLOGY AREA – MID-SENIOR LEVEL

Automation N=599		AI N=309		Blockchain N=233	
Skills	**Frequency**	**Skills**	**Frequency**	**Skills**	**Frequency**
Test automation	0.27	Machine learning	0.48	Cryptocurrency	0.45
Systems engineering	0.25	Python (programming language)	0.39	Finance	0.42
Pharmaceuticals	0.23	Computer science	0.33	non-fungible tokens (NFT)	0.36
Agile methodology	0.19	Data science	0.23	Financial services	0.33
Computer science	0.19	Software engineering	0.23	Web 3.0	0.22
Programmable logic controllers	0.17	Agile methodology	0.22	Binance	0.21
Less	0.14	Amazon web services	0.19	Financial technology (fintech)	0.21
Application programming interface (API)	0.13	Data analysis	0.17	Computer science	0.18
SQL (programming language)	0.12	Algorithms	0.16	Scalability	0.18
Selenium (software)	0.12	c++ (programming language)	0.16	Agile methodology	0.16

Source: LinkedIn data sample (authors' analysis).

Notes: At mid-senior level, the dataset contains 599 automation-related job postings; 309 AI-related job postings; and 233 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

TABLE 5.6 TECHNICAL SKILLS BY EMERGING TECHNOLOGY AREA – SENIOR LEVEL

Automation N=17		AI N=27		Blockchain N=15	
Skill	**Frequency**	**Skill**	**Frequency**	**Skill**	**Frequency**
Finance	0.41	Machine learning	0.37	Cryptocurrency	0.60
Lean manufacturing	0.29	Scalability	0.37	Financial services	0.60
Pharmaceuticals	0.29	Mathematics	0.22	Financial technology (fintech)	0.47
Environment health and safety	0.24	Computer science	0.22	Non-fungible tokens (NFT)	0.33
Information privacy	0.24	Data analysis	0.22	Finance	0.33
Data analysis	0.24	Software engineering	0.19	Digital assets	0.33
Root cause analysis	0.18	Physics	0.19	Accounting	0.27
Product quality (QA/QC)	0.18	Algorithms	0.19	Computer science	0.27
Loan-to-value ratios	0.18	UI/UX writing	0.15	Information privacy	0.20
Supply chain optimization	0.18	Surveys	0.15	International financial reporting standards	0.20

Source: LinkedIn data sample (authors' analysis).
Notes: At senior level, the dataset has a low number of observations across technology areas: 17 automation-related job postings; 27 AI-related job postings; and 15 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

5.3.2 Transversal skills by seniority

Entry-, mid-senior- and senior-level transversal skill requirements for automation, AI and blockchain are presented in Tables 5.7, 5.8 and 5.9, respectively. The high demand for transversal skills occurs to an equal degree across all seniority levels for each emerging technology area ('communication', 'problem solving' and 'leadership'). There is a high degree of overlap in requirements across emerging technology areas for each seniority level (orange shading for skills common to two technologies, green shading for skills common to three technologies), as well as for some technology-specific skills (black shading).

TABLE 5.7 TRANSVERSAL SKILLS BY EMERGING TECHNOLOGY AREA – ENTRY LEVEL

Automation N=254		AI N=146		Blockchain N=19	
Skill	**Frequency**	**Skill**	**Frequency**	**Skill**	**Frequency**
Communications	0.44	Innovation	0.53	Communications	0.58
Innovation	0.33	Communications	0.42	Problem solving	0.37
Problem solving	0.32	Research	0.35	Transferable skills analysis	0.32
Planning	0.19	Detail oriented	0.25	Research	0.32
Leadership	0.15	Problem solving	0.18	Enthusiasm	0.21
Detail oriented	0.14	Writing	0.14	Curiosity	0.21
Teamwork	0.14	Leadership	0.13	Prioritisation	0.16
Troubleshooting (problem solving)	0.11	Teamwork	0.12	Writing	0.16
Self-motivation	0.10	Computer literacy	0.09	Interpersonal communications	0.16
Presentations	0.08	Self-motivation	0.08	Collaboration	0.16

Source: LinkedIn data sample (authors' analysis).
Notes: At entry level, the dataset contains 254 automation-related job postings; 146 AI-related job postings; and 19 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

TABLE 5.8 TRANSVERSAL SKILLS BY EMERGING TECHNOLOGY AREA – MID-SENIOR LEVEL

Automation N=599		AI N=309		Blockchain N=233	
Skill	**Frequency**	**Skill**	**Frequency**	**Skill**	**Frequency**
Communications	0.41	Innovation	0.59	Communications	0.56
Innovation	0.29	Communications	0.56	Innovation	0.30
Problem solving	0.25	Leadership	0.27	Problem solving	0.24
Leadership	0.22	Problem solving	0.25	Self-motivation	0.23
Planning	0.15	Research	0.22	Detail oriented	0.21
Detail oriented	0.11	Self-motivation	0.14	Leadership	0.19
Troubleshooting (problem solving)	0.11	Mentorship	0.13	Research	0.17
self-motivation	0.11	Planning	0.12	Planning	0.13
Mentorship	0.09	Writing	0.11	Interpersonal communications	0.10
Teamwork	0.07	Influencing skills	0.10	Writing	0.10

Source: *LinkedIn data sample (authors' analysis).*

Notes: At mid-senior level, the dataset contains 599 automation-related job postings; 309 AI-related job postings; and 233 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

TABLE 5.9 TRANSVERSAL SKILLS BY EMERGING TECHNOLOGY AREA – SENIOR LEVEL

Automation N=17		AI N=27		Blockchain N=15	
Skills	**Frequency**	**Skills**	**Frequency**	**Skills**	**Frequency**
Communications	0.76	Innovation	0.56	Leadership	0.80
Problem solving	0.53	Communications	0.52	Communications	0.67
Innovation	0.47	Research	0.33	Problem solving	0.47
Leadership	0.41	Leadership	0.30	Interpersonal communications	0.33
Planning	0.35	Problem solving	0.26	Innovation	0.33
Customer service	0.24	Decision making	0.19	Decision making	0.27
Influencing skills	0.18	Thought leadership	0.15	Writing	0.20
Strong work ethic	0.18	Teamwork	0.15	Detail oriented	0.20
Negotiation	0.18	Student engagement	0.15	Analytical skills	0.20
Mentorship	0.18	Interpersonal communications	0.15	Negotiation	0.13

Source: *LinkedIn data sample (authors' analysis).*
Notes: At senior level, the dataset has a low number of observations across technology areas: 17 automation-related job postings; 27 AI-related job postings; and 15 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

5.3.3 Business skills by seniority

Entry-, mid-senior- and senior-level business skill requirements for automation, AI and blockchain are presented in Tables 5.10, 5.11 and 5.12, respectively. Similar business skills are required at each seniority level per technology area (i.e., 'operations', 'management') but they appear to be more strongly required for senior-level job postings. There is a high degree of overlap between automation, AI and blockchain jobs across all seniority levels (orange shading for skills common to two technologies, green shading for skills common to three technologies), as well as some technology-specific skills (black shading).

TABLE 5.10 BUSINESS SKILLS BY EMERGING TECHNOLOGY AREA – ENTRY LEVEL

Automation N=254		AI N=146		Blockchain N=19	
Skills	**Frequency**	**Skills**	**Frequency**	**Skills**	**Frequency**
Operations	0.28	Management	0.22	Marketing	0.26
Management	0.23	Operations	0.18	Operations	0.21
Project management	0.16	Customer service	0.14	Management	0.16
Process improvement	0.10	Training and development	0.11	Project management	0.16
Customer service	0.10	Key performance indicators (kpis)	0.10	Sales process	0.16
Quality management systems	0.09	Employee assistance programs	0.09	Sales	0.16
Quality assurance	0.06	Marketing	0.07	Marketing management	0.11
Standard operating procedure	0.06	Sales	0.07	Process improvement	0.11
Quality management	0.06	Time management	0.06	Time management	0.11
Process validation	0.05	Project management	0.05	Lead management	0.11

Source: *LinkedIn data sample (authors' analysis).*

Notes: At entry level, the dataset contains 254 automation-related job postings; 146 AI-related job postings; and 19 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

TABLE 5.11 BUSINESS SKILLS BY EMERGING TECHNOLOGY AREA – MID-SENIOR LEVEL

Automation N=599		AI N=309		Blockchain N=233	
Skills	**Frequency**	**Skills**	**Frequency**	**Skills**	**Frequency**
Management	0.30	Management	0.22	Management	0.32
Operations	0.25	Operations	0.18	Operations	0.32
Project management	0.23	Project management	0.12	Project management	0.20
Process improvement	0.11	Marketing	0.12	Marketing	0.15
New product development	0.09	New product development	0.08	Governance	0.13
Customer service	0.07	Process improvement	0.07	Customer support	0.12
Quality assurance	0.07	Sales	0.07	New product development	0.10
Continuous improvement process	0.06	Time management	0.05	Sales	0.09
Sales	0.06	Business process	0.04	Product management	0.09
Quality management systems	0.04	Governance	0.04	Stakeholder management	0.07

Source: LinkedIn data sample (authors' analysis).

Notes: At mid-senior level, the dataset contains 599 automation-related job postings; 309 AI-related job postings; and 233 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

TABLE 5.12 BUSINESS SKILLS BY EMERGING TECHNOLOGY AREA – SENIOR LEVEL

Automation N=17		AI N=27		Blockchain N=15	
Skills	**Frequency**	**Skills**	**Frequency**	**Skills**	**Frequency**
Operations management	0.59	Project management	0.37	Project management	0.33
Key performance indicators (KPIs)	0.53	Operations	0.26	Management	0.33
Process improvement	0.35	Marketing	0.22	Sales	0.2
New product development	0.29	Sales	0.22	Revenue growth	0.2
Project management	0.24	Management	0.22	Operations	0.2
Performance measurement	0.24	New product development	0.19	Customer service	0.2
Operational excellence	0.24	Customer support	0.19	Sales strategy	0.13
Marketing	0.24	Business development	0.19	Stakeholder management	0.13
Product management	0.24	Product management	0.15	Selling techniques	0.13
		Service-level agreement	0.11	Marketing	0.13

Source: LinkedIn data sample (authors' analysis).

Notes: At senior level, the dataset has a low number of observations across technology areas: 17 automation-related job postings; 27 AI-related job postings; and 15 blockchain-related job postings. We present the skills that are technology-specific in black, those skills common to two technologies in orange, and those skills common to three technologies in green.

CHAPTER 6

Forecasting demand and supply – Results

6.1 DEMAND FORECASTS

6.1.1 Estimating the proportions of emerging technology jobs

As outlined in Section 3.4.1.1, we employed Lightcast data to extract the total number of jobs advertised in 2021 for each International Standard Classification of Occupations (ISCO) category identified as most relevant for each emerging technology. We then estimated the proportion of jobs within each ISCO category for each emerging technology. We show our estimation results for automation in Table 6.1; for artificial intelligence (AI) in Table 6.2; and for blockchain in Table 6.3.

TABLE 6.1 AUTOMATION JOBS BY ISCO CATEGORY

ISCO code	ISCO occupation	Total job advertisements by occupation	Automation jobs in ISCO category	Proportion of automation jobs in each ISCO
21	Science and engineering professionals	95,750	5,719	5.97%
31	Science and engineering associate professionals	43,719	1,372	3.14%
25	Information and communications technology (ICT) professionals	53,440	921	1.72%
74	Electrical and electronic trades workers	30,999	862	2.78%
12	Administrative and commercial managers	65,015	686	1.06%
24	Business and administration professionals	108,904	446	0.41%
71	Building and related trades workers, excluding electricians	16,821	433	2.57%
13	Production and specialised services managers	30,187	322	1.07%
	Other occupations	509,325	2,599	0.51%

Source: Lightcast data (2021).

TABLE 6.2 AI JOBS BY ISCO CATEGORY

ISCO code	ISCO occupation	Total job advertisements by occupation	AI jobs in ISCO category	Proportion of AI Jobs in each ISCO
25	ICT professionals	53,440	4,080	7.63%
21	Science and engineering professionals	95,750	1,497	1.56%
24	Business and administration professionals	108,904	1,445	1.33%
12	Administrative and commercial managers	65,015	939	1.44%
26	Legal, social and cultural professionals	38,068	612	1.61%
31	Science and engineering associate professionals	43,719	396	0.91%
74	Electrical and electronic trades workers	30,999	359	1.16%
42	Customer services clerks	35,236	320	0.91%
33	Business and administration associate professionals	78,780	311	0.39%
81	Stationary plant and machine operators	24,785	294	1.19%
	Other occupations	379,464	2,275	0.60%

Source: Lightcast data (2021).

TABLE 6.3 BLOCKCHAIN JOBS BY ISCO CATEGORY

ISCO code	ISCO occupation	Total job advertisements by occupation	Blockchain jobs in ISCO category	Proportion of blockchain jobs in each ISCO
25	ICT professionals	53,440	517	0.97%
24	Business and administration professionals	108,904	195	0.18%
21	Science and engineering professionals	95,750	163	0.17%
12	Administrative and commercial managers	65,015	154	0.24%
26	Legal, social and cultural professionals	38,068	100	0.26%
13	Production and specialised services managers	30,187	51	0.17%
74	Electrical and electronic trades workers	30,999	43	0.14%
81	Stationary plant and machine operators	24,785	34	0.14%
	Other occupations	507,012	288	0.06%

Source: Lightcast data (2021).

6.1.2 Cedefop's occupational forecasts

We extracted Cedefop's occupational forecasts (annual growth rates and absolute numbers) for all the ISCO categories where emerging technology jobs are prevalent. Table 6.4 provides Cedefop's occupational forecasts over 2021–2025, and 2025–2030 for the eight ISCO categories where automation jobs are most prevalent. Table 6.5 provides Cedefop's occupational forecasts over 2021–2025, and 2025–2030 for the ten ISCO categories where AI jobs are most prevalent. Table 6.6 provides Cedefop's occupational forecasts over 2021–2025, and 2025–2030 for the eight ISCO categories where blockchain jobs are most prevalent. Recall that

'other occupations' includes all ISCO two-digit occupations, which accounted for 20 per cent of job advertisements within each emerging technology area, and projections refer to these occupations.

TABLE 6.4 CEDEFOP'S OCCUPATIONAL FORECASTS FOR AUTOMATION-RELATED OCCUPATIONS (2021–2025 AND 2025–2030)

	Automation occupations	Forecast 2021–2025		Forecast 2025–2030	
ISCO code	ISCO occupations	Forecast Cedefop annual %	Forecast Cedefop absolute numbers = total demand	Forecast Cedefop annual %	Forecast Cedefop absolute numbers = total demand
21	Science and engineering professionals	2.50%	9,798	0.60%	3,372
31	Science and engineering associate professionals	4.30%	7,526	2.90%	7,415
25	ICT professional	2.70%	9,215	2.50%	11,979
74	Electrical and electronic trades workers	4.30%	6,866	1.90%	4,358
12	Administrative and commercial managers	4.60%	9,046	3.20%	9,353
24	Business and administration professionals	3.00%	18,877	2.00%	17,699
71	Building and related trades workers, excluding electricians	4.70%	14,963	2.60%	12,381
13	Production and specialised services managers	4.10%	14,964	2.70%	14,361
	Other occupations	2.00%	149,341	1.10%	113,204

Sources: Cedefop; Irish Labour Force Survey (IFS, author's analysis).
Note: ISCO-13 and ISCO-25 projections have been revised using Irish Labour Force Survey data.

TABLE 6.5 CEDEFOP'S OCCUPATIONAL FORECASTS FOR AI-RELATED OCCUPATIONS (2021–2025 AND 2025–2030).

	AI Occupations	Forecast 2021–2025		Forecast 2025–2030	
ISCO code	ISCO occupations	Forecast Cedefop annual %	Forecast Cedefop absolute numbers = total demand	Forecast Cedefop annual %	Forecast Cedefop absolute numbers = total demand
25	ICT professionals	2.70%	9,215	2.50%	11,979
21	Science and engineering professionals	2.50%	9,798	0.60%	3,372
24	Business and administration professionals	3.00%	18,877	2.00%	17,699
12	Administrative and commercial managers	4.60%	9,046	3.20%	9,353
26	Legal, social and cultural professionals	2.00%	4,355	1.40%	4,105
31	Science and engineering associate professionals	4.30%	7,526	2.90%	7,415
74	Electrical and electronic trades workers	4.30%	6,866	1.90%	4,358
42	Customer services clerks	2.30%	5,654	1.30%	4,364
33	Business and administration associate professionals	2.40%	13,384	1.40%	10,680
81	Stationary plant and machine operators	5.00%	5,064	5.00%	5,064
	Other occupations	2.20%	148,010	1.20%	113,065

Sources: Cedefop; Irish Labour Force Survey (author's analysis).
Note: ISCO-25 projections have been revised using Irish Labour Force Survey data.

TABLE 6.6 CEDEFOP'S OCCUPATIONAL FORECASTS FOR BLOCKCHAIN-RELATED OCCUPATIONS (2021–2025 AND 2025–2030)

	Blockchain occupations	Forecast 2021–2025		Forecast 2025–2030	
ISCO code	ISCO occupations	Forecast Cedefop annual %	Forecast Cedefop absolute numbers = total demand	Forecast Cedefop annual %	Forecast Cedefop absolute numbers = total demand
25	ICT professionals	2.70%	9,215	2.50%	11,979
24	Business and administration professionals	3.00%	18,877	2.00%	17,699
21	Science and engineering professionals	2.50%	9,798	0.60%	3,372
12	Administrative and commercial managers	4.60%	9,046	3.20%	9,353
26	Legal, social and cultural professionals	2.00%	4,355	1.40%	4,105
13	Production and specialised services managers	4.10%	14,964	2.70%	14,361
74	Electrical and electronic trades workers	4.30%	6,866	1.90%	4,358
81	Stationary plant and machine operators	5.00%	5,064	3.30%	4,981
	Other occupations	2.20%	162,411	1.20%	123,914

Source: Cedefop; Irish Labour Force Survey (author's analysis).
Note: ISCO-13 and ISCO-25 projections have been revised using Irish Labour Force Survey data.

6.1.3 Demand forecast results

In order to produce our demand forecast for emerging technology jobs in Ireland over the short to medium horizon, the percentage of automation/AI/blockchain jobs in each ISCO category (see Tables 6.1, 6.2 and 6.3) was applied to the Cedefop occupational forecasts at a two-digit ISCO level (see Tables 6.4, 6.5 and 6.6). We summed across all ISCO categories to get the total number of forecasted jobs for each emerging technology, over 2021–2025 and 2025–2030. Based on previous research, we assume that 40 per cent of labour demand forecasts will be eligible for new graduates, with 60 per cent of these jobs related to more senior/experienced professionals (McGuinness et al., 2022; 2023b). Tables 6.7, 6.8 and 6.9 show the calculations' results for automation, AI and blockchain, respectively.

TABLE 6.7 DEMAND FORECAST FOR AUTOMATION-RELATED OCCUPATIONS

Automation occupations		Forecast 2021–2025		Forecast 2025–2030	
ISCO code	**ISCO occupations**	**Total demand (Cedefop forecasts)**	**Automation demand**	**Total demand (Cedefop forecasts)**	**Automation demand**
21	Science and engineering professionals	9,798	585	3,372	201
31	Science and engineering associate professionals	7,526	236	7,415	233
25	ICT professionals	9,215	159	11,979	206
74	Electrical and electronic trades workers	6,866	191	4,358	121
12	Administrative and commercial managers	9,046	95	9,353	99
24	Business and administration professionals	18,877	77	17,699	72
71	Building and related trades workers, excluding electricians	14,963	385	12,381	319
13	Production and specialised services managers	14,964	160	14,361	153
	Other occupations	149,341	762	113,204	578
	Total demand		**2,651**		**1,405**
	Graduate demand (~40%)		**1,060**		**562**

Source: ESRI's calculation of Cedefop skills forecasts data and 2021 Lightcast data.

TABLE 6.8 DEMAND FORECAST FOR AI-RELATED OCCUPATIONS

AI occupations		Forecast 2021–2025		Forecast 2025–2030	
ISCO code	ISCO occupation	Total demand (Cedefop forecasts)	AI demand	Total demand (Cedefop forecasts)	AI demand
25	ICT professionals	9,215	704	11,979	915
21	Science and engineering professionals	9,798	153	3,372	53
24	Business and administration professionals	18,877	250	17,699	235
12	Administrative and commercial managers	9,046	131	9,353	135
26	Legal, social and cultural professionals	4,355	70	4,105	66
31	Science and engineering associate professionals	7,526	68	7,415	67
74	Electrical and electronic trades workers	6,866	80	4,358	50
42	Customer services clerks	5,654	51	4,364	40
33	Business and administration associate professionals	13,384	53	10,680	42
81	Stationary plant and machine operators	5,064	60	5,064	60
	Other occupations	14,8010	887	113,065	678
	Total demand		**2,507**		**2,341**
	Graduate demand (~40%)		**1,003**		**936**

Source: ESRI's calculation of Cedefop skills forecasts data and 2021 Lightcast data.

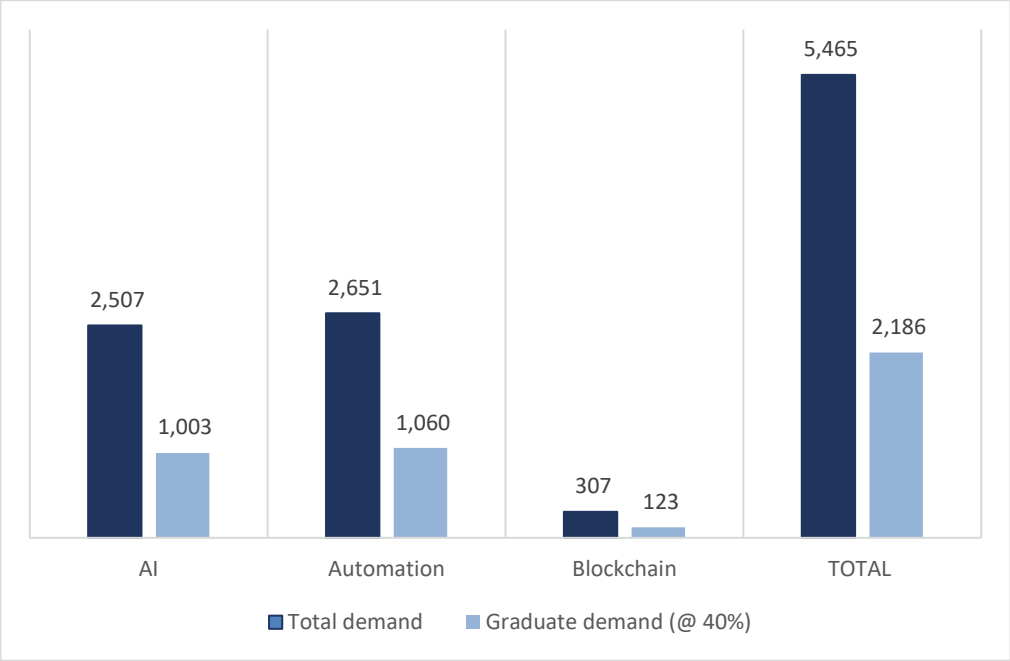
TABLE 6.9 DEMAND FORECAST FOR BLOCKCHAIN-RELATED OCCUPATIONS

	Blockchain occupations	Forecast 2021–2025		Forecast 2025–2030	
ISCO code	ISCO occupations	Total Demand (Cedefop forecasts)	Blockchain demand	Total demand (Cedefop forecasts)	Blockchain demand
25	ICT professionals	9,215	89	11,979	116
24	Business and administration professionals	18,877	34	17,699	32
21	Science and engineering professionals	9,798	17	3,372	6
12	Administrative and commercial managers	9,046	21	9,353	22
26	Legal, social and cultural professionals	4,355	11	4,105	11
13	Production and specialised services managers	14,964	25	14,361	24
74	Electrical and electronic trades workers	6,866	10	4,358	6
81	Stationary plant and machine operators	5,064	7	4,981	7
	Other occupations	16,2411	93	123,914	71
	Total demand		**307**		**294**
	Graduate demand (~40%)		**123**		**118**

Source: ESRI's calculation of Cedefop skills forecasts data and 2021 Lightcast data.

Figure 6.1 presents our occupational forecasts at an aggregated level for AI, automation and blockchain for 2021–2025. At graduate level, 1,003 jobs are projected in AI-related occupations; 1,060 jobs in automation-related occupations; and 123 jobs in blockchain occupations. The overall demand for emerging technology jobs at graduate level is forecast to be 2,186.

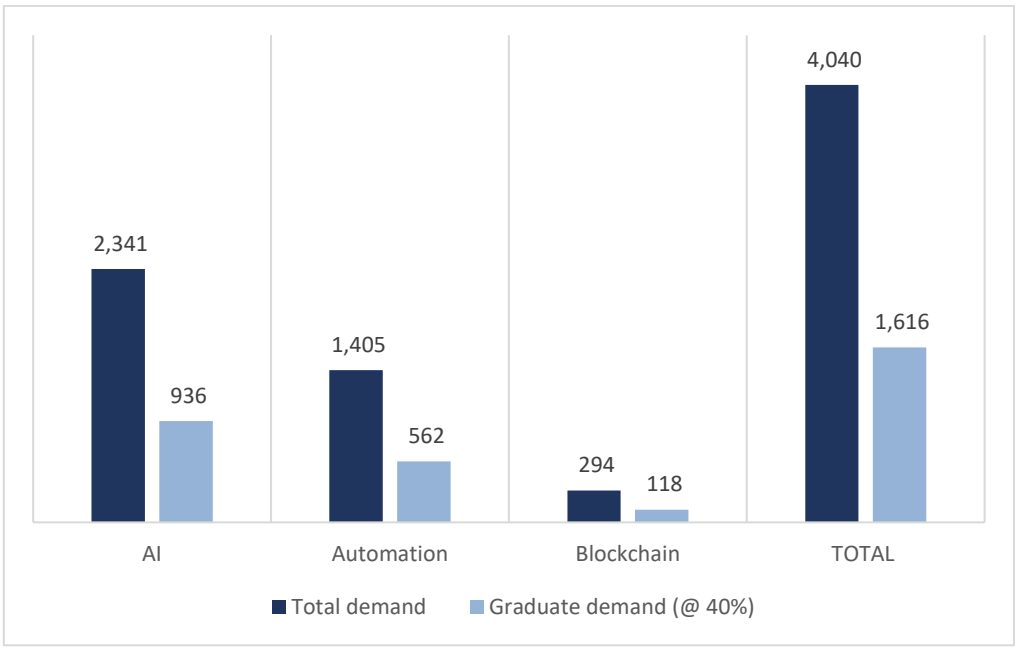
FIGURE 6.1 DEMAND FORECASTS, 2021–2025



Source: ESRI's calculation of Cedefop skills forecasts data and 2021 Lightcast data.

Figure 6.2 shows the occupational forecasts for 2025–2030 at an aggregated level for AI, automation and blockchain. At graduate level, 936 jobs in AI-related occupations are projected, as are 562 jobs in automation-related occupations and 118 jobs in blockchain-related occupations. The overall demand for emerging technology jobs at graduate level is forecast to be 1,616.

FIGURE 6.2 DEMAND FORECASTS, 2025–2030



Source: ESRI's calculation of Cedefop skills forecasts data and 2021 Lightcast data.

Interestingly, the emerging technology jobs demand forecasts are lower for 2025–2030 and for 2021–2025. This is due to lower Cedefop skills forecasts for our selected relevant ISCO occupations in 2025–2030, compared to 2021–2025. For long-term projections, Cedefop (2023) employs data from the European Commission's *The 2021 ageing report*. According to the European Commission study, the working-age population in the EU has been declining since 2011 and is projected to decline continuously until 2070. Furthermore, total employment in the EU increased permanently from 2011 to 2019, before dropping and then recovering from the COVID-19 crisis. Most significantly for our forecasts, total EU employment is projected to decline permanently from 2024, together with the EU working age population.[31]

6.2 SUPPLY FORECAST

Forecasts of graduates in AI, automation and blockchain courses for Ireland for 2021–2025 and 2025–2030 are presented in Table 6.10. Graduate forecasts are based on an average of the number of graduates from 2020 to 2021 presented earlier in Table 3.16 (Section 3.5.2). We assume the supply will remain constant over the years, and the forecast constitutes a lower bound estimate for future number of graduates. The average is multiplied by four for the forecast period 2021–2025, and by five for the forecast period 2025–2030.[32]

TABLE 6.10 SUPPLY FORECAST RESULTS

	Forecast 2021–2025	Forecast 2025–2030
AI	1,492	1,865
Automation	1,480	1,850
Blockchain	80	100
Total	3,052	3,815

Source: ESRI's calculations based on data from the Higher Education Authority (HEA), SOLAS and Quality and Qualifications Ireland (QQI).

6.3 COMPARISON OF DEMAND AND SUPPLY FORECASTS

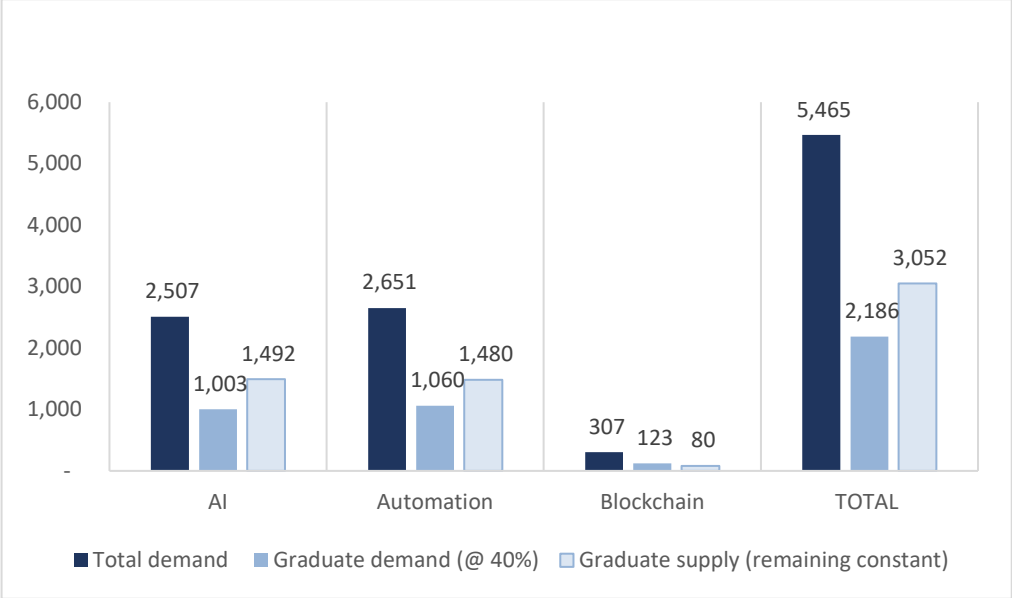
By comparing demand and supply forecasts for emerging technology jobs for the period 2021–2025, the results show that, on aggregate, for AI and automation jobs, graduate supply appears to satisfy graduate demand, over the short- to medium-

31 For additional information, see paragraph 2.1. 'Projected demographic and macroeconomic developments' and Figure 3 of *The 2021 ageing report* (European Commission).

32 The key objective of our analysis is to benchmark levels of labour demand and supply generated by the third level education sector in Ireland, in order to assess the adequacy of the educational supply provision in emerging technology areas. However, it is important to note that supply level can be impacted by both inward and outward migration. These factors lie outside the research agreement for the current study.

term horizon. For blockchain jobs, there is some evidence of over-demand, but the overall number of jobs forecasted is low. Results are presented in Figure 6.3.

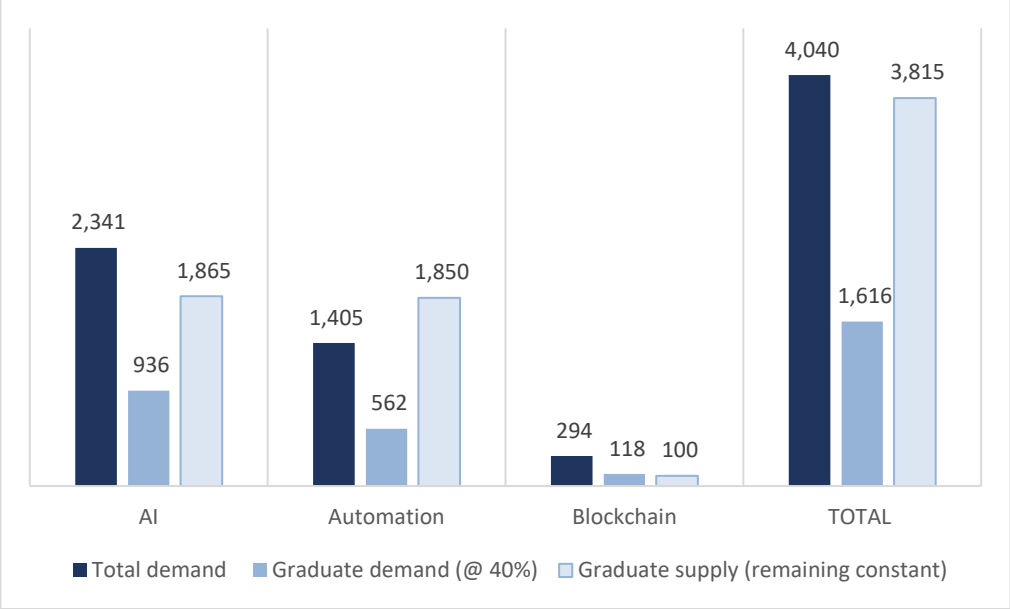
FIGURE 6.3 DEMAND AND SUPPLY FORECASTS, 2021–2025



Source: ESRI's calculation of Cedefop skills forecasts data, 2021 Lightcast data, HEA data, non-HEA data, SOLAS's FET data, QQI data.

Over the period 2025–2030, for AI and automation jobs, the forecast supply at graduate level is expected to exceed the demand forecast (Figure 6.4). This comes as a consequence of Cedefop's occupational forecasts for 2025–2030, which are projected to be lower than for the period 2021–2025: as previously explained, Cedefop's long-term projections assume that from 2024, both employment and working age population will decline over the latter period.

FIGURE 6.4 DEMAND AND SUPPLY FORECAST, 2025–2030



Source: ESRI's calculation of Cedefop skills forecasts data, 2021 Lightcast data, HEA data, non-HEA data, SOLAS's FET data, QQI data.

CHAPTER 7

Emerging technology employers' perceptions

7.1 INTRODUCTION

As part of the research process for this study, we organised a consultation workshop during January 2024 with emerging technology employers. In total, 15 stakeholders were consulted as part of the qualitative study. The stakeholders were chosen to capture a range of emerging technology employers in the fields of artificial intelligence (AI), automation and blockchain. Companies advertising a high number of emerging technology related vacancies on job portals were asked to participate. Our aim was to further investigate this subject, validate our findings and collect important qualitative data for the research in a focus group setting. Representatives and hiring managers from the major tech and consultancy firms were in attendance.[33]

The consultation followed a structured format: first, the Economic and Social Research Institute (ESRI) presented the key findings from this research, after which a list of questions and topics were provided to the employers to guide our discussion, which was moderated by ESRI researchers. The focus groups explored a range of themes including: labour shortages in emerging technologies; skills requirements (current and future employees) for key emerging technologies; education and skill development support; demand and supply forecasts for key emerging technologies; and perceived future changes within industries and organisations.

Systematic analysis of these data led to the identification of both common and diverging views across these main themes. The perspectives highlighted here are not quantitatively representative, but seek to provide an overall qualitative picture of the major issues, as identified by those participants. To preserve anonymity, no individuals or organisations are identified in the analysis. The responses and views of participants were transcribed by ESRI representatives, a summary of which is provided here for each topic discussed.

7.2 FORECASTS AND LABOUR SHORTAGES IN EMERGING TECHNOLOGIES

While the employer representatives were generally happy with the forecast levels of demand, they felt there is a significant possibility that levels of employment in

[33] Invitations were also extended to relevant small and medium enterprises. However, unfortunately, we did not receive any positive responses to our requests to attend. This is potentially due to scarce resources for small and medium enterprises, which may have made it more difficult for them to attend and engage.

AI will rise much more rapidly than predicted in the coming years. It was felt that we are entering a decade of disruptive technologies and that the labour market implications of this are going to be very difficult to predict. The employers generally felt that it is very difficult to accurately identify potential future shortages, due to uncertainty around technological developments at the present moment. Today's jobs landscape may not accurately reflect the jobs landscape of ten years' time. This suggest it is important that, on a general level, employees are able to adapt to change and to show resilience.

The employers emphasised the value of both transversal skills and work experience. They also highlighted that in-house training currently plays an important role in overcoming this skills shortage. They frequently cited that entry-level, highly educated employees required retraining in this regard, and attributed substantial value to work experience. The employers also referred to a recent demand for a new, interdisciplinary technical skillset as opposed to 'hard coders'. They stated that the ability to apply and interpret existing AI tools may be more important than developmental skills, and that, due to gaps in current training and education programmes, the latter might be in short supply.

Respondents were consistently of the view that changes in the level of technology adoption, particularly in AI, would require substantial upskilling and reskilling of workers across all aspects of the labour market. Specifically, they believed that an expected large share of the existing workforce will need to develop more advanced digital skills/literacy and experience in using new technology as it is developed and adopted within firms. It was felt that there is a need for policy to focus on this wider workforce challenge, rather than solely on what universities are doing and, specifically, the number of specialist graduates qualifying each year.

Respondents, in particular, pointed out that a substantial amount of legal requirements will accompany the adoption of new technologies, and that firms need to be prepared for this. Furthermore, a multitude of ethical, governance and data protection challenges are likely to arise, which will create the need for skills development within organisations across a range of areas, including critical thinking and problem solving. Participants expressed the view that Ireland is well positioned to be at the forefront of developing the skills necessary to deal with the ethical and problem-solving issues that future AI will require.

7.3 FUTURE SKILL REQUIREMENTS

There was a wide-ranging discussion on the future skill needs resulting from emerging technologies. Those identified include improved technical skills among graduates from specialist courses in emerging technologies, as well as increased technical competencies among graduates from non-technical fields. In relation to the latter point, there was support among discussants for a more multidisciplinary

approach to education, which might involve all courses having a greater representation of AI and cloud computing, as well as general business skills. It was also perceived that a lack of technical components in non-technical degrees represents a particular constraint. It was stated that there is a need for more emphasis on business process management components within courses that teach students how to adapt new technologies into a business environment. In summary, key skills that were highlighted throughout this discussion included: cybersecurity skills; cloud skills; data analysis; transversal skills ('soft skills'); business capabilities; and AI skills.

Work placement programmes were seen as vital for improving and enhancing graduate employability, by equipping them with practical experience of working in a business environment. Respondents felt that more training courses should include work placement opportunities for students. A number of examples of good practice were cited by respondents, including the bachelor/master of science in immersive software engineering at the University of Limerick and the bachelor of science computer science programme with a year in industry at Queens University Belfast, which has a dedicated team tasked with finding suitable placements for over 500 students annually. The Technological University of Dublin Tallaght was also cited as having a successful work-orientated computer science department. More generally, there is a need for stronger institutions and systems linking universities with businesses. One of the respondents suggested that entry-level employees in the post-COVID era appear to experience greater difficulties in adapting to the workplace environment. It was stated by another respondent that smaller technical colleges/universities are really good at developing courses that prepare students for the world of work. It was also felt that certificate and diploma courses can, at times, be more suitable to employer needs than longer duration degree courses. Throughout, the employers noted the risk of poaching in the current labour market, whereby companies taking on training costs and investing in current employees run the risk of employees moving to another company

Finally, there was agreement on the need for a greater focus on science, technology, maths and engineering (STEM) within primary and second-level schools, which were perceived as 'weak spots' in non-tertiary components of the Irish education system. Employers stated that foundational competencies in STEM subjects were generally lacking in the Irish labour market when compared to other economies. It was expressed that this lack of basic skills within the Irish labour market has led to a smaller Irish workforce pool and requires employers of emerging technology skills to recruit from the international workforce pool.

7.4 EDUCATION AND SKILLS DEVELOPMENT SUPPORT

The focus of this point of the discussion centred around the importance of, and need for, micro-credentials. Within degree programmes, micro-credentials allow

students to diversify their knowledge. They are considered to be a valuable tool for fostering lifelong learning and upskilling, and they can be concentrated in a relatively short time period. From the companies' perspective, micro-credentials are a platform that allows educational and training bodies to adapt quickly to the changing requirements of industry. Generally, it was felt that support and understanding from non-traditional courses and training is lacking, particularly in terms of fitting within the Irish National Framework of Qualifications. Higher education institutions (HEIs) need to be faster and more agile in adapting to change, whether this occurs at module level or involves developing a complete micro-credential. Again, participants expressed the belief that small HEIs tend to be more flexible in responding to the changing needs of employers. The fact that many professional qualifications and micro-credentials are not always offered under the Quality and Qualifications Ireland (QQI) accreditation framework was seen as a challenge. The lack of this recognition seriously disadvantages both employees and employers, and can result in qualified workers migrating to countries where their qualifications are recognised.

There was a consensus view that careers advisory services are not equipped to provide students with the career and qualification options that are within AI, automation and blockchain fields. The promotion and use of 'hackathons' were seen to be a particularly effective way of encouraging young people to consider a career in an emerging technology area. Perceived advantages of hackathons include the way they demonstrate a blend of teamworking and applied technical skills. Through them, prospective workers can demonstrate their full range of abilities in a commercial environment to potential employers. A more interdisciplinary use of hackathons was proposed, alongside the suggestion of renaming this type of event, as 'hackathon' implies they are restricted to the computer programming sphere.

Fundamentally, the education system should provide workers with critical skills and foundational technical skills (for example, general coding competencies in Python). Furthermore, the employers affirmed the need for industry and education institutions to collaborate more closely to smooth the transition from education to employment. The employers gave several examples of instances where industry and education worked closely, including the Technological University of Dublin Tallaght Dublin (Tallaght) and Skillnet at the University of Limerick.

7.5 PERCEIVED FUTURE CHANGES WITHIN INDUSTRIES AND ORGANISATIONS

Participants stressed that policy needs to be developed to enable change to be implemented at a country level, across a whole range of dimensions related to emerging technologies. Participants emphasised that a substantial number of both legal and ethical/privacy requirements will arise following new legislation at EU

level, alongside the adoption of new technologies, and that firms need to be prepared for this. Specific mention was made of the upcoming European Artificial Intelligence Act, the first regulation on AI, which will set out a range of mandatory obligations on employers.

The increases in regulatory requirements will require organisations to scale up their capabilities and will drive the demand for people who can implement change within organisations and interact with the regulators. Furthermore, the application of the new regulations will require changes in the skill sets of everyone working in the impacted fields. Regulatory changes will drive the demand for legal professionals within firms.

Infrastructural constraints may ultimately hamper the pace of widespread diffusion of AI and other emerging technologies, especially in the public sector. Furthermore, the importance of public perception, social attitudes and trust will continue to play a key role in the adoption of AI into daily life.

The last point of the discussion centred around the importance of achieving a greater gender balance in the field of emerging technologies. Participants stressed the importance of an inclusive language in job advertisements, in order to foster gender inclusivity within industries and occupations.

CHAPTER 8

Conclusion

New technological developments have the potential to substantially raise productivity levels within the labour market. It is therefore important that education and training policy is proactive in equipping students and workers to take full advantage of technological progress. However, the development and adoption rate of technological change is such that conventional approaches to skills anticipation, based on historical administrative and survey data, are no longer fit for purpose. As a consequence, we have seen a rapid increase in the use of contemporaneous data approaches, such as those that utilise job advertisements data, in order to provide more timely indications of the evolving nature of technologically driven labour demand.

This research involved the development of a methodological framework that enabled us to identify relevant areas of emerging technology for the Irish labour market, in order to assess the current nature and composition of labour demand for these technologies, including the incidence of a potential skill shortage occurring. Our focus is on automation-, artificial intelligence (AI)- and blockchain-related jobs. AI and automation were identified as areas of emerging technology with the greatest employment implications for Ireland, and both are aligned with the most immediate skill development policy of the Department of Further and Higher Education, Research Innovation and Science (DFHERIS).[34] Blockchain is also included to extend the analysis and build upon prior Economic and Social Research Institute (ESRI) related research.[35] In addition to forecasting the demand and supply for workers in each respective area in Ireland over the next few years, we also examine the competencies currently being requested by employers across the dimensions of technical, business and transversal skills. Our analysis separates out the demand components for new labour market entrants, which is of particular value to education and training providers in determining both the required number of course places and course content.

We analyse an in-house bespoke LinkedIn scraped sample of job advertisements related to automation, AI and blockchain in Ireland that incorporates information on both job posting duration and number of applicants. A measure of *potential skill shortage* is derived to identify vacancies that are potentially 'hard to fill' – with substantially higher-than-average durations and a substantially lower-than-average number of applications. We found that most of the vacancies appear to be

[34] For further information, see: https://www.gov.ie/en/publication/69fd2-irelands-national-skills-strategy-2025-irelands-future/.

[35] Blockchain was previously examined by the ESRI team as part of the CHAISE project (European Commission Erasmus+), for Ireland relative to all European countries. See McGuinness et al. (2022, 2023b, 2024).

filled relatively quickly, and there is no evidence that the incidence of potential skill shortages is higher in any of the emerging technology areas. However, where recruitment difficulties do exist, they are more common in automation posts, particularly for entry-level positions.

This research also aims to inform policymakers in the education fields, and to bridge the gap between employer expectations regarding the skills of graduates, and their actual skill profiles, in the context of a fast-changing and technologically driven labour market. Therefore, we analysed job advertisements data from Lightcast to carry out an in-depth analysis of the key skills most commonly required by employers in the emerging technology areas under study. Our detailed analysis demonstrates that while employers place much emphasis on technical competencies, there is a significant demand for workers to also be equipped with transversal and business skills. The demand for transversal competencies is particularly high for jobs in automation. With respect to technical competencies, there is a good deal of overlap in the employer requirements for AI and blockchain, while the technical requirements for automation jobs tend to be more specific. There is a very high degree of overlap in the transversal and business competencies required by employers across the three emerging technology areas. The most in-demand business skills are common to AI, automation and blockchain. In the analysis, we provide a detailed breakdown of the specific skill requirements for emerging technology jobs from Lightcast data, and a further disaggregation of competencies by level of seniority (entry-level, mid-senior, senior) within our in-house scraped LinkedIn sample.

We mapped automation, AI and blockchain jobs to the International Standard Classification of Occupations (ISCO) system, using Lightcast data to provide demand and supply forecasts for these three job categories by employing Cedefop occupational forecasts. Our labour market forecasting exercise for the medium-term horizon confirmed that the labour market demand for new entrants in automation, AI and blockchain is currently being met by supply projections.

The key objective of our analysis is to benchmark levels of labour demand and supply generated by the third level education sector in Ireland, in order to assess the adequacy of the educational supply provision in emerging technology areas. However, it is important to note that supply level can be impacted by both inward and outward migration. These factors lie outside the research agreement for the current study.

An important aspect of the study was our consultation workshop with employers in emerging technology areas. This both provided validation for our results while also highlighting risk factors and developments that have high importance from a policy perspective. Employers highlighted that the labour market requirements arising from the forthcoming regulatory environment, such as the European

Artificial Intelligence Act, are likely to be substantial. Participants stressed that policy needs to be prepared to assist organisations to implement change that will occur at a national level across a whole range of dimensions related to AI. The increases in regulatory requirements will oblige organisations to scale up their capabilities and will drive the demand for people who can implement change within organisations and interact with the regulators. Furthermore, the application of the new regulations will require changes in the skill sets of everyone that works in the impacted fields. While employers were happy with our methodological approach and forecasts, they stressed that high levels of uncertainty regarding the development and adoption of AI could result in levels of demand exceeding that predicted by our research: demand levels in these emerging technology areas can be somewhat volatile and reactive to external factors, and it should not be assumed that future employment growth is inevitable.

Finally, it is worth highlighting that a key value of the present research is its development of a methodological tool that is highly replicable. As such, it should be implemented periodically to monitor variations in technologically driven labour demand, so that policy can be fully informed of, and reactive to, changing labour market conditions.

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