



Addressing Ireland's Skills Gap: How Technology is Affecting the Labour Market

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Abstract

This thesis explores the impact of emerging technologies on Ireland's labour market and the widening skills gap, looking at technologies such as AI, Cloud, Cybersecurity, Quantum Computing and Business Intelligence. It examines Ireland's digital transformation journey, highlighting its evolution into a global tech hub. The review discusses historical contexts, reskilling initiatives, and policy implications, emphasising the need for proactive measures to address the skills gap. Recommendations are provided for accurately classifying high-tech SMEs as well as investigating educational opportunities aimed at enhancing advanced digital skills. Overall, the thesis underscores the importance of preparing Ireland's workforce for the challenges and opportunities presented by digital advances.

This thesis investigates the impact of emerging technologies, such as Artificial Intelligence (AI), Cloud Computing, Cybersecurity, and Quantum Computing, on Ireland's labour market and skills gap. It examines Ireland's digital transformation, which has positioned the country as a global technology hub, attracting substantial foreign direct investment from major tech giants. It critically evaluates existing reskilling initiatives and policy frameworks, identifying areas for improvement and proposing targeted interventions to enhance skill development efforts. The study underscores the importance of collaborative efforts between government, industry, and academia, and a commitment to lifelong learning to ensure Ireland's continued competitiveness in the global digital economy. Furthermore, the research discusses accurately classifying high-tech small and medium-sized enterprises (SMEs), an overlooked part of Ireland's economy, to further understand their challenges in the labour market. It also investigates strategies for education and training providers to focus on providing the digital skills needed, by developing more updated programs that align with the current and future demands of the labour market.

Resumen

Esta tesis explora el impacto de las tecnologías emergentes en el mercado laboral irlandés y la creciente brecha de competencias, analizando tecnologías como la IA, la nube, la ciberseguridad, la computación cuántica y la inteligencia empresarial. Examina el viaje de transformación digital de Irlanda, destacando su evolución hacia un centro tecnológico mundial. La revisión analiza los contextos históricos, las iniciativas de formación y las implicaciones políticas, haciendo hincapié en la necesidad de medidas proactivas para abordar la brecha de habilidades. Se ofrecen recomendaciones para clasificar con precisión las PYME de alta tecnología, así como para investigar las oportunidades educativas destinadas a mejorar las competencias digitales avanzadas. En general, la tesis subraya la importancia de preparar a la mano de obra irlandesa para los retos y oportunidades que presentan los avances digitales.

Esta tesis investiga el impacto de las tecnologías emergentes, como la Inteligencia Artificial (IA), la Computación en la Nube, la Ciberseguridad y la Computación Cuántica, en el mercado laboral y el déficit de cualificaciones de Irlanda. Examina la transformación digital de Irlanda, que ha posicionado al país como centro tecnológico mundial, atrayendo importantes inversiones extranjeras directas de los principales gigantes tecnológicos. En él se evalúan críticamente las iniciativas y los marcos políticos existentes en materia de reciclaje profesional, se identifican las áreas susceptibles de mejora y se proponen intervenciones específicas para potenciar los esfuerzos de desarrollo de la mano de obra. El estudio subraya la importancia de los esfuerzos de colaboración entre el gobierno, la industria y el mundo académico, y el compromiso con el aprendizaje permanente para garantizar la competitividad continuada de Irlanda en la economía digital global. Además, la investigación analiza la clasificación precisa de las pequeñas y medianas empresas (PYME) de alta tecnología, una parte ignorada de la economía irlandesa, para comprender mejor sus retos en el mercado laboral. También investiga estrategias para que los proveedores de educación y formación se centren en proporcionar las competencias digitales necesarias, desarrollando programas más actualizados que se ajusten a las demandas actuales y futuras del mercado laboral.

Keywords

Skills Gap, Artificial Intelligence, Quantum Technology, Cybersecurity, Soft Skills, High-tech, Strategy.

Palabras Claves

Déficit de cualificaciones, Inteligencia Artificial, Tecnología Cuántica, Ciberseguridad, Cualificaciones blandas, Alta tecnología, Estrategia.

Key Abbreviations

EU	European Union
FDI	Foreign Direct Investment
FET	Further Education and Training
HEA	Higher Education Authority
HEI	Higher Education Institution
ICT	Information and Communication Technology
MNC	Multinational Corporation
MOOCs	Massive Open Online Courses
OECD	Organisation for Economic Co-operation and Development
SME	Small and Medium sized Enterprise
WEF	World Economic Forum

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1. Introduction

1.1 Context for the Study

As new technologies such as Artificial Intelligence (AI), Cloud, Cyber and Quantum Computing continue to reshape industries worldwide, the demand for specific job skills is evolving. In this context, understanding the effects of these technological shifts on employment patterns and skill requirements is essential. This thesis aims to explore the impact of new technologies on employment, with a specific focus on Ireland. Despite its reputation as a digital hub and a magnet for foreign direct investment (FDI) from tech giants, Ireland faces significant challenges in ensuring that its workforce is equipped with the skills necessary to succeed in a changing economic landscape.

Moreover, this thesis looks at skills imbalances in the Irish economy, considering factors such as the mismatch between the skills demanded by employers and those supplied by the workforce. Through an analysis of recent statistics and data, including trends in technology adoption, digital infrastructure, and digital skills, it provides an understanding of the challenges and opportunities presented by Ireland's digital transformation. By examining the wide-ranging effects of new technology on employment and closely scrutinising how these technology advances influence the nature of job skills, this thesis aims to offer insights that can inform policymaking, industry initiatives, and educational strategies aimed at addressing Ireland's skills gap and ensuring its workforce remains competitive in the global economy.

1.2 Methodology

This study adopts a mixed-methods approach, using both qualitative and quantitative secondary data to investigate the impact of emerging technologies on employment and skill requirements in Ireland. The research will primarily rely on an extensive literature review, policy analysis, and comparative analysis. Research begins with a thorough literature review to identify key insights and trends in previous academic research and industry and government reports. Quantitative data analysis is used in assessing the current state of skills supply and demand in Ireland. Statistics from government agencies, international

organisations and industry reports will be used in evaluating skills shortages, employment patterns, and technology adoption rates across sectors. Comparative analysis will benchmark Ireland's performance against other leading European nations, providing a relative perspective on areas of strength and opportunities for improvement. Qualitative policy analysis will look into Ireland's existing workforce development strategies, educational initiatives, and national skills policies. This approach will enable a critical examination of the policy landscape, identifying potential gaps, misalignments, or areas for enhancement to better address emerging skills needs effectively. The analysis of different technology industries will offer real-world perspectives on how technological forces are influencing workforce dynamics and skills requirements. These qualitative insights from employers and workers will be used to back-up the quantitative data.

To conduct this research, the following sources will be used:

- Academic databases for peer-reviewed literature (Google Scholar)
- Government publications and statistical databases (CSO, Eurostat, OECD, EU Commission reports)
- Industry association reports (e.g., World Economic Forum, EY, Deloitte)
- Official policy documents (National Skills Strategy, AI Here for Good Strategy, Quantum 2030)
- Reliable news sources and market publications (Forbes, The Irish Times)

1.3 Statement of the Problem

The Future of Jobs Report 2023 indicates that by 2027, 43% of work tasks will be automated (World Economic Forum, 2023). This projection shows just how quickly new technologies are disrupting the job market, which inevitably leads to disruptions in employment patterns and skills required for future jobs. As automation continues across all industries, there are concerns about the implications for job stability and income inequality in the socio-economic landscape. As automation further widens the skills gap between employers and job seekers, we must look at our current education system and ask: How well are education and training providers and employers preparing employees for future

jobs? What can we do to ensure that employees of all ages are included in learning adequate digital skills, and keep up to date with technology trends in the job market? Looking at these questions, I explore different strategies in determining how to address the challenges of technological disruption on employment. This thesis will contribute to the discussion, examining the effects of advanced technology and new innovations on the labour market, and propose recommendations for further research into this topic.

1.4 Objectives of the Study

1.4.1 Investigate the impact of emerging technologies like AI, Cloud, Cyber and Quantum Computing on Ireland's labour market and the widening skills gap.

This objective is crucial as emerging technologies are rapidly reshaping industries worldwide, leading to significant changes in job roles and skill requirements. By examining the effects of these emerging technologies on employment and the growing skills gap in Ireland, the study aims to provide insights that can inform businesses, educational programs and national strategies. As mentioned in the literature review, technologies like AI and automation are expected to disrupt a substantial portion of job tasks around the world. Recognising the impact of emerging technologies is essential for ensuring Ireland's workforce remains competitive and prepared for the challenges and opportunities presented by technological advances.

1.4.2 Examine Ireland's digital transformation journey and its evolution into a global technology hub

Investigating Ireland's digital transformation journey is essential as the country has positioned itself as a leading technology hub, attracting substantial foreign direct investment (FDI) from tech giants. As highlighted in section 2.2, Ireland's favourable corporate tax rates, highly skilled workforce, and robust digital infrastructure have made it an attractive destination for multinational corporations (MNCs) in the tech sector. However, this rapid digitalisation has also exposed skills deficits, particularly in areas like cybersecurity and with using advanced digital skills. By examining Ireland's transformation into a global tech hub, the study can provide insights into the challenges and opportunities

presented by this evolution, informing strategies to address the skills gap and maintain Ireland's competitive advantage in the global digital economy.

1.4.3 Analyse the historical contexts, reskilling initiatives, and policy implications around addressing the skills gap in Ireland

Understanding the historical contexts, reskilling initiatives, and policy implications related to the skills gap is crucial for developing effective strategies to address this issue. As discussed in sections 2.4 and 2.5, Ireland has a long history of attracting FDI and being at the forefront of technological adoption, which has helped shape the economic position. Analysing these historical contexts can provide valuable insights into the causes of the skills gap and inform future national strategies. Additionally, by examining existing reskilling initiatives and policies, the study can identify areas for improvement and propose targeted approaches for Ireland.

1.4.4 Provide recommendations for accurately classifying high-tech SMEs and investigating educational opportunities aimed at enhancing advanced digital skills

Small and medium-sized enterprises (SMEs), particularly those in high-tech sectors, play a vital role in driving economic progress and innovation in Ireland. As discussed in Chapter III, accurately classifying high-tech SMEs is essential for understanding their workforce requirements and addressing the specific skills in demand. By providing recommendations on this classification, the study can inform targeted education and training policies that support the growth of these critical SMEs. Furthermore, the investigation of educational opportunities to enhance advanced digital skills is highly important, as the literature review highlights the need for educational institutions to adapt current programs to incorporate relevant digital skills. By exploring strategies for incorporating newer technologies into existing courses and developing customised programs, the study can contribute to equipping individuals with the knowledge and expertise required to thrive in a tech-driven world.

2. Literature Review

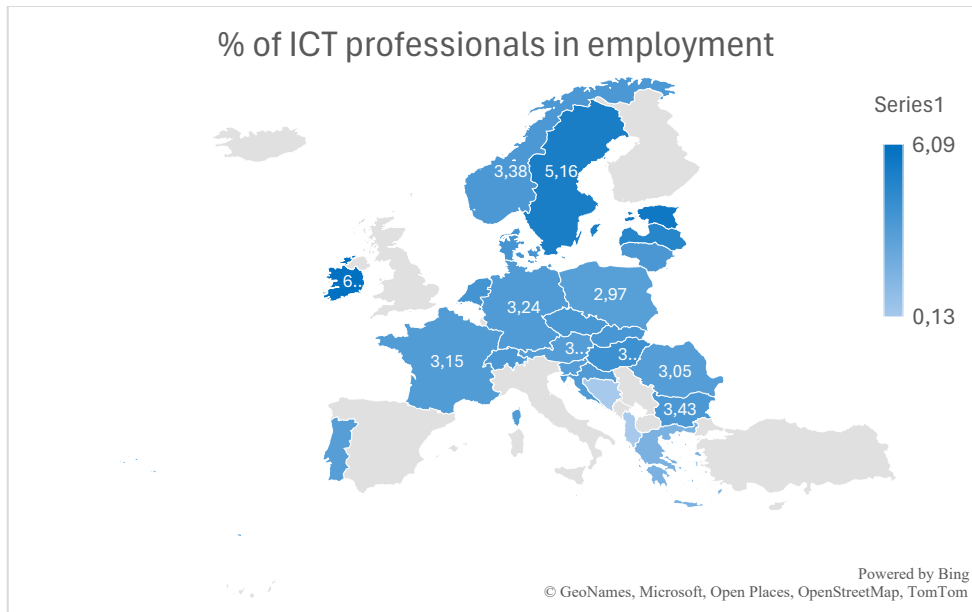
2.1 Background and Context

The rapid advancement of emerging technologies such as Artificial Intelligence (AI), Cloud Computing, Cybersecurity and Quantum Computing has brought with it a new era of innovation and disruption across various industries across Ireland. These technologies are reshaping job roles, creating both opportunities and challenges for individuals and organisations. Artificial Intelligence, for instance, has enabled the automation of tasks that were previously performed by humans, leading to concerns about job displacement and the need for upskilling and reskilling initiatives. This literature review aims to explore the impact of emerging technologies on the widening skills gap and the implications for education and future state of Ireland's workforce.

2.2 Digital Transformation in Ireland

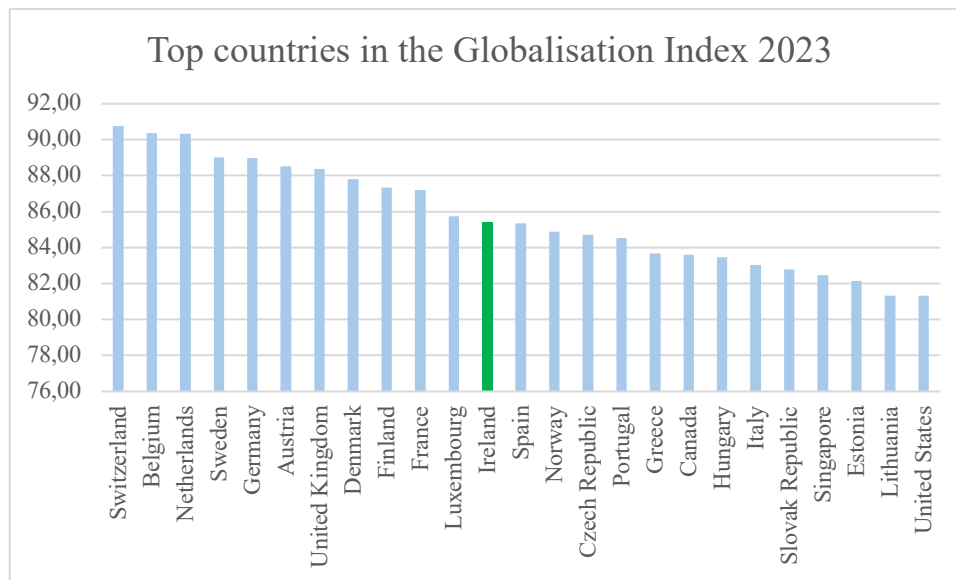
Ireland is seen as a digital hub not only in Europe, but in the world. Thanks to government support, investment incentives, low tax rates and a highly skilled workforce, Ireland has attracted foreign direct investment (FDI) from technology giants like Google, Meta, Apple, Intel and Microsoft (Ciara O'Brien, 2023). Ireland has the advantage of being one of the only English-speaking countries in the EU with Malta, since Brexit. Ireland's corporate tax rate is 12.5% which is significantly lower than the US corporate tax rate of 35%, making it attractive for multinational corporations (MNCs) seeking to enter the European market. Ireland's tech sector includes many industries such as IT manufacturing, software development, ICT services, and digital marketing. Google established its European headquarters in Dublin in 2003 and since then other major tech companies including Meta, X and LinkedIn, have followed. Ireland now has the highest percentage of ICT workers per total employment in Europe at 6.09%, and currently rank 12th on the index of the most globalised economies in the world (Figure 1; Figure 2).

Figure 1: Total percentage of population employed in ICT industries in the European Union in 2024



Source: Eurostat, Percentage of the ICT personnel on total employment [tin00085]

Figure 2: Top 25 countries in the Globalisation Index 2023



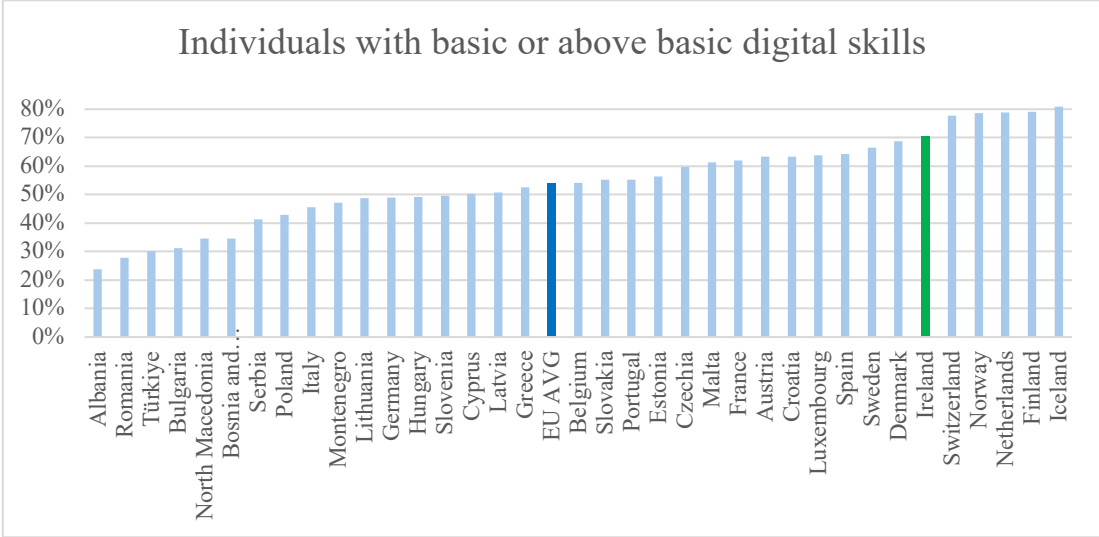
Source: Statista, 2022 KOF Index of Globalization (reconstructed 2024)

Strong digital infrastructure, mobile broadband and connectivity make Ireland a leading technology hub. Ireland is also heavily invested in cloud technology, currently there are 82

datacentres from large US enterprises such as AWS, Google Cloud and Microsoft. Ireland also offers a highly educated and highly skilled workforce that makes it attractive for foreign MNCs to locate themselves in Ireland.

The digital skills gap or the digital divide was used to describe the divide between those who could use computers and the internet efficiently and those who could not (van Dijk, 2006). This term has evolved as most of the population now have at least basic or above basic digital skills, with Ireland ranking 6th in Europe with over 70% of the population having basic or above basic digital skills (Figure 3). Now, governments and businesses are concerned about the level of advanced digital skills (ADS) possessed by the population as they experience a high-demand for ADS in workers in the country with a low-supply. According to research by Carlisle et al, businesses bridging the digital skills gap can support in-house digital innovation and increase employee productivity (Carlisle et al., 2021). While Erdogan agrees that employees with greater digital skills than the required level for their job, will be more productive, innovative and efficient, he mentions the risk of them leaving their job due to being overqualified (Erdogan et al., 2011)

Figure 3: Total percentage of population with basic or above basic level of digital skills in the European Union in 2024



Source: Eurostat, Individuals' level of digital skills (from 2021 onwards) [isoc_sk_dskl_i21\$defaultview]

2.3 Evidence of Skills Gap in Ireland

The Future of Growth 2024 report by the World Economic Forum (WEF) highlights the issue of the skills gap in Ireland. In their country dashboards section, when business leaders were asked “to what extent is the workforce proficient in technology skills?”, Ireland was marked 5 out of 7 for its digital and technology talent. Meanwhile, for the availability of talent in Ireland, it was marked a 4.6 out of 7 when asked to what extent can companies find people with the skills required to fill vacancies in the local labour market (World Economic Forum, 2024). This shows how although Ireland has a high-tech workforce, there remains room for improvement in meeting the demand for skilled professionals in Ireland.

Similarly, according to an EY report, 40% of Irish technology executives say that their organisations are currently planning on implementing a digital transformation or change programme. Improving company culture and strong cybersecurity and privacy are prominent priorities for change. Talent is also seen as a top issue, with over 27% of executives saying that the lack of skilled workers is a significant barrier to implementing their digital transformation. Additionally, over 38% of leaders expect to increase their IT capacity in their business (Walsh & Colin, 2024).

There is a shortage in workers across most technology-focused industries. For example, the cybersecurity industry is nearly 3 million workers short globally. This may have to do with there not being enough places on educational programmes compared with open positions. A study by Goupil et al. provides an example from the US, where it shows that over 60% of cybersecurity teams in the United States are understaffed, with over 50% of those applying to jobs in this field being underqualified for the roles. (Goupil et al., 2022). Although the field of cybersecurity is relatively new, compared to fields like artificial intelligence and quantum computing, it has been around for a while. Since we find it difficult to fulfil the labour demands in the cybersecurity sector, which has had more time to mature, how can we successfully meet the labour shortages in fast-developing fields like artificial intelligence and quantum computing? This question highlights the difficulties in predicting

and meeting the labour needs of developing technologies and emphasises the value of proactive approaches in workforce development and education. Ireland's cybersecurity market demand shows similar insights, with over 6,707 vacant job postings in 2022, which has tripled since 2019 (Cyber Ireland, 2023).

2.4 History of Ireland's Digital Transformation

As mentioned, since the 1980s we have seen an influx of tech giants moving to Ireland. This facilitated the Celtic Tiger which was a period of economic expansion in Ireland between 1995 and 2007 which resulted in its GDP growing 9.4% a year between 1995 and 2000, and total growth over 229% in the 30 year period between 1987 and 2007 (Peters, 2021). Before this period of unprecedented economic growth, Ireland had been among the poorest nations in Europe for more than 200 years. Many factors allowed for the Celtic Tiger boom such as low corporate taxes from the Irish government, low wages, a stable national economy, FDI and recent EU membership.

Since the global financial crash of 2007, Ireland has endured recessions as well as periods of economic growth from 2015-2020. The governments' agencies and policies continued in attracting FDI from foreign firms, particularly from the US. With the US economy booming, MNCs used FDI as a way to avoid high corporate taxes and a way into the European market. Research by Everett, states that countries with high rates of FDI can indirectly make the country more competitive. Local firms adopt similar technologies to those used by MNCs in order to compete with them domestically, which boosts productivity and efficiency across the country (Everett, 2006).

2.5 Technological Advances and Reskilling Initiatives

According to the World Economic Forum, by 2029, 23% of jobs will change due to industry transformation by technologies like Artificial Intelligence (World Economic Forum, 2023). In a follow up report, its mentioned that 44% of workers' core skills will be disrupted during that period, with cognitive problem-solving being the most important skill required followed by analytical thinking and technology literacy (Willige & Markovitz,

2023). Although workers with high tech skills are undoubtedly needed for future job roles, Chrisinger argues that there is now a focus for workers to have strong critical thinking abilities in addition to technical skills in order to properly understand and take advantage of human-machine interactions (Chrisinger, 2019). In his work, he argues that some of the most important skills for the 21st century are not solely tech-focused such as data analysts or cybersecurity specialists but are equipped with a strong level of soft skills to navigate the workplace.

Looking at data from the Future of Jobs Report 2023, by the World Economic Forum shows that often times employees looking to improve their skills have different priorities from those that businesses are looking for. In collaboration with Coursera, the WEF found that individuals have prioritised developing technical or “hard” skills associated with careers in programming and data analytics. But as mentioned above, with the emergence of technologies such as generative AI, employers are now placing a higher demand on “soft” skills (World Economic Forum, 2023). Analytical thinking is the most in-demand skill for businesses, accounting for 9% of the demand, followed closely by creative thinking. Similarly, cognitive skills such as resilience, flexibility, and agility are highly valued, highlighting the significance of both hard and soft skills for businesses globally (World Economic Forum, 2023).

David Autor argues that advances in technology have resulted in a nuanced relationship between technology and humans. In his study, Autor says that although automation of jobs for the most part substitutes jobs, in actual fact, it is a complementary process. He mentions that it is actually intended to take over routine tasks, allowing workers to spend their time on problems that require the comparative advantage of human workers such as problem-solving skills, adaptability, and creativity. (Autor, 2015). Similarly, Shi’s theory of skill matching can be considered when looking at the skills gap. His model is divided into four categories, focusing on the disparity between high-tech and low-tech firms, skilled and unskilled workers, highlighting how high-tech firms tend to hire more skilled workers (Shi, 2002). Due to the fact that IT reduces the organisational cost of communication and

supervision, workers are no longer focusing on routine and specialised tasks, but focus instead on a wide range of tasks within teams, solving key business issues (Sandulli et al., 2014). He argues that workers with higher educational levels have more high-tech skills which are more suited to the requirements of IT-intensive firms. The adoption of new technologies in the workforce will produce a worker-job mismatch. Companies search for workers with high-tech skills to be able to work with these new technologies. However, if workers do not have adequate training in the necessary digital skills, they face a huge disadvantage in their job search.

2.6 Educational Responses to Addressing the Skills Gap

The skills needed to be successful in the modern world have evolved, the gap between the skills learned in formal education and those required to function at work and in society. This gap in skills is a global issue that affects not only individuals, but also has implications for overall productivity and economic growth. According to figures from the European Commission, 37% of European workers lack even the most basic digital skills, let alone the more advanced and specialised skills that businesses require to successfully implement digital technologies (Digital Skills and Jobs Coalition Conference, 2017). To bridge this, educational institutions are looking to include newer technology skills in their programs which will boost levels of advanced digital skills.

Looking at a report from the Journal of European Industrial Training in 2003, we see that this issue has been felt in Ireland for over 20 years. During the height of the Celtic Tiger, policymakers were concerned with the low level of secondary level students entering technology-related jobs which could result in a shortage of workers in this industry (Eade, 2003). Ireland is a knowledge hub in Europe, with over 20% of jobs directly or indirectly coming from foreign direct investment with over 1,600 multinationals operating in Ireland employing 250,000 workers (Department of Enterprise, Trade and Employment, 2024). Although Ireland has improved the academic level of students entering technology-related jobs, the advances in newer technology present a risk to the skills required for the future of work.

Initiatives such as Massive Open Online Courses (MOOCs) and other online learning platforms have emerged to provide accessible avenues for acquiring on-demand technical skills. For example, platforms such as Coursera, LinkedIn Learning, edX and Khan Academy have become popular choices among both professionals and students looking to upskill on their digital knowledge. These courses can be accessed online and, more often than not, free of charge, offering certification upon completion. It levels the playing field by allowing anyone to improve their digital skills, regardless of their educational opportunities. MOOC students are proactively learning on their own to upskill to improve their employment opportunities (Conache et al., 2016).

2.7 Policy Initiatives and Future Directions

Addressing the skills gap requires a multifaceted approach involving collaboration between governments, educational institutions, and industry stakeholders. Under the Digital Skills and Jobs Platform, the European Union is investing over €500M into the further research on tackling this issue. LEADS is one project aimed at addressing the digital skills gap and fostering digital literacy across Europe. LEADS stands for ‘Leading Europe’s Advanced Digital Skills’, and it focuses on providing training and support to individuals seeking to improve their digital skills and enhance their employability in the digital economy (LEADS, 2023). By collaborating with various stakeholders, including educational institutions, industry partners, and EU officials, LEADS seeks to bridge the gap between the supply and demand for digital skills, enabling individuals to access new job opportunities and contribute to the digital transformation of society. Trinity College is a notable member, as well as universities in Spain, Denmark and the Netherlands. This initiative under the Digital Jobs and Skills Platform by the European Union shows that this is a prominent issue that is already under research alongside technological innovation.

Education is the driving force behind bridging the skills gap, providing people with the required skills needed to succeed in the workplace. As a result, governments are working with universities and technological institutions to provide a range of programmes. The Irish

government launched an initiative in 2018 called ‘Springboard+’, which boosts workers employment opportunities outside formal higher education by providing a range of programmes, qualifications and short courses. Springboard+ is co-funded by the Irish government and the European Union under the European Structural and Investment Fund Programme, and these courses can be free-of-charge for unemployed, previously self-employed and returners to the workforce. For others, 90% of the course fee is funded by the Government, requiring participants to cover just 10% of the course’s cost. (Department of Further and Higher Education, Research, Innovation and Science, 2018). To date, over €360m has been spent on Springboard+ and over 100,000 people have benefited from the programme. Springboard+ offers a great example of the initiatives already in place in the EU and how governments are tackling the issue of the skills gap.

Recently, the government announced more than 11,400 free or subsidised places on Springboard+ and Human Capital Initiative (HCI) Graduate Conversion Programmes. Graduate Conversion Programmes offer incentivised places for academic graduates to reskill in areas of skills shortage and emerging technologies. The courses are in areas such as cybersecurity, virtual reality, health innovation, logistics as well as climate, sustainability and energy, aligning with Ireland’s strategic priorities (Department of Further and Higher Education, Research, Innovation and Science, 2024).

The Digital Decade for 2030 acknowledges specific technology areas that the EU should promote further research and upskilling initiatives to leave Europe as a leader in human capital skills as well as technology innovation. Under the ‘Digital transformation to empower EU people and society’ section of the report, it highlights the goal of 80% of the European population (between 16-74) should have at the very least, basic digital skills. As well as employing 20 million ICT specialists in the EU. Criticism by economist Julia Anderson points out that the EU has set its targets too broad and existing strategies lack specificity in addressing the demands of the labour market. She mentions that while initiatives such as the European Skills Agenda and Digital Education Action Plan hold promise in addressing skill gaps, concerns persist regarding their efficacy in addressing

specific demands for advanced digital skills. She also emphasises the importance of tracking unmet employer demand and student needs to ensure targeted program development and implementation (Anderson, 2022).

2.8 Conclusion

In conclusion, the literature review emphasises the influence of upcoming technologies on the Irish labour market. New technologies are transforming industries and creating new job roles, requiring upskilling and reskilling for current workers. Ireland's rapid digital transformation, driven by government support and foreign direct investment, has positioned the country as a global technology hub, but it has also revealed a significant skills deficit, particularly in cybersecurity and more advanced digital skills.

The interaction of technology and job roles reveals that, while high-tech skills are necessary, complementary soft skills such as critical thinking and problem-solving are also important. This relationship emphasises the significance of human-centred skills in leveraging new technology. MOOCs, the Springboard+ programme, and the EU's Digital Skills and Jobs Platform are educational and policy responses to the skills gap, with the goal of improving digital literacy and technical skills. These initiatives offer accessible learning opportunities that are aligned with labour market demands. Continuous collaboration among governments, educational institutions, and industry stakeholders is required to effectively address the skills gap. Policy implications emphasise the need for targeted interventions that cater to high-tech sectors while also encouraging lifelong learning and professional development.

Overall, while Ireland has made significant strides as a digital leader, additional efforts are needed to close the skills gap and prepare the workforce for future technological challenges. This understanding highlights the importance of strategic planning and innovative solutions to maintain Ireland's competitive advantage in the global digital economy.

3. Chapter I

3.1 The Evolution of Employment through Industrial Revolutions

Historically, technological advances have played a pivotal role in shaping the evolution of employment and labour markets. These shifts in employment and in the nature of work have come to be known as industrial revolutions, defined by groundbreaking technological advances of their time. Starting with the First Industrial Revolution in the late 18th century, where steam power and mechanisation transformed manufacturing, societies shifted rapidly from agriculture to industry. In the early 1900s, 90% of the population worked in agriculture in rural areas in 1900, compared to the 10% who lived in smaller villages and towns. Factories emerged, leading to urbanisation as people moved to cities for work. The Second Industrial Revolution (Industry 2.0), driven by electricity and steel, further accelerated industrialisation and globalisation in the late 19th and early 20th centuries. Assembly-line production became widespread, as more and more people swapped agrarian work for urban factory work. Technological transformation was the main driving force in these such as Cort's rolling process for making iron, Crompton's mule for spinning cotton, and the Watt steam engine were invented (Mohajan, 2019). Due to the simplification of labour tasks brought about by advances in technology, workers' skills were replaced with those of supervision, regulation, and machine control.

With the introduction of personal computers by major corporations such as Apple, Dell, HP and IBM in the 1980s and the internet transforming information technology, the late 20th century saw the arrival of Industry 3.0, or the digital revolution. As businesses embraced new technologies and digital tools, job roles such as software developers, network administrators, and data analysts became more in demand, reflecting the growing importance of information technology in various industries. Additionally, the extensive accessibility of the internet promoted worldwide communication and cooperation, resulting in the creation of new employment prospects in industries like ICT, digital services and e-commerce. However, as a result of automation and digitalisation making some tasks

obsolete, Industry 3.0 also brought with it challenges like job displacement in traditional sectors like manufacturing and administrative support. Overall, as businesses and employees adapted to the new requirements, Industry 3.0 had an evolutionary effect on the labour market.

3.2 Industry 4.0 and 5.0: The Next Generations of Technological Revolutions

Today, Industry 4.0 builds upon the digital revolution of Industry 3.0 by integrating cyber-physical systems, automation, and data exchange in manufacturing. Industry 4.0 was the term coined by the German government which describes a set of technological changes in manufacturing enabling the creation of smart factories where machines, products, and systems communicate and collaborate with each other autonomously, and allowing for “workers [to] communicate with computers rather than operate them”, leading to more efficient production processes and improved decision-making for businesses (Tay et al., 2018). The concept was first introduced at the 2011 Hanover Fair in Germany with the widespread adoption of digital technologies in manufacturing. It continues to evolve as companies invest in advanced technologies using AI and robotics to enhance productivity and competitiveness (Rojko, 2017).

Industry 5.0 is still an emerging concept which represents a further evolution of manufacturing that emphasises the integration of human skills and capabilities alongside advanced technologies. Unlike Industry 4.0, which focuses primarily on automation and machine-to-machine communication (M2M), Industry 5.0 seeks to build complex and hyper-connected digital networks without compromising long-term safety and sustainability, balancing automation with human creativity (Coelho et al., 2023). This shift acknowledges the importance of human-centric approaches in manufacturing, such as customisation, craftsmanship, and personalisation, which are difficult for machines to replicate. Potential applications to come from Industry 5.0 could see intelligent healthcare, cloud manufacturing, supply chain management and manufacturing production. Additionally, it can support novel technologies such as edge computing, digital twins, advanced robotics, IoT, blockchain and future 6G networks (Maddikunta et al., 2022).

4. Chapter II

4.1. Ireland's Current Skills Strategy

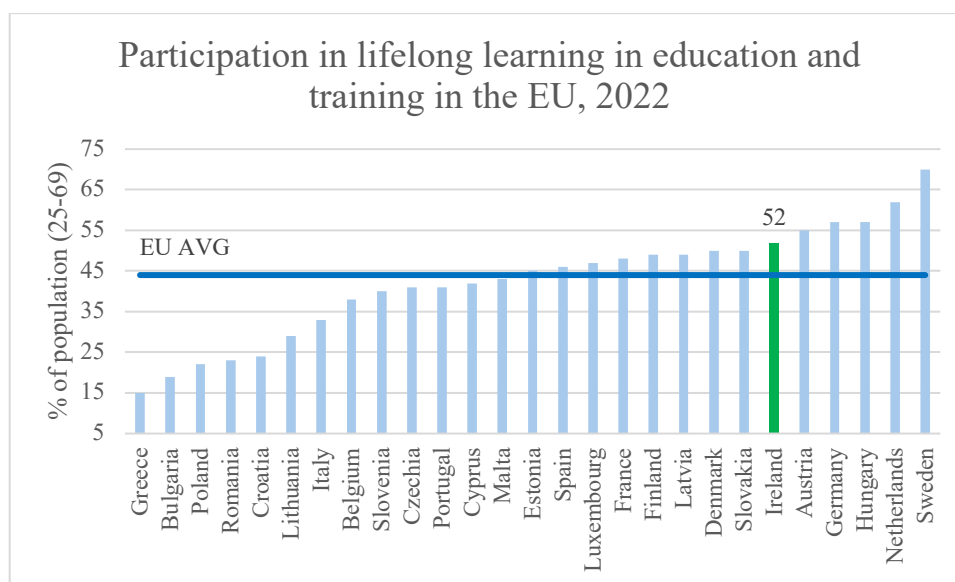
Ireland's National Skills Strategy (NSS) 2025 was introduced in 2016 with the aim to improve companies and individuals who are currently operating in Ireland, and those who plan to. Its vision is to improve people's lives, make Ireland a better place to live and to work in, to promote economic growth in Ireland (Department of Further and Higher Education, Research, Innovation and Science, 2016). The report mentions a quote from then-Taoiseach (Irish Prime Minister) Enda Kenny who said "*A job doesn't just mean an income. A job can transform a life. Give a person a role and a stake. A job offers the chance to make a contribution. It helps young people, in particular, find their own path in life and strike out to a new future*". The strategy's main goals are to improve skills development opportunities, increase employer participation and effective use of skills for greater productivity and competitiveness, continuously improve the quality of teaching and learning at all educational stages, promote lifelong learning across Ireland, and encourage active inclusion to support participation in education, training, and the labour market, thereby increasing the supply of skills. Although the strategy has been relatively successful, with a major increase in apprenticeships and training participation, the success of the strategy has been hindered by major political and economic events since 2016 such as Brexit, Covid-19 and Russia's war on Ukraine. Today, the country faces challenges such as labour market shortages, regional inequalities, surging house prices and recently, Ireland has been ranked the least productive workforce in the EU (Eoin Burke-Kennedy, 2024). Due to Russia's invasion of Ukraine, Ireland has taken in over 73,000 refugees, exacerbating a housing shortage, and with energy and food prices increasing these factors are affecting the real income of workers. The Covid-19 pandemic accelerated the digitisation of learning, allowing for more access to education and training courses. Due to these issues, the OECD Skills Strategy report has outlined relevant strategies to assist Ireland in reevaluating the NSS 2025 to make sure it is still fit for purpose (OECD, 2023).

4.2 OECD Skills Strategy Recommendations

4.2.1 Lifelong learning participation in Ireland

The OECD Skills Strategy Ireland report has highlighted four main concerns that Ireland is currently facing with its current NSS 2025 strategy. The report mentions Ireland that needs to increase participation in lifelong learning, to ensure that workers are actively engaged in improving their skillset. According to the European Union, lifelong learning is defined as an intentional search for knowledge throughout life, after the end of formal education. It is aimed at improving a person's skills and competences for personal or professional reasons (Eurostat Statistics Explained, 2023). Ireland ranks 6th in Europe for participation in lifelong learning at 52%, just above the EU average of 44% (Figure 4). However, it still lags behind top performing countries such as Sweden and the Netherlands, with 70% and 62% respectively (Central Statistics Office, 2024). Although lifelong learning opportunities in Ireland are generally perceived as being of high quality, participation in lifelong learning in Ireland is not as high as expected (OECD, 2023).

Figure 4: Total percentage of population aged 25-69 participating in lifelong learning in education and training in the European Union in 2022



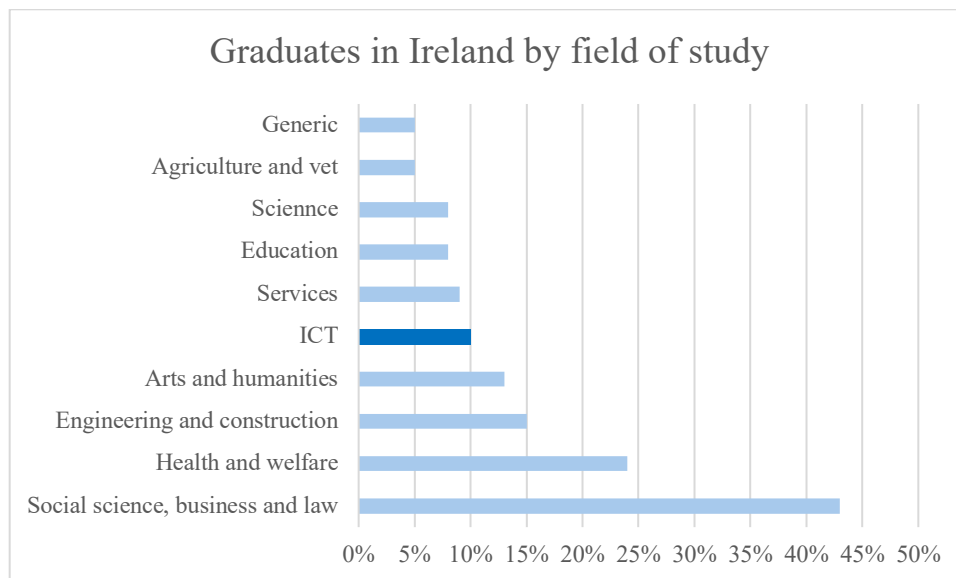
Source: CSO, 2022 | Percentage of persons aged 25-69 by their participation rate in lifelong learning in education and training in EU member states, 2022

4.2.2 Addressing the skills gap among adults

Another problem is that many adults do not have the skills to succeed in an increasingly complex and interconnected world. While many adults have tertiary education, they feel the skills they have do not adequately prepare them for the future of work (OECD, 2023). In 2022, 38% of 20-24 year olds in Ireland are currently participating in third level education, which is just above the EU average of 36%. Although this is relatively high in the EU, it could be improved upon compared to other EU nations such as Sweden and the Netherlands. Additionally, education and training providers must ensure that graduates feel prepared for the challenges of the workforce when leaving tertiary education, by identifying the top skills required for the future of work.

Over 141,000 students graduated from Ireland’s education system, including Higher Education Institutions(HEIs) and Further Education and Training (FET). Over 48% of those graduated studied social science, business, law, health and welfare, with only 10% studying ICT related courses (Daly & Condon, 2024) (Figure 5). A focus on boosting participation in more technological subjects is needed for Ireland’s next skills strategy.

Figure 5: Total percentage of students who graduated in 2022 by field in Ireland

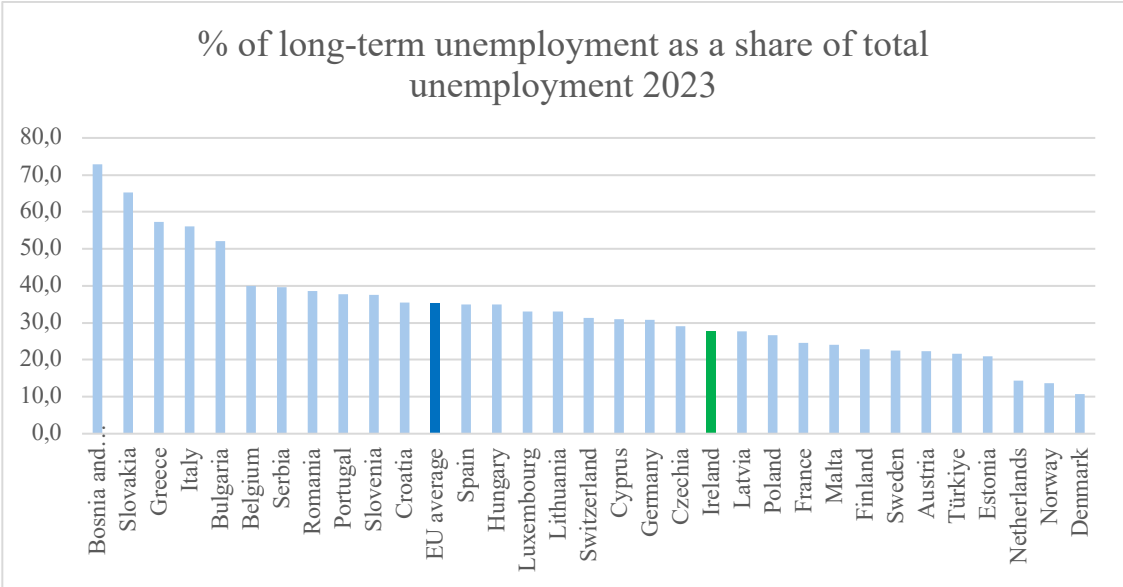


Source: SOLAS, data from HEA, QQI (FET & selected HE), SOLAS/ETBI, IAASA and Irish Tax Institute

4.2.3 Enhancing underutilised skills in the labour market

Ireland is facing the issue that the skills of some adults could be more fully activated in the labour market. The OECD report encourages Ireland to provide opportunities, encouragement and incentives to engage in reskilling initiatives for the country to gain full economic and social value from investing in developing digital skills. Although Ireland has high employment rates, with 70% of the labour market employed, almost 30% of those unemployed are long-term (unemployed for 12 months or more), which indicates a reliance on government support rather than them re-entering the workforce (Figure 6). To combat this, the government must include disadvantaged members of society to engage in their reskilling initiatives to ensure no groups are left behind and improve Ireland’s overall employment performance (OECD, 2023).

**Figure 6: Total percentage of long-term unemployment as a share of total unemployment
In the European Union in 2023**

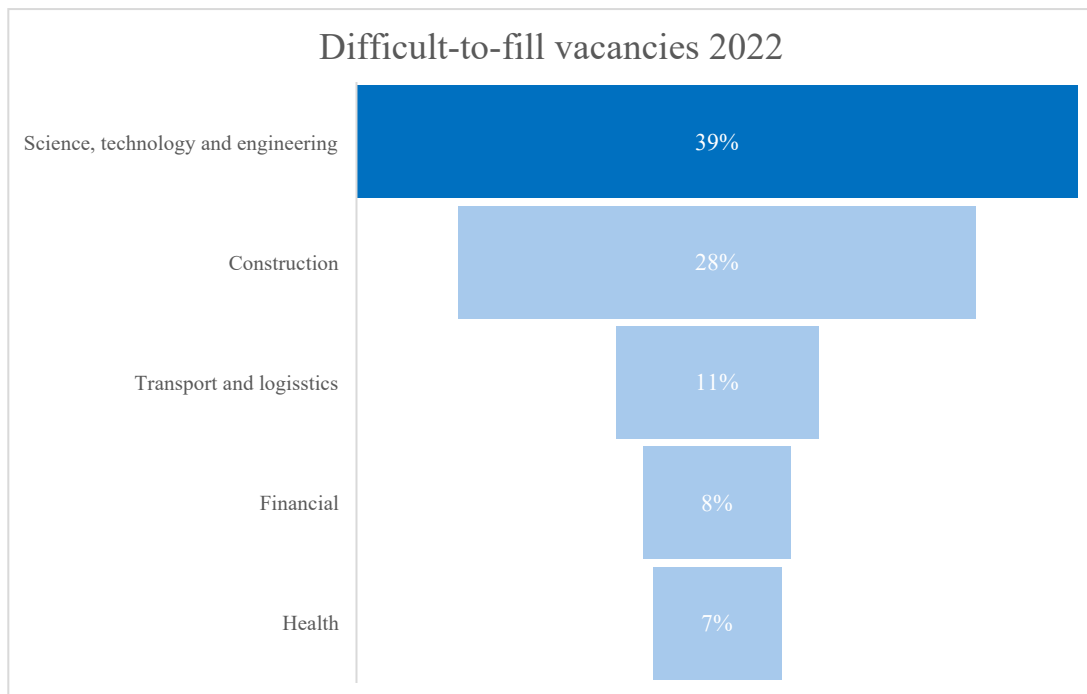


Source: Eurostat, Long-term unemployment (12 months or more) as a percentage of the total unemployment [(%
lfsq_upgal\$defaultview]

4.2.4 Addressing skill imbalances in Ireland

The final issue is that skill imbalances are relatively high in the Irish economy. The skill imbalance does not only refer to skill shortages in certain areas but also to skill mismatches, where workers skills exceed or fall short of the required skills for the job. This report shows that FDI is causing an increase in demand for workers, which is unmet by the Irish supply. Migration of workers into Ireland is something relied upon by MNCs, with over 34% of migrants granted permits working in ICT (OECD, 2023). According to SOLAS' difficult-to-fill vacancies 2022 report, due to hybrid and remote working becoming standard across the country since the pandemic, it has raised the importance of digital readiness for many businesses. A level of standard digital skills is now a minimum expectation across sectors such as science, engineering and logistics and becoming increasingly essential in industries where it was not necessary previously to have digital skills (SOLAS, 2022). More specifically in STEM-related sectors, businesses are struggling to fill vacancies across the country, according to 39% of Irish recruitment agencies (Figure 7).

Figure 7: Total percentage difficult-to-fill job vacancies in Ireland by field in 2022



Source: SOLAS, Difficult-to-fill vacancies survey, October 2022

4.2.5 Conclusion

Ireland's National Skills Strategy (NSS) 2025 has made significant progress in increasing apprenticeship and training participation, but it still faces significant challenges, exacerbated by events such as Brexit, COVID-19, and Russia's invasion of Ukraine. To improve the strategy's effectiveness, it is critical to increase participation in lifelong learning, with the goal of matching top European performers such as Sweden and the Netherlands. Addressing the skills gap among adults is critical, as it ensures they are better prepared for future job challenges by emphasising technological subjects in school. Furthermore, activating underutilised skills in the labour market through reskilling opportunities and incentives, particularly for disadvantaged groups, will maximise the economic and social value of digital skill development. Finally, addressing skill imbalances, including shortages and mismatches, is crucial. Promoting digital readiness across all sectors, particularly in STEM and ICT fields, will help businesses meet their demands and increase vacancy fill rates. These measures will keep Ireland's skills strategy relevant, effective, and beneficial to the country's economic growth and workforce development.

5. Chapter III

5.1 Differentiating High-Tech and Traditional SMEs in Europe

The distinction between high-tech and traditional SMEs has become increasingly important in recent years with the rise in new technology and tech startups in Ireland. High-tech SMEs are significant employers of new graduates, particularly those with qualifications in technical fields. Understanding the employment patterns within these SMEs provides insights into the career prospects for recent graduates and highlights the importance of equipping students with industry-relevant skills. 51% of SMEs in Ireland reported difficulties in recruiting staff with the necessary skillset with cyber security, financial

management, and marketing and sales identified as the top-needed skills for SME growth (Skillnet Ireland, 2024).

Ireland's National Digital Framework "Harnessing Digital" aims to position Ireland as an international economic leader and aims to increase adoption of digital technologies by SMEs in Ireland, highlighting the benefits of Ireland's digital transformation across productivity, innovation and competitiveness. The strategy aims to have at least 90% of Irish SMEs at a Basic Digital Intensity level by 2030 (Department of the Taoiseach, 2022).

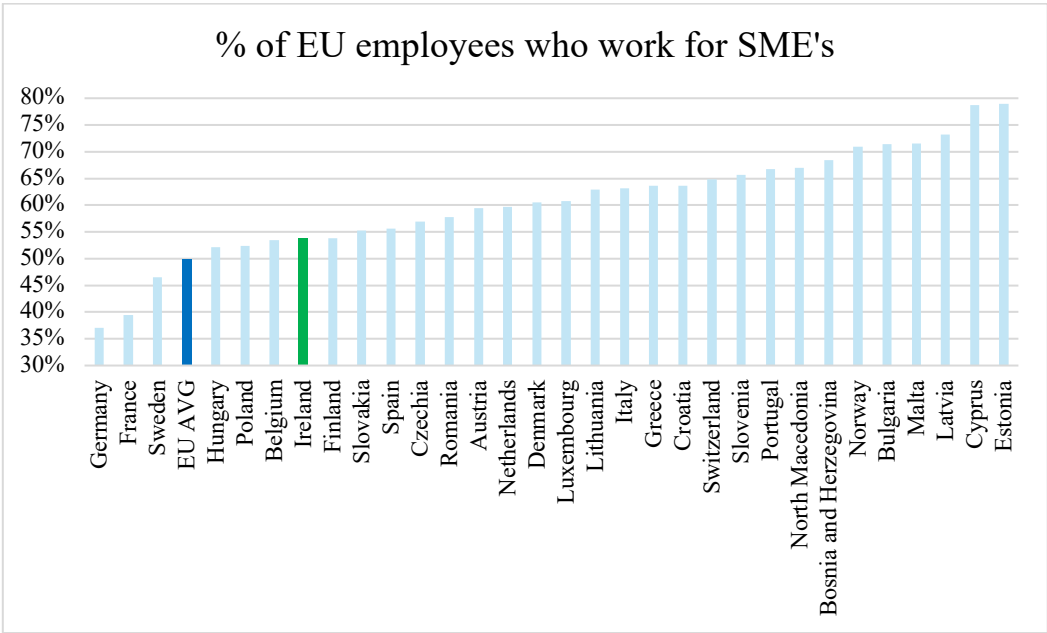
5.2 Importance of SMEs in Ireland

Enterprises qualify as SMEs if they employ less than 250 people and if their turnover is less than €50 million a year (Official Journal of the European Union, 2003). In Europe, there are about 23 million SMEs, with over 102 million employees, and employing around two-thirds of the workforce in the private sector (European Investment Bank, 2022). Ireland currently has over 309,000 SMEs which employ over 54% of the total workforce (Statista, 2024). SMEs play a vital role in driving economic progress and providing opportunities to local communities such as employment, entrepreneurship, competitiveness, regional development, and social impact. More specifically, Irish high-tech SMEs are concentrated in sectors such as ICT, pharmaceuticals, and advanced manufacturing. These sectors demand a highly skilled workforce capable of contributing to research and development, problem-solving, and the implementation of cutting-edge technologies. Compared with larger firms, new and small enterprises are often relatively vulnerable, reflecting more niche markets and more specialised suppliers (OECD SME & Entrepreneurship, 2023).

There have been efforts to define more technologically advanced SMEs as high-tech although the definition is often hard to come by. According to OECD industry classifications, enterprises that spend more than 4% of their annual turnover on R&D are considered to be high-tech, such as ICT or pharmaceutical companies (D'Auria, 2011). Similarly, The European Network for SME Research classifies enterprises as high-tech if

they are either: highly innovative, R&D intensive or are using sophisticated and complex production technologies (Gliga & Evers, 2010).

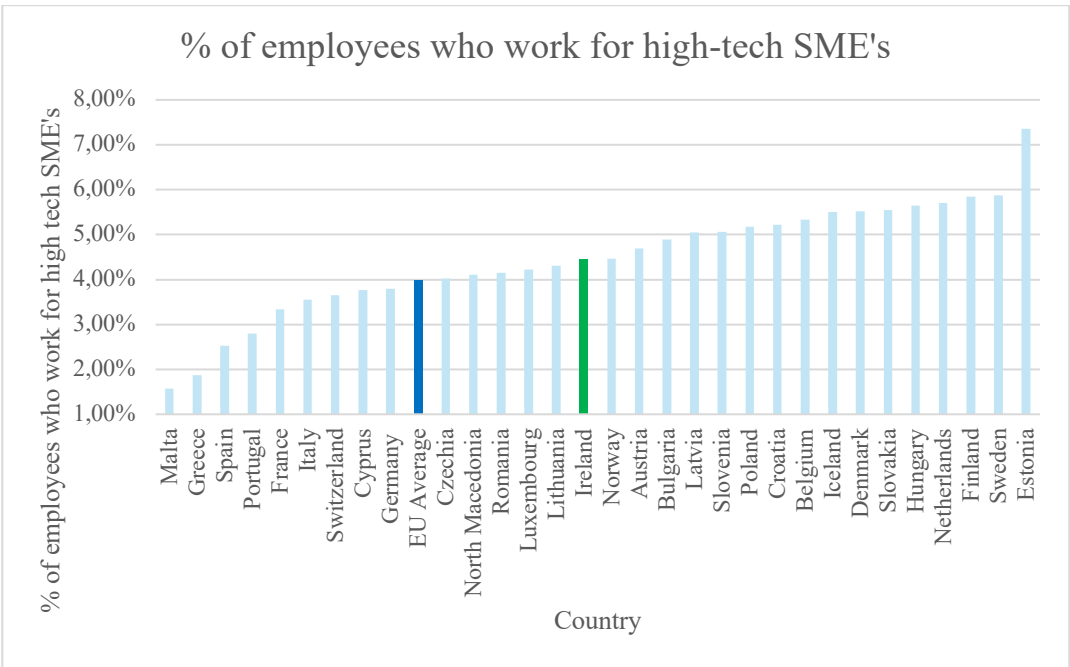
Figure 8: Total percentage of employees who work for SMEs out of all Enterprises in the European Union 2023



Source: Eurostat, Enterprise statistics by size class and NACE Rev.2 activity (from 2021 onwards)
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Figure 8 provides insights into the distribution of SME employees across EU countries, relative to the overall employed workforce. Notably, countries such as France, Germany and Ireland, which boast stronger financial positions, exhibit lower levels of SME employment. This trend could be due to the prevalence of multinational corporations (MNCs) and Foreign Direct Investment (FDI) in these countries, especially in Ireland, which tends to create more job opportunities in larger enterprises. Conversely, EU countries like Cyprus, Estonia, Portugal, and Greece have higher levels of SME employment, potentially driven by fewer high-paying jobs at larger organisations and a less educated workforce.

Figure 9: Total percentage of high-tech SME employees out of all SME employees in the European Union in 2023 (by sector)



Source: Eurostat, Enterprise statistics by size class and NACE Rev.2 activity (from 2021 onwards) [SBS_SC_OVW\$DEFAULTVIEW]

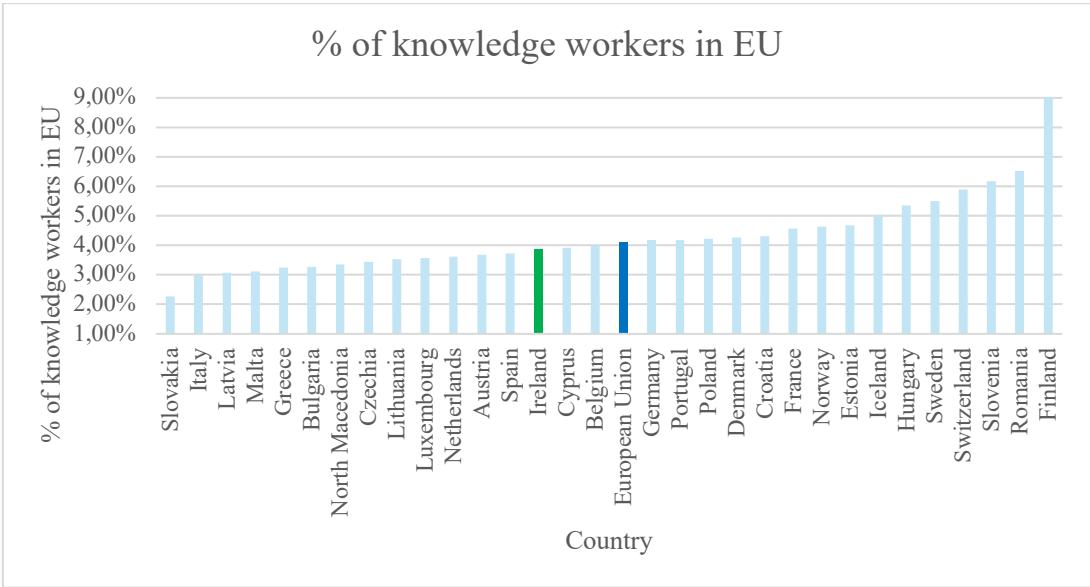
Legend: employees who work in NACE sectors J62 and J63.

Sectors: J62 - Computer programming, consultancy, and related activities; J63 - Information service activities

5.5 Categorising high-tech SMEs by sector

Figure 9 shows the percentage of high-tech SME employees in the EU. Ireland ranks just above the EU average of 4%, which significantly lags behind the likes of Estonia with over 7% working for high-tech SMEs, measured by size and sector. One limitation of using NACE (European Classification of Economic Activities) code classification to define high-tech SMEs is that the data includes employees who work for high-tech SMEs but are not directly involved in high-tech activities within the organisation (Eurostat, 2008). This means that employees in non-technical roles or administrative staff, are counted as part of the high-tech workforce. While these employees play crucial support roles within high-tech SMEs, including them in this classification can dilute the accuracy of the classification and may result in an overestimation of the high-tech workforce.

Figure 10: Total percentage of Knowledge Workers in the European Union in 2023 (by occupation)



Source: Eurostat. Employed persons by detailed occupation (ISCO-08 two-digit level) [LFSA_EGAI2D__custom_6479647]; Enterprise statistics by size class and NACE Rev.2 activity (from 2021 onwards) [SBS_SC_OVW__custom_6467523]
Legend: employees in technical and knowledge-intensive occupations (ISCO: OC - 21-26 and OC - 31-35)

5.6 Categorising high-tech SMEs by occupation

Knowledge workers are defined by those working in technical and knowledge-intensive industries. ISCO is the International Standard Classification of Occupations which is a four-level classification of occupation groups managed by the International Labour Organisation (European Commission, 2024). As shown in figure 10, Ireland is ranked similar to the EU average of knowledge workers. Using ISCO classification codes to define high-tech SMEs may lead to the inclusion of individuals working in high-tech occupations but not necessarily employed in high-tech companies. ISCO codes provide a more precise depiction of high-tech occupations but does not guarantee that these individuals are working within high-tech SMEs. For example, a software developer employed in a non-high-tech company may be categorised as part of the high-tech workforce based on their occupation. However, this individual may not directly contribute to technological innovation and the growth of high-tech SMEs.

5.7 Recommendations

Given the significant role high-tech SMEs play in the Irish economy, assessing their workforce requirements can help identify specific skills that are in high demand. The classification of SMEs as high-tech has an impact on understanding and addressing the skills demand in Ireland's SME market. By focusing on the specific skills needs of high-tech SMEs, we can develop targeted education and training and policies that support the growth of SMEs critical sectors in Ireland.

6. Chapter IV

6.1 AI skills demand analysis

Ireland released its national strategy on AI in July 2021 called “AI - Here for Good”. It focuses on placing Ireland at the forefront of change, given Ireland’s IT talent, entrepreneurship and the fact that the world’s largest ICT businesses operate in the country (Department of Enterprise, Trade and Employment, 2021). According to the WEF, over 19% of the global workforce could have over 50% of their tasks automated by AI (World Economic Forum, 2023).

6.1.1 AI adoption in Ireland

The adoption rate for new technologies such as generative AI is skyrocketing in Ireland with over 49% of organisations having adopted the technology for everyday use (McCorry, 2024).

Almost half of the respondents (47%) believe the technology will improve productivity in their organisation, compared to 17% who disagree with the statement. However, it is noted in the report that MNCs are using the generative AI up to 30% more on average when compared to domestic firms. Although it is a drastic statistic, there is still a lot of time for Irish firms to become early adopters of the technology.

6.1.2 Barriers to AI adoption for Irish businesses

Adopting AI technology in Irish businesses faces several significant barriers. One major obstacle is the insufficient or incompatible IT infrastructure within many firms, as well as the lack of internal data. Irish firms also view the reputational risks associated with the use of artificial intelligence as a substantial barrier, significantly more than the average perception across European enterprises. However, the most pressing challenge identified by Irish businesses, consistent with the findings across the EU, is the difficulty in hiring new staff with the necessary skills for AI adoption, with over 85% of the respondents identifying this as a major barrier (Expert Group on Future Skills Needs & National Skills Council, 2022). Additionally, over 75% of workers in AI and data science in Ireland are men, highlighting the underrepresentation of women in the sector.

6.1.3 AI Skills in demand in Ireland

A report in response to Ireland's National AI strategy, provides an introduction and framework to the skills-related issues and challenges relevant to the adoption of AI in Ireland. It is mentioned that job disruption is seen as a more plausible outcome in Ireland rather than job loss, due to the implementation of AI in businesses (Expert Group on Future Skills Needs & National Skills Council, 2022). Evidence points to AI replacing individual tasks, which will likely increase growth, productivity and competitiveness in the business. Ireland has a workforce with the highest share with AI skills in the European labour market, although it is mentioned that the skills may be highly concentrated within technology MNCs, and unrepresentative of other sectors.

The WEF's Future of Jobs Report 2023 has AI ranked 15th as a core skill required for employment, although it is third biggest priority for company training strategies and first for companies with over 50,000 employees. AI as a skill is strongly prioritised in many industries such as: Insurance and Pensions, Management, Media, Entertainment and Sports, Information and Technology Services, Telecommunications, Business Support and Premises Maintenance Services, and Electronics. AI skills far exceed the technological skills required by companies compared to programming skills, network and cybersecurity

skills, general technology skills and UX design skills. Additionally, the WEF estimates that specialised roles in AI will grow by 30-35% by 2027 (World Economic Forum, 2023).

6.1.4 Education and Policy on AI

Educators in Ireland were asked to rank the broad skills students needed to ensure they are fully prepared for what AI will bring in the next 5-10 years. The results of the survey show that awareness and understanding of AI and its implications were most important (75%), closely followed by soft skills (73%), with AI-specific skills and expertise coming last (66%) (Expert Group on Future Skills Needs & National Skills Council, 2022). The survey results show that understanding the risks of AI are deemed more important than expertise in the technology.

According to OECD director for education and skills, Andreas Schleicher, new technologies have an opportunity to better engage students in classes, pushing educators to create assessments that test how students think rather than what they can recite in an exam. He mentions that “If as a teacher your only business is knowledge transmission, AI will make you irrelevant.” And that “AI is not going to replace teachers, but teachers who are good at using AI will replace teachers who don’t get that message.” His message shows his views on the future of education, and how technologies like AI have created a need for a new style of teaching (Carl O’Brien, 2024).

Ireland is at the forefront of EU nations in negotiating the policy implications of the European Union AI Act. The AI Act, published in March 2024 sets an important goal, that it does not regulate the technology which would limit innovation, but will regulate the use of the technology. By categorising AI-applications from low-risk to high-risk, this will ensure a high level of protection of health, safety and fundamental human rights (European Parliament, 2024). The government of Ireland will also promote sandbox initiatives to trial use of new AI products in prominent sectors such as Fintech and Medtech. Sandboxes allow businesses and developers to innovate and trial their innovations without facing the full weight of regulation. This helps governments encourage innovation, monitor potential

risks of new technology and can help guide the development on policy (Department of Enterprise, Trade and Employment, 2023).

6.2 Cloud and Cyber industry analysis

As cloud services are delivered by data centres, there has been growth in the size of the Irish cloud market with over €10bn in data centre investments over the past 10 years and the market growing 25% a year. Cloud services represent €314bn of annual exports in 2020, representing 33% of all Irish exports (Chris Kavanagh et al., 2022). The cyber sector in Ireland currently employs 7,351 professionals, with nearly 50% working for domestic companies. However, foreign direct investment (FDI) significantly influences this sector. Companies with FDI employ 71% of all cyber professionals in Ireland, with a notable presence from the US, where 28% of firms originate, contributing to 55% of employment in the cyber sector (Cyber Ireland, 2022).

6.2.1 Cloud and Cyber adoption in Ireland

Cloud technology adoption is proven in Ireland over the past 10 years, with many businesses comfortable storing their data in the cloud, understanding the risks that come with storing information locally. Over 32% of Irish businesses now host all their corporate data on the cloud, with over 54% in the process of migrating to the cloud (Walsh & Colin, 2024; Allen et al., 2021). Cloud services are provided by reputable businesses within the Irish market, and as mentioned earlier, have a strong foothold in the Irish market with over 82 datacentres across the country. In 2024, many see cloud technology as an easy-adoption option for their business, where they can store their workloads and data on the cloud and can focus on other aspects that drive their business forward. The reason behind this easy-adoption we see is that cloud is proven to be safe, with highly skilled providers who understand the risks and threats of cloud-based systems. To date, Irish businesses are seeing added business value, improved security and sustainability benefits from cloud adoption.

Cybersecurity awareness is high in Ireland, with many businesses investing in ensuring their data is protected from cyber-attacks, with AI posing a new threat with malicious

attacks. Last year, the Health Service Executive (HSE) which is Ireland's public healthcare system, was victim to a cyber-attack that leaked over 90,000 patients' data online (Health Service Executive, 2023). This attack underscored the vulnerability of the HSE's cyber protection and sent a message to other businesses and government organisations to ensure they are adequately prepared to face wide-spread cyber threats in the future.

6.2.2 Cloud and Cyber skills gap analysis

98% of organisations globally are facing a cloud skills gap, finding it difficult to hire people with general cloud skills, cloud architecture knowledge, and skills required for adapting, monitoring and troubleshooting cloud issues. Reskilling and retaining existing employees will not be enough on their own to plug the gap, making the hiring of people with cloud skills a top priority. Similarly, 98% of those have said that a lack of cloud skills has negatively impacted their business operations (SoftwareOne, 2023).

The state of the cyber skills gap in Ireland shows similar insights. According to a report by Cyber Ireland, to meet the demand of 10,000 cyber professionals in Ireland by 2030, requires an additional 1,000 skilled cyber professionals each year (Cyber Ireland, 2023). Additionally, over 41% of cyber teams are understaffed, with over 48% of Irish firms having an open or unfulfilled role. To add, 34% of Irish businesses say that the lack of technical talent is the main reason for this. To meet the demand requires the training of new workers in cybersecurity, as well as encouraging cross training and upskilling from ICT professionals in other sectors. While there still remains a lag in skills between industry and academia in these sectors, Ireland is improving its supply of relevant skills for cloud and cyber, ensuring that graduates from third level education have the correct skills to meet the demands in the labour market (Department of Communications, Climate Action and Environment, 2019).

6.2.3 Education and Policy on Cloud and Cyber

In Ireland, there are currently only 10 cloud-related courses available through HEA, FET and online (Courses.ie, 2024). There is a lack of cloud specialist education and training in

the country, which limits the development of companies adopting cloud technology to their business.

In October 2018, Ireland launched a new Cyber Security Skills initiative provided by Skillnet Ireland working with the National Cyber Security Centre (NCSC), Garda National Cyber Crime Bureau, FET and universities. With the aim of bridging the skills gap for cybersecurity roles and setting standards of skills required in the industry, the plan has attracted more young people to cybersecurity, promoting continuous development of skills for workers and prioritised women entering the sector. This strategy has trained more than 5,000 young professionals for cyber related roles in the country (Department of Communications, Climate Action and Environment, 2019). Additionally, universities have focused on providing more cybersecurity courses in Ireland, with over 10 undergraduate courses and 15 master degrees in cybersecurity, which has almost doubled since 2018 (Mastersportal, 2024; Bachelorsportal, 2024).

6.3 Quantum technology analysis

Quantum technologies will enhance the range of possibilities in computing, sensing, simulation, and communication, allowing for new approaches to social and environmental issues, with applications across industries such as digital, pharmaceuticals, finance, and manufacturing. For example, the anticipated ability of quantum computers to process extremely complex information could enable us to make climate predictions with great speed and accuracy. Quantum sensors will improve medical diagnostics, while quantum communications will offer unparalleled security abilities (Department of Further and Higher Education, Research, Innovation and Science, 2023). Ireland boasts a highly attractive market for new technology with nine of the top ten technology companies, and three of the top four internet companies operating in Ireland. Ireland plans to exploit this opportunity by heavily investing into quantum technology, as the global market remains relatively untapped.

It is important to note that quantum computing has not yet reached practical applicability, in

comparison to previously mentioned technologies like AI, Cyber and Cloud. Currently, no company has developed a quantum computer capable of outperforming classical supercomputers on tasks beyond niche research problems with limited practical applications. These companies are primarily focused on addressing numerous technical challenges to realise functional quantum computing. Additionally, they are selling various types of quantum computers to research laboratories dedicated to advancing the ability of quantum computing technology (Smith, 2023). The difference between quantum computing and classical computers are the way they read information. A classical digital computer uses bits to store and process information with each bit representing either 0 or 1. When a computer performs an operation, these values either stay the same or change: 0 becomes 1, or 1 becomes 0. In contrast, a quantum computer uses the principles of quantum mechanics to enhance the capability of classical bits. Quantum bits, or qubits, can represent the states 0 and 1 simultaneously, which is known as quantum superposition (Johansson et al., 2021).

6.3.1 Quantum adoption in Ireland

Ireland has launched the IrelandQCI project in 2022, which aims to promote Ireland as a European leader in quantum communications infrastructure. IrelandQCI project is part of an EU-wide quantum communications infrastructure programme called EuroQCI. IrelandQCI is being funded by the Irish Government and the EU under the Digital Europe Programme, with total funding of €10m (Department of Enterprise, Trade and Employment, 2023). The consortium consist of experts from six different universities in Ireland (SETU, UCD, UCC, Trinity, Maynooth and Galway) as well as HEAnet which is Ireland's National Education and Research Network and ESB Telecoms, one of Ireland's largest telecommunications providers (Department of the Environment, Climate and Communications, 2022).

6.3.2 Quantum skills in demand in Ireland

Ireland's Quantum 2030 strategy highlights the country's robust research presence in the quantum field, marked by the creation and funding of IrelandQCI. While Ireland is not yet the leading hub for quantum technologies in Europe, the strategy aims to attract industry

players to establish operations in Ireland and fostering investment and growth in the sector. The strategy focuses on increasing R&D in quantum technologies, promoting talent, and enhancing collaboration between research and quantum players.

Microsoft have partnered with Trinity College Dublin to accelerate course offerings in quantum tech and train new workers for the industry. As part of the partnership, Microsoft offers funding to PhD students research new innovations with quantum. Additionally, they fund scholarships to promote more women working in the sector by providing master's courses in quantum science and technology in Trinity (Microsoft Pulse, 2024). This initiative is part of Ireland's National Quantum strategy to develop future skills needed to position Ireland at the forefront of quantum computing. In May 2023, Microsoft further invested in Irish quantum research, with the creation of the Trinity Quantum Alliance (TQA) along with IBM, Horizon Quantum Computing, Algorithmiq and Moody's Analytics. Already Trinity have seen groundbreaking research projects using Microsoft's quantum computing technologies (Trinity College Dublin, 2023).

6.3.3 Education and Policy on Quantum technology

In November of 2023, the now-Taoiseach (Irish Prime Minister) Simon Harris unveiled Ireland's National Quantum Strategy 2030, outlining the efforts and focus from a government perspective on quantum technologies. The report follows five pillars to ensure Ireland is well aligned in the development in quantum technology in Europe. The first pillar guarantees support from government funded projects such as IrelandQCI which will enhance applied quantum research in the country, fostering breakthrough research discoveries and innovation in Ireland. The second pillar focuses on developing a pipeline of agile, innovative and highly skilled workers across quantum science, engineering and technology, promoting equal opportunities and attracting women to the sector. Thirdly, the strategy outlines Ireland's advantage of national and international collaboration. Ireland hopes to build strong partnerships within the quantum sector and learn from international best practices through national and international initiatives such as IrelandQCI and EuroQCI. The fourth pillar of the strategy aims to drive innovation, entrepreneurship and

competitiveness within the Irish quantum market, particularly in SMEs and domestic companies. As well as promoting the collaboration between universities and businesses working with quantum technology. Since quantum technology is a recent technological innovation, the Irish government's fifth pillar of its quantum national strategy aims to create awareness about quantum and the opportunities within the sector, promoting real-world benefits of its application (Department of Further and Higher Education, Research, Innovation and Science, 2023).

6.4 Conclusion

The analysis of AI, cloud, cyber, and quantum technologies in Ireland shows the critical importance need of further investments in education and training. For instance, Ireland's "AI - Here for Good" strategy emphasises the need to equip the workforce with AI skills to remain competitive globally. Similarly, the Quantum 2030 strategy outlines initiatives to develop a pipeline of skilled workers in quantum science and technology, like Microsoft's partnership with Trinity College Dublin to fund courses and promoting further research. By prioritising education and aligning with national strategies, Ireland has the opportunity to capitalise on the opportunities presented by emerging technologies, by ensuring its workforce is prepared for working with future technologies.

7. Discussion

7.1 Summary of Key Findings

This research explores the widening skills gap in Ireland's labour market resulting from the rapid adoption of emerging technologies like AI, cloud computing, cybersecurity, and quantum computing. As these advanced technologies continue disrupting industries and automating tasks, there is a critical need to understand the specific skills that will be in demand for future jobs. The research investigates whether Ireland's workforce is being adequately prepared through education and training initiatives to meet the evolving skills requirements driven by technological change. Ireland is positioned as a global tech hub

attracting foreign MNCs, ensuring its labour market has the necessary digital skills to take advantage of the emergence of new technology.

Chapter I highlights the historical context of technological advances, tracing the evolution of employment and labour markets through past industrial revolutions. From the steam-powered machinery of the First Industrial Revolution to the digital revolution of Industry 3.0, each phase bringing about significant changes in the labour market and types of job roles. The rise of Industry 4.0, characterised by the integration of cyber-physical systems and automation in manufacturing. Furthermore, the emergence of Industry 5.0 emphasises the importance of human skills alongside advanced technologies, highlighting the need for a balanced approach to automation.

Chapter II discusses Ireland's current skills strategy, highlighting the National Skills Strategy (NSS) 2025 introduced in 2016. The NSS aimed to enhance the skills of individuals and the skills needed for companies operating in Ireland. Despite its vision to address skills challenges and driving economic growth, challenges such as Brexit, COVID-19, and Russia's war on Ukraine have hindered its success, exacerbating already present issues like labour shortages, housing problems and regional inequalities. To address these, the OECD recommends focusing on lifelong learning, addressing skill gaps among adults, enhancing underutilised skills in the labour market, and balancing skill imbalances. Lifelong learning is essential to keep workers engaged in improving their skill sets, with Ireland ranking 6th in Europe but still lagging behind top performers like Sweden and the Netherlands. Addressing the skills gap among adults in technological fields, is crucial, as evidenced by the low percentage of graduates in ICT-related courses. Moreover, underutilised skills in the labour market need activation through reskilling initiatives, ensuring inclusive participation. Finally, addressing skill imbalances, including shortages and mismatches, is crucial, especially in high-demand sectors like STEM, where businesses struggle to fill vacancies.

Chapter III focuses on differentiating high-tech and traditional SMEs in Europe and highlights the vital role SMEs play in driving economic progress in Ireland. High-tech SMEs, concentrated in sectors like ICT and pharmaceuticals, require a highly skilled workforce. Better understanding employment needs for Irish SMEs will create more opportunities for growth in this sector, from more targeted education and training programs to better linking new graduates with SMEs with a high-tech focus.

Chapter IV analyses industries such as AI, cloud, cyber, and quantum technologies in Ireland. AI adoption is growing, although with notable barriers such as inadequate IT infrastructure and the difficulty in hiring skilled staff. Similarly, cloud adoption is on the rise, but there is a significant skills gap, requiring more focused education and training initiatives. In the cyber sector, Ireland faces challenges with understaffing, highlighting the need for more skilled professionals in the industry. Lastly, Ireland is investing in quantum technology, aiming to become a European leader by promoting research opportunities, talent development, and collaboration with quantum leaders.

7.2 Interpretations of the Findings

The data and findings from this research highlight several key patterns and relationships regarding the impact of emerging technologies on Ireland's labour market and skills gap. There is a clear relationship between the adoption of advanced technologies like AI, cloud computing, cybersecurity, and quantum computing, and increasing demand for workers with specialised digital skills in these areas. As shown in Chapter IV, industries are facing shortages of qualified professionals, limiting technology implementation for businesses.

The results align with expectations that Ireland's rapid digital transformation and position as a global tech hub would expose significant skills deficits, especially in the fields of AI and quantum technology, as they are more recent innovations. This mirrors previous research highlighting the challenges many European nations face in developing an adequately skilled workforce for new technologies. An unexpected finding was the persistent importance of "soft" skills like critical thinking, problem-solving and creativity,

in addition to technical expertise. This contradicts common assumptions that purely technical competencies would be most important and suggests a more balanced approach to learning advanced digital skills while understanding the need for human-centered skills to understand the implications and applications of new technology. While educational initiatives like the Springboard+ program are helping upskill workers, the data indicates these may not be keeping pace with evolving industry demands.

7.3 Implications of the Study

The research is relevant in that it highlights a key economic challenge for Ireland, by ensuring its workforce has the necessary skills to capitalise on technological advances and maintain global competitiveness in the technology sector. Reiterating findings from Chapter II, skill imbalances and mismatches between labour supply and demand persist, despite above EU average employment levels. Aligning with previous studies emphasising the importance of lifelong learning and reskilling needs, the implications point to a need for more responsive skills strategies. Simply relying on existing strategies may leave Ireland under-equipped to realise the full potential of new technologies. Additionally, the research contributes new insights into Ireland's specific strengths and vulnerabilities around technology skills. While affirming its strengths as a digital leader attracting top tech talent, it also exposes vulnerabilities in developing skills for fields like quantum computing that have not yet reached maturity.

7.4 Limitations of the Study

While this research provides valuable insights into the impact of emerging technologies on Ireland's labour market and skills gap, it is important to acknowledge its limitations. One key limitation is how quickly technologies like AI, quantum computing, and cybersecurity have grown. The study only shows current available data, but as we know, the skills needed for industry adoption are always changing. This makes it challenging to draw definitive conclusions about long-term skills requirements and demand projections. Additionally, data availability and measurement posed constraints. Furthermore, the research took a national-level approach, while local and regional dynamics may vary in terms of skills supply,

educational opportunities, and technology investment. Given that most of Ireland's technology companies are naturally based in its largest cities: Dublin, Cork and Galway. A more regional geographic analysis could uncover additional data on where Ireland should focus on improving digital skills.

Despite these limitations, the results remain valid and valuable for addressing the core research questions. This study integrated data from a wide range of credible sources, including government agencies, industry associations, academic literature, and international organisations. This comprehensive approach enhances the credibility and validity of the findings, by triangulating research findings. Additionally, identifying skills gaps and preparing the workforce for the future requires a forward-looking approach. While quantitative projections have limitations, qualitatively mapping overarching trends and relationships is valuable for strategic planning. Despite the potential for measurement inaccuracies, the consistent patterns observed across multiple factors (such as increasing technology adoption, persistent skills shortages, and the need for further education and training) indicate the challenges that need to be addressed. Finally, the research aimed to provide a foundational understanding rather than definitive conclusions, intending to promote discussion, further investigation, and collaborative action among government, industry and education and training.

7.5 Comparative Analysis

Throughout this essay, I have compared Ireland's position in relation to skills and shortages of the labour market. While Ireland boasts a strong position in terms of ICT employees in the country, most are concentrated in the many MNCs in the country. Ireland has high levels of third level graduates in the country, however the fields studied are different from the current requirements in the labour market in fields like STEM and ICT. As seen throughout the thesis, Ireland's current strategies fall short of leading countries in Europe with participation rates in lifelong learning and third-level education participation among young adults. Ireland is in a strong position to improve upon its current position on a European level, which will help grow jobs in the Irish economy.

7.6 Recommendations for Future Studies

To effectively address the widening skills gap and position Ireland's future workforce for success, this research recommends the following practical steps. The first step is to encourage and facilitate ongoing professional development by subsidising certifications, qualifications and implementing reskilling opportunities that allow workers to update their digital skills without having to leave their roles to study formal education. This can be either through online MOOCs or local upskilling initiatives like Springboard+ online qualifications and FET courses. The second step is to ensure cooperation between government, employers, and education and training providers in defining and implementing the next-generation skills strategies, including reskilling initiatives and promoting lifelong learning. Additionally, Ireland should take advantage of its public-private partnerships to launch specialised future skills programs, where business provides a program for students to learn the exact skillset needed for roles they require, as seen with Microsoft's partnership in funding quantum education in Trinity College Dublin. Finally, Ireland should invest in regional "tech accelerator" hubs beyond major cities like Dublin and Cork to promote SME growth and skills development nationwide.

As for future research directions, studies could explore global best practices in workforce reskilling initiatives from leading nations that could inform Ireland's future skills strategy. Additionally, it would be beneficial to develop new methods to more accurately forecast evolving skills demand given the uncertainty around technological deployment and labour market disruption. Furthermore, conducting a skills gap analysis focused more specifically on emerging technologies like quantum computing would help pinpoint areas of skill shortages to improve Ireland's opportunity to become a leading global player in the industry. Another important area to further examine is the relationship between diversity and technological innovation to ensure an inclusive and prepared workforce. Through coordinated, forward-thinking approaches like those recommended, Ireland can position itself and its workforce at the forefront of technological advances and adoption.

8. Declaración de Uso de Herramientas de Inteligencia Artificial Generativa en Trabajos Fin de Grado

ADVERTENCIA: Desde la Universidad consideramos que ChatGPT u otras herramientas similares son herramientas muy útiles en la vida académica, aunque su uso queda siempre bajo la responsabilidad del alumno, puesto que las respuestas que proporciona pueden no ser veraces. En este sentido, NO está permitido su uso en la elaboración del Trabajo fin de Grado para generar código porque estas herramientas no son fiables en esa tarea. Aunque el código funcione, no hay garantías de que metodológicamente sea correcto, y es altamente probable que no lo sea.

Por la presente, yo, William Lavelle, estudiante de Administración y Dirección de Empresas con mención internacional (E4) de la Universidad Pontificia Comillas al presentar mi Trabajo Fin de Grado titulado "Addressing Ireland's Skills Gap: How Technology is Affecting the Labour Market", declaro que he utilizado la herramienta de Inteligencia Artificial Generativa ChatGPT u otras similares de IAG de código sólo en el contexto de las actividades descritas a continuación

1. **Brainstorming de ideas de investigación:** Utilizado para idear y esbozar posibles áreas de investigación.
2. **Referencias:** Usado conjuntamente con otras herramientas, como Science, para identificar referencias preliminares que luego he contrastado y validado.
3. **Metodólogo:** Para descubrir métodos aplicables a problemas específicos de investigación.
4. **Estudios multidisciplinares:** Para comprender perspectivas de otras comunidades sobre temas de naturaleza multidisciplinar.
5. **Constructor de plantillas:** Para diseñar formatos específicos para secciones del trabajo.
6. **Corrector de estilo literario y de lenguaje:** Para mejorar la calidad lingüística y estilística del texto.
7. **Sintetizador y divulgador de libros complicados:** Para resumir y comprender literatura compleja.

8. **Generador de datos sintéticos de prueba:** Para la creación de conjuntos de datos ficticios.
9. **Generador de problemas de ejemplo:** Para ilustrar conceptos y técnicas.
10. **Revisor:** Para recibir sugerencias sobre cómo mejorar y perfeccionar el trabajo con diferentes niveles de exigencia.

Afirmo que toda la información y contenido presentados en este trabajo son producto de mi investigación y esfuerzo individual, excepto donde se ha indicado lo contrario y se han dado los créditos correspondientes (he incluido las referencias adecuadas en el TFG y he explicitado para que se ha usado ChatGPT u otras herramientas similares). Soy consciente de las implicaciones académicas y éticas de presentar un trabajo no original y acepto las consecuencias de cualquier violación a esta declaración.

Fecha: 05/06/2023

Firma: **William Lavelle**

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