Intelligent futures: Working with automation & digitisation to deliver sustainable employment and growth

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Table of Contents

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1 Introduction and background

1.1 The University of Ulster Economic Policy Centre (UUEPC) was tasked by the Department for the Economy (DfE) to develop a policy paper on the impact of automation on the Northern Ireland (NI) economy as part of the DfE Research Programme 2018-21. The purpose of this report is to support development of a future that works for NI.

1.2 Automation may be defined as the substitution of labour by capital, reducing or eliminating the need for people to perform specific tasks in the production process[1]. It comprises both artificial intelligence (AI) and robotics, both of which have exhibited growing capabilities in recent periods to the extent that a new machine age is imminently anticipated.

1.3 In broad terms, AI may take four forms encompassing the completion of: routine, manual tasks (automated intelligence); productivity-enhancing tasks (assisted intelligence); decision enhancement (augmented intelligence); and full automation encompassing automation of an entire process (autonomous intelligence)[2].

1.4 The paper follows the structure outlined below;

- A literature review to identify consensus views on the impact of automation, expectations for the future and theoretical best practice in policy.
- A policy review of initiatives, policies and programmes that have been implemented in relation to automation, competitiveness, developing skills that are relevant to the future of work and assisting in the transition of workers to a more automated environment. This section focusses on policies that show practical evidence of successful outcomes.
- A data analysis of NI's potential future performance through the lens of technological progress, automation and skills requirements. This section contains forecasts of the potential impact of automation on the NI economy.
- Findings from company consultations carried out by UUEPC to investigate the levels of automation in place across NI and to help identify policy suggestions from industry.
- A summary of findings, conclusions and presentation of NI-focussed and evidence-based policy suggestions that will help prepare individuals and enterprises for work in the fourth industrial revolution.

[1] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

[2] PwC (2017). The Economic Impact of Artificial Intelligence of the UK Economy.

2 Literature Review

2. This section summarises the academic literature on previous industrial revolutions and current / future automation in terms of impact (and expected impact) on economic structure, employment and labour market frictions, and equality. Much of the literature currently available focusses on the downside risks of automation, given the difficulties of identifying opportunities, new jobs and tasks for which the technology does not yet exist. Consequently, this literature review highlights risks associated with automation, taking a mitigation approach; and draws out upside opportunities where feasible to do so.

2.1 Lessons from history: Industrial Revolutions 1-3

2.1.1. In relatively recent history, there have been several periods of marked increase in efficiency via technology and substitution of labour by capital. These periods have been associated with significant shifts in the composition of economies and have been transformative to wider society.

2.1.2. Some debate exists as to whether we are currently in the third or fourth industrial revolution; however, for the purpose of clarity, this paper treats automation as a separate transformative force to digitalisation. Figure 2.1 summarises the nature and impacts of each of the three previous 'Industrial Revolutions'.

Figure 2.1: Key Features and impacts of Previous Industrial Revolutions

First Industrial Revolution (c. 1760-1830)	Second Industrial Revolution (c. 1870 - early 1900s)	Third Industrial Revolution (c. 1950 - early 2000s)
		
Key Features		
Mechanical Production • invention & development of the steam engine, railroads and steamships improving transportation • increased efficiency within the textiles sector & iron production through mechanisation • a macro-level shift to industrialisation & growth of factory work	***Science and mass production*** • developments in machines & tools used in factories • increased mechanisation • invention of the internal combustion engine • utilisation of the power of electricity, oil & gas • the development of the assembly line	***Digitisation*** • invention / development of semiconductors, microprocessors, computers & mobile phone technology • a shift from mechanical and analogue electronic technology to digital electronics • early automation including ATMs, industrial robots, etc. • creation & accessibility of the internet • development & mainstreaming of cloud computing
Impacts		
· Urbanisation · Decreased price of goods · High unemployment, especially amongst unskilled workers · Creation of new work (banks, shopkeepers, insurance, etc.) · Deteriorated living standards · stagnant real wages (Engel's pause) · decreased working conditions · Increased share of profits in national income at the expense of labour / land · Deteriorated health & life expectancy · Emergence of a middle class · Increased national purchasing power	· Further urbanisation · Real wages increased with productivity · Stabilised profit rate & factor shares · Increased productivity led to reduce prices ·Unemployment remained a problem · Sanitation & public health initiatives were introduced across cities, increasing the standard of living · A new middle class emerged ("white collar workers") · Businesses expanded over large geographical areas · Due to pace of invention, fixed capital became obsolete over short timescales · Inequality increased ·International trade increased, many countries introduced protectionist trade policies	· Labour displacement by computers, typically in administrative functions · Increased labour productivity · Job tasks changed (e.g. bank tellers have moved further towards sales) · Creation of new work (e.g. digital security, programming, etc.) · Overall employment rates increased · Transformation in leisure activities · Significantly increased globalisation and widespread outsourcing · National scale became less important to economic performance

2.1.3. During the 18th and 19th centuries, industrialisation in Ireland was concentrated in Belfast and Dublin, and focussed on a limited number of sectors – brewing, linen, and shipbuilding – with both linen and shipbuilding concentrated in what is now NI[3].

Case 1: The Linen Industry[4]

For most of its history, the linen industry existed as a cottage industry, with production occurring in a domestic setting. The sector experienced dramatic export-driven growth during the 18th century; during the second half of the century, adoption of water-powered machinery, increased specialisation, and increasingly used production techniques enabled the required increases in productivity to meet demand. This facilitated an explosion in exports, from c. 2 million yards in 1713 to over 47 million yards by 1796 – around 80% of which was produced in the province of Ulster.

While the first Industrial Revolution saw increased mechanisation and use of technology, the second saw the move into factory production and further advancement in production techniques, such as widespread adoption of steam-driven wet spinning. The increased level of industrialisation resulted in capital substitution for labour, and reduced remuneration, which contributed to emigration between 1830 and 1850 (although it should be noted that this coincides with the period of the Great Famine).

In the second half of the 19th century, increased mechanisation improved productivity, enabling mills to grow in size. The industry became concentrated in east Ulster, with a commercial hub focussed in Belfast. Although cheap labour had been a source of comparative advantage in the early stages of mechanisation, the improved productivity and resulting economies of scale became fundamentally important by the end of the 19th century.

The linen industry in (what is now) NI remained a dominant and globally competitive producer through the late 19th and early 20th centuries, declining with increased globalisation and availability of cheap labour (particularly in China).

Key elements in the success of this industry include strong product demand, entrepreneurship, an appropriately skilled workforce and industry adaptation to technological progress through reorganisation of production.

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[3] Bradley, J. (1999). 'The history of economic development in Ireland, North and South' *Proceedings of the British Academy*, vol.98, pp.35-68.

[4] Information sourced from:

Bielenberg, A. (2009). *Ireland and the Industrial Revolution: The Impact of the Industrial Revolution on Irish Industry, 1801-1922*. Routledge, Oxon.

Bradley, J. (1999). 'The history of economic development in Ireland, North and South' *Proceedings of the British Academy*, vol.98, pp.35-68.

2.1.4. Over the past two decades, NI has seen significant changes to its economic composition, with large declines in manufacturing and increases in services. In the past 15 years in particular, the financial services, technology and legal sectors have seen rapid expansion, fuelled partly by inward investment.

2.1.5. NI has benefitted substantially from the globalisation element of the third Industrial Revolution, attracting a high level of investment from US fintech and cyber security development projects. NI is now ranked as the top global destination for such investments[5], many of which are feasible only through technological developments made.

2.2 Industrial Revolution 4: Trends & timings

2.2.1. The economy is currently experiencing a fourth Industrial Revolution, characterised by cyber-physical systems including automation (AI, machine learning and robotics), augmented reality, and genome editing. PwC identify three overlapping stages in the roadmap to automation to 2030 and note that the first is already well underway[6].

2.2.2. Key technological drivers of change expected over the period to 2022 are the existence of omnipresent and high-speed mobile internet, cloud computing, widespread adoption of big data analytics and developments in AI[7]. It should also be noted that wider macro trends are being experienced across the globe and these will also affect the impact of automation on the economy. Such trends include environmental sustainability, demographic change[8,] and policy moves towards trade protectionism and tightened monetary policy[9].

2.2.3. As with previous instances of widespread economic disruption, individuals may experience rapid change as the impact on their job becomes apparent – this may be perceived as immediate disruption on a micro scale[10]. However, at the macro level, change will not happen overnight. While the World Economic Forum

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[5] Invest NI. *Track record*. Available from www.investni.com (last accessed 09 January 2019).

[6] The three identified stages are:

2.2. The algorithm wave (automation of computational tasks and analysis of structured data)

2.3. The augmentation wave (automation of repeatable tasks and analysis of unstructured data in semi-controlled environments. Likely to come to full maturity in the 2020s)

2.4. The autonomy wave (automation of manual labour and physical dexterity and problem-solving in dynamic, real-world situations such as driving. May only come to maturity in the 2030s)

PwC (2018). *Will Robots Really Steal Our Jobs? An International Analysis of the Potential Long-Term Impact of Automation*.

[7] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[8] Bakhsh, H. et al. (2017). 'The future of skills: Employment in 2030' *Pearson, NESTA*.

[9] World Trade Organisation (2018). 'Latest trends in world trade 2017-2018' in *World Trade Statistical Review 2018*. Available from www.wto.org (last accessed 03 January 2019).

[10] Manyika, J., Chui, M., Bughin, J., George, K., Willmott, P. and Dewhurst, M. (2017). *'A future that works: Automation, employment and productivity'* McKinsey Global Institute.

(WEF) has noted an acceleration of pace of change between 2016 and 2018[11], the fourth Industrial Revolution will take place over a timespan of decades.

2.2.4. At a macro level:

- Time is firstly required for the technology to develop the required capabilities and for that technology to be integrated into specific activities – this is estimated as a one- to nine-year lead time[12].
- Secondly, it is likely that the cost of new technology will initially be high (due to e.g. purchase costs, costs of integrating the new technology, and costs of restructuring) – in one global business survey, 44% identified that the high cost of scaling and difficulty in justifying the business case were factors preventing the move from piloting new technology to rolling it out[13].
- As such, for widespread adoption to take place, it is expected that the cost of the technological solution must be equal to or less than the cost of labour. Advanced economies with higher wage levels are therefore theoretically more likely to adopt automation sooner than emerging economies[14].
- NI's lower wages may lessen the incentive for businesses to invest in automation; this could cause NI to fall behind in the automation revolution.

2.2.5. Research identified that a £1 increase in the minimum wage (from £7.50 to £8.50) would result in just a 0.24pp decline in the share of total automatable employment (an elasticity of -0.055)[15],[16],[17]. In other words, employment at risk of automation[18] is not particularly sensitive to marginal changes in the minimum wage rate – such changes are therefore not expected to result in widespread incentive to automate. As the cost of technology continues to fall, and more automation becomes technically possible, these estimates may change.

2.2.6. Automation will not be simultaneously adopted and deployed by all firms;

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[11] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[12] Manyika, J., Chui, M., Bughin, J., George, K., Willmott, P. and Dewhurst, M. (2017). *'A future that works: Automation, employment and productivity'* McKinsey Global Institute.

[13] World Economic Forum (2019). *4 Myths about manufacturing in the Fourth Industrial Revolution*. Available from www.weforum.org last accessed 08 February 2019.

[14] Manyika, J., Chui, M., Bughin, J., George, K., Willmott, P. and Dewhurst, M. (2017). *'A future that works: Automation, employment and productivity'* McKinsey Global Institute.

[15] Lordan, G. (2018). 'Minimum wage and the propensity to automate or offshore' *Low Pay Commission*.

[16] Analysis utilised Quarterly Labour Force Survey data from 1994 to 2017 and the Annual Survey of Hours and Earnings from 1998 to 2015.

[17] The research does, however, note that larger effects of wage increases were felt in manufacturing, where elastic demand was estimated. The total figure also masked some demographic effects and it was found that, in those technically automatable jobs, older and minority workers were at greater than average risk.

[18] Based on UK wage data between the late 1990s and mid-2010s.

rather, it is commonplace for many firms to observe the outcomes for those first movers and early adopters. Consequently, widespread adoption and deployment generally takes at least a decade and, based on previous examples, may take almost 30 years from the technology's commercial availability[19].

2.2.7. It should also be noted that a 'Skills Revolution' is occurring alongside this Industrial Revolution, as humans are developing and learning new skills to prepare for working alongside machines. This 'Skills Revolution' is vital preparation for automation and will be a lifelong process of continual learning. The need to expand and develop additional skills is explored throughout this report.

2.3 Expected impact of automation: Employment & productivity

2.3.1. Over the period 2000 to 2015, the UK experienced a technology-driven shift from low-skill, routine jobs to high-skill, non-routine work. Over this period, 800,000 jobs were lost; however, 3.5 million new jobs were created, corresponding to net added value of £140 billion in wages[20].

2.3.2. Although all regions of the UK experienced benefits from growth in higher-skilled occupations, this was not shared equally. Consequently, in this next phase of technological development, it will be important to take a proactive approach to sub-regional economic development to maximise the gains to NI and avoid further disparities being realised. ManpowerGroup report that 47% of CEOs (across 42 countries surveyed) have started digital transformation and 34% of businesses have already seen a transformative contribution to business growth[21].

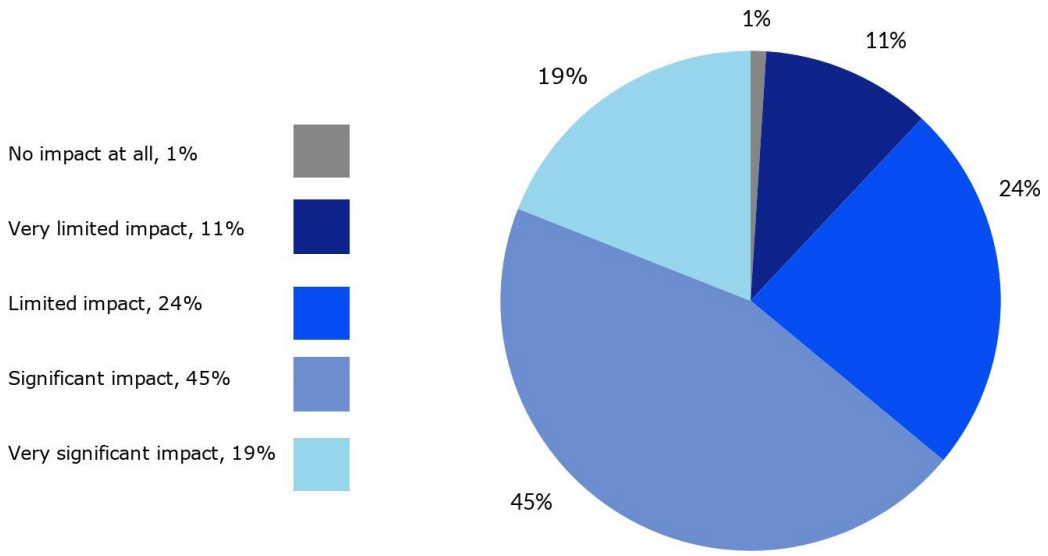
2.3.3. A survey carried out by Deloitte found that the majority of businesses expect technology to have a 'very significant impact' (19%) or 'significant impact' (45%) on their organisation as shown in Figure 2.3. Just 1% of organisations expect technology to have no impact.

[19] Lordan, G. (2018). 'Minimum wage and the propensity to automate or offshore' *Low Pay Commission*.

[20] Deloitte (2015). *From Brawn to Brains: The impact of technology on jobs in the UK*.

[21] ManpowerGroup (2017). *From C-Suite to Digital Suite: How to Lead Through Digital Transformation*. Available at: www.manpowergroup.co.uk (last accessed 03 June 2019).

Figure 2.3: Predicted impact of technology on business.



Source: Deloitte (2015). *From Brawns to Brains: The Impact of technology on jobs in the UK.*

2.3.4. Further, 73% of businesses surveyed intended to increase their headcount over the next 10 years, whilst only 5% planned to reduce it[22]. This survey highlights the pervasive impact technology is expected to have across organisations; it is unlikely that a given organisation will be unaffected by technological change.

2.3.1 Productivity

2.3.1.1. Evidence from previous Industrial Revolutions suggests that automation will increase productivity through, for example, improved speed and accuracy in completion of processes, or through augmentation of human decisions. The potential uplift to labour productivity growth is estimated at 2% within the next 10 years, which is a notable increase on trend growth rates of approximately 0.5% since 2010[23].

2.3.1.2. McKinsey predicts the contribution of automated machines could raise productivity on a global scale from 0.8% to 1.4% annually. This would increase the UK's GDP by 10% by 2030[24]. Automation will help the UK to achieve a productivity boost that it otherwise would not be able to achieve solely through a reliance on a human workforce.

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[22] Ibid.

[23] Skilling, D. (2018). '*The impact of disruptive technology on small advanced economies'* Landfall Strategy Group.

[24] Manyika, J., Chui, M., Bughin, J., George, K., Willmott, P. and Dewhurst, M. (2017). *'A future that works: Automation, employment and productivity'* McKinsey Global Institute.

2.3.1.3. McKinsey supports that increased productivity will be necessary to maintain standards of living because of a tight labour market and demographic changes, mainly in the form of an ageing population[25]. For NI the increase in productivity, as well as potential extra jobs that could be created may help to maintain low levels of unemployment.

2.3.1.4. Due to the importance of productivity improvements, a number of authors highlight the need to remove barriers to investment and accelerate automation[26]. Examples of such policies would be to invest in infrastructure, education and skills, increased Research and Development (R&D) and innovation. These will be explored in further detail in Section 3.

2.3.2 Risks to jobs and tasks

2.3.2.1. Early research by Frey and Osborne[27] suggested that 35% of jobs in the UK are at high risk of automation to 2030; when the UK sectoral composition is transposed onto NI, this would imply that up to 50% of jobs in NI are at risk[28]. Several authors utilise these data and apply similar methodologies, resulting in relatively high proportions of jobs at risk[29]. However, criticisms have been levelled against the work; in particular that occupations generally comprise a bundle of tasks, not all of which may be easily automatable[30]. Occupations labelled "high-risk" often contain a large share of difficult-to-automate tasks; consequently, the risks of automation may be overstated by such works[31].

2.3.2.2. Whilst early research focuses on jobs, more recent research focuses on the tasks that make up a job. Although tasks may be removed from workers, it does not necessarily mean that their entire job will be eliminated; rather, the nature of occupations will change to meet the new needs of an organisation[32]. Workers may then be redeployed to other tasks, meaning jobs are not lost[33].

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[25] Ibid.

[26] See for example:
Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from www.mckinsey.com (last accessed 03 December 2018).
Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

[27] Frey, C.B. and Osborne, M.A. (2013). 'The future of employment: How susceptible are jobs to computerisation?' *Oxford University*.

[28] Work carried out by UUEPC on behalf of DfE (2018).

[29] See for example Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.
This paper estimates that approximately 44% of UK jobs are at high risk of automation, and that NI and the North East of England are the regions that have the most jobs at high risk (48%).

[30] Autor, D.H. (2015). 'Why are there still so many jobs? The history and future of workplace automation' *Journal of Economic Perspectives*, vol.29(3), pp.3-30.

[31] Arntz, M., Gregory, T. and Zierahn, U. (2016). 'The risk of automation for jobs in OECD countries: A comparative analysis' *OECD Social, Employment and Migration Working Papers*, No.189.

[32] Deloitte (2015). *From Brawn to Brains: The impact of technology on jobs in the UK*.

[33] Expert Group on Future Skills Needs, EGFSN (2018). *Digital transformation: Assessing the impact of digitalisation on Ireland's workforce.*

2.3.2.3. McKinsey estimates that globally just 5% of current occupations and a third of activities in 60% of all occupations could technically be automated[34],[35]. Their mid-point scenario identifies that approximately 20% of UK activity could be displaced by adoption of automation by 2030[36].

2.3.2.4. Taking a similar approach in terms of task versus occupation, the Organisation for Economic Co-operation and Development (OECD) estimates that approximately 10% of workers in the UK are at high risk (i.e. have a greater than 70% probability) of automation. The majority of those at high risk have the lowest levels of education (49%) and are in the lowest income quartile (55%)[37].

2.3.2.5. Those tasks at high risk are identified as being physical activity that is highly structured and predictable, or straightforward data collection and processing[38]. Roles that may become redundant include:

- secretarial roles;
- assembly and factory work;
- cashier / clerk roles; and
- driving roles[39].
- The World Economic Forum (WEF) suggest that approximately half of surveyed companies expected some reduction to the full-time workforce. This will be due to a reduction in the number of task hours competed by human to decrease[40]. This reduction is shown in Figure 2.3.2.

[34] Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., Ko, R. and Sanghvi, S. (2017). 'Jobs lost, jobs gained: Workforce transitions in a time of automation' *McKinsey Global Institute*.

[35] A survey carried out by McKinsey Global Institute in March 2018 also identified that just 6% of companies expected their workforce in the US and Europe to shrink as a result of automation & AI. Bughin, J. et al. (2018). 'Skill shift: Automation and the future of the workforce' *McKinsey Global Institute*.

[36] Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., Ko, R. and Sanghvi, S. (2017). 'Jobs lost, jobs gained: Workforce transitions in a time of automation' *McKinsey Global Institute*.

[37] Arntz, M., Gregory, T. and Zierahn, U. (2016). 'The risk of automation for jobs in OECD countries: A comparative analysis' *OECD Social, Employment and Migration Working Papers*, no.189.

[38] Manyika, J., Chui, M., Bughin, J., George, K., Willmott, P. and Dewhurst, M. (2017). 'A future that works: Automation, employment and productivity' *McKinsey Global Institute*.
Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from www.mckinsey.com last accessed 03 December 2018.

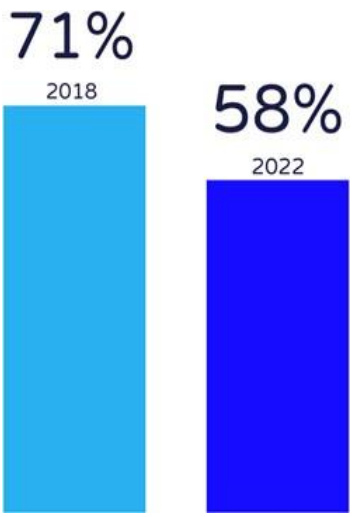
[39] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[40] World Economic Forum (2018). *Artificial Intelligence and Robotics.*

Figure 2. 3.2: Survey conducted by the WEF expect that task hours completed by human workers to be reduced (2018 compared to 2022)

WEF expected that by 2022, the proportion of tasks hours completed by humans would reduce to 58%, compared to 71% in 2018[41]. Over a longer period, there exists more uncertainty over the extent to which entire jobs or tasks within roles could be automated.

Source: World Economic Forum (2018). *Artificial Intelligence and Robotics.*



2.3.2.6. While an estimated 10% of workers globally are in occupations at high risk of automation, 70% are in occupations that have an uncertain outlook42. In such cases, rather than a straightforward substitution of labour by capital (i.e. full automation), automation is more likely to augment labour (i.e. partial automation) and therefore increase productivity[43],[44]. It may imply, for example, increased use of coding programmes to autocomplete data fields, or the introduction of 'cobots'45 to the workplace.

2.3.2.7. Increased productivity reduces costs for businesses and may consequently lower the price of the output46; the impact of this productivity improvement on employment would therefore be dependent on the price elasticity of demand in the product market47. The Expert Group on Future Skills Needs (EGFSN) anticipate that due to AI and cognitive systems' increasing affordability and

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[41] Ibid.

[42] Bakhshi, H. et al. (2017). 'The future of skills: Employment in 2030' *Pearson, NESTA*.

[43] Bessen, J. (2016). 'How computer automation affects occupations: Technology, jobs and skills' *Boston University School of Law: Law & Economics Working Paper*, no. 15-49.

[44] PwC estimate that AI could improve productivity by 14.3% by 2030. PwC (2017). The Economic Impact of Artificial Intelligence of the UK Economy.

[45] 'Cobots' (or collaborative robots) are defined as robots that are designed to physically interact with humans in a shared workspace. This contrasts with traditional robots, designed to operate autonomously or with limited guidance.

[46] Another potential outcome is that prices are kept at pre-automation levels, resulting in an increase in returns flowing to owners of capital (rather than labour). Such issues are addressed in Section 2.5.1 on automation's effect on income equality.

[47] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

availability, jobs could be impacted sooner than expected[48].

2.3.2.8. Additionally, lower prices can lead to increased consumption of complementary goods/services, or of other, unrelated goods/ services due to the income effect.

2.3.2.9. Where demand is inelastic, a decrease in price leads to a relatively small increase in the quantity demanded. As such, it is likely that fewer employees will be required in this scenario than prior to automation and unemployment will increase. Examples of products with price inelastic demand include electricity and medicines.

2.3.2.10. However, in markets where demand is elastic, a decrease in price causes a larger than proportionate increase in the quantity of the good demanded. This may result in increased employment, in order to produce sufficient quantities49. Examples of products with elastic demand include those associated with leisure activities.

2.3.3 Opportunities in jobs and tasks

2.3.3.1. Although there are downside risks associated with automation, there are possible substantial gains in terms of employment. For example, 10% of the combined UK and US workforce are estimated to be in growth occupations[50]; in particular, roles in healthcare and education are expected to see an increase in demand due to wealthier and ageing populations[51].

2.3.3.2. Further, over 25% of companies surveyed by WEF expect automation to lead to the creation of new roles by 2022 and 38% expect to extend their workforce[52]. By 2030, 21-33% (555-890 million) people in the global workforce could be in newly created jobs[53].

2.3.3.3. ManpowerGroup found that 87% of employers plan to increase or maintain their employee headcount. For the UK, up to 10% of employers are planning to increase their headcount, and their headcount has the potential to grow further as automation uptake increases and firms experience the benefits associated with automation such as increased productivity. ManpowerGroup foresee automation as an employment opportunity that will require the

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[48] EGFSN (2018). *Digital Transformation: Assessing the Impact of Digitalisation on Ireland's Workforce.*

[49] An empirical example of this is the 40% increase in the number of US bank branches (and therefore teller staff) between 1988 and 2004, due to increased productivity following introduction of ATMs.

[50] Bakhshi, H., Downing, J.M., Osborne, M.A. and Schneider, P. (2017). 'The future of skills: Employment in 2030' *Pearson, NESTA*.

[51] PwC (2018). *Will Robots Really Steal Our Jobs? An International Analysis of the Potential Long-Term Impact of Automation*.

[52] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[53] Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from www.mckinsey.com (last accessed 03 December 2018).

development of skills and a lifelong learning approach to meet continued employability[54].

2.3.3.4. To 2022, WEF[55] identify emerging, in-demand roles in:

- analysis (e.g. Data Analysts and Big Data Science Specialists);
- technology (e.g. Developers and Machine Learning Specialists);
- inter-personal relationships (e.g. Sales & Marketing Professionals and User Experience Designers); and
- other forms of specialist expertise (e.g. Blockchain, process automation, and information security).

2.3.3.5. It is not possible to anticipate the completely new products or services that may be brought to market in the next 20 years as a result of automation. Consequently, it is infeasible to predict the precise new roles (or their value) that will accompany such products and services; however, research suggests that roles and tasks created are highly skilled. As an example, 10 years ago a 'Digital Marketing Executive' was an uncommon, if not unheard-of, role. Today this is a common role across many organisations, with the skills also being incorporated in marketing courses at universities and further education (FE) organisations[56].

2.3.3.6. Additionally, various authors forecast that there will be an increase in the 'gig economy' or zero-hour, temporary contracts for workers, as well as increased work for freelancers. Short-term contracts would be expected to be relied upon particularly in the transitional stage for an organisation as often these workers are employed for short-term projects due to their expertise. However, with an increased use of these contracts, employability law may need to change to protect these workers, such as in the form of sick leave, for which they are often not currently covered. Labour market regulation will be required to ensure freelancers or 'gig economy' workers are not exploited[57].

2.3.3.7. Although many new roles and tasks will be highly-skilled or sought-after, this will not be the case in all new work. The Nevin Economic Research Institute (NERI) identified that automation has already created a level of polarisation in the NI workforce between "lovely" and "lousy" jobs[58].

- Lovely jobs are typically described as those seeing an increase in

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[54] ManpowerGroup (2018) *Skills Revolution 2.0 Robots Need Not Apply: Human Solutions for the Skills Revolution*.

[55] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[56] EGFSN (2018). *Digital Transformation: Assessing the Impact of Digitalisation on Ireland's Workforce.*

[57] Ferenstein, G. (2018) *How The Gig Economy Can Help Workers Thrive Through Automation.* Available at: www.forbes.com (last accessed 20 June 2019).

[58] MacFlynn, P. and Wilson, L. for NERI. (2019). *The Future of Work: The Impact of Automation Technologies for Job Quality in Northern Ireland.*

autonomy, with work that is creative, caring, involves planning and decision-making, and or utilises cognitive skills[59], for example, the increase in non-routine tasks within service occupations that are of "good quality"[60].

- Lousy jobs are those with reduced autonomy, low / no skills requirement, poor conditions and increased work-related stress[61].

It will therefore be important to monitor the nature of job creation in NI on an ongoing basis to ensure new jobs are generally of good quality.

2.3.3.8. Section 2.3.2 highlighted that automation presents opportunities for augmentation of labour – in addition to simply improving the quantity or quality of humans' work, this complementarity may even generate new, associated job roles. Case Study 2 highlights current changes in warehouse logistics, which have generated new roles in quality control and technology maintenance. Further roles emerging across the economy over the past 5-10 years include app developers and drone operators.

Case Study 2: Changing Roles in Manufacturing Logistics[62]

Automation has already reinvented the logistics sector and, specifically warehouse operations, in the following ways.

- Multi-Shuttle Systems- This involves automated storage and retrieval systems that can retrieve goods without human intervention.
- Swarm Autonomous Guided Vehicles (AGV)- AGVs will operate freely or on tracks to bring items from a picking station based on instructions from the order-flow software.
- Smart Storage- Storage solutions that use advanced analytics and digital tools to place and retrieve items in the most efficient way, adjusting storage media, based on the product, picking and order characteristics.
- Analytics Tools- Algorithms that help operators analyse performance, identify trends, and make predictions to inform operating decisions.

Large operators in this sector (for example Amazon) have adopted these technologies with great success, enabling both improved efficiency and reduced error in their processes. Adopting these forms of automation creates new roles in the sector beyond just machine maintenance. For example, the equipment gathers data that can be analysed to further improve firm performance and flex resource in anticipation of consumer behaviour – this requires employment of data scientists and modellers.

[59] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

[60] NERI measured job quality based on employment arrangements and working hours, earnings and quality of the working environment. See MacFlynn, P. and Wilson, L. for NERI. (2019). *The Future of Work: The Impact of Automation Technologies for Job Quality in Northern Ireland.*

[61] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

[62] Dekhne, A. et al. in McKinsey (2019). *Automation in Logistics: Big Opportunity, Bigger Uncertainty*. Available from www.mckinsey.com (last accessed 13 May 2019).

2.3.3.9. Widespread rollout of such technology requires a sufficient pool of skilled labour – achieving this in NI may require a degree of upskilling, re-skilling and preparation of current students for the future of work. It is expected that automation will redefine roles across the board and this will require people to be adaptable and flexible in their approach to education and work.

2.3.4 Opportunities through increased consumption

2.3.4.1. Consumption may be impacted where automation results in lower-priced goods and services; aggregate demand may also remain steady or increase as consumers spend their "surplus" income elsewhere. As noted in Section 2.3.2, the extent of such impacts will be determined by price elasticity of demand.

2.3.4.2. PwC identified[63] that the impact of AI is expected to be multi-phased: a productivity-driven impact is estimated until 2024 and then consumption-side impacts will dominate from 2025-30. In other words, the supply side of the economy will see the first effects of automation over the period to 2024 as productivity increases; this is expected to be followed by effects on the demand side of the economy into the 2030s, via changes in consumption.

2.3.4.3. In addition to economic growth through new employment opportunities, those in new work occupations tend to earn higher wages than observationally similar workers in pre-existing occupations[64]. For example, as computer adoption increased, computer use was associated with higher wages – the skills of such employees enabled them to demand a higher wage premium[65].

2.3.4.4. Higher incomes may result in increased consumption via the purchase of tangentially related (complementary) goods and services[66] or an increased spend on unrelated leisure activity or personal services, which have highly income-elastic demand[67].

2.3.4.5. PwC have estimated the level of increased spending power to 2030 (Figure 4). NI households are expected to gain £1,934 on average, one of the lowest in both absolute and relative terms across the UK regions, due to relatively weak trade links[68].

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[63] PwC (2017). *The Economic Impact of Artificial Intelligence of the UK Economy*. Available at: www.pwc.co.uk (last accessed 20 June 2019).

[64] Lin, J. (2011). *'Technological adaptation, cities and new work'* The Review of Economics and Statistics, vol.93(2), pp.554-574.

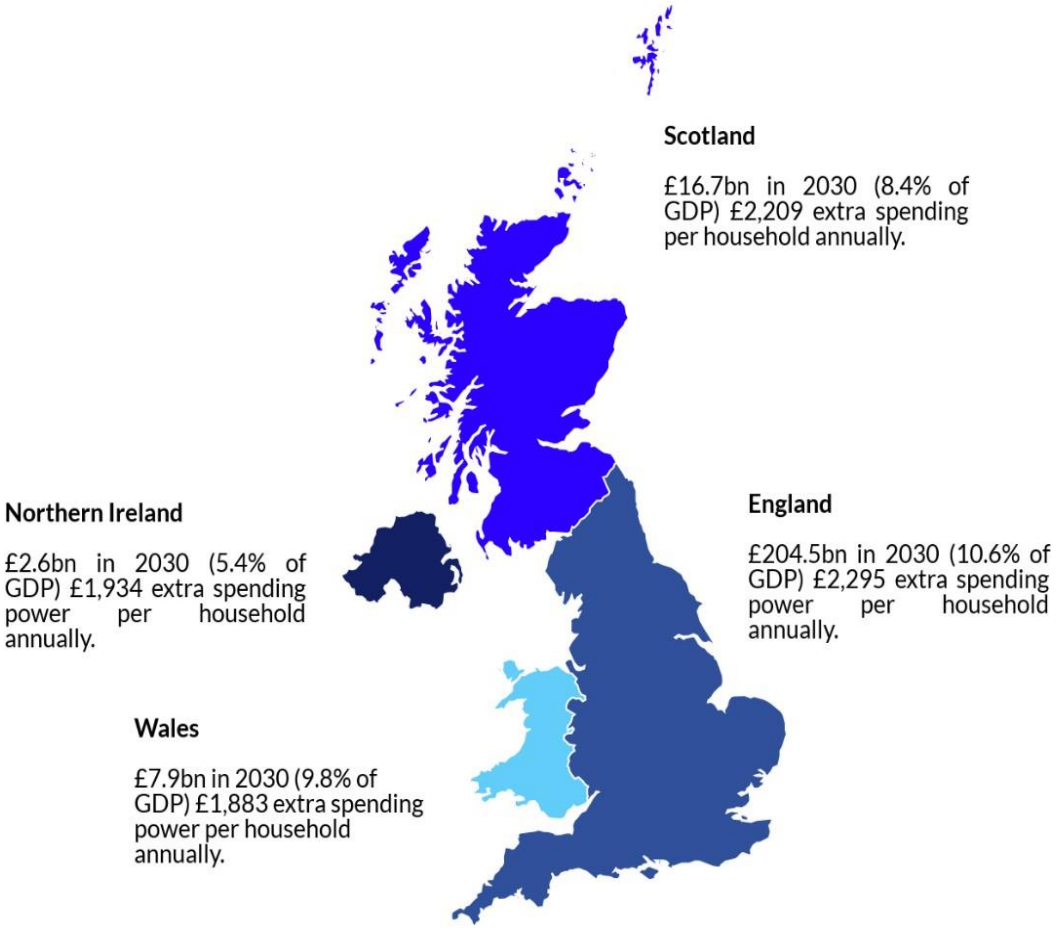
[65] Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., Ko, R. and Sanghvi, S. (2017). 'Jobs lost, jobs gained: Workforce transitions in a time of automation' *McKinsey Global Institute*.

[66] For example, automation in the construction industry is reducing the production cost of pre-fabricated homes. Assuming this also lowers the purchase price, demand would be expected to increase for furnishings, appliances, etc.

[67] Autor, D.H. (2015). 'Why are there still so many jobs? The history and future of workplace automation' *Journal of Economic Perspectives*, vol.29(3), pp.3-30.

[68] PwC (2017). *The Economic Impact of Artificial Intelligence on the UK Economy*. Available at: www.pwc.co.uk (last accessed 19 June 2019).

Figure 2.3.4: Impact of AI on GDP and consumption per household in 2030 by UK Region



Source: PwC (2017). *The Economic Impact of Artificial Intelligence on the UK Economy.*

2.4 Future skills and labour market frictions as a barrier to transitioning

2.4.1. While it is not possible to predict the exact new roles (or their value) resulting from automation, several authors[69] have identified key skills globally for job roles in the future as being:

2.4.1.1. inter-personal skills (management and social / emotional intelligence);

2.4.1.2. higher-order cognitive skills (problem-solving, persuasion and creativity); and

2.4.1.3. systems skills (such as data analytics).

2.4.2. For the UK specifically, key higher-order cognitive skills identified are judgement and decision-making, problem solving, fluency of ideas, and operations analysis. Broad-based knowledge and foreign languages are also expected to be valuable complements[70].

2.4.3. McKinsey[71] has identified the current occupations bearing greatest resemblance to those projected skills profiles in the UK tend to be in the creative industries and hospitality (including professions such as florists, tailors, photographers, catering managers and chefs). These consistently utilise skills that are, at present, distinctively human.

2.4.4. A shortage of softer skills was noted in The Employer Skills Survey 2015 as causing difficulty for employers' filling vacancies, contributing to the overall skills gap in NI. Due to the shortage of both softer and technical skills, 42% of the employers (with hard-to-fill vacancies) surveyed said they were having difficulty introducing new work practices and 29% said they were having difficulty introducing technological change as a result[72]. It is therefore important that policy helps to rectify these skills shortages so that technological changes can be smoothly implemented.

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[69] See for example:

Autor, D.H. (2015). 'Why are there still so many jobs? The history and future of workplace automation' *Journal of Economic Perspectives*, vol.29(3), pp.3-30.

Bakhshi, H. et al. (2017). 'The future of skills: Employment in 2030' *Pearson, NESTA*.

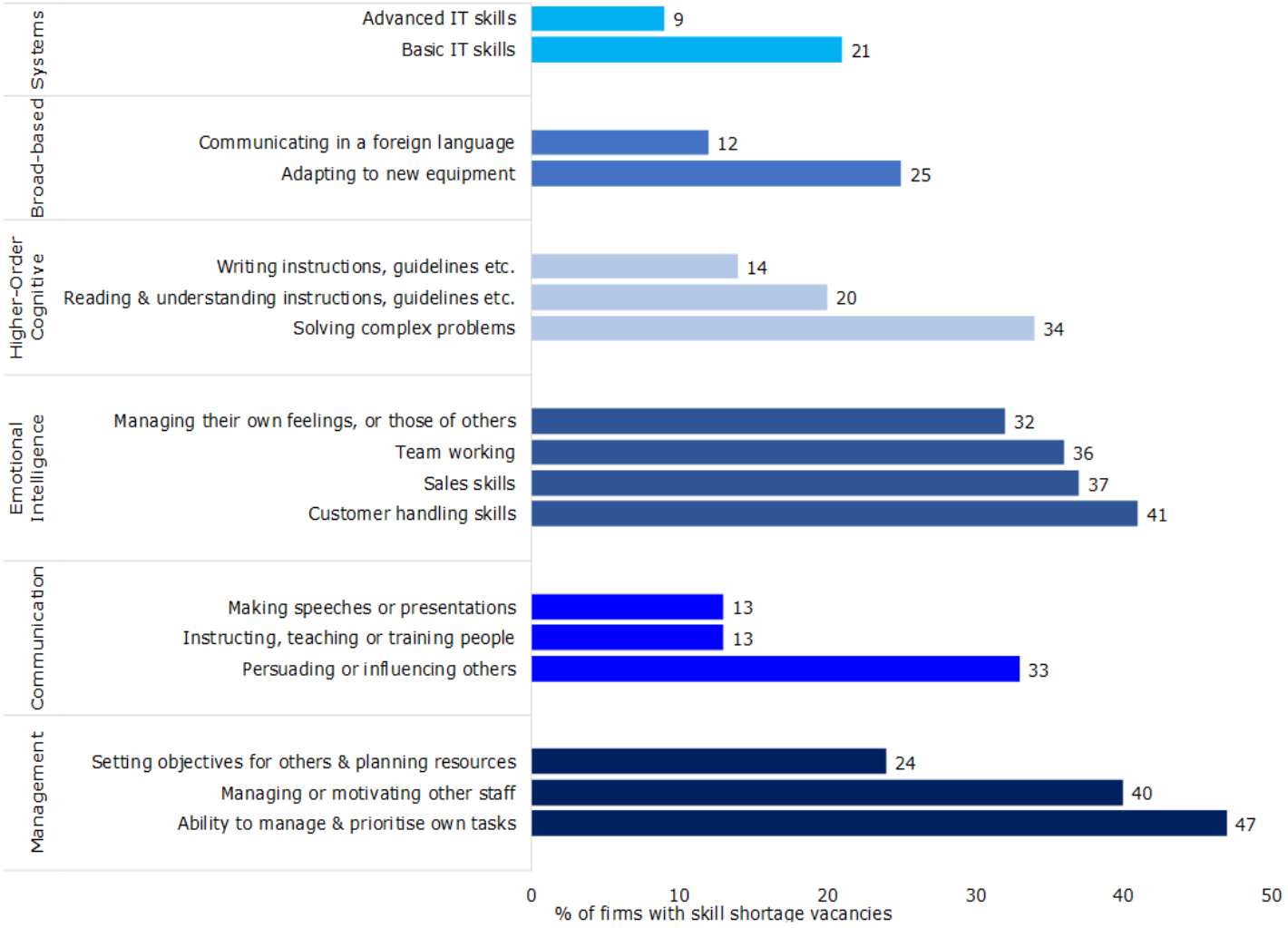
Bughin, J. et al. (2018). 'Skill shift: Automation and the future of the workforce' *McKinsey Global Institute*.

[70] Bakhshi, H. et al. (2017). '*The future of skills: Employment in 2030' Pearson, NESTA*.

[71] Ibid.

[72] UK Commission for Employment and Skills. (2016). *UK Employer Skills Survey 2015: Northern Ireland Results Slide Pack.* Available at: www.gov.uk (last accessed 24 May 2019).

Figure 2.4.1: Soft skills that employers with skills-shortages found difficult to obtain from applicants

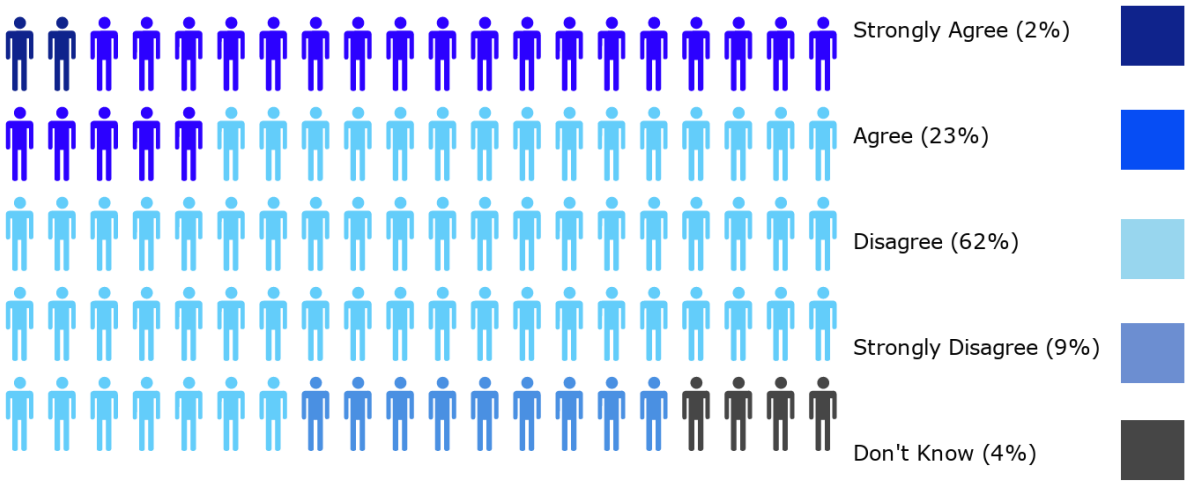


Source: UK Commission for Employment and Skills. (2016). *UK Employer Skills Survey 2015: Northern Ireland Results Slide Pack*. Available at: www.gov.uk (last accessed 24 May 2019).

2.4.5. In addition to soft skills, Deloitte's (2019) survey of 158 organisations highlights a current skills mismatch in delivery of digital strategic objectives (Figure 2.4.2). Only one quarter of surveyed Executives believed their organisation had the right skills in place to execute their strategy[73].

[73] Deloitte (2019). *Aligning Strategy, workforce and technology. Digital Disruption Index.*

Figure 2.4.2 Survey responses to the statement: 'Our talent pool has sufficient knowledge and expertise to execute our digital strategy'.



Source: Deloitte (2019). *Aligning Strategy, workforce and technology. Digital Disruption Index*.

2.4.6. At present, those sectors with the largest skills shortages globally are data analytics, IT, mobile and web design, and R&D. Many employers have identified difficulties in filling vacancies due to a lack of appropriate skills and the average time to fill a vacancy in 2016 was 28 days, an increase of 40% from 2005[74]. Skills mismatch has been a consistent feature in the labour market in the 21st century – for example, this issue was highlighted over a decade ago in NI, with concerns regarding ICT and STEM skills[75].

2.4.7. Skills mismatches can have significant implications for the economy and the labour market – for example, when firms are deciding where to locate their operations, access to a skilled labour force is cited more frequently (74%) as a key concern than access to a low cost of labour (64%)[76]. Skills mismatches can increase labour costs (inefficiencies and upskilling costs), constraints on production (due to vacancies) and limits to the extent of technological progress that is feasible[77]. Therefore, ensuring the quantity and quality of skills to meet demand should be a key policy feature in NI's preparation for automation[78].

2.4.8. The labour market may be sluggish to respond and underprovide skills

[74] Bughin, J., Hazan, E., Lund, S., Dahlström, P, Wiesinger, A. and Subramaniam, A. (2018). 'Skill shift: Automation and the future of the workforce' *McKinsey Global Institute*

[75] Varney, D. (2008). *Review of the Competitiveness of Northern Ireland*.

[76] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[77] OECD (2012). *Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies*. OECD Publishing.

[78] OECD (2012). *Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies*. OECD Publishing.

demanded by the market for several reasons, including the following[79]:

- Upfront cost of training or formal qualifications to the individual or business[80].
- Opportunity Costs. Re-skilling may require workers to forgo wages during the re-skilling process and they may have to temporarily exit the labour market.
- Imperfect rationality. People tend to be short-sighted and may undervalue the expected returns to human capital investment, instead placing a higher value on time and money in the present.
- Imperfect information. Returns to training may be highly uncertain – as people tend to be risk averse, this makes the investment a less attractive proposition.
- Imperfect labour markets. Companies tend to provide below-optimal training due to the risk the employee will be poached by a rival firm.
- Other barriers- Personal barriers for the individual may be a deterrent to re-skilling.

2.4.9. ManpowerGroup forecast that, by 2022, 54% of employees globally will require significant reskilling and upskilling. They estimate that for 35% of employees needing to reskill, the process could take up to 6 months, for 9% of employees it will take 6 to 12 months and 10% will take over one year to develop new skills. They further project that, by 2020, 84% of employers expect to be upskilling their workforce; in 2018 this was 54%[81].

2.4.10. Additionally, McKinsey estimate that 3-14% of the global workforce will need to change occupational categories by 2030[82]. Applying these figures to NI suggests occupational switching of 23,300-122,800 people[83]. These figures indicate that skills preparation is vital to preparing the workforce for this change, and by having a workforce with the correct skills it will enable a smooth, and timely, transition to different occupations.

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[79] See for example:

Brunello, G. and De Paola, M. (2004). 'Market failures and the under-provision of training' *Paper prepared for the joint EC-OECD seminar on Human Capital and Labour Market Performance*.

Keep, E. (2015). 'Market failure in skills' *Skills for Business Sector Skills Development Agency*.

[80] The cost of a degree is a relatively high proportion of annual income for the average worker in NI and availability of student loans / assistance tends to be restricted to the first undergraduate or HE qualification. As such, for those requiring a further qualification to re-skill, the upfront cost may be prohibitive. While increased education may increase workers' opportunities, there are also external benefits to higher levels of education that are unlikely to be priced into wages.

[81] ManpowerGroup (2019). *Humans Wanted: Robots Need You.* Available at: www.manpowergroup.com (last accessed 17 June 2019).

[82] Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from www.mckinsey.com (last accessed 03 December 2018).

[83] Labour Force Survey (January to December 2017). Available from: www.nisra.gov.uk (last accessed 7 January 2019). Note percentages have been directly applied to the 2017 NI total employment figure and do not take account of NI specific sectoral composition.

2.4.11. McKinsey notes that it is important for each organisation to fully understand how automation will impact them and be prepared for the resultant changes to their business[84]. Their survey of executives carrying out digital transformations identified that smooth transitional processes tend to be characterised by:

- a clear set of business objects with a limited number of themes;
- shared accountability and buy-in of the transformation;
- flexible, highly-skilled talent allocation;
- flexibility and adaptability of organisational policies; and
- ensuring the correct amount of investment is in place, which may involve reallocating operational expenditures[85].

2.4.12. Given the various forms of market failure underlying skills mismatches and shortages, government policy is fundamental to correction, and the importance of the policy response increases with the pace of automation and shifts in required skills[86]. However, responsibility does not rest with government alone[87]; rather, there must be collaboration with educational institutions and businesses to ensure the most appropriate skills are being accessed[88].

2.4.13. Educators have a responsibility to adapt what and how they teach in order to meet workforce requirements[89] and deliver the labour market of the future[90]. Such adaptations may be in relation to the nature of training offered (e.g. short, accredited courses rather than multi-year degrees) or in more closely tailoring content to the demands of employers[91].

2.4.14. The UUEPC regularly carries out research to identify NI future skills needs and gaps by level, sector and subject area. The 2019 UUEPC Skills Barometer has found that, over the next decade, one third of job opportunities will require at least degree-level qualifications. However, there is projected to be a significant undersupply of Level 3-5 qualifications, whilst there is an oversupply of qualifications at Level 2 and below[92.]

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[84] Manyika, J., Chui, M., Bughin, J., George, K., Willmott, P. and Dewhurst, M. (2017). 'A future that works: Automation, employment and productivity' *McKinsey Global Institute*.

[85] McKinsey Digital. (2019). *Five Moves to Make During a Digital Transformation*. Available from: www.mckinsey.com (last accessed 1 May 2019).

[86] Autor, D.H. (2015). 'Why are there still so many jobs? The history and future of workplace automation' *Journal of Economic Perspectives*, vol.29(3), pp.3-30.

[87] Baboolall, D., Pinder, D., Stewart, S. and Wright, J. (2018). *Automation and the future of the African American workforce.* Available from www.mckinsey.com (last accessed 03 December 2018).

[88] Deloitte (2015). *From Brawn to Brains: The impact of technology on jobs in the UK*.

[89] Ibid.

[90] Autor, D.H. (2015). 'Why are there still so many jobs? The history and future of workplace automation' *Journal of Economic Perspectives*, vol.29(3), pp.3-30.

[91] Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., Ko, R. and Sanghvi, S. (2017). 'Jobs lost, jobs gained: Workforce transitions in a time of automation' *McKinsey Global Institute*.

[92] Economic Policy Centre. (2019*). NI Skills Barometer 2019*. Ulster University.

2.4.15. For Level 6+ qualifications, the top three subjects that are currently undersupplied are engineering and technology, mathematical and computer sciences and physical / environmental sciences. The Skills Barometer has projected that the most 'in-demand' degree subjects from 2018-2028 will be nursing and computer science[93]. The demand and supply of skills is constantly evolving, and so the education system needs to build in flexibility to meet the challenges this presents[94].

2.4.16. Any changes throughout the education system should be accompanied by informative career education[95], both for those still in compulsory education and for older workers engaging in re-training activity, in order to increase uptake of the most economically relevant skills[96].

2.4.17. Individuals in the labour market also have a responsibility to undertake lifelong learning, rather than a single, undeviating career path from school to retirement[97]. In a rapidly changing environment, those who do not adapt may be vulnerable to further technological advances, in the form of unemployment and lower wages, particularly given that job roles are expected to change more quickly than in the past[98]. However, given the market failures outlined in paragraph 2.4.8, government may need to ensure appropriate individual incentives[99].

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[93] Ibid.

[94] For more information on some education policies in NI see section 3.3.

[95] Baboolall, D., Pinder, D., Stewart, S. and Wright, J. (2018). *Automation and the future of the African American workforce*. Available from www.mckinsey.com last accessed 03 December 2018.

[96] The Youth Voice Census in the UK indicated that careers information was not always evenly provided, for instance across gender 79% of females surveyed said that traineeships had never been discussed with them, whilst only 37% of young men were likely to visit a university. The information provided to young people contributes to the selection of future study or career choices and so it need to be consistent and up to date with in demand skills and jobs. The Policy Tools (section 7.2) suggests increased and open career guidance will help to overcome this.

Youth Employment UK (2019). *Youth Voice Census Report 2019.* Available from: https://www.youthemployment.org.uk. (last accessed 11 October 2019).

[97] Deloitte (2015). *From Brawn to Brains: The impact of technology on jobs in the UK*.

Expert Group on Future Skills Needs, EGFSN (2018). *Digital transformation: Assessing the impact of digitalisation on Ireland's workforce*.

Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from www.mckinsey.com (last accessed 03 December 2018).

World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[98] Expert Group on Future Skills Needs (EGFSN) (2018). *Digital transformation: Assessing the impact of digitalisation on Ireland's workforce*.

[99] Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from: www.mckinsey.com (last accessed 3 December 2018).

2.4.18. Further, businesses must facilitate and enable retraining to take place for those employees most likely to be affected by automation[100]. Business could also take a lead in the provision of on-the-job training[101]. However, research indicates that those most in need of re- and up-skilling are presently the least likely to receive it through employers[102]. In Europe, fewer than half of companies (45%) intend to retrain staff as the primary method of meeting future skills challenges[103] and, globally, approximately 25% of companies are undecided or unlikely to pursue retraining of existing staff[104].

2.4.19. Overall, the research base is clear that changes in technology will alter the types of jobs available and what those jobs pay[105]. The net impact of automation is expected to be positive; however, it is expected that labour market frictions will be significant and transitions difficult[106]. This section has highlighted the roles of each actor within the system; however, the importance of collaborative working cannot be overstated. Government, educators, businesses and individuals must work together to ensure NI captures fully the opportunities presented by automation. Potential policy initiatives and examples of best practice will be explored in detail in Section 3.

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[100] Expert Group on Future Skills Needs, EGFSN (2018). *Digital transformation: Assessing the impact of digitalisation on Ireland's workforce*.

[101] Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., Ko, R. and Sanghvi, S. (2017). 'Jobs lost, jobs gained: Workforce transitions in a time of automation' *McKinsey Global Institute*.

[102] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[103] Bughin, J., Hazan, E., Lund, S., Dahlström, P, Wiesinger, A. and Subramaniam, A. (2018). 'Skill shift: Automation and the future of the workforce' *McKinsey Global Institute*.

[104] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[105] World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

[106] See for example:

Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from www.mckinsey.com (last accessed 3 December 2018).

Manyika, J., Chui, M., Bughin, J., George, K., Willmott, P. and Dewhurst, M. (2017). 'A future that works: Automation, employment and productivity' *McKinsey Global Institute*.

World Economic Forum (2018). *The Future of Jobs Report 2018*. Centre for the New Economy and Society Insight Report.

2.5 Automation and equality

2.5.1 Income equality

2.5.1.1. In the UK, capital ownership is highly concentrated amongst the wealthiest households[107]:

- the wealthiest 10% own almost 50% of private wealth, while the poorest 50% own just 9%;
- the wealthiest 10% own almost 70% of the UK's financial wealth;
- the median financial wealth of the richest 10% is £153,900 meanwhile for the least wealthy half of households, it is just £400; and
- capital income accounts for 20% of income for those earning over £1 million, 5% for those earning £20,000 to £30,000, and almost nothing for the poorest households.

2.5.1.2. Automation is projected to increase GDP and the "average" household's spending power. However, there is a risk that the benefits of automation will remain concentrated amongst those who own capital and who are highly skilled workers. The IPPR suggest this could lead to the poorest households experiencing a decline in the standard of living[108].

2.5.1.3. If real wages do not increase in line with real productivity, the share of income from labour will decline relative to that from capital. Given the highly unequal distribution of capital ownership in the UK, this will accelerate income inequality[109]. Evidence[110] would indicate that a greater share of income is already being earned by capital, rather than labour; wages therefore have not kept pace with productivity. Automation has the potential to reinforce this trend.

2.5.1.4. Consequently, IPPR identifies that ownership of capital should be broadened for future wealth to become more equally distribute[111] such as increased taxation on capital profits to be redistributed through welfare programmes. This will in turn help to make technology work for everyone as wealth will be dispersed more evenly. Redistributive tax and welfare policies will be explored further in

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[107] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

Private wealth refers to what is generally understand by the term "wealth". It includes assets such as houses, cars and financial wealth.

Financial wealth is made up of formal financial assets (bank accounts, savings accounts, stocks and shares); informal financial assets (money saved at home); and liabilities (formal borrowing, overdrafts and arrears on household bills).

Wealth is a stock – it is measured at a single point in time; income is a flow – it is measured over a defined time period.

[108] Ibid.

[109] Ibid.

[110] Marsh & McLennan Companies. (2018). *The Twin Threats of Aging and Automation.*

[111] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

Section 3.2.4 to identify how other countries are tackling capital wealth and inequality, this information will help to inform policy recommendations in Section 7.2.

2.5.1.5. Over the past 50 years, there has been a decline in the number of middle-income households. Approximately 33% of that decline in middle income is as a result of a move into lower income brackets, while 67% of that change has been an upwards shift into higher income brackets[112]. It is possible that this trend could accelerate over the period to 2030 as a result of automation causing job tasks to be re-bundled[113]. This further highlights the importance of future tax and welfare redistribution policies as a more equal distribution of income gained by capital may be required to help workers negatively impacted by automation to supplement their labour income for capital income.

2.5.1.6. Competition amongst firms for high-skilled workers is expected to increase[114] (thereby driving up the wage rate) and several high-wage occupations are expected to grow (such as highly-skilled medical professionals[115]. This competition may be additionally heightened due to migration issues in NI whereby a relatively large proportion of highly-skilled individuals leave after A-levels and University study causing a continual 'brain drain' issue as well as the potential implications of Brexit.

2.5.1.7. While some low-skill occupations are expected to have increased employment opportunities (such as food preparation and hospitality[116]), low-skill, low-wage jobs are expected to be the most displaced by automation[117]. These jobs are typically taken up by individuals with low levels of education who may not be qualified to move into higher value-added employment opportunities. Concerns have been raised by various authors about the potential of these low-skilled individuals having a higher chance of falling into long-term unemployment. If this were to happen it would increase reliance on the welfare state and income inequality in NI. In combination, it is therefore expected that the current pattern of income inequality and polarisation is likely to worsen over time, unless low-skilled workers who become unemployed re-train, and are able to source new employment or take on new tasks[118].

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[112] Ibid.

[113] Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from www.mckinsey.com (last accessed 03 December 2018).

[114] Bughin, J., Hazan, E., Lund, S., Dahlström, P, Wiesinger, A. and Subramaniam, A. (2018). 'Skill shift: Automation and the future of the workforce' *McKinsey Global Institute*.

[115] Manyika, J. and Sneader, K. (2018). *AI, automation, and the future of work: Ten things to solve for*. Available from www.mckinsey.com (last accessed 03 December 2018).

[116] Lawrence, M., Roberts, C. and King, L. (2017). *Managing Automation: Employment, inequality and ethics in the digital age.* IPPR Commission on Economic Justice.

[117] Bughin, J., Hazan, E., Lund, S., Dahlström, P, Wiesinger, A. and Subramaniam, A. (2018). 'Skill shift: Automation and the future of the workforce' *McKinsey Global Institute*.

[118] Bughin, J. et al. (2018). 'Skill shift: Automation and the future of the workforce' *McKinsey Global Institute*.

2.5.2 Regional equality

2.5.2.1. In addition to general income inequality issues, it is likely that the impact of automation will be geographically concentrated. This is due to variation by region in the proportion of jobs susceptible to automation, estimated by one study as 39% in London but c48% in NI[119]. Section 4 and 5 will examine the anticipated geographical impacts in NI based on UUEPC data analysis.

2.5.2.2. EGFSN noted that 11% of workers in the border region in Ireland were at high risk from automation, whilst 64% were at medium risk. This may be due to the types of jobs which are at risk such as agriculture, forestry and fishing, manufacturing and construction as well as other factors such as the skills and qualifications of the population in these areas[120]. They further noted that since unemployment in this area is already higher than the Irish average, anxiety associated with automation may be heightened in this area[121]. While the EGFSN analysis concentrated on effects in Ireland, it is not unreasonable to anticipate similar impacts in the areas around the land border in NI. Additionally, a report by Queen's University Belfast (QUB) noted that 30% of NI citizens surveyed travelled across the border for work or educational purposes[122] therefore jobs at risk in the Irish border regions have the potential to impact NI residents.

2.5.2.3. At a UK wide level, PwC[123] identify that 46% of individuals with Level 2 qualifications are at risk of automation, falling to 12% for those with undergraduate degrees. NI has a higher proportion of adults aged 25 to 64 years with only level 0-2 qualifications (24.7%) than the UK as a whole (19.6%)[124]. Consequently, NI is at risk of a relatively high level of automation when compared with other UK regions.

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[119] World Economic Forum (2018). The Future of Jobs Report 2018. Centre for the New Economy and Society Insight Report.

[120] Crowley, F. and Doran, J. (2019). *Automation and Irish towns: who's most at risk?* University College Cork. Available at: www.ucc.ie (last accessed 18 June 2019).

[121] EGFSN. (2018) *Digital Transformation Assessing the Impact of Digitalisation on Irelands Workforce*.

[122] Hayward K. (2018). *Brexit at the Border: Voices of Local Communities in the Central Border Region of Ireland/ Northern Ireland.* Queen's University Belfast and Irish Central Border Area Network. Available at: www.qub.ac.uk (last accessed 18 June 2019).

[123] PwC. (2017). *UK Economic Outlook March 2017*, p30.

[124] Eurostat. (2019). *Population Aged 25-64 by educational attainment level, sex and NUTS 2 regions (%).* Available at: https://ec.europa.eu/eurostat/data/database (last accessed 02 May 2019).

2.5.3 Gender equality

2.5.3.1. An IMF study of 28 OECD countries plus Singapore and Cyprus, estimated that 11% of female-dominated jobs and 9% of male-dominated jobs are at high risk of automation[125]. There are, however, a variety of contrasting figures estimating the jobs at risk of automation by gender; Table 1 sets out a small number of examples for the UK.

Table 1: Estimates of UK jobs at risk of automation by gender

Source	Male jobs at risk	Female jobs at risk	Total jobs at risk
PwC (2017)[126]	35%	26%	30%
McKinsey[127]	24%	22%	23%
IPPR[128]	41%	47%	44%

2.5.3.2. When considering gender-based impacts of automation, it is important to assess the current work profile. Females are more likely to be qualified to degree level than males[129] but are currently under-represented in managerial and executive roles. Such roles generally carry a relatively low risk of automation[130] and tend to be relatively highly paid. Given this dichotomy, it is unclear whether females would be more or less likely to be at high risk of disruption from automation.

2.5.3.3. Females currently make up less than a quarter of employees in STEM occupations in the UK, which are likely to have a high degree of complementarity with automation technology, rather than being threatened by it[131]. MATRIX note that, by retirement age, Females constitute only 6% of science, research, engineering and technology professionals in NI[132]. Figure 2.5.3.1 examines this further.

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[125] IMF Staff Discussion Note (2019). *Gender, Technology and the Future of Work*. Available at: www.imf.org (last accessed 18 June 2019).

[126] PwC (2017). *Will robots really steal our jobs? The potential impact of automation on the UK and other major economies.* Available at: www.pwc.co.uk (last accessed 11 June 2019).

[127] Titled in document: Potential effects on employees by 2030, % of 2017 base employment. Mckinsey Global Institute (2019). *The future of Females at work: Transitions in the age of automation*. Available at: www.mckinsey.com (last accessed 20 June 2019).

[128] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

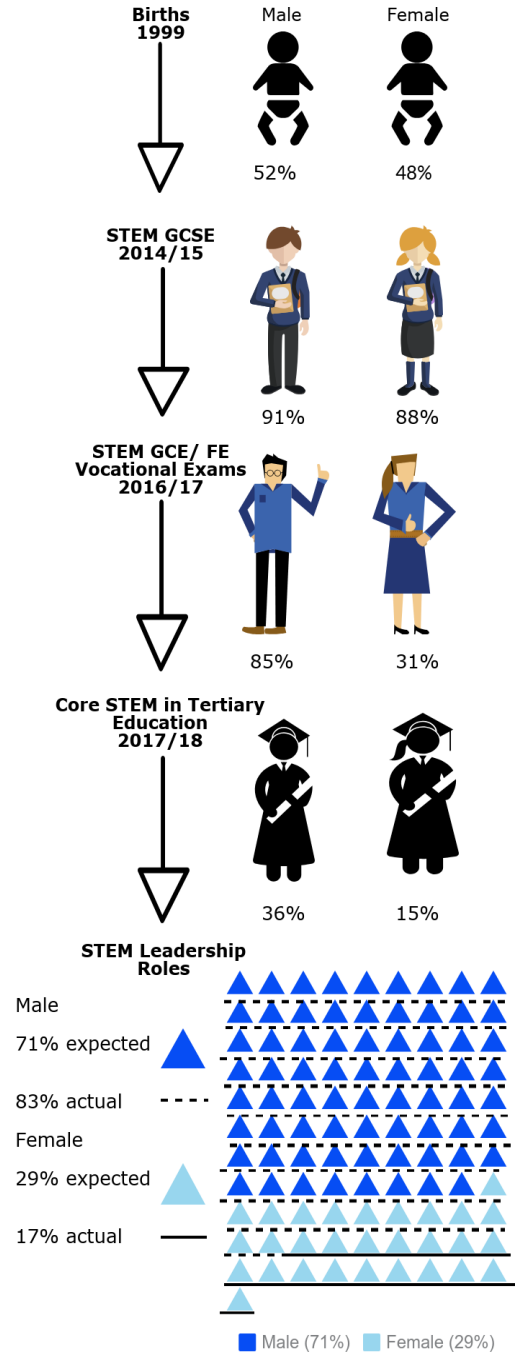
[129] In NI 33.9% of males aged 25-64 have gained tertiary education (Levels 5-8), meanwhile 40% of females have gained this level of education in any field. Eurostat. (2019). *Population Aged 25-64 by educational attainment level, sex and NUTS 2 regions (%).* Available at: https://ec.europa.eu/eurostat/data/database (last accessed 02 May 2019).

[130] PwC (2018). *Will robots really steal our jobs?* Available at: www.pwc.co.uk (last accessed 11 June 2019).

[131] Statistics derived from the Labour Force Survey 2017. Available at: www.wisecampaign.org.uk (last accessed 04 January 2019).

[132] MATRIX-NI Science Industry Panel (2018). *Females in STEM*.

Figure 2.5.3.1: Females' progression through STEM in NI



STEM stands for science, technology, engineering and mathematics. There is no universally-accepted definition of included subjects but DfE distinguishes between broad and narrow STEM:

- Medicine & Dentistry
- Subjects allied to Medicine
- Biological Sciences (N)
- Veterinary Sciences, Agriculture & related subjects
- Physical Sciences (N)
- Mathematical Sciences (N)
- Engineering (N)
- Computer Sciences (N)
- Technologies (N)
- Architecture, Building and Planning

Those marked with an 'N' are included in the narrow definition.

MATRIX highlight a key drop-off of Females in STEM occurs in the selection of subjects to pursue at A-level. This does not appear to result in a significant difference in awards of broad STEM qualifications from NI Higher Education Institutes (HEI) (52% of males, 46% of females)[133]. However, a notable gender split is evident when considering core STEM qualification at this level (36% of males, 15% of females).

Given the ratio of graduates is approximately 2:1 male, it might be expected that STEM employment would have a similar male to female ratio across all career stages. However, Females constitute just 17% of STEM leadership roles in NI (on average across all age groups). A critical point appears to occur in NI Females' STEM careers around their mid- to late-40s, where representation at higher levels drops significantly. It continues to do so to retirement, by which stage just 6% of STEM professionals in NI are Females.

Source: MATRIX-NI Science Industry Panel (2018). *Females in STEM*.

[133] DfE (2019). *Qualifications 2017/18: Tables*. Available at: www.economy-ni.gov.uk (last accessed 21 May 2019).

2.5.3.4. Whilst the European Commission note that 85% of the machine learning workforce is male[134], females tend to dominate healthcare and education-based roles; rising demand in these industries may therefore further disproportionately absorb displaced females[135]. To facilitate this, consideration would need to be given to accessibility of training programmes – this is considered in further detail in Section 2.4. Whilst increased absorptive capacity in such professions is a positive in terms of retaining females in the labour market, it may result in increased average wage disparity, given that these industries tend to comprise a high proportion of low-paid roles.

2.5.3.5. At present, the gender pay gap is 8.6% among full-time employees in the UK, decreased from 17.4% in 1997[136]; policy intervention may be required to ensure this trend is not reversed. One such suggestion is to reward roles based on social value (rather than their ability to generate profit), which would involve, for example, roles in care work receiving higher pay for their contribution to society[137]. Implementation in practice would necessitate a significant culture shift and, most likely, a degree of government intervention that may be neither practical nor desirable. A range of policy measures are explored in further detail in Section 3.

2.5.3.6. Further opportunities may exist for females as a result of automation beyond (what are currently) female-dominated industries. Automation could, for example, provide individuals with greater access to flexible working patterns (including remote working)[138]. Given that domestic caring responsibilities tend to disproportionately fall to females[139], increased flexibility could improve access to traditionally male-dominated roles and improve career development prospects for females.

2.5.3.7. Time outside of paid work may be split into domestic, care, or leisure activities. Whilst there is only small gender-based disparity in time allocated to leisure activities, the UK has a significant gender gap in time dedicated to domestic and caring responsibilities: 85% of females do housework or cooking every day for at least one hour, compared to just 49% of men; and 41% of females have daily caring responsibilities for at least one hour, compared to just 25% of men[140].

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[134] European Commission, Servoz, M. (2019). *AI The Future of Work? Work of the Future!* Available at: https://ec.europa.eu (last accessed 09 October 2019).

[135] PwC (2018). *Will Robots Really Steal Our Jobs? An International Analysis of the Potential Long-Term Impact of Automation*.

[136] ONS (2018). *Gender Pay Gap in the UK: 2018*. Available at: www.ons.gov.uk (last accessed 04 January 2019).

[137] Howcroft, D. and Rubery, J. (2018). *Automation has the Potential to Improve Gender Quality at Work*, The University of Manchester.

[138] Hegewisch, A. et al. (IWPR) (2019). *Females, Automation, and The Future of Work.*

[139] European Institute for Gender Equality (2017). *Gender Equality Index 2017*. Available at: https://eige.europa.eu/ (last accessed 13 June 2019).

[140] Ibid.

2.5.3.8. Although cultural factors may underpin some of this disparity, they are beyond the scope of this report to address. However, the difference may also be (at least in part) a rational economic decision. Where domestic or caring responsibilities are such in a household that a choice must be made between those and work, it is a rational decision for the lowest earner (or potential earner) to transition from paid to unpaid work. Consequently, given the current gender pay gap, it is (to some extent) expected that a higher proportion of females than men will undertake significant daily domestic and or caring work.

2.5.3.9. Automation has the potential to profoundly change this gender divide in the allocation of unpaid time. Where the standard working week is reduced across the economy, males may have increased opportunity to become involved in those domestic or caring roles (where currently, there is an economic incentive to be in paid work instead). Further, where remote working becomes more commonplace, time otherwise spent commuting would become available for allocation to domestic, caring or leisure activity. Such examples might be described as indirect impacts or facilitative properties of automation. Over the next decade, it might be expected that further domestic automation may take place and reduce the time burden of domestic and caring responsibilities – this will directly affect females in the UK, given the current share of unpaid work undertaken.

2.5.3.10. The academic literature has not yet reached a consensus on the expected outcomes of automation, regarding potential gender differences[141]. Given the potential for increased disparity in the labour market, it will therefore be important for government to proactively and appropriately manage and distribute the gains of higher productivity, in addition to considering the incentive structures that frame individual workers' and firms' education and employment decisions[142].

2.5.4 Age equality

2.5.4.1. The UN projects that by 2050 more than one third of the world's population will be over the age of 50[143]. Global birth rates are in decline; consequently, it is vital that older workers are guided through the automation revolution to retain them in the workforce and thereby help maintain, or increase, productivity levels.

2.5.4.2. Marsh & McLennan Companies identify that in the UK, 47% of tasks completed by older workers are at risk of being automated. For comparison, in China,76%[144] of tasks by older workers are at risk[145]. This risk may be linked to the skills set of older workers, particularly surrounding technology skills, and

[141] Hegewisch, A. et al (IWPR) (2019). *Females, Automation, and The Future of Work.*

[142] Baboolall, D., Pinder, D., Stewart, S. and Wright, J. (2018). *Automation and the future of the African American workforce*. Available at: www.mckinsey.com (last accessed 03 December 2018).

[143] United Nations Department of Economic and Social Affairs (2017). *World Population Prospectus: The 2017 Revision, Key Findings and Advance Tables*

[144] Ibid.

[145] These figures were calculated using UN figures and their nine categories of employment and then mapped to the 'probability of computerisation' values from Frey and Osbourne. A weighted average was then given to predict the risk of automation for older workers in each country.

the tasks their occupation requires them to perform that could be automated[146]. OECD found that only 10% of adults aged 55 to 65 were able to complete multiple-step technological tasks; in comparison 42% of people aged 25-54 were able to complete these tasks[147]. Consequently, there is an immediate vulnerability associated with being an older worker in a developing automated age.

2.5.4.3. All authors discussing age and automation agree that retraining, and lifelong learning will need to become a normal feature of the workplace. Inclusive policies will need to be in place to prevent older workers from becoming displaced by automation[148]. Older workers need to be incorporated in to the technological age; without this, automation could deepen social instability[149].

2.5.4.4. However, Gratton and Scott's global survey identified that today's workers aged 45+ are seeking new opportunities – 60% are investing in new skills for work[150]. The Kauffman Index, which tracks entrepreneurship and start-up activity in the US, reported that 24.4% of new entrepreneurs in 2016 were aged 55-64; in 1996 this age group made up 14.8% of start-ups[151]. In NI 59% of men aged 55-64 still in work are self-employed, and the figure for Females is 29%[152].

2.5.4.5. The Northern Ireland Cohort for the Longitudinal Study of Ageing (NICOLA)[153] states that NI has the second lowest employment rate of older adults with only one third of those aged over 50 being in a form of employment. Retaining older people in the workforce will help to keep them economically active as well as other associated benefits, such as to health. Therefore, at an individual level, the inclusivity of older workers in the automation age is also important from a social and health perspective.

2.5.4.6. The Mercer Workforce Monitor emphasises the need to engage an older workforce after Brexit. They project that the UK is embarking on a workforce crisis that is currently being masked by the number of immigrant workers helping to meet shortages. Automation could help meet the potential future need for more workers in low skilled jobs that are currently being filled by immigrant workers. The retention of older workers will also help to meet workforce shortages; an additional 900,000 people could be added to the labour

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[146] Marsh & McLennan Companies, Global Risk Centre (2018). *The Twin Threats of Aging and Automation.* Available at: www.mercer.com (last accessed 19 April 2019).

[147] Marsh & McLennan Companies, Global Risk Centre (2018). *The Twin Threats of Aging and Automation.* Available at: www.mercer.com (last accessed 19 April 2019).

[148] Ibid.

[149] Ibid.

[150] Gratton, L. and Scott, A. (2016). *Our Assumptions About Old and Young Workers Are Wrong- Harvard Business Review*. Available at: https://hbr.org (last accessed 08 May 2019).

[151] Kauffman Foundation (2016). *The Kauffman Index: Start-Up Activity- National Trends*.

[152] Cruise, S. and Kee, F. (ed). (2017). *Early Key Findings From A Study of Older People in Northern Ireland- The NICOLA Study*. Queen's University Belfast.

[153] Cruise, S. and Kee, F. (ed). (2017). *Early Key Findings from A Study of Older People in Northern Ireland- The NICOLA Study*. Queen's University Belfast.

market by increasing participation in the 55-60 age range by 5% and in the 60-65 age range by 10%[154].

2.6 Summary

2.6.1. The 4th Industrial Revolution is currently happening across the world and, although it will not be an overnight process, it does have the potential to dramatically alter every facet of people's lives, from education to work to leisure. This research has focussed on the economic impacts of automation with the purpose of highlighting benefits NI might expect, risks NI might face, and paving the way to consideration of appropriate economic policy interventions in Section 7. It should be noted that an economic focus is only one part of the picture; ethical concerns, are an important element of an automated future and whilst they are beyond the scope of this research, it is recommended that policy makers also give these appropriate considerations.

2.6.2. Automation has the potential to have a positive economic impact in NI at a macro level through:

- increased consumption with lower prices;
- increased productivity;
- increased employment and employment in better quality jobs; and
- an increase in the average wage.

2.6.3. However, estimates of the actual impact vary significantly depending on the assumptions made within the various models. While early work (see for example Frey and Osborne) assumed heavy job losses, more recent work highlights that the majority of jobs will evolve in terms of tasks completed. Further, automation presents significant opportunity in the creation of new work – human labour may be complemented or augmented by the work of machines, and new industries and occupations may emerge as technology advances.

2.6.4. Although automation has the potential to generate net benefits across the economy, it may have some negative impacts at a micro level. Businesses that do not evolve and adapt may lose competitiveness, lose market share and potentially exit the market, and individuals may face job displacement and or be expected to perform new and different job tasks to which their current skills are not yet suited. This may result in wage decreases, especially during periods of reskilling.

2.6.5. Automation has the potential to increase the income gap – one estimate suggests that 10% of jobs in the UK are at high risk of displacement, and the majority of those workers are low skilled and on a low income. There is a further risk that wealth resulting from automation will remain concentrated amongst capital owners (i.e. additional business profits will flow, not to workers, but to business owners and shareholders). As capital ownership is already concentrated amongst the wealthiest individuals, there is a significant risk that

[154] Mercer Workforce Monitor (2018). *Diversification: Is There a N.E.E.T Solution to the Workforce Crisis?* Available at: https://www.uk.mercer.com (last accessed 08 May 2019).

automation could result in increased inequality in NI without redistributive policy measures.

2.6.6. Although there is currently a gender gap in NI, it has been closing over time. The impact of automation on this trend is, however, unclear. On the one hand, females are currently under-represented in STEM occupations that are expected to be more insulated from automation-related displacement, and under-represented at more senior levels of management. On the other hand, female-dominated industries (such as creative professions, healthcare and education) are expected to see large increases in demand for labour, although they tend currently to pay lower wages. Automation may also result in more flexible working patterns that may aid females career progression with potential for greater redistributive effects in the allocation of domestic and caring responsibilities. The net impact for Females is unclear across the research landscape.

2.6.7. Older workers will be needed in the labour market to help maintain productivity levels and help with a growing and ageing population. However, studies have found that the skillset of older workers differs to that of younger workers and only 10% of adults aged 55 to 65 were able to complete multiple-step technological tasks. Policy must take into consideration the factors associated with being an older worker to ensure automation is inclusive of all age groups.

2.6.8. Many of the risks posed by automation can be addressed through workforce skills. "Uniquely human" skills (such as higher order cognitive skills, emotional intelligence and creativity) will become increasingly important over the next decade, and familiarity with the technology will become a necessity. It is therefore important that government, educators and businesses work collaboratively to prepare the future workforce and reskill the existing workforce appropriately. Individuals will also have a responsibility to engage in lifelong learning and development to ensure their personal skillset remains relevant in a rapidly evolving economy.

3 Policy Review

3.1 Comparison of Global Policy Approaches

3.1.1. This section has reviewed a range of automation-related policy measures[155] across eleven countries and regions[156]. This review indicated a complementary policy focus on:

- R&D;
- Skills and education;
- support for business; and
- taxation and inequality.

3.1.2. These complements have been used as key themes to organise Section 3.2 to provide a summary of similar policy actions across the countries reviewed[157]. A more in-depth analysis of international policy actions to support automation can be found in Annex 3.

3.1.3. In addition, consideration is given to the current NI policy landscape in order to draw out appropriate recommendations, harnessing synergies wherever possible will be used to help identify best practice and lessons learned in the development and implementation of automation policy within NI.

3.1.4. The Automation Readiness Index[158] has been used throughout this review as it assesses the policy environment in twenty-five countries to measure their individual preparation and readiness for automation[159]. The Index enables countries to be compared using reliable and comparable information.

3.1.5. A factor limiting this review is that many of the policies discussed are still ongoing and as such not enough time has passed for these policies' successes or challenges to have been adequately evaluated, or for sufficient results to have been produced for an effective review which may limit the best practices that can be identified for potential use in the NI policy toolkit.

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[155] Where direct automation policies are not in place, indirect policies have been reviewed as their implementation will help the associated countries lay the groundwork necessary for automation to succeed. For example, Estonia's e-Estonia policy has helped to digitalise public services.

[156] The policy landscape was reviewed for Germany, Estonia, Singapore, the UK, Scotland, South Korea, Ireland, Canada, Japan, Finland, and China.

[157] With the exception of China as it was not possible to source robust, unbiased information on the performance of policies within the *Made in China 2025* strategy. Consequently, although possible to identify what policies have been developed, it is not possible to assess their appropriateness for inclusion in best practice lessons for NI; as such, China's approach has not been detailed.

[158] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 03 June 2019).

[159] The Index brings together an overall measure of readiness for automation as well as individual component measures in areas such as education, skills and innovation to help countries identify how they can better their policy environment to be ready for automation.

3.2 Summary of key themes and policy actions

3.2.1 R&D

3.2.1.1. A consistent link between **investment in R&D** in preparation for, and successfully implementing automation has been highlighted throughout the policies reviewed. The reasoning behind the link between R&D investment and automation readiness is that this investment contributes to a country's innovative and knowledge environment which can be used to base key decisions upon which overall can help to stimulate automation uptake. The top three spenders on R&D relative to the size of their economy (GDP)- South Korea, Japan and Germany- are also amongst the top-ranking countries in the Automation Readiness Index[160]. South Korea has become one of the most automated countries in the world aided by their continual investment in R&D since the 1980s, in 2017 South Korea spent approx. $84.2billion (USD) on R&D which was 4.6% of their GDP' [161].

3.2.1.2. Public R&D expenditure can help to stimulate private R&D for instance in Europe, Germany has been a leader in investment of public spending in R&D, with 2.94% of the GDP spent in 2016[162] whilst private investment in R&D by German machine and equipment companies invested €5.7 billion in 2016[163].

3.2.1.3. Collaboration between industries, policy makers and academics is a prominent feature across the review assisting with the development and application of R&D. For example,

- the UK's Industrial Strategy Challenge Fund awarded £68million for four research and innovation projects to bring together industry and researchers[164].
- Germany's state backed research projects have helped to support business' application of Industrie 4.0 (I40), which is Germany's strategy for digitalised manufacturing. Wittenstein AG, a German manufacturer of gearboxes, received government funding to help apply I40 to digitalise their production process[165]. Not only were financial resources provided but also the expertise required to help adapt the new ways of working for the factory.

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[160] Ibid

[161] Budget Proposal 2019 (2019). Available at: http://english.moef.go.kr/popup/180830/popup20180830.html (last accessed 09 July 2019).

[162] The World Bank (2016). *Research and development expenditure (% of GDP).* Available at: https://data.worldbank.org (last accessed 03 June 2019).

[163] Grune, C. for Germany Trade and Invest (2018). *The Robotics & Automation Industry in Germany.* Available at: www.gtai.de (last accessed 05 June 2019).

[164] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 03 June 2019).

[165] Federal Ministry for Economic Affairs and Energy (nd). *Industrie 4.0 Schaufensterfabrik at WITTENSTEIN bastain GmbH.* GmbH. Available at: www.plattform-i40.de (last accessed 04 June 2019).

3.2.2. Skills and education

3.2.2.1. **Out-of-date skills** are repeatedly cited as a factor limiting the progression and implementation of automation causing skills and education to become key policy focuses.

3.2.2.2. Ireland, Scotland and Estonia have focused on the development of **digital skills** and more recently **coding and programming skills.**

3.2.2.3. Across the UK training is being provided to upskill computer science teachers and increase student participation of this subject[166], resulting in a 25% increase in A level computer science entries since 2017[167].

3.2.2.4. These programmes highlight the importance of not only targeting pupils to ensure that they are well-equipped with the skills required for the future of work, but investment must also be directed towards teachers to ensure the skills development of teachers to enable them to deliver a quality level of education is delivered, ensuring the long-term development of education.

3.2.2.5. **Vocational training with industry partners** has been a focus in countries such as Germany and the UK to increase student's **industry skills** and increase **the role of industry in education**. For instance, the UK is developing a 'T level' technical qualification which will see teachings move away from traditional classroom learning to provide participating students with 'on-the-job' experience and training through an industry placement whilst also gaining an accredited qualification[168]. NI Universities can also learn from Dublin College University's (DCU) STEM Teacher Internship programme[169] as it allows student teachers to learn industry skills that they would not gain in a classroom setting.

3.2.2.6. To help workers re-train or upskill Singapore's SkillsFuture for Digital Workplace (2017) aims to benefit 100,000 Singaporeans[170] with curriculum developed with industry partners to customise training needs[171]. This goes in partnership with Singapore's SkillsFuture Credit which give those aged 25 and above SGD$500 credit to incentivise people to develop their skills independently of the

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[166] HM Government (2017) *Industrial Strategy- Building a Britain Fit for the Future.*

[167] HM Government (2018). *Forgoing Our Future- Industrial Strategy- The Story So Far*.

[168] Department for Education (2018). *Implementation of T Level Programmes. Government Consultation Response.* Available at: www.gov.uk (last accessed 30 May 2019).

[169] Dublin City University (2019). SSTEM Teacher Internship programme connects teachers and industry at DCU. Available at: www.dcu.ie (last accessed 03 June 2019).

[170] Helkkula, K. (2018). *AI for all: How Finland (and other countries) are delivering free, accessible digital skills training.* Nesta Available at: www.nesta.org.uk (last accessed 23 May 2019).

[171] For instance, the Asian Culinary Institute has been involved in developing key learning lessons for participants from this sector.
More information available from SkillsFuture. (2017). *Factsheet on SkillsFuture for Digital Workplace.* Available at: www.ssg-wsg.sg (last accessed 30 May 2019).

workplace[172],[173]. Regardless of whether training is employer or individually led, it is important that programmes are accredited, relevant and up to date with skills demanded in the workplace An emphasis has been placed on lifelong learning to develop a mind-set in recognising the importance of learning and developing skills throughout an individual's life due to the way in which future job roles and skills are expected to evolve. Lifelong learning promotes a new mind-set in which learning is self- motivated, ongoing and voluntary by individuals throughout their life.

3.2.2.7. Career counselling can be used as a method to educate individuals as to how the changing demand for skills and jobs that come with automation will impact them, helping the public to be more informed. This has been a feature in Estonia, Singapore and Scotland.

3.2.3. Business Support

3.2.3.1. **Support for SMEs** is an important feature for all of the countries to ensure that automation uptake is not limited to larger organisations. This support is being achieved through the following methods.

3.2.3.2. **The sharing of best practices and mentoring schemes such as:**

- The UK's 'Be the Business' programme which aims to provide a mentoring scheme for SMEs adopting new technology[174].
- Scotland's 'Digital Boost' programme provides support and workshops to help business grow[175].
- Futurepreneur Canada to help entrepreneurs aged 18-39 take the next step to develop their business by providing mentoring from a business expert as well as financial assistance[176].

3.2.3.3. **Support for testing new technology** such as:

- Estonia has introduced grants and credits to allow companies to test new

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[172] Helkkula, K. (2018). AI for all: How Finland (and other countries) are delivering free, accessible digital skills training. Nesta Available at: www.nesta.org.uk (last accessed 23 May 2019).
SkillsFuture Credit (2016). *Skills Future Credit*. Available at: www.skillsfuture.sg/Credit (last accessed 30 May 2019).

[173] Scottish Government (nd). *Digital Support for Businesses*. Available at: www.gov.scot (last accessed 31 May 2019).

[174] Department for Business, Energy & Industrial Strategy (2019). Business Basics Programme. Available at: www.gov.uk (last accessed 30 May 2019).
Be the Business (nd). *About Be the Business*. Available at: www.bethebusiness.com (last accessed 30 May 2019).
HM Government (2018). *Forgoing Our Future- Industrial Strategy- The Story So Far*.

[175] Scottish Government (nd). *Digital support for businesses.* Available at: www.gov.scot (last accessed 13 June 2019).

[176] Futurepreneur Canada (nd). Who We Are. Available at: www.futurpreneur.ca (last accessed 31 May 2019).

technology[177].

- Technology testbeds have also been introduced in Germany through I40 and funding from the Ministry of Education and Research[178].
- The UK's 'Business Basics Programme' provides financial support for SMEs to test and adopt technology[179].

3.2.3.4. **Financial support** through various methods such as:

- Voucher schemes available in Scotland and Finland. Scotland's Digital Vouchers awards successful applicants up to £5,000 to help meet the costs of investing in digital est AI and data solutions for a new product/service that requires external expertise[180]
- South Korea aim to increase the private sector by providing funding for project technology[181]. Finland has developed Tekes innovation vouchers which SMEs can use to t which were previously suspended due to financial or regulatory problems[182].
- Germany's 'Central Innovation Programme for SMEs' (ZIM) offers grants for R&D activities to help increase the innovative capacity and competitiveness of SMEs. Due to the Programme's easy application process, 78% of applications succeed[183] whilst it has also been complimented for its: reduced bureaucracy and swift procedures; pre-application support; the openness of the programme to all technologies; availability to all in Germany; and the ability for SMEs to be able to undertake a project specifically linked to their own industry[184].

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[177] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 03 June 2019).

[178] Federal Ministry for Economic Affairs and Energy (nd). *A consistent focus on the needs of SMEs.* Available at: https://www.platform-i40.de (last accessed 05 June 2019).

[179] Department for Business, Energy & Industrial Strategy (2019). Business Basics Programme. Available at: www.gov.uk (last accessed 30 May 2019).

Be the Business (nd). *About Be the Business*. Available at: www.bethebusiness.com (last accessed 30 May 2019).

HM Government (2018). *Forgoing Our Future- Industrial Strategy- The Story So Far*.

[180] Business Finland (nd). *Innovation Voucher*. Available at: www.businessfinland.fi (last accessed 25 June 2019).

[181] Digital Impact (2015). *Digital Scotland Voucher-Up To £5000*. Available at: www.digitalimpact.co.uk (last accessed 07 May 2019).

[182] Ministry of Economy and Finance (2018). *Measures To Promote Investment And Support The Job Market*. Available at: www.moef.go.kr (last accessed 25 June 2019).

[183] INNO-Partnering Forum (2010). *ZIM, the Central Innovation Programme for SMEs- Part of Deliverable D2.2 INNO-Partnering Forum*. Available at: www.taftie.org (last accessed 05 June 2019).

[184] Ibid.

3.2.3.5. **To enable business growth:**

- Canada has provided late stage capital under the Venture Capital Catalyst Initiative[185].
- In the UK a 'Scale Up Task Force' and 'Scale Up Champion' have been appointed to help understand limits to business growth and to provide guidance as to how to overcome these limits[186].

  Across the EU there are 18 Digital Champions to help promote a digital single market in Europe with a focus on developing digital skills[187]. These 'Champion' roles highlight the potential need for an oversight group or leader in future policy to provide a continued and constant focus on a new policy.

3.2.4. Tax and inequality

3.2.4.1. As automation uptake increase it can lead to increased income inequality, to tackle this some countries are introducing **tax and welfare policies.**

3.2.4.2. In South Korea, tax incentives were initially introduced to encourage automation uptake, however this led to unintended consequences where the increase in automation uptake resulted in displaced jobs. Currently businesses can deduct 3- 7% of an investment in automation from their corporate taxes; this new policy will decrease this by up to 2% points[188] to make up for lost income taxes from workers and to help welfare recipients[189]. This reduction is being considered by many as a 'Robot Tax' and has been received with mixed reviews[190].

3.2.4.3. In February 2017 the European Parliament rejected a 'robot tax', which would have aided the retraining of displaced workers. It was rejected due to concerns regarding this tax disincentivising innovation[191]. Members of the European Parliament (MEPs) are aware that capital wealth will increase with automation which has the potential for increased income inequality as laid out in Section

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[185] Innovation, Science and Economic Development Canada (2019). *Building a Nation of Innovators.* Available at: www.canada.ca.innovation (last accessed 20 May 2019).

[186] HM Government (2017). *Industrial Strategy- Building a Britain Fit for the Future.*

[187] European Commission (2018). *Digital Champions*. Available at: https://ec.europa.eu/digital-single-market/en/digital-champions (last accessed 09 July 2019).

[188] Abbott, R. and Bret, B. (2018). *"Should Robots Pay Taxes: Tax Policy in the Age of Automation."* Harvard Law & Policy Review, vol. 12, no. 1, pp. 145-176. Available at: https://heinonline.org/HOL/P?h=hein.journals/harlpolrv12&i=151 (last accessed 22 May 2019).

[189] Abbott, R. and Bret, B. (2018). *"Should Robots Pay Taxes: Tax Policy in the Age of Automation."* Harvard Law & Policy Review, vol. 12, no. 1, pp. 145-176. Available at: https://heinonline.org/HOL/P?h=hein.journals/harlpolrv12&i=151 (last accessed 22 May 2019).
Sung-Won, Y. (2017). *Korea Takes First Step to Introduce 'Robot Tax'*. Available at: www.koreatimes.co.kr (last accessed 20 May 2019).

[190] Sung-Won, Y. (2017). *Korea Takes First Step to Introduce 'Robot Tax'*. Available at: www.koreatimes.co.kr (last accessed 20 May 2019).

[191] Abbott, R. and Bret, B. (2018). *"Should Robots Pay Taxes: Tax Policy in the Age of Automation."* Harvard Law & Policy Review, vol. 12, no. 1, pp. 145-176. *Available at:* https://heinonline.org/HOL/P?h=hein.journals/harlpolrv12&i=151. (last accessed 22 May 2019).

2.5.1, but they also voted against the introduction of a general basic income[192]. This is an area which should be monitored and reviewed so that NI can learn from best practices and to ensure inequality issues are considered in any future policy.

3.2.4.4. Finland has tried to tackle inequality through a basic income trial as a method of helping citizens gain employment without losing their unemployment benefits, however the trail has been deemed unsuccessful as employment figures remain largely unchanged with out-of-date skills cited as a factor limiting participants on the trail from gaining employment[193].

3.2.4.5. For the UK in the case that there is significant job displacement as a result of automation **Universal Basic Income (UBI)**, which has been an issue of debate previously, may gather haste. UBI has the potential to help create a more equal society by redistributing wealth gained through capital production which would empower individuals by providing them with a personal resources to use to have more choice over work, education, training and leisure whilst potentially helping to create more financial stability for individuals[194]. However, there is mixed public opinion of UBI globally, for instance in Switzerland voters rejected a basic income referendum[195].

3.2.4.6. In Alaska, the Alaska Permanent Fund has been in place since 1982 which gives Alaska natives funds from this state-owned investment fund. The amount given can change year by year depending on oil prices, but it is shown as a successful method of how capital, public resources can be shared to benefit a larger proportion of society. It has helped to cut down on poverty whilst maintaining employment[196].

3.2.4.7. **Regional development** has also become a focus in South Korea due to export-led growth favouring the Capital Region and coastal areas causing regional imbalances. To overcome this regional development has become a priority with a particular focus on education and business opportunities through a bottom-up approach to address regional policies, allowing them to become more **suitable and specific** to each region[197].

3.2.4.8. Other countries are attempting to **tackle inequality through education** in order to upskill citizens who may be most at risk from automation to ensure that they are equipped to avail of job opportunities and are not displaced. Estonia's Lifelong Learning Strategy 2020 aims to increase the collaboration

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[192] VoteWatch Europe (2018). *Agreement or Polarisation? How European Institutions and MEPs React to Regulating AI*. Available at: www.votewath.eu (last accessed 22 May 2019).

[193] Hiilamo, H. (2019). *Heikki Hiilamo: 'Disappointing results from the Finnish basic income experiment'.* University of Helsinki. Available at: www.helsinki.fi (last accessed 23 May 2019).

[194] The Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA) (2015). *Creative citizen, creative state*. Available at: https://medium.com (last accessed 16 October 2019).

[195] The Portal of the Swiss Government (nd). *Popular initiative for an unconditional basic income*. Available at: https://www.admin.ch/gov/ (last accessed 16 October 2019).

[196] Matthews, D. (2018). *The amazing true socialist miracle of the Alaska Permanent Fund.* Available at: https://www.vox.com/policy-and-politics (last accessed 16 October 2019).

[197] OECD Development Centre (2012). *Industrial Policy and Territorial Development: Lessons from Korea*.

between employers and education to address **skills mismatches**[198] potentially to increase adult participation in education so that they can enter in to highly skilled and high paid jobs[199].

3.2.5. Additional general theme

The reviewed policies consider **citizen buy-in** to ease labour market frictions and to help manage the anxiety and expectations associated with automation.

Germany's I40 aims to be a social policy and has aimed to keep workers informed through the involvement of trade unions into their High-Tech Strategy[200].

The UK Industrial Strategy aims to achieve public support by increasing good quality jobs and creating a Good Work Plan to improve work practices and protect workers' rights[201].

[198] Ministry of Education and Research (2014). *The Estonian Lifelong Learning Strategy 2020*. Available at: www.hm.ee/sites/default/files/estonian_lifelong_strategy.pdf (last accessed 24 June 2019).

[199] Ministry of Education and Research (2014). *The Estonian Lifelong Learning Strategy 2020*. Available at: www.hm.ee/sites/default/files/estonian_lifelong_strategy.pdf (last accessed 24 June 2019).

[200] Klitou, D et al. for the European Commission. (2017). *Digital Transformation Monitor- Germany: Industrie 4.0*.

[201] HM Government. (2017) *Industrial Strategy- Building a Britain Fit for the Future*

3.3 NI policy landscape

3.3.1. This section will address what policies are currently in place in NI that will help prepare for automation.

3.3.2. To start, the continuation of digitalisation will allow citizens and business to become accustomed with technology developments which may help to manage concerns regarding automation. NI has policies in place to assist with digitalisation from various government departments. Some of these policies are:

- The Strategy for Digital Transformation of Public Services with a goal to increase the quality of public services by developing the innovation environment along with a skilled workforce and increased use of technology. This Strategy aims to coordinate with the eHealth and Care Strategy and the Industrial Strategy for NI.
- The eHealth and Care Strategy aims to achieve a more personalised service, success so far has included generating a Health Care Number for citizens as well as an electronic care record. The continued fostering of innovation would see the collaboration of Health and Social Care (HSC) with universities, businesses and government to advance the development of innovative products and ensure best practice is deployed across NI. The Strategy aims to develop an eHealth & Care Innovations Network that will act as a hub for innovation and ideas in the NI health industry[202].
- The Digital Transformation Service[203] which works with organisations and citizens to ensure that the Digital Transformation Programme is delivered. This includes aspects such as 'Digital First' which involves new or redesigned services using online platforms as the first method to engage with citizens[204].

3.3.3. Prior to the NI Assembly's dissolution in January 2017, broad political agreement had been reached regarding the draft Programme for Government. This is being taken forward via the Outcome Delivery Plan (ODP) for 2018-19[205]. The ODP contains several objectives and commitments that will support

[202] Health and Social Care Board (2016). *eHealth and Care Strategy for Northern Ireland*. Available at: www.health-ni.gov.uk (last accessed 23 May 2019).

[203] From the Department of Finance.

[204] Department of Finance (nd). *Digital Transformation Service*. Available at: www.finance-ni.gov.uk (last accessed: 23 May 2019).

[205] The Executive Office (2018). *Outcomes Delivery Plan 2018-19*. Available at: www.executiveoffice-ni.gov.uk (last accessed 08 January 2018).

automation and improvements to productivity across the economy. Some of these are shown in Table 3. In combination, the ODP takes a whole-of-government approach to factors associated with the removal of barriers to investment, development of a skilled workforce and improvement in productivity performance for NI.

Table 3: ODP Outcomes and Actions

Outcomes	Actions
Outcome 1: *We prosper through a strong, competitive regionally balanced economy*	• Productivity will be driven through innovation, R&D, improvement of skills and employability and continuing to attract inward investment.
Outcome 5 (DfE): *We are an innovative, creative society where people can fulfil their potential*	• Accreditation and incentivisation of innovation and R&D activity. • Growth of regional clusters in new and emerging technology. • Development of a framework for statutory education evaluation. • Steps to reduce the 12% gap with target for premises able to access superfast internet. • Development of a Digital Infrastructure Strategy for NI.
Outcome 6 (DfE): *We have more people working in better jobs*	• Recognises the importance of attracting inward investment in the growth of jobs in NI and raising our productivity. • Also encompasses improved linkages between government, academia and industry to ensure relevant workforce skills and increased graduate employment at the appropriate level[206].

3.3.4. Additionally, a NI Industrial Strategy 2017 draft aimed to provide NI with a globally competitive economy by 2030. This was to be achieved through the 5 pillars of growth that included:

- Accelerating innovation and research.
- Enhancing education, skills and employability.
- Driving inclusive and sustainable growth.

[206] There is significant overlap between increasing appropriate graduate employment and the objective to increase attractive employment opportunities, which is under Outcome 10.

- Succeeding in global markets.
- Building the best economic infrastructure.

3.3.5. The NI Innovation Strategy 2014-2025 aims to overcome the low levels of innovation in NI compared to the UK[207] using the themes of cultural change and knowledge generation, exchange and exploitation. This is to be supported by actions such as increasing expenditure on R&D to over £1.2billion per annum(in 2016 £750million was spent on R&D[208]), increase investment that facilitates collaboration between businesses and potentially developing an Innovation Council with Innovation Champions who would provide leadership to help with the cultural change required[209]. The 2019 Regional Innovation Scoreboard gave NI a 'strong' for innovation performance[210], improving on previous positions such NI's 'moderate' ranking in 2010[211]. Therefore, the continued work of the Innovation Strategy will assist with the development of an environment conducive to automation in NI.

3.3.6. NI has a modern education system in terms of curriculum and examination results are mid-table in an international context. NI must try to build upon this success through the continual development of the school curriculum with the added view that it needs to meet employer's and the future economy's needs. The statutory components of the school curriculum currently include ICT, science and technology. The Council for the Curriculum, Examinations and Assessment (CCEA) have developed subjects such as Software Systems Development (SSD) for A Level[212], allowing pupils to develop software and programming skills as well as learning related languages such as Java. SSD along with subjects such as Digital Technology and Moving Image Arts help to make up the Digital Skills Curriculum & Qualifications Framework, which highlights how the curriculum helps to develop digital skills through subjects offered from Key Stage 1 to University Entry allowing for schools to contribute towards the development of digital citizens[213].

3.3.7. Schools have been proactively adapting to meet the future demand of skills by

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[207] Northern Ireland Executive (2014). *Innovation Strategy for Northern Ireland 2014-2025*. Available at: www.economy-ni.gov.uk (last accessed 25 June 2019).

[208] DfE. (2016). *Northern Ireland Annual Innovation Scoreboard 2016*. Available at: www.economy-ni.gov.uk (last accessed 27 June 2019).

[209] Northern Ireland Executive (2014). *Innovation Strategy for Northern Ireland 2014-2025*. Available at: www.economy-ni.gov.uk (last accessed 25 June 2019).

[210] European Commission (2019). *Regional Innovation Scoreboard 2019*. Available at: UK Innovation Scoreboard 2019 (last accessed 14 October 2019).

[211] DfE (nd). *EU Regional Innovation Scorecard*. Available at: www.economy-ni.gov.uk (last accessed 27 June 2019).

[212] CEA (nd). *Software Systems Development*. Available at: https://www.rewardinglearning.org.uk/microsites/software/ (last accessed 26 June 2019).

[213] CEA (2017). *Digital Skills Overview*. Available at: http://ccea.org.uk/digitalskills/overview(last (last accessed 26 June 2019).

using various methods and resources to incorporate technology into lessons. Case study 3 demonstrates how Holy Cross Girls' Primary School has taken a forward-thinking approach to incorporate ICT and future skills.

Case Study 3: Holy Cross Girls' Primary School, Belfast[214]

Holy Cross Girls' Primary School was rated outstanding by the Education Training Inspectorate (ETI) for their use of ICT throughout the school. There is an overall recognition from the school that girls are underrepresented in ICT and the expectation is that, by introducing pupils to these skills at a young age, it will give them the confidence and interest to continue using these skills.

They are preparing their all-girls school for the future through their forward-thinking approaches to the school curriculum by:

- incorporating the use of computers, iPads, laptops, interactive whiteboards and programmable devices in to teaching practices;
- appointing two ICT co-coordinators who have developed a progression grid for pupils to be assessed throughout their primary school education. These co-ordinators also work with teachers to develop learning materials and to make ideas a reality as to how to best teach digital skills;
- upskilling teachers to give them the confidence to teach with technology and approach lessons with new ideas and practices;
- introducing an afterschool coding club for girls in P4-P7; and
- holding events such Hive Hackers, which introduced Key Stage 2 pupils to programming with PwC.

Holy Cross Girls' Primary School aim to give their pupils the confidence to use ICT to develop other skills such as analytical capabilities, problem solving and numeracy skills.

3.3.8. The school curriculum also incorporates the development of human skills and aims to instil a culture of lifelong learning. However, IPPR[215] suggest that NI's FE and HEI programmes are targeted towards learners who are Under 21. Figure 3.3.1 would support this as it shows the enrolments by age of people in FE and HEI in 2016/17. The European Regional Innovation Scorecard notes that NI has lifelong learning participation rate of 28%, for comparison Scotland's lifelong learning participation rate is 41%[216]. This highlights the need to

[214] CEA. (2018). *Holy Cross Girls' Primary School Case Study.* Available at: ccea.org.uk (last accessed 24 May 2019).

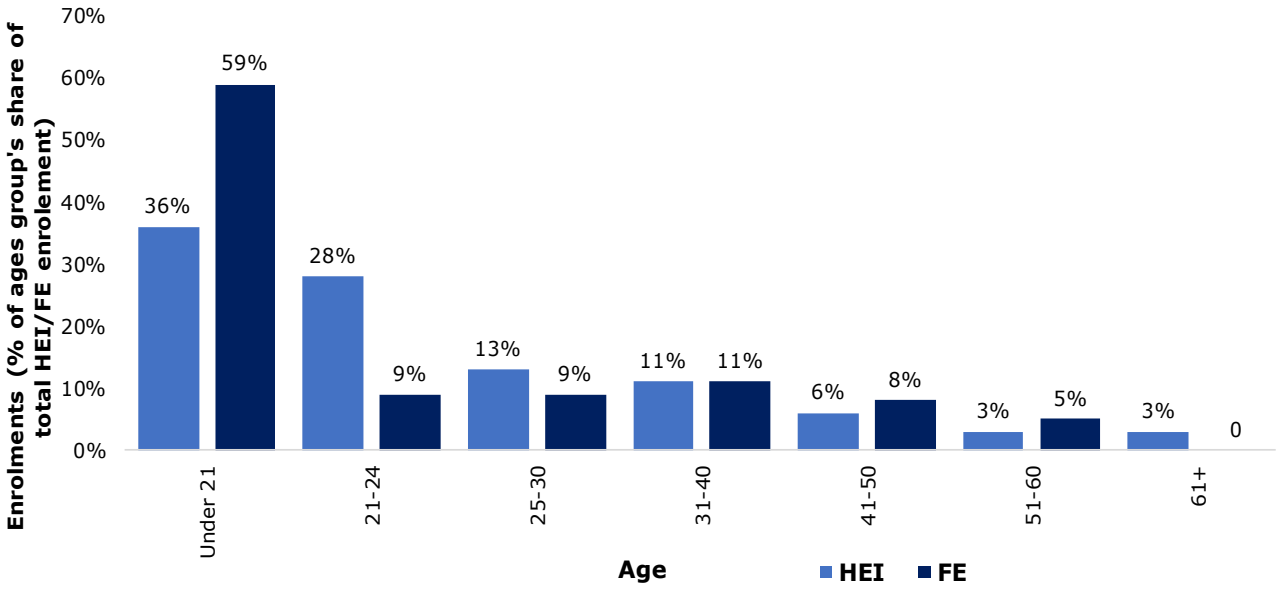
[215] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

[216] This is calculated by the share of the population aged 25-64 enrolled in education or training aimed at improving knowledge, skills and competences. Information gained from:

European Commission (2019). Regional Innovation Scoreboard. Available at: European Commission Regional Innovation Scoreboard (last accessed 14 October 2019).

continue to develop solutions to embed lifelong learning.

Figure 3.3.1 Enrolments by age in NI HEI and FE colleges for 2016/17 (% of age group's share of total HEI or FE enrolments)



Source: DfE 2018 in IPPR. (2018). *Preparing for Automation and Ageing- A Successful 21st Century Skills System for Northern Ireland and Scotland.*

3.3.9. DfE have invested in skills programmes such as InnovateUs and Skills Focus[217]. These aim to develop the skills of adults employed in SMEs to help drive innovation and growth. The programmes involve an organisation working with a FE college to develop a specific and tailor-made training activity to upskill their workforce.

3.3.10. Additionally, the Northern Ireland Strategy for Further Education involves the collaboration of FE colleges with employers to tailor curriculum and qualifications aiming to deliver positive economic development[218]. There is a focus on upskilling the existing workforce by taking advantage of the flexible nature of learning that FE colleges can provide. The Strategy does incorporate the need for using technology in teaching practices and the teaching of ICT and STEM subjects. However, there is no specific focus on the role of automation in education and future skills.

3.3.11. Regarding HEI, NI universities are also adapting and developing courses to equip students with skills for the future as well as developing curriculum with industry partners. For instance, QUB offer a Postgraduate course in Software

[217] DfE. (2018). *InnovateUS & Skills Focus*. Available at: https://www.nibusinessinfo.co.uk (last accessed 22 May 2019).

[218] Department for Employment and Learning (2016). *Further Education Means Success: The Northern Ireland Strategy for Further Education.* Available at: www.economy-ni.gov.uk (last accessed 24 May 2019).

Development (part-time) specifically for individuals from a non-computing background[219]. Ulster University offer Postgraduate programmes such as Data Science; recognising the demand for high-intensity data skills this course aims to develop these skills through modules such as Machine Learning, Data Modelling and Data Science Foundations. Development (part-time) specifically for individuals from a non-computing background. Ulster University offer Postgraduate programmes such as Data Science; recognising the demand for high-intensity data skills this course aims to develop these skills through modules such as Machine Learning, Data Modelling and Data Science Foundations[220].

3.3.12. In terms of career guidance, research suggests that whilst information on study choices and careers is readily available across multiple sources, it requires improvements as the information can be:

- hard to digest;
- conflicting and inconsistent; and
- overlooked as schools often do not provide students with all options which are available to them in order to protect their own enrolments[221],[222]. Due to this it can often be difficult for FE colleges to gain access to schools to provide guidance on options which are available to school students, therefore there is a degree of unwillingness to collaborate in case it takes resources away from one education institution to another[223].

3.3.13. In regard to R&D and business support, Innovation Vouchers are available for SMEs. These Vouchers provide a business with up to £5,000 which they can use to gain access to a knowledge provider from a University, College or Public Sector Research body to develop their idea or product[224]. These vouchers have helped organisations such as EcoHog Ltd. who design and manufacture recycling equipment for waste processes globally. EcoHog Ltd. used the Innovation Voucher to gain access to specialist technology and software information at Ulster University and South West College's Design Associates and

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[219] QUB. (nd). *Software Development (Part Time)*. Available at: www.qub.ac.uk (last accessed 08 August 2019).

[220] SI News (2018). *Ulster University- Fostering the next generation of computing and data experts*. Available at: https://studyinternational.com (last accessed 08 August 2019).

[221] Committee for Employment and Learning (2013). *Inquiry into Careers Education, Information, Advice and Guidance in Northern Ireland.* Available at: niassembly.gov.uk (last accessed 09 October 2019).

[222] The 2019 Youth Voice Consensus Report conducted a survey to gather information about careers education, the results included that 77% of young people had never been spoken to about a traineeship and 61% had never been informed about how to start their own business. More information is available at: https://www.youthemployment.org.uk (last accessed 11 October 2019).

[223] Invest NI. (2019*). Innovation Vouchers Frequently Asked Questions*. Available at: https://secure.investni.com (last accessed 15 May 2019).

[224] Invest NI. (2019*). Innovation Vouchers Frequently Asked Questions*. Available at: https://secure.investni.com (last accessed 15 May 2019).

Innotech Centre to overcome an issue they were having with fan design[225].

3.3.14. Meanwhile research published by Matrix in June 2019 suggests that NI has the necessary environment in place to develop an AI Centre of Excellence (AICE@NI). This is due to the knowledge sharing environment currently in place as well as collaboration by NI's two universities would have significant impact for AI R&D in NI as well as the rest of the UK and potentially link NI to global Centres of Excellence[226]. Matrix's work further highlights the demand for automation strategies in NI at present.

3.3.15. Industries are also proactively seeking technology developments and are investing in technology to increase productivity, quality and efficiency. Investments that some organisation have made are explored in more detail in Section 6 with information gathered from UUEPC company consultations.

3.3.16. Overall, NI has already made progress in preparing for the future of work through the policies and actions outlined here. The augmentation and scaling up of these policies will be significant in helping to prepare NI for the fourth industrial revolution.

3.4 Lessons for NI

3.4.1. This review has established key themes which can be taken into consideration in future NI policy. These themes include R&D, skills and education, business support, citizen engagement and inequality and taxation. The large scale of the policy review further highlights how automation has the potential to impact all parts of the economy.

3.4.2. From the policies reviewed there is notable focus on digitalisation, particularly in Scotland, Ireland and Estonia. NI should continue its pursuit of digitalisation and digital skills as this is an important step in the process of preparing industries, public services and citizens for future automation technology. However, there is an opportunity for NI to develop an automation strategy to lead the way for the other UK regions during the automation revolution.

3.4.3. In terms of R&D this must be carried out by public and private actors in order to support a culture of innovation that should seek to develop automation technology and better understand its workings.

3.4.4. This review has emphasised that due to the number of small businesses in NI[227], particularly micro-businesses, uptake of automation may be limited to larger organisations. This may be due to access to resources both financially and in

[225] Invest NI. (2019*). What Could a £5000 Innovation Voucher do for your Business?.* Available at: https://www.investni.com (last accessed 15 May 2019).

[226] Matrix (2019). *Northern Ireland is a "powerhouse" in Artificial Intelligence*. Available at: https://matrixni.org/northern-ireland-is-a-powerhouse-in-artificial-intelligence/ (last accessed 27 June 2019).

[227] 95% of businesses in NI are SMEs, whilst 17.2% of all organisations in NI are micro-businesses. Enterprise Research Centre (2018). *Understanding micro-businesses in Northern Ireland.* Available at: www.economy-ni.gov.uk (last accessed 09 July 2019).

expertise as well as an organisation's own motivation and need for pursuing automation. To assist smaller organisations, Invest NI's R&D grants as well as their Innovation Vouchers are complimented for helping to develop the innovative capacity of businesses[228].

3.4.5. NI can also learn from Germany's I40 which has been limited to larger organisations due to their access to resources however, Germany's ZIM policy highlighted the need for reduced bureaucracy, fast paced support and personalisation of projects that made the ZIM policy attractive and accessible to SMEs[229].

3.4.6. Further factors to consider in future policy include the need for knowledge sharing and expert advice. This was highlighted in policies such as Canada's Futurepreneur[230] scheme which provides mentoring and financial support to help entrepreneurs take the next step in developing their idea into a business.

3.4.7. Standardisation has been an additional factor limiting the uptake of policies such as Germany's I40 and so this should be an area of consideration for policy developments surrounding emerging technology. This is an important factor to NI as many companies, particularly SMEs, may be unwilling to invest in technology without knowing how future standards may impact their organisation. Belfast City Deal's development of technology testbeds[231] is one method that NI is providing to encourage participation in acquiring new technology for businesses.

3.4.8. NI's excellent education system should continue to develop to suit the needs of a modern and future-focussed economy. Future policy should aim to be develop the education system where possible to ensure that skills sets and attitudes help individuals to participate, this will also enable automation to be a long-term project as it will help to tailor children's attitudes now for the future. Industry and education collaboration have been highlighted for its importance in developing skills to meet the needs of employers. Overall, education will be a key player in helping to generate future buy-in to automation from citizens.

3.4.9. In terms of adult learning, NI can learn from Singapore and Scotland which encourage individuals to take control of their own learning rather than skills development being completed as a requirement of an employer. Scotland's Digital World[232] campaign aimed to promote the career opportunities that came

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[228] Invest NI. (nd). *Funding for innovation and R&D*. Available at: www.investni.com (last accessed 16 August 2019).

[229] INNO-Partnering Forum (2010). *ZIM, the Central Innovation Programme for SMEs- Part of Deliverable D2.2 INNO-Partnering Forum*. Available at: www.taftie.org (last accessed 5 June 2019).

[230] Futurepreneur Canada (nd). Who We Are. Available at: www.futurpreneur.ca (last accessed 31 May 2019).

[231] Belfast City Council (nd). Belfast City Region Deal- it's a big deal. Available at:

www.belfastcity.gov.uk (last accessed 27 June 2019).

[232] Scottish Government (2017). *Realising Scotland's Full Potential in a Digital World: A Digital Strategy for Scotland*. Available at: https://www.gov.scot (last accessed 31 May 2019).

with upskilling or retraining. It will be important that future policy helps to engender an environment of lifelong learning and this should aim to be instilled in the NI population from a young age.

3.4.10. This policy review has re-emphasised that it will be important that future policies continue to be inclusive of all sections of society, particularly targeting under-represented groups, so that automation policies work for the betterment of NI. Regional inequality was noted as a current issue for South Korea. To ensure regional imbalances do not occur, it will be important that future policies understand the needs of local councils and that there are widespread opportunities in education and business across NI.

3.4.11. To support inclusivity, automation and the future economy will require enhanced collaboration between the Executive, government departments, local councils, the education system and industries. The policy review has highlighted that innovation cannot be driven by government policy alone and so future policy should help provide the groundwork needed to steer industry to work more closely with Government, identifying the core skills, assisting with policy development and supporting key projects.

3.4.12. Finally, the policies reviewed indicated the need for a long-term approach and flexible approach to be taken regarding automation policy. The United Nations Industrial Development Organisation (UNIDO) note there is not a 'one size fits all' approach for every country or industry[233]. The policies reviewed emphasise the need for policies to be updated as technology is tried and tested with achievements and failures expected along the way. South Korea has incorporated this in to their actions to help encourage SME productivity and R&D by exempting SMEs from penalties if they carry out research and are not able to achieve the end goal[234].

[233] United Nations Industrial Development Organisation (2018). *What Can Policymakers Learn from Germany's Industrie 4.0 Development Strategy?.* Available at: www.unido.org (last accessed 15 June 2019).

[234] Ministry of Strategy and Finance (2012). *Measures for Productivity Enhancement of SMEs to Build a 'Creative Economy'*. Press Release. Available at: www.mofs.go.kr (last accessed 25 June 2019).

4 Industry Consultations

4.1. UUEPC carried out 18 consultations from August to September 2019 with a variety of organisations across NI. These consultations provided primary information to help understand the levels of automation currently in place, how the future of work may be impacted and ensure that policy suggestions emanating from industry are incorporated in the research.

4.2. Invest NI put forward several companies for consultation whilst other participants were included through UUEPC outreach from academic and network connections as well as industry events.

4.3. This section explores the key themes emerging from the organisations consulted and explores the suggestions which were made for future policy support to assist with further developing automation in NI.

4.4. Later this section provides company profiles detailing the levels of automation within the various organisations consulted, with permission granted by the consultees for their organisation's information and views to be published as part of this report. These insights and ideas have been used to help inform the policy recommendations in Section 7.

4.5. Consultee Profiles can be found in Annex 2 as well as the guided questions used when engaging with consultees (Annex 1). The breakdown of organisations consulted by industry sector is shown in Table 4 below.

Table 4: Consultations by Industry Sector

Sector	Number of Consultations
Financial Services	1
Retail	1
Hospitality	1
Public Sector	1
ICT/ Software Services	2
Food Manufacturing	2
Pharmaceutical/ Health Product Manufacturing	2
Manufacturing of automotive/ heavy metal parts/ plastics/ glass	8

4.1 General themes identified from consultations

4.1.1. Overall, the consultees that UUEPC engaged with highlighted the spectrum of automation and its stages that are currently in place in NI. Many consultees had carried out some or significant levels of automation with a diverse range of automated machines and/or software processes now active across the various organisations. For some organisations, automation was essential as their product had been created using recent technology such as the use of 3D Printers or machine learning techniques, therefore automation is now a routine feature for these businesses. For other businesses, automation has had to be integrated into their organisation and workforce.

4.1.2. For those who had little or no automation this was due to the nature of their business and/or low product volumes which did not support the capital investment that would be incurred. For these organisations the cost of automated solutions was more than the cost of labour. As a result, these organisations have opted to add an extra shift, employ extra staff or increase working hours to meet demand. The conclusion was that some organisations had not yet reached a tipping point in terms of labour availability, wage rates and payback periods that would result in increasing levels of automation.

4.1.3. Additionally, some companies had difficulty automating due to their niche product range and limited access to knowledge regarding automated workings. These organisations also stated that there was a lack of available expertise in NI regarding automation, robotics, machine learning and future technologies available to companies seeking to invest had caused slowdown in their investment. This was both in terms of consultancy and Government support.

4.1.4. The consultations found that the main drivers for implementing automation were:

- to grow productivity and allow for 24/7 production;
- increase efficiency, reduce waste and down time;
- provide consistency and/or increase quality of products;
- maintain or increase competitiveness due to cost savings that automation offers;
- automate due to a lack of skilled workers;
- help overcome the high turnover of staff within some sectors;
- assist with product innovation; and
- increase health and safety, although this was an additional benefit cited by many, rather than a specific driver.

4.1.5. Investment in automation has enabled those who were consulted to achieve their objectives that are noted above, but also resulted in a range of secondary benefits. For instance, increased health and safety was a significant secondary benefit for many businesses as automation had reduced the potential for injuries such as through repetitive strain or manual movements of heavy machines.

4.1.6. A significant and positive finding was that every organisation reported that automation had not led to staff cuts and that headcount reductions were not a major motivating factor for automating. Instead, automation has removed boring, repetitive jobs tasks allowing staff to perform higher value-added tasks. However, reskilling or upskilling was at times required of staff in order for them to be able to work alongside and/or control machines. Consequently, skills shortages within the workforce was a recurring theme throughout the consultations. Many consultees also spoke of the difficulties in recruiting and retaining new staff with the necessary technology and softer skills set that organisations now require. Therefore, this highlighted the mismatch between skills and industry needs currently in place in NI.

4.1.7. The most prominent concern of consultees was the availability of highly skilled and talented workers within NI that will be required to work in a more automated environment. This applied to a lack of skills within the current workforce as well as concerns regarding the future supply of labour from the education system. Enterprises recognised the need to upskill and retrain workers to overcome the shortage of skills many consultees cited the continuation of their apprenticeship and graduate schemes as well as in house training.

4.1.8. Consultees were asked if automation had resulted in increased wages, as suggested by the academic literature as it led to increased productivity and the re-skilling or upskilling of workers to more valuable roles. However, consultees suggested that they had not increased wages as a result of automation, instead in some cases they had opted to provide additional non-financial incentives for workers such as improved working conditions and/or working facilities such as an onsite gym. Consultees suggested that the changing demographics of the workforce had led to financial incentives not being a great motivator for workers, particularly younger workers who were more motivated by increased leisure time. Lastly, a rise in the minimum or living wage was a concern for employers who were concerned at this additional cost and felt that it was a driver for automation at the lower end of the labour market.

4.1.9. In order to gain buy-in from employees and to help facilitate a smooth transition to include more automation, consultees spoke of the need to communicate effectively with staff to include them in the process and many included Trade Unions[235]. Many consultees said that workers were initially fearful but bought in to automation once it was implemented and they could experience the benefits from new working practices whilst also being reassured that their job

[235] During consultations Managing Directors, R&D Officers, Operation Mangers and/or those leading automation projects were consulted, the scope of this project did not allow for the opinions of the employees to be directly included. However, this is a group which UUEPC recognise would beneficial to speak with in order to gain their opinions on how automation has impacted their work and how they have adapted to automation.

was safe. Some were pleased that automation had removed tasks that involved working in hot or physically challenging environments, in effect, tasks that the employees were glad to see coming to an end.

4.1.10. Consultees in financial and IT service organisations were concerned about the future supply of highly skilled workers available for FDI investors, given the rate of growth in the sector and output of the education system in NI. All were concerned at new FDI competing in the local market for talent, which had driven up wages. In the longer term, these organisations were concerned about how FDI and skills policies were intertwined.

4.1.11. Most consultees recognised that automation may act as a positive factor to help overcome any challenges their organisation may face due to Brexit. Some consultees, particularly in manufacturing, expressed that their job applications from the migrant workforce had decreased in recent years, for a variety of reasons including the depreciation of Sterling, robust economic and wage growth in potential migrant's home economies. For some migrant workers contemplating returning home, Brexit had acted as a catalyst to push them to choose to leave NI. Overall, these issues highlighted that the demand for labour and skills from the migrant workforce is significant in a variety of industries and roles across NI and firms were considering how automation may need to be employed to address labour shortages related to Brexit, Sterling depreciation and outputs from the local education system.

4.2 Policy suggestions from consultees

4.2.1. All organisations that were consulted noted that policy support should have a focus on the continued development of skills for the fourth industrial revolution across the current and future workforce. Policy suggestions included:

- the need to continue to update and adapt the school, FE and HE curricula to meet employer needs;
- increased use of ICT and technology and its teachings within education;
- continuing to focus and promote studies in STEM subjects across all levels of education, particularly for females to further enhance their career options and representation in the workforce;
- promotion and development of lifelong learning to instil a can-do and flexible attitude to work and new ideas in current and future workers;
- the Apprenticeship Levy[236] was suggested to be updated so that NI firms could benefit from this scheme, rather than just bearing the cost; and
- continued Invest NI support to provide training support for businesses.

4.2.2. Some organisations, particularly in manufacturing, had difficulty recruiting and retaining workers of school-leaver age. They often found this was due to the perception of careers in manufacturing and therefore, this is an area which

[236] The Apprenticeship Levy is a 0.5% tax on businesses with a wage bill of more than £3 million.

policy support and engagement by industry could help to overcome with increased career guidance and industry knowledge at schools, colleges and universities. Many consultees were willing to increase their links with the education system such as through partnerships with HE college to help deliver curriculum based on their industry's needs. Therefore, future interventions could help to guide and encourage deeper links between industry and education to help reduce skills mismatches and so that students are correctly informed about demanded careers and skills.

4.2.3. Currently, some consultees must recruit expert automation knowledge from Great Britain, or further afield at high costs. The development of expert consultants in automation, machine learning and future technology in the private sector and within policy support bodies in NI was suggested by some consultees as a necessary area of development.

4.2.4. Additionally, or in conjunction with expert consultants, an increased knowledge sharing environment would be beneficial so that organisations could share their experiences of automation. Many consultees were willing to collaborate to share their development and challenges that they faced when implementing automation with other likeminded organisations.

4.2.5. Most consultees had benefitted from R&D tax credits as well as capital grants from Invest NI, and they were keen to continue to be able to access this form of support. However, some suggested that the administration process, particularly during the application stages was costly for organisations predominantly smaller companies who may not have staff and financial resources to dedicate to application processes. Invest NI support was preferred to UKRI or Innovate UK support as in the view of the consultees, the competition-based system operated by UK based organisations meant that assistance was not guaranteed, whereas the Invest NI support was.

4.2.6. Organisations that had previously benefitted from capital grants, spoke of the difficulty in meeting Invest NI employee-based growth targets as a method of granting or measuring the success of policy support. Indeed, this form of target had actively discouraged automation. Consultees (particularly smaller or newly created firms) noted that they would benefit from policy support which had different measures of success such as increases to productivity or innovation.

4.2.7. Table 5 summarises the areas which consultees would like future policy support to focus on.

Table 5: Consultee future policy support ideas

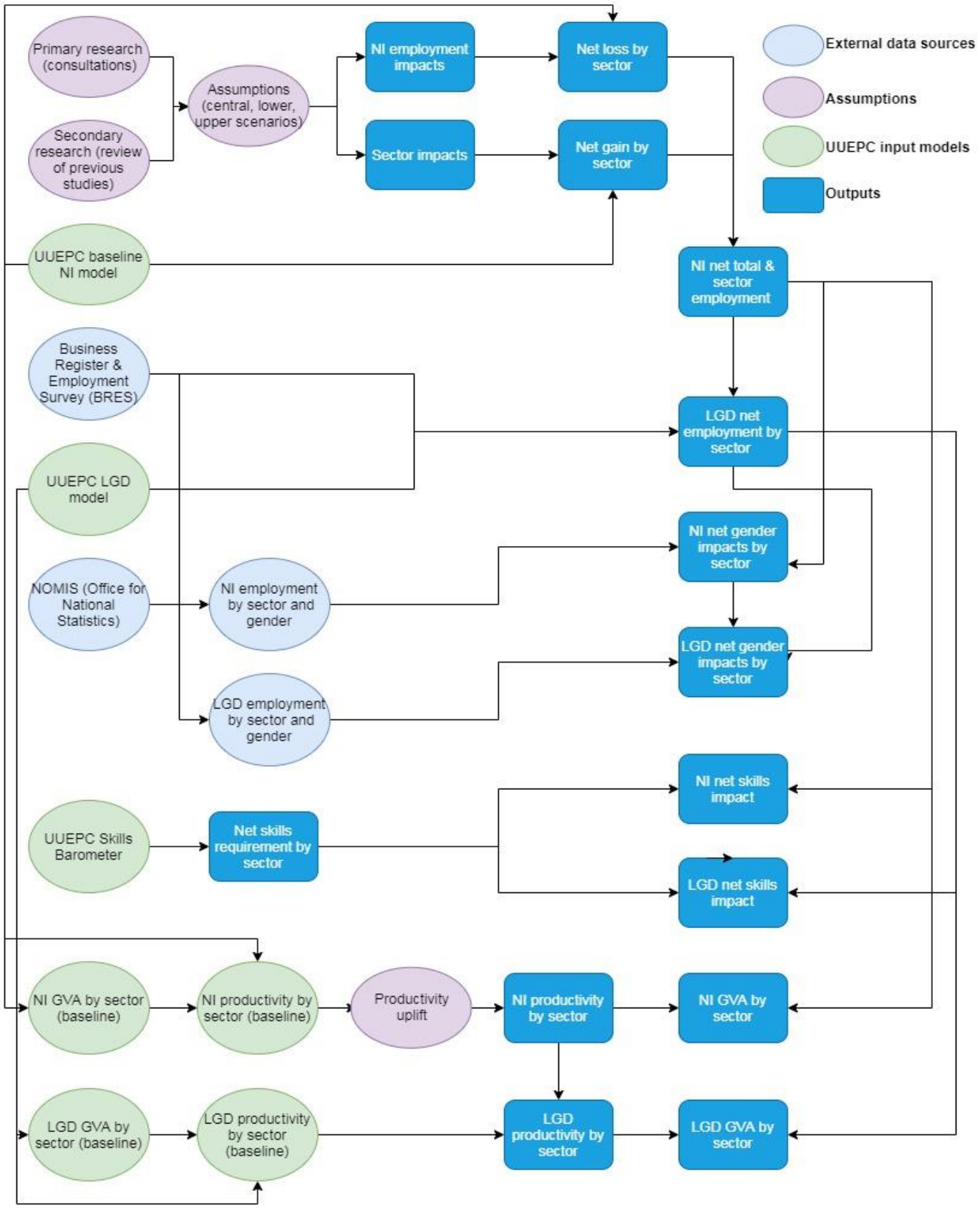
Summary of consultee's future policy suggestions
Continuation of R&D tax credits and capital grants, however, reduce the administrative processes.
Adapt support targets (currently employee-based targets) to those that align with business development needs, such as output or productivity.
Skills development within education by continuing to update curricula to meet industry needs, increase the use of ICT and technology in education, increase STEM study participants and continue the promotion of lifelong learning.
Increased career guidance and partnerships between education and industry to help inform students of realistic career and skills demanded in the workforce.
Continuation of Invest NI training for current workers to help them adapt to automated workings.
Develop industry partnerships to facilitate a knowledge sharing environment based on automation and the challenges or success companies have faced.
Development of expert automation consultants to assist companies investing and implementing automation.

5 Modelling the potential impacts of automation on the NI economy

5.1. The potential economic impact of automation in NI has been estimated by undertaking a review of relevant academic research, gathering available data for NI and taking account of findings from the consultations undertaken with NI businesses. The NI and local forecasting models and the Skills Barometer create a baseline against which to consider scenarios for a more automated future for NI. The automation model provides estimates for the impact of automation upon the NI economy as a whole, by sub-region, by gender and by skill level. The automation model estimates the additional, or differential impacts of a more automated economy to 2030.

5.2. This type of modelling is from a macro perspective and focuses, quite necessarily on employment as one of the driving factors. The economic forecasting models are based on employment, productivity and GVA. The most recently published academic literature focuses on tasks rather than jobs, and industry consultations confirmed the task-based approach that has been adopted in recent publications. However, modelling specific tasks is beyond the capability of macro forecasting models and therefore this section focuses on the GVA, employment, wages, productivity, skill, gender and sub-regional impacts. Figure 5.1 provides an illustration of the model framework.

Figure 5.1 Automation model methodology



Source: UUEPC

5.3. Three scenarios have been produced in the automation model: lower, central and upper. The lower scenario models the potential outcome in a low growth environment with no additional policy support for automation. The central scenario models an economy in which automation policies are implemented more rigorously and productively and therefore GVA begins to grow as a result. The upper automation scenario models an increasingly automated economy with skills inflows and significant policy support focused on automation and increasing productivity.

5.1 Employment erosion due to automation

5.1.1. This paper uses estimates published by PwC, Deloitte, McKinsey and OECD for the number or proportion of jobs that are at risk from automation over the next one or two decades. These estimates focus on the proportion of jobs at high risk from automation rather than the extent of tasks in a sector that could potentially be automated. It should be noted that it is much more challenging to specify the types of jobs that might be created and their value to society or employers. For this reason, the literature focuses much more heavily on the types of employment that are at risk.

5.1.2. A range of factors including, but not limited to, elasticities of substitution will be particularly important in firms' decisions to automate where technical feasibility exists. Data are not currently available with sufficient granularity to enable such analysis for NI. The consultations do however provide some insight and assumptions based on the consultations are included in the model.

5.1.3. Employment impacts are a tangible outcome regarding the impact of automation. While tasks may be automatable, that does not directly translate to loss of a job. Instead of redundancy, there may be a repositioning exercise for such individuals, the likelihood of which would increase where the pace of change at enterprise level is slow.

Table 6: Jobs at high risk of automation

Source	At high risk	Region	Timing
Deloitte	35%	UK	2030
McKinsey	20%	UK	2030
PwC	30%	UK	2034
Arntz *et al*. (OECD)	10%	UK	2030

5.1.4. PwC's estimation of jobs at high risk runs to the "early 2030s" – for the purpose of specificity in identifying NI-specific risk, this has been capped at 2034 and within the model is scaled to stop at 2030[237], representing approximately 73% of the total impact detailed in their published reports.

5.1.5. For all scenarios, to estimate job losses, an average of the reported jobs at high risk for the four reports has been applied.

[237] The NI-specific model runs to 2030 to maintain consistency with the majority of published work.

5.1.6. PwC and Deloitte provide sectoral breakdowns of jobs at high risk (for the UK). The results have been used to inform which sectors are likely to feel the biggest impact of job losses resulting from automation. Their research identifies transportation, retail and manufacturing as the sectors that have a high risk of jobs that will be displaced by automation. The research and findings from UUEPC consultations are used to reach a final estimate of sectoral impacts.

Table 7: Summary of employment assumptions

Source	Central	Upper	Lower	Sources
Employment (at risk)	22%	22%	22%	Deloitte, McKinsey, PwC, Arntz *et al*. (OECD)
Employment (jobs gained)	25%	28%	19%	PwC, McKinsey and UUEPC consultations. McKinsey research suggests 2.6 jobs created per jobs lost. UUEPC have amended this to 1.7, 2.0 and 1.1, which are in line with consultation findings.

5.2 Employment opportunities from automation

5.2.1. These estimates are based on anticipated employment growth from PwC to 2037, McKinsey's estimate of jobs created per job lost to 2030, and UUEPC primary research (table 8).

5.2.2. In order to ensure estimates were on a consistent basis, the PwC growth was scaled back to end in 2030 instead of 2037. This assumes a linear progression of growth over each intervening year.

5.2.3. The McKinsey estimate transforms the expected number of jobs at high risk under the average scenario, by multiplying the estimated jobs lost by 2.6 and expressing as a proportion of total jobs in 2018. Based on consultations, this estimate was high and did not reflect the views of businesses within NI. As such, a range of values in place of the 2.6 were used to calculate job gains relative to jobs lost. The average was then calculated as the midpoint of the estimates (table 8).

Table 8: Estimated job gains

Source	Published information			Growth from 2018 to 2030	Average
	Estimate	Region	Timeframe		
PwC	20%	UK	To 2037	12%	35%
McKinsey	2.6 per job lost	Global	To 2030	57%	35%
Central	1.7 per job lost	NI	To 2030	37%	25%
Lower	1.2 per job lost	NI	To 2030	44%	19%
Upper	2.0 per job lost	NI	To 2030	27%	28%

5.2.4. PwC identified a sectoral breakdown for estimated job creation which is used alongside enterprise consultations to inform which sectors are the most likely to grow as a result of automation.

5.3 Net jobs impact

5.3.1. The net employment impact is the key output and is calculated as the expected employment creation minus losses for each scenario over the forecast period.

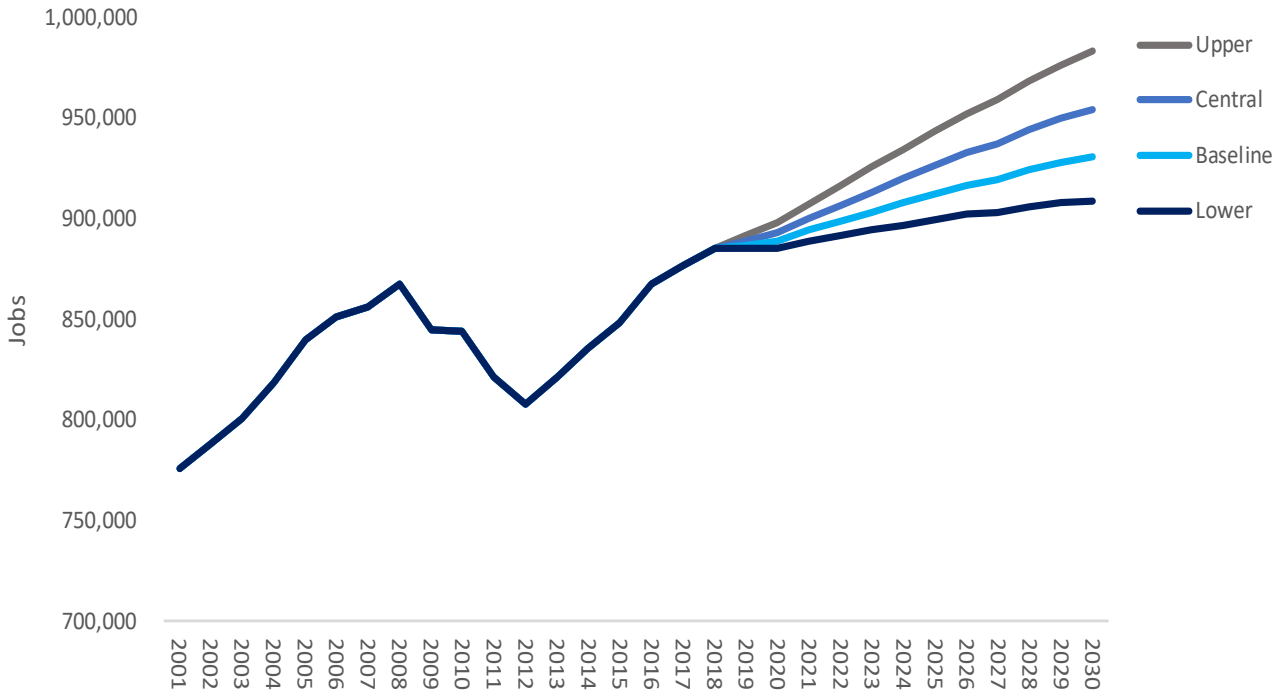
5.4 Total employment

5.4.1. The automation model builds upon UUEPC baseline forecasts to determine the NI-specific impacts of automation. A key assumption within the baseline is that the UK's exit from the European Union (EU) will be an orderly one e.g. there will be a transitional period inclusive of a conducive trade deal. At the time of writing, it remains to be seen how NI may exit Europe. Furthermore, consumer expenditure will continue to be a key driver of economic growth in NI. In the context of Brexit, global uncertainty and geo-political risks, a slowdown in GVA and employment growth is predicted over the coming years until 2021, before beginning to pick up pace.

5.4.2. In contrast to what may be expected given 'automation anxiety', the UUEPC automation model suggests that there will be a greater amount of jobs available by 2030, in comparison to the baseline (figure 5.4.1). Specifically, almost 70,000 jobs will be created (24,000 more than UUEPC baseline forecasts). While the scale of jobs may appear optimistic, over the 12-year period this equates to an annual average growth rate of 0.6% (the equivalent figure for the baseline is 0.4%).

5.4.3. In the upper scenario, which assumes 2 jobs are gained for every job lost, almost 100,000 jobs are created (0.9% growth per annum). The lower scenario however suggests that only 23,000 jobs would be created, which is just half of baseline estimates (0.2% per annum). The range between the best- and worst-case scenarios is 75,000 jobs - around 8% of total employment in 2018.

Figure 5.4.1: Total employment, baseline versus automation scenarios, NI, 2001 - 2030

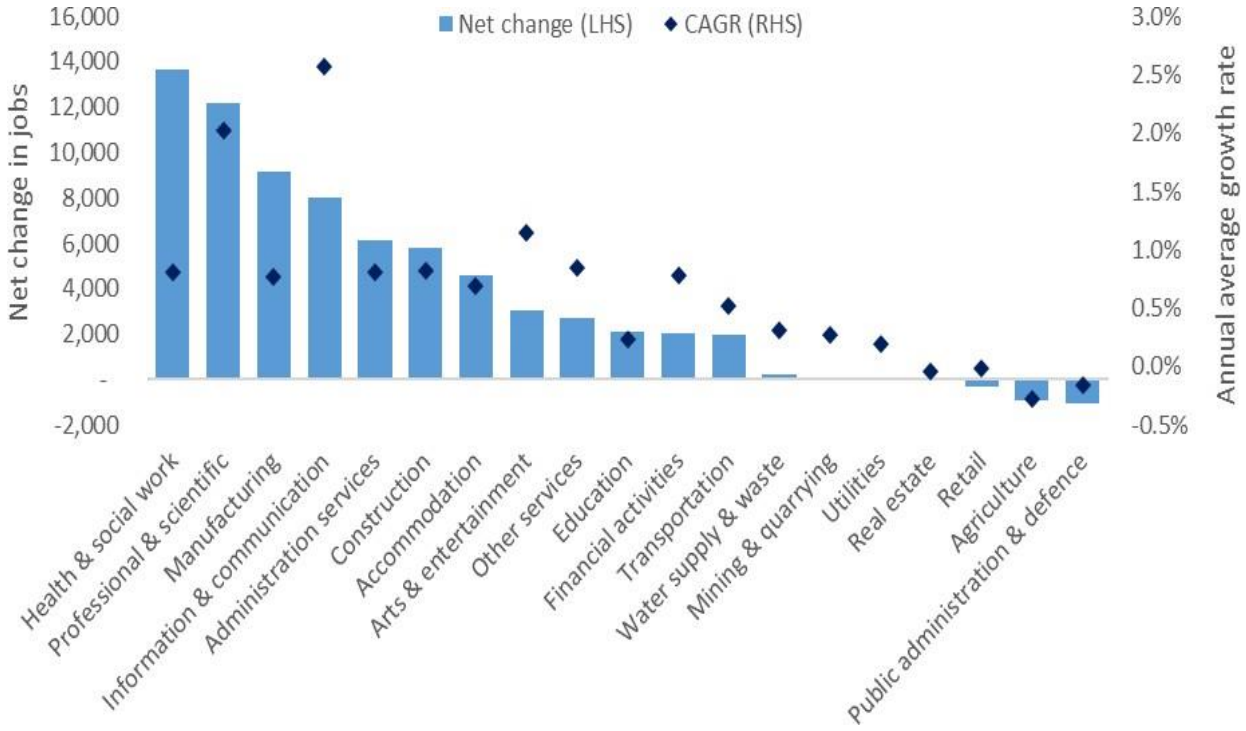


Source: UUEPC

5.5 Sectoral employment

5.5.1. Health and social care and professional services experience the largest net employment gains in NI, creating 14,000 and 12,000 jobs respectively (figure 5.5.1). Health and social care is the second largest employer within NI (135,000 jobs representing 15% of all jobs). When analysing growth in the context of sector size, the fastest growing sectors are ICT and professional services with annual average growth rates of 2.6% and 2.0%. These sectors are expected to grow given the demand for employees that can develop, implement and manage the new technologies that arise with automation adoption. For example, the use of machine learning algorithms to identify fraudulent activity in the banking sector, or the development of software and programmes to store and analyse large amounts of data which current software cannot yet handle.

Figure 5.5.1: Growth in jobs, net change and average annual growth, central automation scenario, NI, 2018 - 2030



Source: UUEPC

5.5.2. An overview of how different sectors are incorporating automation is provided in table 9. The health and social care sector is expected to embrace automation through virtual assistants, improved detection and diagnosis through AI and machine learning, and medical robotics, to name a few. The IPPR's Embracing technology in health and social care report suggests that by 2030 savings achieved through automation could reach up to £18.5 billion. These suggested savings are accrued due to the value of time released for NHS staff as a result of productivity gains (saving £12.5 billion) and improved productivity from accelerated automation in the social care sector (£5.9 billion a year)[238].

5.5.3. It is anticipated that employment growth will continue within the sector due to an aging population and the requirement for human interaction. According to population projections produced by the Northern Ireland Statistics and Research Agency (NISRA), the proportion of individuals aged 60 and over will increase from 21% in 2016, to 27% - an increase of 145,000 people. Currently, the sector faces pressures due to high demand of services and limited supply of staff and automation will help to alleviate these pressures through efficiency gains, rather than resulting in a reduction in staffing.

[238] Embracing Technology in Health and Social Care

Table 9: Potential Automation Implementation by Sector

Sector and Potential Automation Implementation	
Agriculture • Automated machinery and robots • IOT • Aerial imagery • Drones • GPS technology[239]	**Mining and quarrying** • Robotic machinery (self-driving vehicles) • Drones • 3D printing[240]
Manufacturing • Industry specific robotics and machinery • Data analysis[241] • Virtual reality	**Utilities** • AI and smart appliances • Cloud and blockchain services • IOT • Data analytics • Electric vehicles • Smart buildings[242]
Water supply & waste • Automated robotics (advanced metering infrastructure- AMI) • Cloud-based services • Data analytics[243]	**Construction** • Robotics • Self-driving vehicles • 3D printing[244] • Digitalised buildings • Virtual reality
Retail • Self-serving tills • Data analytics • Robotic machinery – warehouse picking machines • IOT[245]	**Transportation** • AI • Self-driving vehicles • Data analytics • Traffic management solutions[246]
Accommodation • Self-ordering kiosks • Mobile apps for keyless rooms • AI • Voice command technology[247]	**Information & Communications** • AI • Data analytics • IOT • Digitalisation

[239] Nichols, M.R. (2019). *How is Automation Changing the Agriculture Industry?* Available at: http://www.visiontimes.com/2019/08/14/how-is-automation-changing-the-agriculture-industry.html (last accessed 19 August 2019).

[240] Mining Technology (2017). *Robots and recruitment: the impact of automation on mining jobs.* Available at: www.mining-technolgy.com (last accessed 19 August 2019).

[241] Information gained from UUEPC consultations.

[242] Deloitte Insights (2019). *Digital innovation Creating the utility of the future*. Available at: www.deloitte.com (last accessed 19 August 2019).

[243] Water & Wastewater Treatment (2014). *Automation: The key to an efficient water industry?* Available at: https://wwtonline.co.uk (last accessed 19 August 2019).

[244] Everly, R. (2017). *3 ways automation will change the construction industry*. Available at: www.inman.com (last accessed 19 August 2019).

[245] Szajna-Hopgood, A. (2018). *The rise of automation: Should retailers be worried?* Available at: www.retailgazette.co.uk (last accessed 19 August 2019).

[246] Bharadwaj, R. (2019) *AI in Transportation- Current and Future Business-Use Applications*. Available at: https://emerj.com/ai-sector-overviews/ai-in-transportation-current-and-future-business-use-applications/ (last accessed 19 August 2019).

[247] Hospitality Technology (2017). *7 Ways Hotels are Moving to an Automated Future*. Available at: https://hospitalitytech.com/7-ways-hotels-are-moving-automated-future (last accessed 19 August

	• Machine learning[248]
Financial activities • Robotic Process Automation[249] • Data analytics • Artificial intelligence • IOT • Digital services[250]	**Real estate** • Data analytics • IOT • Digital services[251]
Professional & scientific • Industry specific robots • Data analytics • IOT • AI[252]	**Administration services** • Automated systems • IOT[253]
Public Admin' & defence • AI • Robotics • Data analytics • Automated systems[254] • Cybersecurity[255]	**Education** • AI • Digital products[256]
Health & social work • Industry medical robotics • 3D printing • AI[257]	**Arts and entertainment** • Automated activities • Virtual reality entertainment[258] • Robotics • Data analytics Digitalised services[259]

158. Retail and manufacturing are the two sectors that experience the largest variation in net job change across the automation scenarios (figure 5.5.2).

2019).

[248] McKinsey & Company (2017). *What's now and next in analytics, AI, and automation*. Available at: www.mckinsey.com (last accessed 19 August 2019).

[249] Strategic Finance (2016). *The Power of Finance Automation*. Available at: https://sfmagazine.com/post-entry/december-2016-the-power-of-finance-automation/ (last accessed 19 August 2019).

[250] McKinsey Digital (2012). *Automating the bank's back office*. Available at: www.mckinsey.com (last accessed 19 August 2019).

[251] Kardell, A. (2019). *3 Reasons Why Real Estate Automation Makes Agents More Efficient*. Available at: https://blog.homespotter.com/2019/05/01/real-estate-automation/ (last accessed 19 August 2019).

[252] Information gained from literature review.

[253] Patel, S. (2017*). 6 Administrative Tasks You Can Automate*. Available at: www.inc.com (last accessed 19 August 2019).

[254] Cox, L. (2016). *Automation in the Public Sector*. Available at: https://disruptionhub.com/automation-public-sector/ (last accessed 19 August 2019).

[255] PwC (2018). *What will be the net impact of AI and related technologies on jobs in the UK?* Available at: www.pwc.co.uk

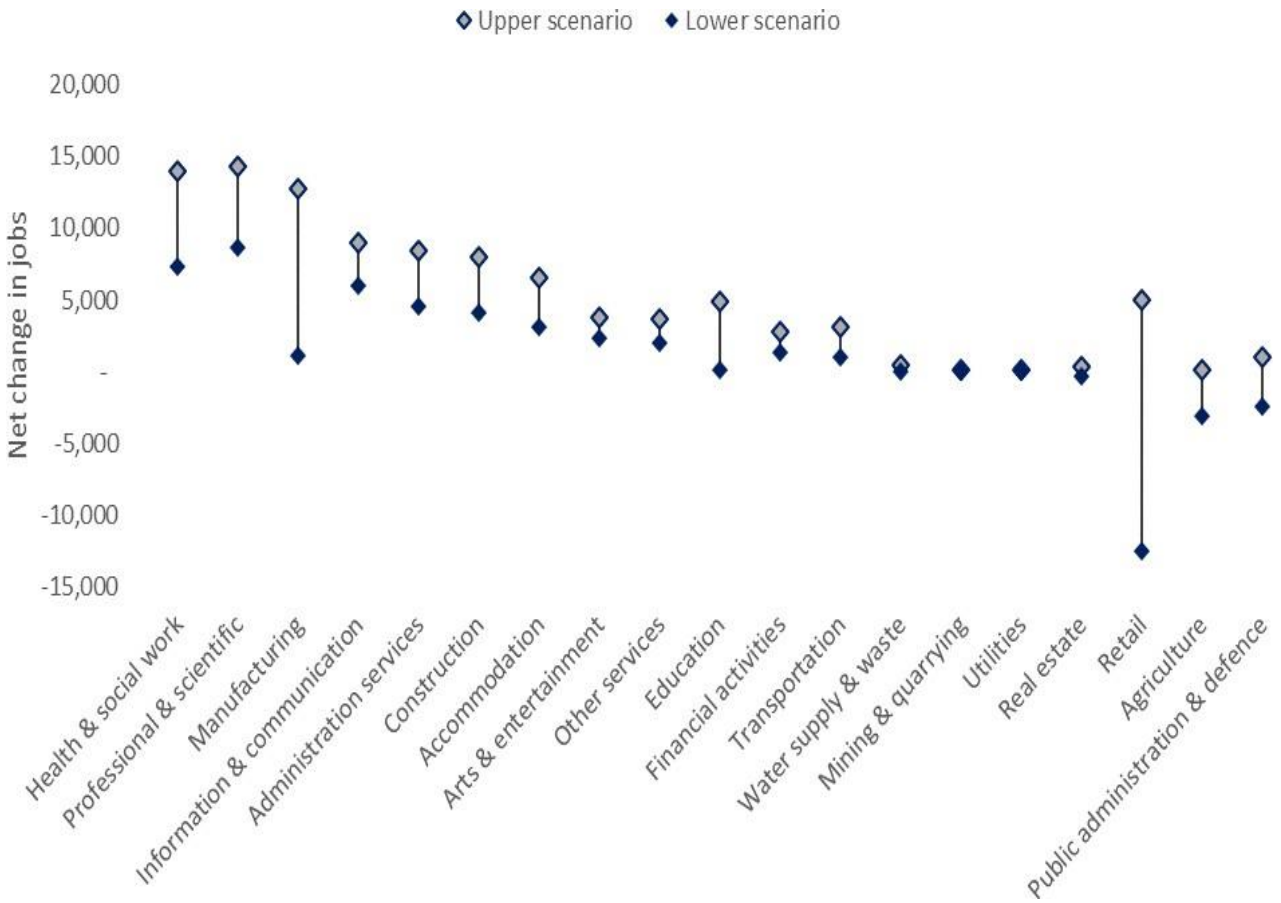
[256] PwC (2018). *What will be the net impact of AI and related technologies on jobs in the UK?* Available at: www.pwc.co.uk

[257] Ibid.

[258] Virtual living (2017). *How Entertainment Industry Uses Virtual Reality*. Available at: www.virutalliving.io (last accessed 19 August 2019).

[259] PwC. (nd). *Data and Analytics in the Entertainment and Media sector*. Available at: www.pwc.co.uk (last accessed 19 August 2019).

Figure 5.5.2: Growth in jobs, net change, upper versus lower automation scenario, NI, 2018 - 2030



Source: UUEPC

5.5.4. Retail gains 5,000 jobs in the upper scenario but loses 12,500 under the lower scenario. In the context of the size of the sector and the time period, these represent average annual growth rates of 0.3% and -0.8%.

5.5.5. Automation processes are already evident throughout the retail sector with many stores investing in shelf-scanning robots and promotion of self-service through standalone checkouts. Research from McKinsey suggests that around half of the activities in retail can be automated using current technologies. The lower scenario is a reflection of the jobs at risk if retailers decide to replace them with processes. The fact that activities can be automated however does not necessarily mean that jobs will be lost. The processes can be used to increase efficiency by cutting costs and supporting and bolstering margins in a competitive environment. Time of individuals will be freed, and workers can be cross trained to perform additional tasks such as advising customers and helping with queries. Consultations with NI businesses in the retail sector found that consumers still demand human interaction. In the upper scenario, efficiency gains are prevalent however rather than reducing staff, firms will focus on innovation and redeploy hours to more valuable activities. New workers will be required, and existing staff will also be upskilled and retrained where possible.

5.5.6. The central scenario predicts that retail within NI will remain relatively steady, losing 300 jobs over the next 12 years. The scenario recognises a subdued demand for new jobs as a result of implementing automation processes yet does not assume significant job growth in sector due to efficiency gains and innovation.

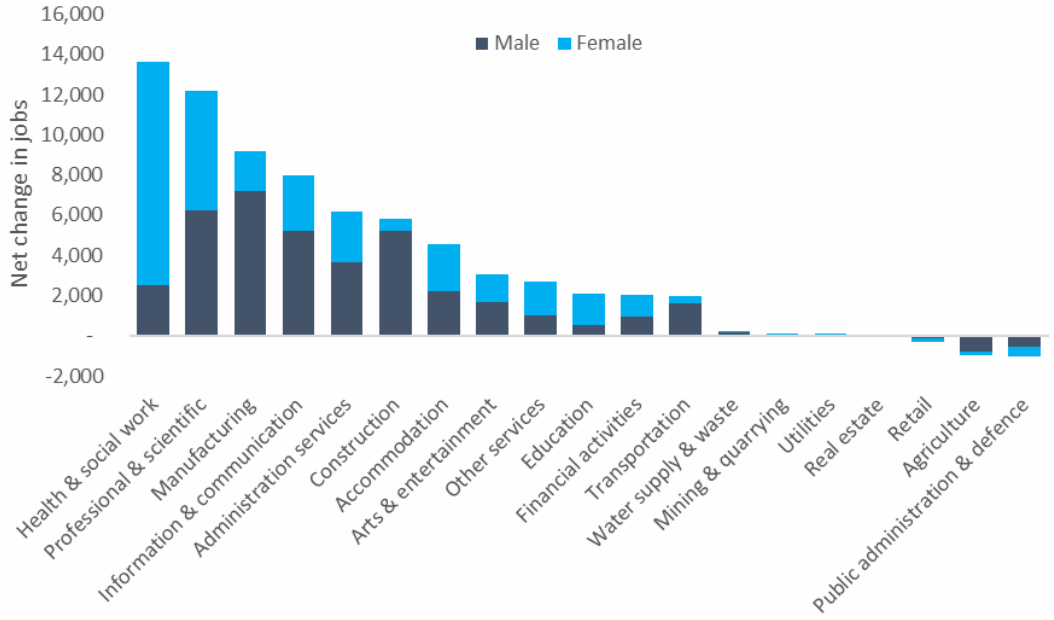
5.5.7. In the upper automation scenario, manufacturing gains 13,000 jobs growing at a rate of 1.1% per annum. In contrast, manufacturing growth is subdued in the lower scenario. Jobs are gained rather than lost, but the rate of growth falls to 0.1% per annum (1,200 jobs). Much research suggests that automation anxiety exists within manufacturing and it is one of the sectors most 'at risk' of job losses. This is because automation processes can be developed to replace a production facility (fixed/hard automation) where processing operations are fixed by equipment configuration. Programmable automation is also applicable where products are made in batch quantities, and the production equipment is reprogrammed for each batch. An extension of programmable automation is flexible automation, where variety is limited, and reprogramming is done through a computer rather than using the production equipment. That way, different products can be produced in one batch.

5.5.8. Although manufacturing processes can be automated, primary and secondary research suggests that this will not lead to significant employment reductions. The consultations with manufacturing businesses suggests that many products are niche and vary, therefore investing in machinery would not yield high returns because of variation between products. Some processes can be implemented to increase efficiency, but not to the extent that jobs are replaced. Of those who produced a large volume of products and invested in robots in production, jobs were not lost but rather gained as individuals needed to be retrained/hired to develop programmes and manage the robot. Overall, it was suggested that implementing automation processes was a necessity for many manufacturing businesses within NI due to staff shortages and businesses are keen to retain staff, but further automating may result in a reduced need to hire.

5.6 Gender

5.6.1. Of the 70,000 jobs expected to be created in the central scenario, just over half (53%) are expected to be taken by males. The sector that employs the largest proportion of males is manufacturing, representing 20% of jobs created for males. The next largest sector is professional services at 17%. The equivalent for females is health and social work where one-third (36%) of net new jobs are created, with the majority likely to be filled by females.

Figure 5.6.1: Growth in employment, net change, sector breakdown by gender, NI, 2018 - 2030



Source: UUEPC

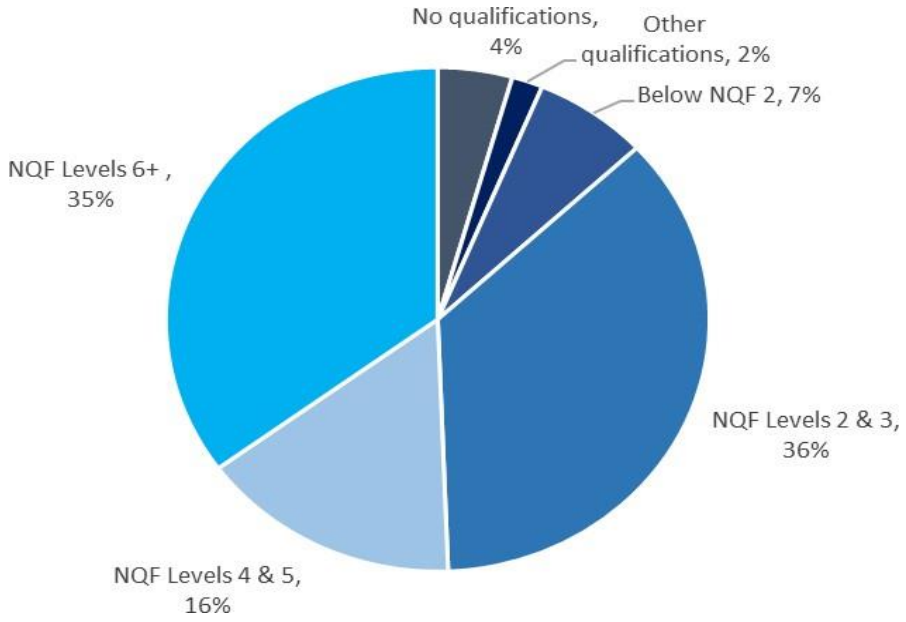
5.7 Skills

5.7.1. The sectoral composition of new jobs and replacement demand in existing jobs determines the skill requirements for the future. The UUEPC Skills Barometer allows for the estimation of the net skills requirement by the highest NQF level. It is important however to acknowledge that skills and qualifications are not the same. Employees can be highly skilled yet have a low level of formal qualification, which would be the case for experienced workers in manufacturing, for example.

5.7.2. Under the automation scenario, the overall skills composition is similar to the baseline, which is unsurprising as the Skills Barometer scenario is for more robust growth than the baseline scenario. Within the central scenario there are 24,000 more jobs than in the baseline (2,000 each year on average), which are spread across a number of sectors. Even though the most rapid rate of growth is experienced by ICT and this is a highly skilled sector, it represents just 11% of net new jobs.

5.7.3. When analysing the skill requirements of net new jobs over and above the baseline, this gives an indication as to the accessibility of jobs created. Figure 5.7.1 highlights that of the 24,000 net change in jobs, more than one-third are likely to require a degree level education (NQF level 6+). Another third are likely to require skill level of NQF levels 2 & 3.

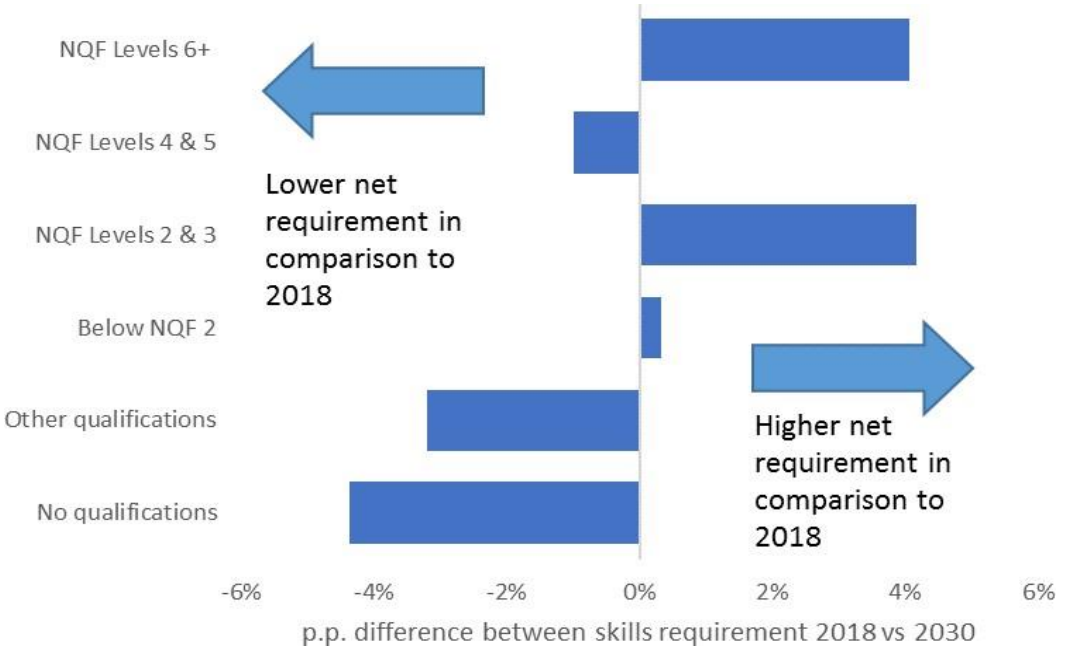
Figure 5.7.1: Skill requirements of net new jobs created in central scenario vs baseline, NI, 2030



Source: UUEPC

5.7.4. Figure 5.7.2 illustrates the skill requirements of the economy in 2030 compared to 2018. The central automation scenario estimates that there will be a higher demand from jobs requiring individuals who are educated to at least degree level, and those with 5 GCSEs (A*-C) or A-levels, or to an equivalent level.

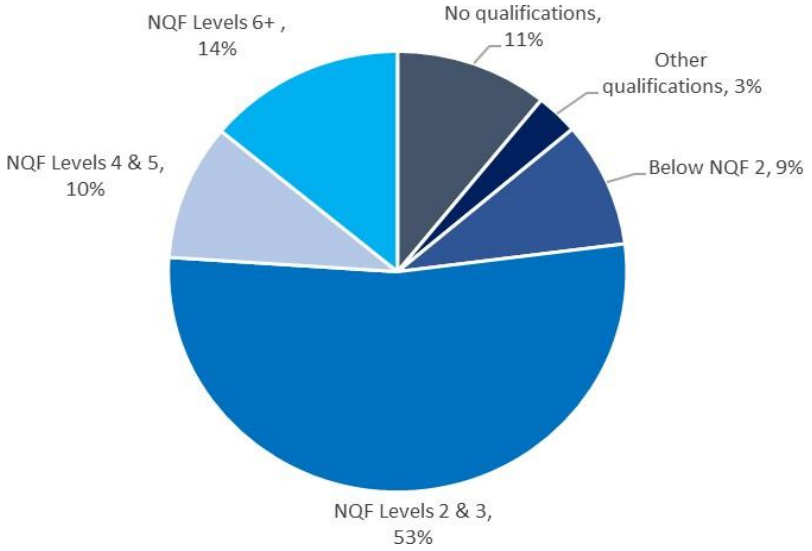
Figure 5.7.2: Comparison of skill requirements, NI, 2018 baseline vs 2030 central scenario



Source: UUEPC

5.7.5. Figure 5.7.3 highlights that of the jobs lost, more than four-fifths (86%) require less than degree level education (below NQF level 6), although some degree level jobs are at risk (accountants etc). Those expected to be most heavily impacted are individuals with a skill level equivalent to NQF levels 2 & 3 (5 GCSEs Grades A*-C, A-level), representing more than half (53%) of the reduction in jobs in comparison to the baseline expectations.

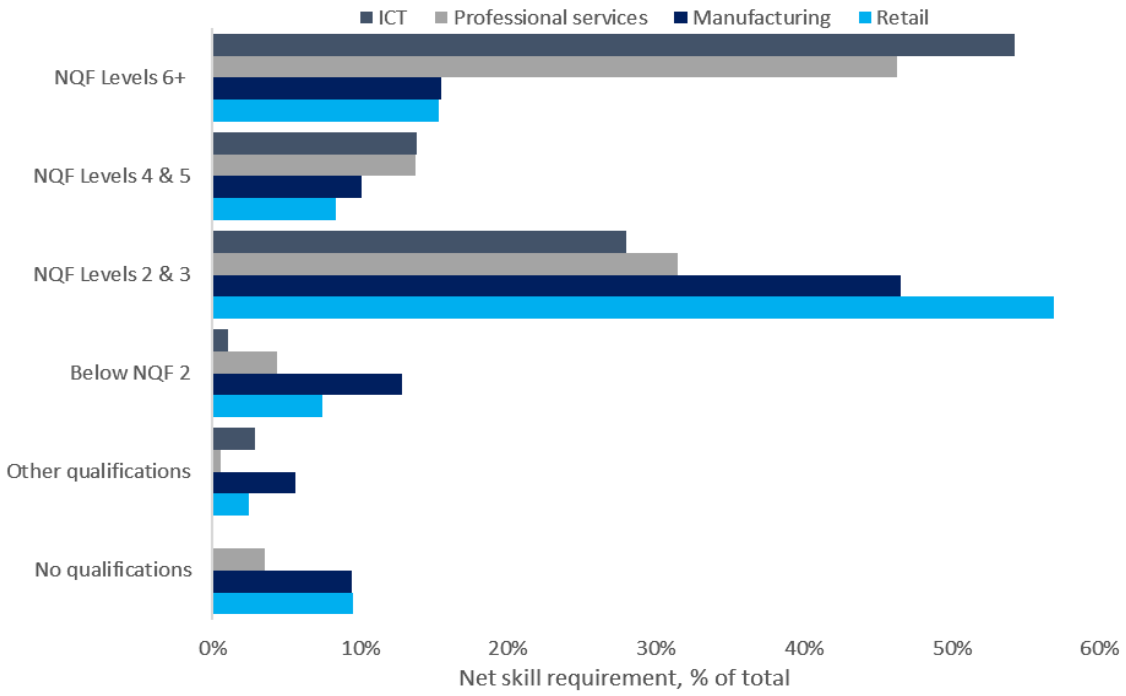
Figure 5.7.3: Skill requirements of jobs lost in lower scenario vs baseline, NI, 2030



Source: UUEPC

5.7.6. The reason for the impact upon middle and lower (formally) skilled individuals is a result of the skills profile of the sectors most at risk under the lower scenario. Retail and manufacturing are at risk of losing the largest number of jobs, whereas ICT and professional services experience the largest growth. Figure 5.7.4 illustrates the different skill requirements of the four sectors. ICT demands that 54% of workers have at least degree level education, with the equivalent for professional services being 46%. In retail nearly three-fifths (57%) of the skills requirement is filled by those with NQF level two or three.

Figure 5.7.4: Skill requirements by sector, NI, 2030



Source: UUEPC

5.7.7. Overall, in the central scenario the majority of jobs created through the implementation of automation processes will require either a degree level education, or NQF level 2 & 3. Under the lower scenario, employment will be created in high skilled sectors whereas job losses will occur in sectors that require a lower level of formal qualifications (retail and manufacturing). Therefore, accessibility of jobs may be an issue for lower skilled workers.

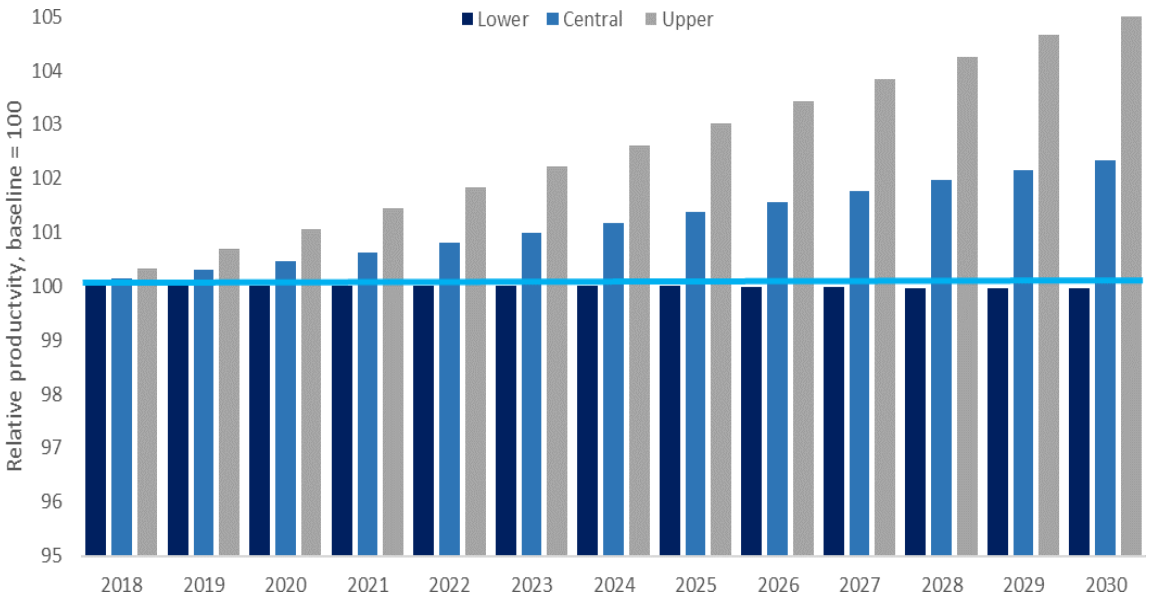
5.8 Productivity

5.8.1. Productivity refers to the amount of outputs produced (goods and services) per unit of inputs (raw materials, capital and labour) and boosting it is one of the key reasons to engage in automation. In an economic context, productivity is measured by dividing total gross value added (GVA) by employment.

5.8.2. Under the central scenario, by 2030 automation will lead to an increase in productivity to £51,300 at an annual growth rate of 1.2%. Productivity is 5%

higher than the baseline in the upper scenario, and steady in the lower scenario (figure 5.7.5).

Figure 5.7.5: Productivity, automation scenarios relative to UUEPC baseline, baseline = 100, NI, 2030



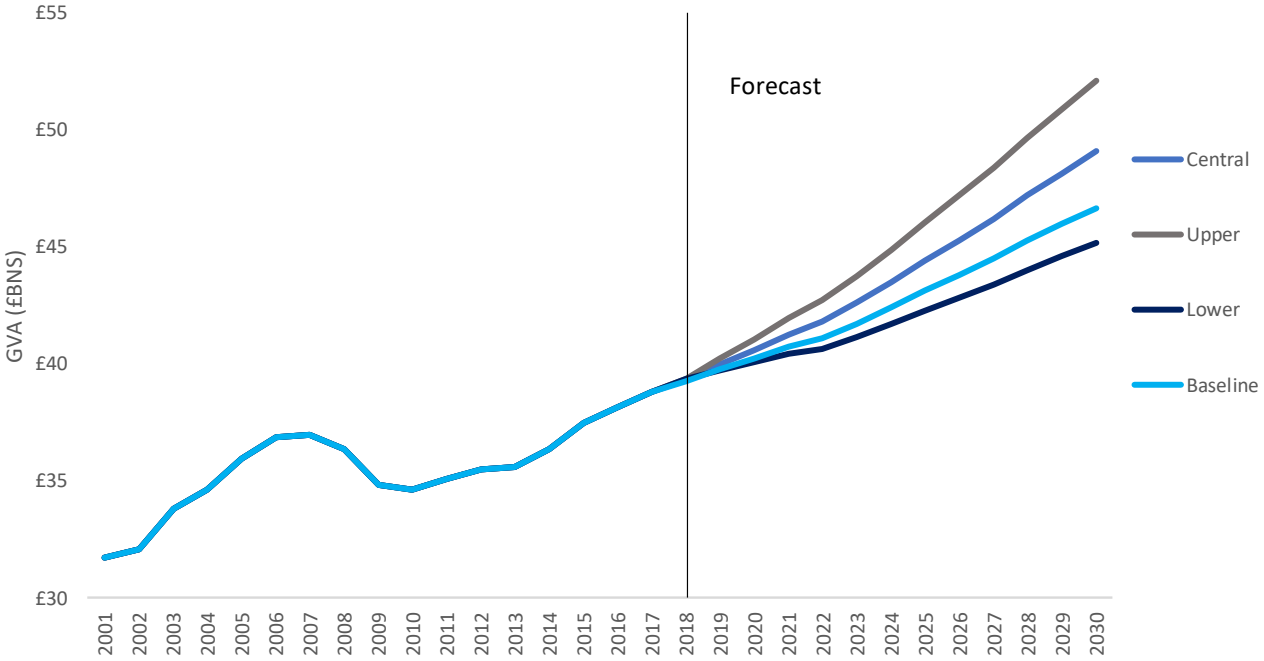
Source: UUEPC

5.9 Gross Value Added (GVA)

5.9.1. In the central scenario, GVA is £49 billion. This represents an average annual growth rate of 1.8%, similar to that experienced in NI between 2012 and 2017. The faster growth rate in GVA is driven by productivity uplifts as a result of firms adapting automation processes, as well as higher levels of employment i.e. jobs created as a result of automation.

5.9.2. In the upper scenario, these effects are exaggerated and as such, GVA grows at an average annual rate of 2.3% resulting in GVA of £52 billion. For the lower scenario, productivity remains at similar levels to the baseline. A larger number of individuals are employed in sectors categorised as high productivity, however these gains are not enough to offset the overall loss of employment. To that end, GVA is £3billion lower than the baseline (£44 billion) and the average annual growth is 1.2%.

Figure 5.9.1: Total GVA (£bn), baseline versus automation scenarios, NI, 2001 - 2030

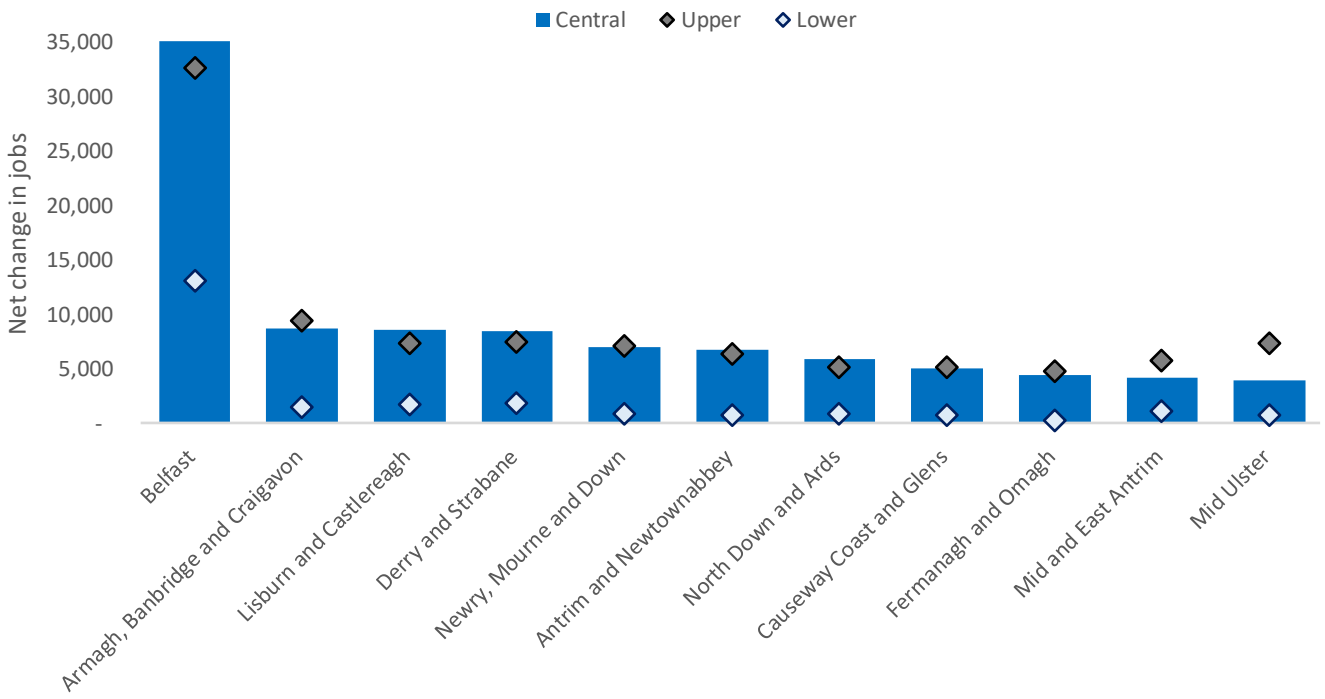


Source: UUEPC

5.10 Local economic impact on automation

5.10.1. The automation models are sectorally driven and as such, the impact upon council areas depends upon the concentration of each of the sectors impacted. Of the jobs created, 25,000 (37%) are likely to be in the Belfast City Council area (figure 5.10.1). All areas however benefit from the employment growth associated with automation. Within Belfast, the fastest growing sector is forecast to be ICT (2.4% per annum) followed by professional services (2.1% per annum). In 2018, 60% of all NI ICT jobs were based in Belfast. Armagh, Banbridge and Craigavon is the second placed council after Belfast in terms of potential employment gains. One-quarter of these are in health and social care (0.8% per annum), one-fifth in manufacturing (0.7% per annum), and a further 1,100 jobs in professional services (0.8% per annum).

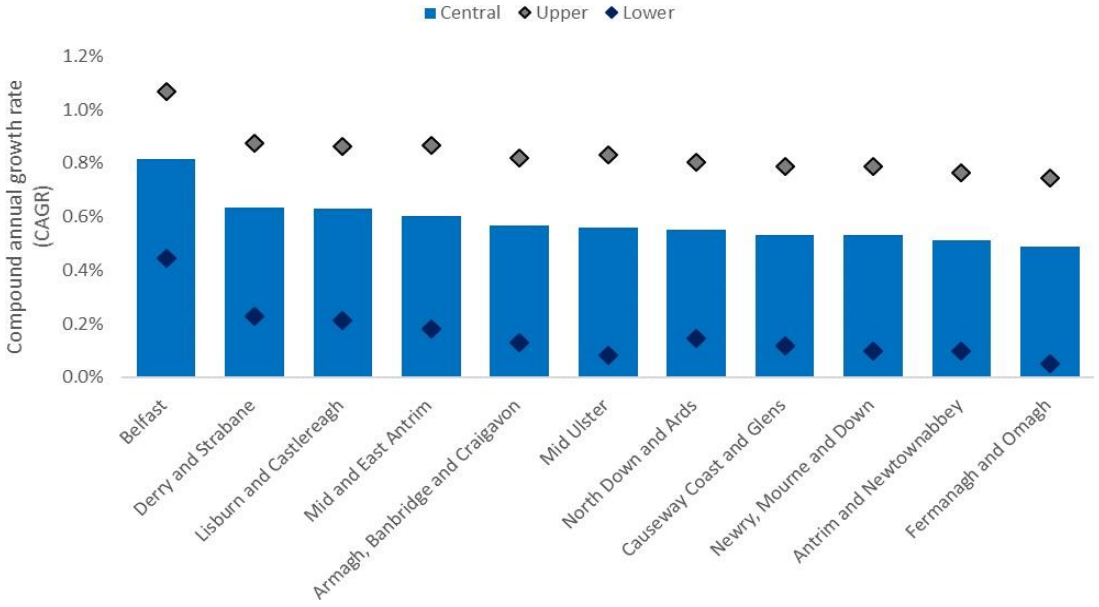
Figure 5.10.1: Net change in jobs automation scenarios, NI LGDs, 2018 - 2030



Source: UUEPC

5.10.2. In terms of growth rates, which take account of the size and sectoral composition of the local economy, Belfast again reaps the benefits with the fastest average annual growth rate of 0.8%. Derry and Strabane gains 5,300 jobs and represents the second fastest growth rate of 0.6%. Within the council area, health gains 1,500 jobs (0.9% growth per annum) followed by ICT (700 jobs) which is the fastest growing sector at 2.2% per annum.

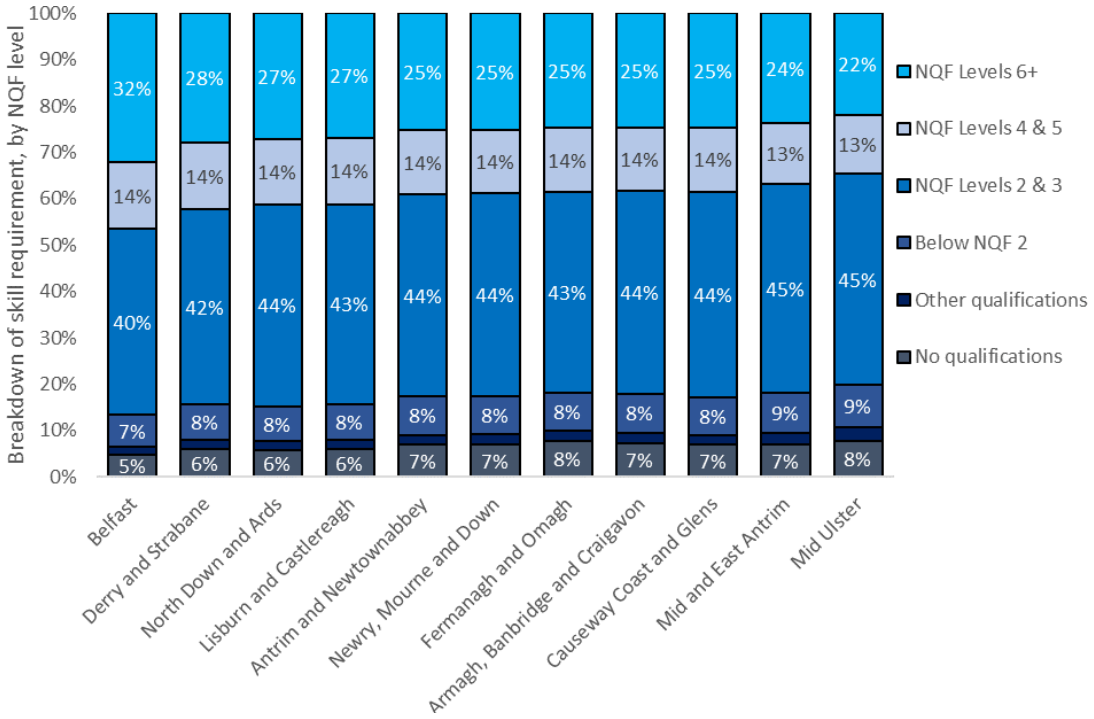
Figure 5.10.2: Average annual job growth, automation scenarios, NI LGDs, 2018 - 2030



Source: UUEPC

5.10.3. In terms of the skills demands, Belfast requires the highest skill levels, with one-third of jobs requiring an education equivalent to NQF level 6+ (figure 5.10.3). The reason is the proportion of jobs in ICT and professional services, both of which require a relatively high level of formal qualifications. Mid-Ulster is the local area which require the smallest amount of individuals educated to degree level, as three-quarters of jobs are expected to be at NQF level 5 and below. Two-fifths of all jobs in Mid-Ulster are expected to be within manufacturing and retail (27%, 16%) and these sectors are more accessible, requiring lower levels of formal skills (refer to figure 5.7.4 for skills differences in comparison to ICT).

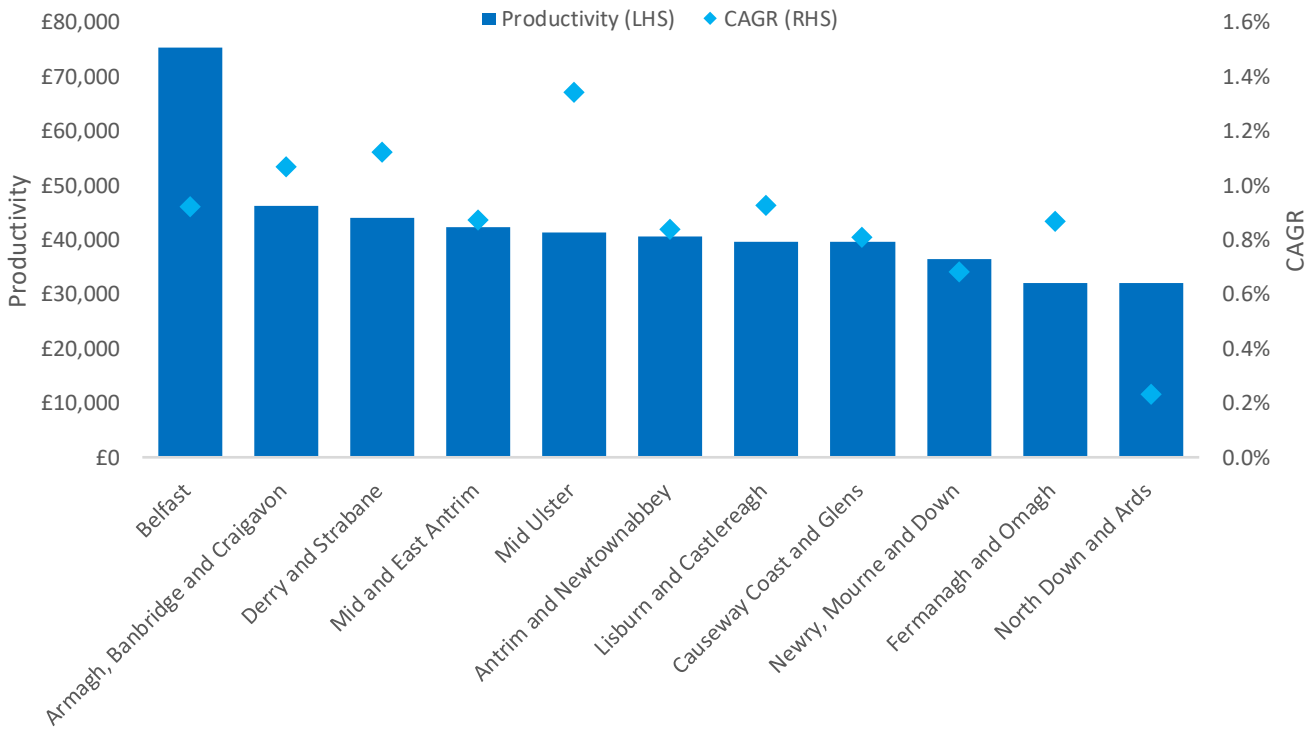
Figure 5.10.3: Breakdown of skill requirement, NQF level, central scenario, NI LGDs, 2030



Source: UUEPC

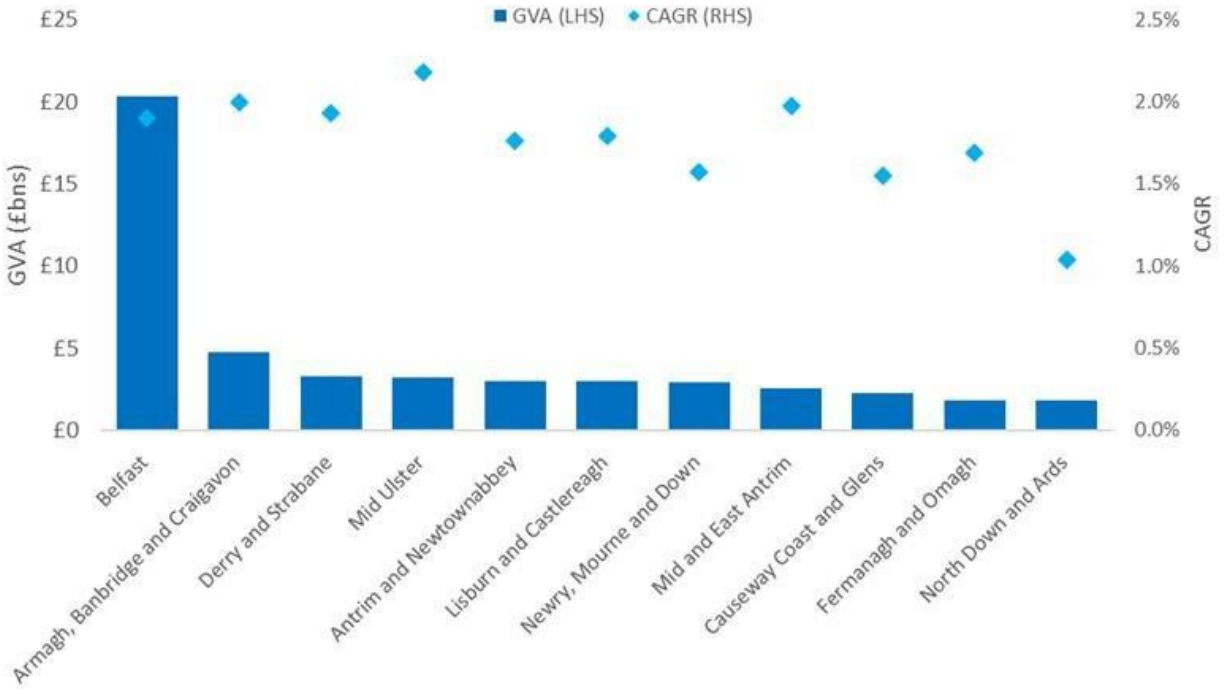
5.10.4. Belfast has the highest average level of productivity of all the council areas at £76,800. This is a result of having a larger proportion of individuals in highly productive sectors, alongside the productivity uplift associated with implementing automation processes and a large proportion of the working population commuting into the area daily. Mid-Ulster experiences the fastest growth in productivity at 1.6% per annum. This growth is driven by the addition of jobs in productive sectors (such as ICT), and productivity uplifts in sectors where Mid-Ulster holds a large concentration of jobs (e.g. manufacturing).

Figure 5.10.4: Productivity, level and average annual growth rate, central scenario, NI LGDs, 2030



Source: UUEPC

Figure 5.10.5: GVA, level (£bn) and average annual growth rate, central scenario, NI LGDs, 2030



Source: UUEPC

5.10.5. Overall the analysis and forecasts are generally positive for NI at a macroeconomic level. These findings are aligned to the academic literature and findings for other countries. It should be noted however, that the microeconomic implications for some individuals (especially older workers, those who are not in employment, the low skilled and low-income groups) and some enterprises (as more competitive firms take market share) are likely to be negative. These micro implications cannot be modelled through the UUEPC framework, however other elements of this research cast enough light on the potential distributional issues that may arise with higher levels of automation that they can be on the policy radar and be dealt with accordingly.

5.10.6. The automation model is used to project what a more automated economy could look like in NI focussing on employment, GVA, productivity, gender and skills. The potential local economic impacts are modelled too, and this analysis suggests that automation is likely to concentrate existing clusters of employment, rather than help to increase employment in areas of greatest need of additional employment opportunities. Therefore, NI's employment and income distribution policy framework should be focussed towards those areas in greatest need, and towards the individuals with the lowest skills levels and those skills that may suffer from lower demand or obsolescence in a more automated environment.

5.10.7. Regarding skills, the model suggests that by 2030 NI will have a greater proportion of employment requiring individuals who are educated to at least degree level, and those with 5 GCSEs (A*-C) or A-levels, or equivalent. This supports the findings from UUEPC's company consultations and academic literature, which found that companies are demanding highly skilled and educated staff in subjects such as data analytics, maths and physics in order to progress automation further. Therefore, subject choices are important in the preparation for the future of work to address current challenges and prevent future skills and subject mismatches as far as possible.

5.10.8. It will be important that policy action initially targets individuals with the lowest skills set to offset any long-term job displacement as a result of automation. This is because the model supports that of the jobs lost 86% are those that require less than degree level education (below NQF level 6), those most affected are individuals with a skill level equivalent to NQF levels 2 & 3.

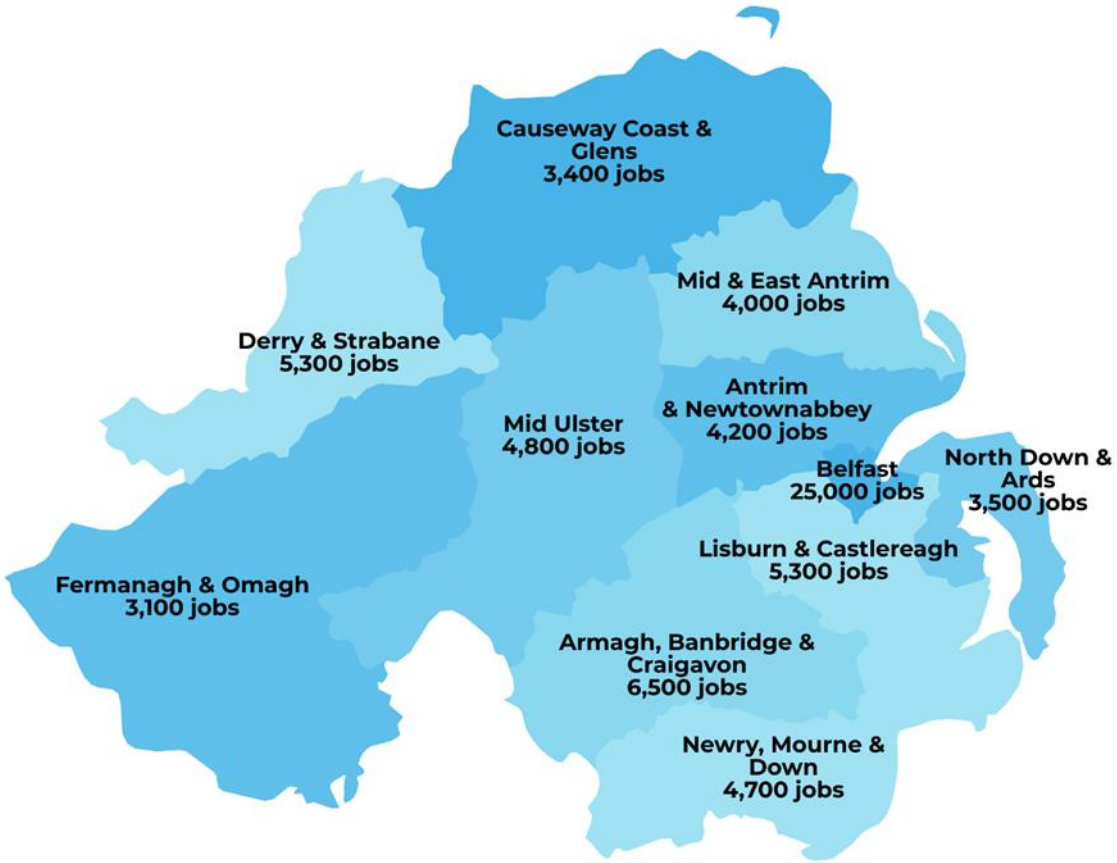
5.10.9. In terms of gender, automation will present opportunities and challenges that differ by sector and therefore, it is unclear if automation on its own will increase or reduce the potential to correct gender imbalances in the workforce. Consultees were clear that automation reduced the number of physically challenging and "dirty" manufacturing tasks and therefore more automated roles were equally suitable for males and females. The same consultees also noted however, that fewer females study STEM subjects and therefore the gender imbalance is a somewhat cultural issue that needs to be addressed in homes and within the primary and secondary education system.

5.10.10. If NI is to achieve the central or upper scenarios, additional policy intervention will be required in the skill and enterprise support arenas. A range of policy suggestions are included later in the document. The key forecasts are included in table 10.

Table 10. NI GVA, productivity and employment by scenario, 2030

	Lower	Central	Upper
GVA (2030)	£44bn	£49bn	£52bn
Productivity	£50,000	£51,300	£52,700
Employment	23,400	69,400	98,600

Figure 5.10.6: Outline of where jobs created under the central scenario will be situated



6 Summary of key findings

6. The fourth industrial revolution is well underway and will undoubtedly have far-reaching implications for the NI economy, enterprises and citizen in many ways over the next decade. Automation has already had an impact and will continue to change and shape the types of jobs that are available, the skills required for those jobs, create opportunity for new ideas and enterprises and products for consumers. Like all industrial revolutions, some tasks, products and processes and categories of employment will be in less demand and the policy response relating to those who could potentially lose out as a result of automation are as important as those that help to support machine learners, robotics engineers and modern production techniques.

6.1 Boosting competitiveness to improve living standards

6.1.1. The global economy is becoming more automated and competitor economies have launched automation strategies and are investing policy initiatives, enterprises, education systems and individuals in order to prepare as best they can for the future of work. Northern Ireland has two key economic challenges. One is relatively lower productivity than competitor economies and the other is economic inactivity. If average living standards in NI are to be maintained or grow, both of these challenges need to be addressed.

6.1.2. The academic literature, company consultations and modelling have demonstrated that automation can boost productivity, sometimes by a significant degree and therefore a proactive policy stance that will encourage automation should, without doubt, form a key strand of NI economic policy. Automation will continue throughout the global economy and those who lead will have first mover advantages.

6.1.3. The literature and company consultations demonstrate that as tasks are automated, the enterprises benefit from enhanced productivity, lower unit costs of production, better margin and enhanced health and safety outcomes, which can also reduce insurance costs in the longer term.

6.1.4. However, there is a tipping point at which automation becomes a feasible, or better option for enterprises. In terms of rates of return, there is evidence that the balance of advantage remains with employment focussed solutions at this point in time, partly due to wage levels in NI. Whilst the cost of technology and automation is decreasing, the lower risk and lower cost option (in the short run) is to add labour in the form of another shift, or overtime which suggests that there is available capacity and automation is not yet necessary in many instances.

6.1.5. Firms also report challenges in terms of the bespoke nature of their products in many instances, which then require automation solutions that are tailored to their specific requirements. In Northern Ireland, firms report that there are limited options in terms of other specialist companies that can help them automate and that solutions are often sourced from GB or further afield in Europe. As such, there is potentially a role for the public sector in developing

the automation solutions sector within NI and also in terms of linking NI-based enterprises to those outside NI that can assist in order to assist the level of knowledge and technology transfer.

6.2 Addressing employment fears

6.2.1. Automation creates anxiety for many as it is viewed as a threat to employment and wage-earning potential in the future. This research suggests that there are two perspectives –the economy wide perspective (macro) and the individual perspective (micro), both of which require careful consideration when designing policy responses. In short, the often-presented perspective in the media of the loss of large swathes of employment focus only on the negative and is, from this research-based perspective one sided and overly pessimistic.

6.2.2. The perspective that the research presents in the round is that there will be winners and losers as the economy grows and evolves and technologies come and go. The macro perspective demonstrates that automation is a route to increased productivity, better margins, reduced costs, better health and safety outcomes and the ability for companies to increase their market share and ultimately increase employment in many cases. The research has demonstrated that automation creates more employment opportunities than it removes and the modelling of a more automated scenario for NI shows that 70,000 employment opportunities could be created alongside increased productivity, generating additional GVA and raising standards of living.

6.2.3. The micro perspective is largely based on skills. If individuals possess skills that are in demand in more highly automated environments, i.e. those that are not easily automated such as creativity, empathy, problem-solving, persuasion and those system-based skills that are required such as data analytics, they are likely to do well as the level of automation increases. Conversely, if individuals do not possess these skills and are employed in roles that are easily automated, their employment and earnings potential is likely to be eroded as a result of automation. These groups tend to be the lower skilled and lower income groups, which focusses policy attention on how these individuals can be re-skilled into areas in which their employability and earning potential improves.

6.3 Dealing with inequalities

6.3.1. There is significant debate whether automation is likely to augment income, gender, age or geographic inequalities or will help to address them. The evidence would suggest that in terms of income inequalities, that automation is likely to concentrate additional wealth in higher income groups. These are the groups that have access to capital in order to automate in the first instance and are more likely to benefit from the additional profits and market share generated by automation. Lower income groups, which on average comprise of lower skilled individuals are likely to see employment and earnings potential eroded and therefore, their share of income in a more highly automated environment is likely to be lower. As such, policy thoughts should focus on the

potential options for redistribution of income to those at the lower end of the spectrum and how any public spending could enhance skills and employability.

6.3.2. In terms of geography, the situation is more nuanced. Technology provides the opportunity to work remotely, engage in the gig economy and for additional forms of self-employment. However, the local employment data suggests that there are sectoral concentrations in specific areas within NI (ICT and professional services in Belfast, manufacturing of machinery in mid-ulster etc.) and historically, agglomeration effects mean that new starts are in the same areas as they spin-out of larger companies and cluster in order to ensure that they have access to the required skills. In summary, whilst the opportunity exists, to a large extent the evidence suggests that those areas that have good employment opportunities are likely to benefit most from additional growth. Therefore, policy makers will be concerned with sub-regional aspects of automation and how opportunities can be encouraged in areas beyond the traditional hubs.

6.3.3. In terms of gender inequalities, the situation is also nuanced. The evidence would suggest that automation does away with tasks that are the most physically demanding, dirty or dangerous and creates technologically focussed opportunities that are equally suitable for either males or females. On the face of the evidence, the removal of "male only" tasks and the creation of opportunities suitable for both would suggest that automation should improve gender balance in the workforce.

6.3.4. However, the company consultations and modelling suggest that there are lower proportions of females in the sectors that are likely to be most significantly impacted by automation and that applications to these companies are predominantly male, as is the output from the education system in STEM subjects. The exception is the healthcare sector which is predominantly female and is likely to grow significantly over the next decade due to the pressures of caring for an increasingly aged population. The implication is that females are making choices within the education system that influence their potential to secure employment in a more highly automated environment, which is concerning and should be a focus of careers education and subject choice for GCSE and A-level students.

6.3.5. In terms of age, older workers are the least likely to be appropriately skilled for working in a more automated environment. These workers are likely to see their earning potential eroded over the final years of their careers and if they are made redundant will face a significant challenge to become reemployed at a similar level. Manufacturing enterprises face a specific challenge as a large proportion of shop floor employees are male and in the 50 plus age group. These enterprises cite the challenges of retaining millennial employees and apprentices and therefore the age profile of the production workforce is heavily skewed towards older workers. The sector may need to engage in a wider promotion and information campaign in order to attract and consider the employee experience vis-à-vis other opportunities in order to help retain a larger proportion of younger employees.

6.4 Brexit – a driving factor for automation?

6.4.1. Brexit, along with other factors such as the Sterling depreciation, rapid growth of economies such as Poland and increasing real wages in those economies has resulted in NI becoming a less attractive place to live and work for many foreign nationals. Enterprises report that European employees who have been based in NI for more than five years have, in most cases, chosen to stay whilst many of those who have located here for fewer years have chose to leave NI. As a result, the number of new European nationals travelling to NI for employment has dropped significantly, creating an issue for some sectors (notably agriculture and manufacturing) in terms of accessing appropriately skilled labour at existing wage rates.

6.4.2. As a result, some enterprises have had to consider changes to their operating model, including revising the remuneration packages, engaging directly with colleges and universities and automating tasks where possible. These companies report challenges in recruiting individuals with the required skills and that they have to provide in-house training.

6.4.3. NI's current employment levels have relied less on migrant labour sources, this is a result of Brexit and the increased competitiveness of economies that had supplied labour to NI as some migrant workers have left NI. An unexpected consequence of Brexit is that the restricted access to available labour sources has encouraged automation on a more rapid pace, or to a greater extent than would have been the case without it.

6.5 The future of education

6.5.1. The role of the education sector and the preparedness for the future of work is a key theme in the literature, competitors' strategies and in the company consultations. The supply of labour and skills was the most prominent issue highlighted throughout our consultations, more so than issues regarding the financial costs of automating. Whilst NI's education system has a strong track record, the research suggests that more can be done to help future proof skills to meet demands and minimise skills mismatches whilst helping to equip the current and future workforce with the high skills automation demands.

6.5.2. In general, the view from the private sector is positive, although most noted that those leaving education could be better equipped for the world of work and some felt that they needed to provide in-house specific training as the pace of technological change is outpacing the rate of change in the education sector. Those in industry acknowledge that it is difficult for educators to design and implement courses and curricula in order to keep up with the pace of technological change and also that the earning potential for those with key skills is significant in the private sector.

6.5.3. The challenges around skills availability, especially in relation to ICT has prompted some enterprises to look beyond NI in order to set up bases and secure skills at more affordable rates. Smaller indigenous enterprises report challenges of retaining labour when staff are often attracted by larger

corporates that can offer more attractive terms and conditions. As a result, policy makers will want to focus on the supply of STEM skills and in particular the appropriate balance of FDI inflows to NI versus the output of the education system in order to retain the competitive offering in the sector. The appropriate balance of the supply of ICT skills, migration policy and FDI policy in relation to the sector is a subject that is worthy of further research as there appears to be the potential for overheating in this specific sector to impact upon its international competitive offering.

6.5.4. In order to help citizens, develop to become an effective part of the workforce for the future, the education system must instil in children an ability to deeply understand technology and extract and utilise data effectively, not just how to use a machine and read figures. This forward-thinking model is required to develop a culture of innovation and help to futureproof the economy. Technical skills that are likely to be in demand include:

- Advanced ICT;
- Coding;
- Programming;
- Data analytics;
- Machine learning; and
- STEM.

Soft skills that are required include:

- Problem solving;
- Communication;
- Team working;
- Judgement;
- Management;
- Social and emotional intelligence;
- Creativity; and
- Independent thinking.

6.5.5. The future of work will also require assistance for those with lower skill levels in order to ensure that opportunities are available to them. Reskilling and upskilling those already in the workforce will be essential in order to ensure that those of working age develop and enhance their knowledge and skills base over what could now be a fifty-year working life. The changing nature of employment means that individuals must now be lifelong learners, who are able to develop over their working lives. Many will now have a number of careers, instead of just one and therefore skills that enhance flexibility and transferability will be key.

6.6 The employment and automation fulcrum

6.6.1. This research has established that enterprises in NI are on a spectrum in terms of automation uptake. There are firms that are heavily engaged in automation, designing and implementing their own solutions. These companies are highly innovative, forward thinking and employ a range of highly skilled and mobile staff. There are other enterprises that are automating and implementing tried and tested "off the shelf" solutions, such as purchasing robotic welders. There are others that are thinking about automation and how best they might approach and deal with this issue and then a range of firms that are not automating, but instead are employing additional employees or shifts in order to meet demand.

6.6.2. The research suggests that there is a tipping point at which the returns to capital exceed the returns to labour and whilst Brexit and other factors have impacted upon the availability of labour in some sectors, the upward pressure on wages is not yet serious enough to drive significant numbers of automation projects. As such, productivity growth is likely to be limited and if the incentive framework does not change in NI, then it is likely that enterprises will continue to favour additional employment over automation and lower productivity and standards of living will remain a policy challenge for generations to come.

6.7 Conclusion

6.7.1. The fourth industrial revolution is well underway across the world and will happen with or without NI. There are a number of enterprises in NI that have successfully automated a range of tasks and are reaping the rewards. Their employees have in some cases benefitted as dangerous and demanding tasks have been automated out of their role and opportunities for increasing their earnings have presented themselves.

6.7.2. Automation is a route to higher productivity and employment (despite the fears), lower prices and higher living standards. Relatively lower productivity than competitor nations is a key economic challenge for NI and there is a significant policy imperative to tackle lower productivity, which features heavily in each and every economic strategy.

6.7.3. The education system is viewed in a positive light, although most acknowledge that the curricula, assessment systems and careers advice needs to take more cognisance of the rate of technological change and develop skills, knowledge and attitudes to lifelong learning and flexibility that equip individuals for the workplace. Reskilling those in areas that are at most risk of automation is imperative in order to ensure that they can retain their earning potential and employability.

6.7.4. Automation can help to eradicate or embed inequalities and therefore monitoring the evidence and developing the appropriate policy response to tackle such issues will be important for how automation is viewed throughout society and also in terms of how public services are funded.

6.7.5. The final section of this report focuses on a range of policy suggestions which could help NI prepare for a more automated future.

7 Policy suggestions

7.1. This research has demonstrated that the fourth industrial revolution is well underway. Public policy has a significant role in terms of helping NI compete in a more automated and disrupted world and to provide support to those who may be negatively impacted. The rate of technological change is rapid, and it will be a challenge for policy to keep pace. This means that policy responses must be nimble and be monitored and evaluated continually to ensure that they are keeping pace with developments.

7.2. Whilst the evidence suggests that the initial resources needed to invest in automation both in time and money may be high, the cost of not acting now could have more significant negative consequences in the longer term.

7.1 An automation Centre of Excellence and a strategy for NI?

7.1.1. There are many strategies and policies in place in NI to help grow the economy, boost productivity, enhance the skills supply and enhance innovation. However, there is no overarching automation or fourth industrial revolution strategy in place, which creates a significant gap in the policy framework. It would seem obvious at the conclusion of this research automation should move further up the policy agenda, given the scale of the competitiveness and productivity challenges that already face NI, and its relatively low level of readiness in terms of working in a more automated environment.

7.1.2. Automation is also much broader than an "economy only" issue. It impacts on healthcare, public administration and public finances (all of which are beyond the scope of this specific research project) and therefore it would seem that an organisation, perhaps an NDPB, or a division within The Executive Office, should champion and develop an automation strategy for NI, recruit staff with experience of automating, design and implement specific assistance packages for assistance to enterprises in order to help them automate, with an objective of raising productivity and competitiveness. Alternatively, or in addition, the Northern Ireland Civil Service Board could oversee these functions. Ultimately, it will be essential that automation is embedded in to any future PfG and Outcome Delivery Plan for NI to ensure that automation is a key feature across the policy agenda.

7.1.3. These research findings support the Matrix proposal to develop an AI Centre of Excellence for NI (AICE@NI)[260]. With respected individuals and an appropriate

[260] Matrix (2019). Northern Ireland is a "powerhouse" in Artificial Intelligence. Available at: https://matrixni.org/northern-ireland-is-a-powerhouse-in-artificial-intelligence/ (last accessed 27 June 2019).

institutional architecture, there is an opportunity for NI to develop an automation support hub. Initially, the expertise may need to be recruited from outside NI, however, it will provide an opportunity to transfer international knowledge and best practise and develop the local skills base. The European Commission note that there is no research centre in Europe dedicated to AI with enough scale and international visibility to attract global researchers[261]. Development may help to attract further inward investment to support the development of skills at a high level, helping NI to become a leader of automation.

7.1.4. The research also found that start-ups and smaller enterprises have the most significant challenges with automation and retaining skilled staff. These factors suggest that assistance should be targeted at SMEs and micro-organisations who want to automate but may not have the financial resilience or technical know-how[262].

7.2 Articulating the benefits of automation

7.2.1. There are significant fears regarding automation replacing employees and reducing their earning potential. Unfortunately, the public debate around automation focusses almost singularly on the potential negative implications, rather than informing society about the history of automation through three industrial revolutions, how it has lowered prices, increased purchasing power and enabled consumers to access goods that were previously unaffordable. As such, there appears to be significant asymmetric information and there is a role for Government and Academia in terms of raising the quality of available information and understanding of policy and spending choices that will be required for NI to thrive and for citizens to maintain or increase living standards in the future.

7.2.2. It would be beneficial if there was a mechanism for wider public engagement and dialogue to articulate the benefits of automation and public policy choices that may be required to prepare NI for a more automated future.

7.3 The future of education and skills

7.3.1. Education and skills are key themes throughout the academic literature, policies and strategies in place in competitor nations and in the consultations. Whilst NI has an education system that is reasonably competitive, investments by competitors are seeing the relative position eroded on a range of indicators. Appropriate investments in education and skills for those in the workforce and in education are essential in order to ensure that individuals are well equipped,

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[261] European Commission, Servoz, M. (2019). *AI The Future of Work? Work of The Future!* Available at https://ec.europa.eu (last accessed 09 October 2019).

[262] SME's limited access to funding and was noted during the literature and policy review as well as company consultations.

flexible and resilient to technological change and that enterprises have access to appropriately skilled individuals to meet their needs.

7.3.2. Regarding educational development, policy action here will require a long-term perspective in terms of the length of time needed to successfully implement these policies and for effective results to be produced.

7.3.1 Primary education

7.3.1.1. The school curriculum should maximise the use of ICT and technology where possible across all subject areas so that pupils continue to develop skills allowing them to be confident using ICT. It should also focus on developing a range of soft skills that are not easily automatable, such as creativity and teamwork.

7.3.2 Secondary education

7.3.2.1. The secondary curriculum should build upon the primary curriculum in terms of developing soft skills, but also include "systems skills" such as data analytics, coding and programming. This could be achieved by incorporating the teachings in to subjects such as ICT, Technology or Maths, alternatively these could be specific taught subjects. Schools should also be encouraged to develop industry partnerships to assist with these teachings. In general, there should be more focus on STEM subjects and ensuring that these are taught in all schools across NI.

7.3.2.2. Career guidance is vitally important in terms of helping children to choose subjects and skills that are likely to be in demand in the future. It is important that student's choices are based on information that clearly outlines the variety of options available for achieving success. There are significant gender imbalances in the STEM workforce, and whilst automation creates more opportunities for females as it removes some of the most physically demanding tasks, graduates are still predominantly male and therefore females are at risk of lower levels of employability in a more automated world.

7.3.2.3. This research also found that there is a potential gap in that FE colleges often do not have access to schools to inform students of study and apprenticeship opportunities. It is important that this barrier for FE colleges is removed in order to effectively prepare for the future of work and prevent skills mismatches. To address this same issue in England, The Baker Clause was developed which gave technical colleges the right to promote their activities in schools[263]. NI policy makers may need to consider action such as this to ensure that the interests and needs of the candidate should be considered when advice is provided rather than encouraging decisions based on organisational targets[264].

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[263] Bentley-Gockmann, N. (2019). *Our work can help make a success of the Baker clause.* Available at: worldskills.org (last accessed 09 October 2019).

[264] Refer to Section 3.3, paragraph 120 which discusses shortcomings of career guidance.

7.3.3 Further and higher education

7.3.3.1. Those involved in the tertiary education system should consider how to increase the supply of skilled STEM graduates in NI as demands are currently outstripping the supply. The MASN cap applied to Universities in NI and the rate at which student fees are set should be considered as part of this policy issue.

7.3.3.2. Education providers also need to keep pace with industry developments, and it is noteworthy that both Ulster and QUB now deliver Data Analytics and Machine Learning courses. However, it takes some time to develop and approve new courses and academic institutions must continue to monitor industry developments and tailor existing courses and implement new courses as demands change.

7.3.3.3. The Further Education sector has worked closely with a range of manufacturing enterprises to help develop robotics projects, and these have been beneficial to the companies involved. The focus on robotics has helped to address skills shortages, such as welders in the Mid-Ulster area. Developing the expertise and supporting the FE sector to provide more broad ranging support will be beneficial to the future of work and automation.

7.3.3.4. Similar to private sector enterprises, those in the FE and HE who have automation skills and experience are highly mobile and therefore, the sector must consider how to recruit and retain up-to-date industry skills in order to be able to train the workforce of the future.

7.3.4 Lifelong learning strategy

7.3.4.1. The changing nature of work and the range of careers that individuals are likely to have over their careers means that lifelong learning will become a more common feature of an individual's working life. It is suggested that a Lifelong Learning Strategy[265] should be developed for NI. This Strategy would help to provide leadership and the importance of continued skills development through the promotion of opportunities already available in NI. This may help empower individuals, raise understanding of the individual benefits and help them to take ownership of their learning experience whilst helping to manage public resources for education and training.

7.3.4.2. Workforce skills development projects are already supported by public sector programmes, and it will be important that these continue in the future, with a focus on automation specifically and employing expertise from outside NI, when appropriate. It is suggested that a range of automation training and certification training is developed for, inter alia, robotics, data analytics, machine learning and coding. These certifications will help those in the workforce to increase their skills level, benefitting the enterprises in terms of productivity and helping to address skills shortages.

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[265] Learning and Work Institute (2017). *Healthy, Wealthy and Wise: The impact of adult learning across the UK* (NI Impact Forum). Available at: learningandwork.org (last accessed 09 October 2019). Northern Ireland Assembly (2019). *Research and Information Service Member's Briefing Paper. Adult Learning Policy in Northern Ireland: a Preliminary Consideration*

7.4 A migration strategy for NI?

7.4.1. In a post Brexit world, NI may need to consider a form of migration strategy for NI, if the volume of STEM and automation skills demanded continue to exceed those produced by the education sector. Options may include targeting NI diaspora, support for those returning home and focussing on labour markets relative to which NI is relatively attractive in order to attract those with skills that are in excess demand.

7.5 Supporting enterprises to automate

7.5.1. It will be essential that enterprises are supported to automate where possible in order to improve productivity and competitiveness, helping employers to create "good" sustainable jobs for the longer term. Good jobs in this context are defined as jobs that include reasonable pay, conditions and tenure of contract.

7.5.2. Supporting enterprises to automate will require a strategic change in direction in terms of how enterprises are financially assisted in NI. Policy and project targets would need to be focussed much less on employment and more on productivity. This change would also require resources to be reallocated towards productivity enhancing programme and initiatives and staff to be assigned productivity, rather than employment safeguarding or maintenance targets.

7.5.3. Thought should be given to measuring the Total Societal Impact (TSI) of enterprises before and after financial assistance projects have completed. Some examples of metrics that could be used include:

- Shareholder value
  - Profits, dividends, bonuses, etc
- Corporate longevity
  - Productivity enhancement, Net Asset Value, IRR, net margin etc.
- Social responsibility
  - % of returns paid as wages in NI, supply chain in NI, employment from unemployed or inactive, investment in workforce for automation etc.

7.5.4. Enterprises noted that the application process was overly bureaucratic and could be minimised, however this must be balanced against appropriate use of public expenditure and taxpayers monies, a subject which is pertinent at this point in time.

7.5.5. There are a range of supports that are used to help enterprises automate, and it would seem beneficial if a single overarching automation programme was established, with appropriately skilled staff and the transfer of resources from other programmes. This would simplify the policy patchwork to a significant degree for enterprises and assist them on an even basis. Start-up's and SME's report significant challenges in terms of accessing support and retaining staff and these enterprises, based on need, are those that are likely to generate the greatest level of additional activity for the NI economy.

7.5.6. Enterprises also reported that within NI there is limited access to automation expertise, and often this is outsourced. Therefore, the development of a panel of expert automation consultants within NI may greatly assist firms to provide impartial advice and support when companies are investing in automation.

7.6 Targeting public assistance

7.6.1. There were concerns amongst consultees that some sectors / enterprises / locations / technologies were more or less well supported by public policy and financial assistance. Part of the issue appears to be that the range of programmes that could be used to support enterprises to automate (Grant for R&D, Innovation Vouchers, KTP etc) are not well understood by those in the private sector, and that Selective Financial Assistance (SFA) capital support appears to be utilised in many cases despite the fact that it operates with an employment control target. As budgets become more constrained, effective and measured targeting will become more important.

7.6.2. Assistance from Invest NI is published by enterprise; however, enterprises are unaware. This move is laudable and support from other areas of Government is not published in the same way. However, there remains an information failure in that the enterprises are not aware of where to source information about how, and by how much other enterprises are supported.

7.7 Alleviating inequalities

7.7.1. This research revealed that automation has the potential to increase several inequalities including age, geography, skills, income and potentially gender.

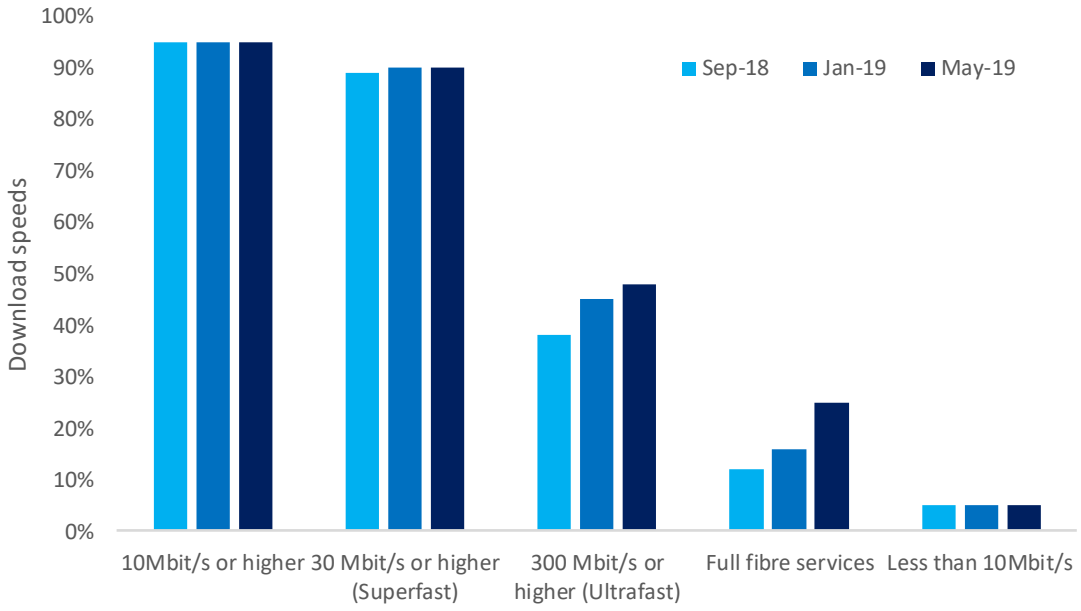
7.7.2. Whilst is it beyond the specific scope of this research, it will be important that the impact of automation on those who are in low skill, low income and unemployment or inactivity is monitored, and resources are allocated to provide support and training for those individuals to work in a more technologically focussed environment.

7.7.3. Automation is likely to focus the returns to capital with a small number of individuals and therefore, how the Rating system works in NI (perhaps with smaller floor areas) will be important going forward. The majority of economic activity in NI is concentrated in Belfast, and it is likely that automation will augment this trend. As such, NI will need to consider how employment opportunities can be encouraged throughout NI, and this may mean lower rates of support in the areas in which activity is strong and higher rates in the more deprived areas. Specific metrics for decision-making and assistance rates would need to be considered with local economic evidence and targets for measuring success.

7.8 Developing the technological infrastructure

7.8.1. NI has a reasonably good and fibre-enabled broadband infrastructure that has helped to maintain a competitive edge in recent decades. However, policymakers will need to continue to invest in NI's tech infrastructure to ensure that enterprises have access to class leading speeds and connectivity. Figure 7.8.1 highlights that NI has significantly developed broadband access with 95% of premises having access to broadband by May 2019, however only 48% of NI premises have access to 'ultrafast broadband' for downloading by the same date which is of importance to increase productivity. NI should endeavour to continue these positive developments.

Figure 7.8.1: Percentage of NI premises with access to broadband by download speed (Sep. 18- May 2019)



Source: Ofcom Connected Nations

7.9 Engagement by enterprises

7.9.1. Enterprises and trade associations will also need to play a key role in the development of a 4th industrial revolution strategy for NI. The private sector has a key role to play in terms of providing access to alternative education pathways for those who do not choose academic routes. This can be supported by increased apprenticeship opportunities, increased training in industries which result in formal qualifications and FE colleges being able to provide information in schools to show alternative study options.

7.9.2. Employers will also need to engage with employees and unions to articulate the purpose and impacts of automation in order to assist with employee buy-in which is vital to ensuring the successful utilisation and acceptance of automation. This links to the wider public perspective on automation.

7.10 An eye on reserved policy matters for the UK

7.10.1. At a UK wide level or in the case that there is significant job displacement, UUEPC recognise that action may need to be taken to redistribute wealth generated by capital to overcome lost income tax. This may involve changes to the taxation or rates system, however as tax setting powers are not a devolved issue it is important that NI policy makers track the impact of automation on the workforce so that this information could be used for lobbying assistance in future[266]. Methods of broadening capital ownership include:

- introducing Universal Basic Income as a method to redistribute wealth fairly, it is a high level intervention tool which could be deployed particularly to assist citizens on the lowest income scale and to help prevent any increase in income polarisation, this may require increased taxation on capital to provide financial resources;
- increased taxation on capital profits to enable profits to be redistributed through welfare programmes or through jobs roles such as carers or nurses receiving higher pay for their contribution to society rather than their ability to generate profit; a Citizens' Wealth Fund in which investment in assets and company shares would be made on behalf of the public allowing for collective ownership of capital;
- increasing Employee Ownership Trusts which would allow for dividends to be shared to employees; and
- more radical options such as compulsory profit sharing for organisations above a certain size[267].

7.11 Potential future research

7.11.1. The findings of this project indicate that the impact of automation will be far reaching, impacting all sectors and industries across NI to some degree. However, the scope of this project did not include individual sectors to be heavily investigated and so a more detailed analysis is required to provide specific policy recommendations. UUEPC are aware that the implementation of automation has the potential to help create a proactive Health and Social Care system, we suggest that additional research be carried out in this area for automation to be integrated into the health sector in the near future. This would assist with providing public services to an aging and growing population as well as to help manage limited government resources.

7.11.2. There are also significant concerns regarding the availability of ICT skills versus FDI policy, across a range of sectors as employees are more difficult to recruit

[266] Lawrence, M., Roberts, C. and King, L. (2017). 'Managing automation: Employment, inequality and ethics in the digital age' *IPPR Commission on Economic Justice*.

[267] The successes and challenges of 'robot taxes' in other parts of the world could also continue to be noted for future guidance.

and retain and enterprises have reported significant wage inflation. When combined with the reduction in incoming EU migrant employees with ICT skills, these factors impact negatively on their (and NI's) overall competitiveness. It is suggested that further research such as DfE's Skills Demanded by the Digital IT Sector[268] should be commissioned to investigate stock and future supply of ICT skills across all industries and NI's FDI strategy in tandem.

[268] DfE. (2019). *Research Bulletin 19/8, Skills Demanded by the Digital IT Sector.* Available at: https://www.economy-ni.gov.uk (last accessed 28 November 2019).

8 Annex

Annex 1 - Automation Consultation Guided Questions

8.1.1. To what extent has automation been implemented to date- specific projects/processes? What do these entail? What is the overarching aim of implementation? Timeline of implementation?

8.1.2. The driving factors (e.g. necessity, desire for additional growth, skills shortages etc.) behind current/future implementation?

8.1.3. What is the degree of access/are the implications for business (exports, competitiveness, skills, promotion, redundancies, changes in role etc.)? If not yet achieved, what are expectations?

8.1.4. Have any policy supports been availed of? Is there enough support? (leads onto next question)

8.1.5. What barriers/challenges has the company been faced with? Any policy suggestions that you might have, that would help to automate further in the future?

Annex 2 - Company Profiles

8.2.1. - Manufacturing

Who?
Ryobi Aluminium Casting UK Ltd., manufacturer of casting products for the automotive industry, based in Carrickfergus.
Turnover: £76,865,822[272] (2017) **Employee Numbers:** 459[273] (2017)

What automated processes/machines have been implemented?
Ryobi has invested £50million throughout their organisation since 2008 and has 68 robots.

What were the driving factors behind implementation?

- 2008 was a tipping point for Ryobi and recognised that they need to do something extra to stay competitive, automation was implementation as a necessity from 2008.
- Health and safety
- Quality assurance and reliability of robots.
- Economic factors in order to reduce costs.

What have been the consequences of introducing automation?
A higher level of technician is required with automation, skills shortages has been an issue for Ryobi and they have tried to overcome this through the continuation of their graduate programme, placement opportunities for university students and by working with Northern Regional College to develop apprenticeship programmes.

Have any policy supports been availed of?
Ryobi have received support from Invest NI in the form of training grants as well as capital grants.

Are there any policy suggestions that may help to automate further in future?
Ryobi recognise that policy support had been increasingly harder to get, suggested that it would be beneficial for there to be a renewed focus on education and infrastructure which may help to attract global investment.

Brexit may require government help to NI such as grant aid (EU restrictions are currently limiting this).

[272] Ryobi Aluminium Casting UK Ltd. (2018). Full accounts made up to 31 December 2017. Available at: https://beta.companieshouse.gov.uk/company/NI024284/filing-history (last accessed 14 August 2019).

[273] Ibid.

Who?
NC Engineering, a leading manufacturer of Agricultural machinery, plant equipment & commercial trailers based in Hamiltonsbawn, Armagh.
Turnover: £18,794,810[274] (2018) **Employee Numbers:** 155[275] (2018)

What automated processes/machines have been implemented?

A robotic welding system which has the ability to learn and make adjustments to account for manufacturing tolerances.
A fully automated laser cutting unit complete with material handling tower.
3 CNC (Computer Numerically Controlled) lathes complete with C & Y Axles cutting and bar feed up to ø117mm
Automatic CNC saw complete with Cross transfer tables, In/Out feed conveyor & small parts removal.

What were the driving factors behind implementation?
The scarcity of labour and skills, particularly of fabricated welders across NI which has encouraged the investment in machines.
The retention of workers has also been a factor especially of younger workers, 25% of welders move within a year therefore technology allows NC Engineering to better utilise their workers. For instance, the robotic welder allows 3 workers per shift to be used to perform other, higher skilled tasks.

What have been the consequences of introducing automation?
Robotics has benefited NC Engineering due to their ability to produce consistent, high quality items at a constant rate, the almost 100% efficiency rate of a robot was expressed compared to a human worker. It was estimated that the introduction of robotics has led to savings equating to two full time salaries. However, no reduction in the workforce has been made as a result of automation, instead workers are being used for higher skills tasks and some have had the opportunity to retrain and upskill to the role of a programmer/operators so that they can manage the automated machines.

There could also be potential for more jobs in future surrounding data collection and usage, NC Engineering are currently working with Invest NI on a project to capture all data under one system.

Additionally, robotics has enabled NC Engineering to remain competitive within their market and have continued to attract international customers.

Have any policy supports been availed of?
NC Engineering have received support from Invest NI to implement automation this included £141,000 for R&D support[276] and SFA capital support.

[274] NC Eng ineering (2018). Full accounts made up to 30 September 2018. Available at: https://beta.companieshouse.gov.uk/company/NI015976/filing-history (last accessed 14 August 2019).
[275] Ibid.
[276] Invest Northern Ireland (2015). Invest NI R&D Support Helps NC Engineering Develop Innovative Machinery for Export. Available at: https://www.investni.com/news/invest-ni-r-and-d-support-helps-nc-engineering-develop-innovative-machinery-for-export.html (last accessed 9 August 2019).

Are there any policy suggestions that may help to automate further in future?

To overcome skills shortages within the Manufacturing & Engineering industries for future generations there will need to be a change to the industrial strategy leading to more of an emphasis on practical skills within schools and a revitalisation of practical skills courses within the regional colleges in NI combined with careers councillors with industry knowledge. NC Engineering currently work closely with local Universities, regional colleges and schools to support the work carried out by assisting in practical placements for school leavers, engineering apprenticeships, Engineering placement & KTP programs (Knowledge transfer partnerships).

It was expressed that a bespoke inhouse academy or training facility for people without industry skills has been considered by NC Engineering to assist with their demand for labour, but this requires a high amount of investment and resources (classroom facilities, trainers, equipment etc.). Instead it was suggested that possibly Invest NI could lead this type of facility for industries or working in conjunction with regional colleges to update their facilities with the latest cutting-edge technology.

Who?
Unitrunk Limited a manufacturer of metal cable management solutions based in Lisburn.
Turnover: £25,738,518[277] (2017) **Employee Numbers:** 126 (2017)[278]

What automated processes/machines have been implemented?

- Robotic folding cell costing £350,000.
- Automated punching machine costing £1.5million and took 18 months to implement.
- The next step for Uni-Trunk will be the development of product identification so that there is reduced need for product knowledge as scanners, barcodes and QR codes can be used to quickly identify products.

What were the driving factors behind implementation?

- To increase productivity and capacity.
- Increase flexibility within the factory as machines can run independently at weekends.

What have been the consequences of introducing automation?
Automation has allowed for a more beneficial use of staff as well as the potential for staff to upskill to in other areas such as managing the machines. Automation has created different roles for staff, with no jobs lost as a result of automation being implemented.

A secondary benefit of automation has been increased health and safety.

It was noted that there is a current issue of recruiting workers for manufacturing roles across NI, possibly due to the perception of the nature of the work involved.

Have any policy supports been availed of?
Uni-Trunk has worked with the NITC to receive consultancy expertise to implement its automation processes, they have also received R&D tax credits and R&D support from invest NI however this was limited potentially due to their larger size.

Uni-Trunk has worked with the Northern Regional College in a knowledge sharing capacity to better understand the robotic folding cell prior to its implementation.

Are there any policy suggestions that may help to automate further in future?
Uni-Trunk suggested that it would be beneficial if the bureaucracy associated with policy support was reduced, particularly during the application stage this is due to the significant administration costs which are associated with this.

They would also like the continuation of the tax credits as well as grants.

To overcome the shortage of workers within the manufacturing sector it would be beneficial if one organisation provided leadership/guidance about promoting this sector particularly to young people.

A forum for manufacturing companies from across industries to meet and discuss successes and challenges for implementing automation would be beneficial to facilitate knowledge sharing. Unitrunk have found speaking with other companies beneficial as it has helped them to be cost effective and know how to best use their resources.

[277] Uni-Trunk Limited (2018). Full accounts made up to 31 December 2017. Available at: https://beta.companieshouse.gov.uk/company/NI005095 (last accessed 14 August 2019).

[278] Ibid.

A forum for manufacturing companies from across industries to meet and discuss successes and challenges for implementing automation would be beneficial to facilitate knowledge sharing. Unitrunk have found speaking with other companies beneficial as it has helped them to be cost effective and know how to best use their resources.

Who?
Encirc Limited, a glass bottle manufacturer based in Derrylin, Enniskillen.
Turnover: £285,582,000 (2017)[279] **Employee Numbers:** 1,207 (2017)[280]

What automated processes/machines have been implemented?

- Line 14 Project aiming to use machinery from end to end and use information (data) with purpose to get information quicker and prevent backlog during production.
- Lean Project which helps to reduce resources and wastage on the production line.
- Encirc plan to use 'cobots' in future to overcome loss of production when machines have to be swabbed with oil by human workers every 20 minutes.

What were the driving factors behind implementation?

- Automaton allows for a more diverse and inclusive workforce, specifically in the factory where there is one female operator working in the 'hot end' of the factory, whilst their migrant workforce has dropped in recent years.
- Increased health and safety and well-being of workers.
- More sustainable and environmental workings are permitted with automation.
- Helps to overcome the demands for different working styles wanted by future workers (shorter working week and shifts).
- Maintained or increased productivity and quality of goods.

What have been the consequences of introducing automation?
Automation has enabled Encirc to remain competitive and at the forefront of technology in the glass industry (Encirc was a technology disrupter in 1998, the industry is now very 'safe' and so they need to be doing something different to stay ahead).

Encirc still requires a human workforce and envisage this workforce working alongside 'cobots' in future, 'cobots' will allow the human workforce to perform higher valued tasks. Staff have been informed throughout the development of new technology and procedures through the company's 'Workplace' app. Other methods of informing/retaining staff have included through Engage Champions and non-financial incentives for staff (gym onsite, social activities and charitable work).

Have any policy supports been availed of?
Encirc are currently applying through the Industrial Strategy Challenge Fund Made Smarter stream for funding to complete a digital project enabling the collection and analysis of production data to further improve the output, quality and carbon impact of the containers it produces.

Are there any policy suggestions that may help to automate further in future?
Encirc suggested that a method of knowledge sharing would be beneficial, for instance work carried out academically is often not shared. Encirc expressed that there is a personal network elsewhere which they can not avail of, possibly due to their size and location.

[279] Encirc Limited (2018). Full accounts made up to 31 December 2017. Available at: https://beta.companieshouse.gov.uk/company/NI030990/filing-history (last accessed 7 August 2019).

[280] Ibid.

Due to the fast speed at which their factory works any future policy may need to take this in to consideration so that larger organisations such as Encirc can apply for policy support.

Who?
Montupet (U.K) Ltd. manufacturer of aluminium castings to develop and supply automobile parts. Their parent company is the Canadian organisation, Linamar whilst in NI they are based in Dunmurry.
Turnover: £87.3million[281] (2017) **Employee Numbers:** 569[282] (2017)

What automated processes/machines have been implemented?

- Heavy duty robots to lift parts from core machines
- Their heat treatment process is fully automated
- AI
- X-ray systems

What were the driving factors behind implementation?

- Investing in automation was the next step for growth and cost competitiveness within their market.
- May help Linamar to diversify in to the growing electrification and hybrid automobile market.

What have been the consequences of introducing automation?
As a result of automation Linamar have experienced a reduction in labour costs, for instance previously their heat treatment line had 6-7 staff, automation has cut this down to 2 operators. Overall, Montupet still have a requirement for a human workforce and some lines have not been automated due to the high investment costs which has so far been more expensive than labour.

Montupet invested in automation up to 15 years ago and so the gradual progression to automated processes has helped staff to be more accepting of the integration of automated machines.

Montupet have had difficulty recruiting individuals with skills in automation and robotics causing them to develop these skills inhouse. This has resulted in some of their workers being upskilled to operate and maintain the machines.

Automation has removed repetitive, manual handling tasks and so a secondary benefit has been increased health and safety.

Have any policy supports been availed of?
Montupet have benefited from Invest NI's R&D grant, however they have not had any live projects with Invest NI for the last 2 to 3 years.

They have a good working relationship with the Regional Colleges and have been able to tailor some courses to suit their skills needs and gain student apprentices. They also take on university placement students as well as provide design days for A-level school pupils where they can experience manufacturing for a day such as building table top robots.

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[281] Montupet (U.K.) Ltd. (2018). *Full accounts made up to 31 December 2017.* Available at: https://beta.companieshouse.gov.uk/company/NI022131/filing-history (Last accessed 29 August 2019).

[282] Ibid.

Are there any policy suggestions that may help to automate further in future? Montupet expressed that their apprenticeship scheme is well tailored to meet their needs, but they continue to contribute to the Apprenticeship Levy whilst not receive the benefits in return. It would be beneficial for organisations such as Montupet to benefit from these existing policies.

Montupet expressed the need to expand skills in automation and robotics across apprentices and university students. Therefore, future policy support could further help to provide training to develop these skills across a wider range of people. They expressed the benefits of inhouse training and so future policy could work with industry to tailor specific programmes.

Who?
Nugent Engineering are a manufacturer of farm machinery and trailers based in Dungannon.

What automated processes/machines have been implemented?
Nugent Engineering are at the early stages of automation and have recently purchased a prototype welding robot with a view to implement automation in the next 3 to 5 years.

What were the driving factors behind implementation?
Automation will allow Nugent Engineering to:

- work smarter to produce consistent, high quality products at a higher rate;
- help with product development;
- remove the repetitive work tasks;
- allow for fewer staff who are more highly skilled and higher paid; and
- help overcome the shortages of labour particularly from the local area in welding.

What have been the consequences of introducing automation?
The purchase of the prototype robot will act as a catalyst for change within Nugent Engineering, there has been a positive attitude within the organisation towards automation as it will help to generate new ways of working and product development.

Have any policy supports been availed of?
Nugent Engineering have received R&D grants from Invest NI, they have a good working relationship with South West College to learn from and gain apprentices. South West College have also been trying to set up a Welding Academy to assist with the shortages of welders.

Are there any policy suggestions that may help to automate further in future?
It was expressed that as automation uptake is increased there may be difficulties with infrastructure in the area, particularly energy infrastructure's capacity to supply and so this should be an area for future consideration by local authorities.

Also, it has been found that acquiring expert help to assist with automation is limited and expensive, therefore Nugent Engineering are preparing to develop their own expertise inhouse which would be more affordable. Policy support could possibly assist in providing expertise.

Who?
Whale Pumps, part of Munster Simms Engineering Ltd., based in Bangor are a manufacturer of low voltage pump, plumbing and heating systems specifically for caravans, RVs and boats.
Turnover: £19,991,835[283] (2017) **Employee Numbers:** 182[284] (2017)

What automated processes/machines have been implemented?

- 12 injection moulding machines.
- Wire cutting.
- Lab testing as well as factory floor product testing machines.

What were the driving factors behind implementation?

- The time saved by using machines has resulted in lower labour costs changes which previously taken 2 hours now take 40 minutes.
- Quality assurance guaranteed.
- Machines have aided with product development and improvement.
- Health and safety concerns.

What have been the consequences of introducing automation?
Smarter working has been enabled through automation, allowing staff to be used to perform higher value or different tasks as well as opportunities to upskill such as for programme logical control (PLC).

Some machines can also work independently during weekends allowing for greater productivity.

Often it has been found that the cost of a new machine is not viable in this market due to the niche and low volume products that Whale Pumps develop; they have found it difficult to find automated solutions that would create the same quality and requirements needed in their market.

Have any policy supports been availed of?
Whale Pumps have received R&D funding from Invest NI as well as assistance to provide training.

They have also worked with South Eastern Regional College to provide staff training as well as links with Queen's University Belfast to develop machines and participate in the Engineering Leadership Programme as well as placement opportunities for students.

Are there any policy suggestions that may help to automate further in future?
Capital funding would be welcomed along with bespoke tailored training programmes. Knowledge and application support would be beneficial to help apply automated processes as well as a timely application process.

[283] Munster Simms Engineering Ltd. (2018). Full accounts made up to 31 December 2017. Available at: https://beta.companieshouse.gov.uk/company/NI006278/filing-history (last accessed 14 August 2019).

[284] Ibid.

Who?
Axial3D are a medical technology company offering 3D printing for the healthcare sector and are based in Belfast.
Employee Numbers: 18

What automated processes/machines have been implemented?

- 3D printing capabilities with different sizes and ranges to meet customer's needs
- Machine learning
- Blockchain applications
- Use of AR to embed details in the physical product.

What were the driving factors behind implementation?
Automation and continuous R&D has been a feature of Axial3D since their beginning due to the nature of their forward-thinking product and workforce. The uniqueness and benefits of their product has allowed the Axial3D to grow and reach a global market as they intend to work with insurance companies, particularly in the US to provide a forward-thinking approach to healthcare.

Automation has also allowed the monotonous aspects of job roles to be removed.

What have been the consequences of introducing automation?

- Due to the advanced nature of Axial3D they have published a patent regarding machine learning and blockchain.
- Their work has been published in research journals.
- Whilst their staff often arrive highly educated, Axial3D is prepared to upskill staff from a variety of degree backgrounds and carry out continuous development with their staff.

Have any policy supports been availed of?
Axial3D have benefited availed of support from:

- Innovate UK
- Eurostars
- Private equity
- Invest NI's Innovation Vouchers and R&D grants
- InterTradeIreland

Are there any policy suggestions that may help to automate further in future?
In terms of university education, Axial3D communicated that whilst practical skills are important students also need to gain and benefit from the philosophical teachings of their subject. They have found this benefits a graduate's long-term career aspects as they gain a more in-depth knowledge of their subject. There may need to be a step back of industries within academic education to enable these teachings.

An increased focus on entrepreneurship within NI would help facilitate wealth and talent remaining here.

They expressed the potential to further increase the 'Sister City' relationship between Boston and Belfast.

In Belfast it has been difficult to access technology resources compared Sheffield's Advanced Manufacturing Park or Edinburgh's High-Performance Computing Centre. The development or accessibility to a similar centre would be beneficial for NI and help to attract investment.

Axial3D's work has been supported through private equity and would like to see a continuity of availability to capital.

Future policy support should also recognise value creation within a company especially those with a smaller but highly valuable workforce so that policy meets the needs of these companies.

Axial3D attend economic and international conferences where they would seek out collaboration for funding calls, currently many companies are holding off on these due to Brexit. As a result of Brexit, Axial3D have lost one of their employees who moved back to Germany.

Who?
GlaxoSmithKline (GSK) who research, develop and manufacture pharmaceutical medicines, vaccines and consumer healthcare products globally, with Irish locations in Sligo[285], Dublin, Cork and Dungarvan.
Turnover: £30,821,000,000[286] (2018) **Employee Numbers:** 95,450 globally (2018)[287] and 1,450 across Ireland[288]

What automated processes/machines have been implemented?

- The Sligo base has low levels of investment in automation as their volumes do not support the capital investment required. Currently it is more cost effective to employ a human than invest in automation, this is partially due to the demands of customers such as multiple packaging configurations for different markets making certain process difficult and costly to automate.
- Automation has been introduced where tasks are deemed to be risky such as heavy lifting processes.
- To meet European requirements regarding the traceability of medicines one line has been fully automated to assist with serialisation.

What were the driving factors behind implementation?

- Quality assurance
- Health and Safety
- Removal of repetitive tasks

What have been the consequences of introducing automation?
No jobs are expected to be lost because of automation, instead staff can be used to perform higher value-added tasks whilst also enabling employees to be upskilled. However, employees would not necessarily receive extra pay for this upskilling, but GSK recognise they are adding to their staff's longer-term employability and ability to move up in the organisation

Due to GSK's large size and reputation they have acted as a standard setter within their market.

Have any policy supports been availed of?
GSK Sligo were a recipient of IDA credits and grants after a decision to reverse site closure, however, these were not cashed in due to GSK's own funds being available.

It is difficult to achieve lab-based automation, and this is an area GSK are working on with Institute of Technology Sligo to take out the human interpretation of data results which may present less opportunities for human error and increase quality.

Are there any policy suggestions that may help to automate further in future?
The development of digital skills, starting in primary education along with further diversity amongst teachers in Ireland would help to increase the styles of teachings

[285] The Sligo site which we visited is due to close by 2021.

[286] GSK. (2018). *Annual Report 2018*. Available at: https://www.gsk.com/en-gb/investors/corporate-reporting/annual-report-2018/#tab-1-1 (last accessed 27 August 2019).

[287] Ibid.

[288] IDA Ireland (nd). *GSK*. Available at: www.idaireland.com (last accessed 27 August 2019).

practices and knowledge that children learn. These efforts will combine to develop workers of the future who can support high skilled and high productivity jobs.

Local talent, particularly at Masters or PhD level, needs to be supported to stay in Ireland as GSK have found that many people with these skills are choosing to work abroad. Infrastructure across Ireland such as broadband access needs to continue to be developed to support technological advancements.

Who?
Moy Park, a food manufacturer with NI sites based in Craigavon, Dungannon and Ballymena.

Turnover: £1.6billion[289] (2018) **Employee Numbers:** 10,307 (UK. France and the Netherlands, 2018)[290]

What automated processes/machines have been implemented?

- Automation implemented includes an AMF deboning machine which took 6 months to install and data capturing processes which allows Moy Park to track information on a bird by bird basis. They also have an eLearning environment.

What were the driving factors behind implementation?

- Shortage of labour supply is more and more challenging, particularly from the local community.
- The retention of workers has been a factor, migrant workers often prefer temporary contracts in order to return home for long periods.
- Cost of production is decreased with automation.

What have been the consequences of introducing automation?
Automation has allowed for increased efficiencies and competitiveness as well as reduced waste with the AMF-deboning machine. It was expressed that a skilled worker would outperform the butchery task however it is difficult to gain (train?) workers with these skills. Overall, although automation is in place the demand for labour is still significant within Moy Park.

Automation has led to roles in engineering and supervisor positions as well as increasing the ability of data collection and usage to enhance and diversify their product capabilities. Staff have bought in to automation through effective communication of new workings and the removal of job tasks which they found less attractive.

Moy Park have found certain elements of their supply chain difficult to automate due to the complexity of their products as well as the changing nature of the UK food industry; creating different demands. The cost of automation has also been a barrier to further implementation.

Have any policy supports been availed of?
Moy Park has received training and upskilling support from Invest NI. They have also received a Plant Machinery Grant.

[289] Moy Park Holdings (Europe) Limited. *Full accounts made up to 29 December 2018*. Available at: https://beta.companieshouse.gov.uk/company/NI070325

[290] Ibid.

Are there any policy suggestions that may help to automate further in future?
Government policy on the level of the National Minimum Wage affects the labour costs of production. An increase in the labour costs of production would affect the payback calculation in a labour versus automation investment decision.

Support for further training and knowledge sharing would be welcomed.

Who?
Irwin's Bakery are a manufacturer of bread, fresh pastry goods and cakes based in Portadown.
Turnover: £30,161,769[291] (2018) **Employee Numbers:** 317[292] (2018)

What automated processes/machines have been implemented?

- Multitex dough moulder
- ERP system
- New picking system
- Automated cake decorating
- Tumbler machines
- Robotic handling equipment

What were the driving factors behind implementation?

- Automation was the next step to remain competitive in the food market.
- To improve manual handling processes.
- Increase productivity and efficiency.
- Increase diversification of the product base.
- To add more value-added jobs into the process through upskilling.

What have been the consequences of introducing automation?
No jobs losses have been made as a result of automation, they have been able to re-deploy staff into different roles that are either value added or more flexible that suits that every changing market that we operate in. Staff have been included in the automation process through communication with Trade Unions.

Irwin's has worked with Lawson Software who provide industry expertise to develop business software to help improve their supply chain, improve cost control, provide less administration tasks and improve their supplier relationship management[293].

They have also worked with Sysco Software to use Microsoft Dynamics Nav which aids the digitalisation of the baking industry, to streamline their internal and external processes such as production schedules and compliance issues to achieve Irwin's efficiency saving targets through Bakery Resource Management[294]. This was the foundation for Irwin's SMART bakery journey, embracing Industry 4.0.

Automation has also:

- reduced down time and waste
- reduced the accident rate resulting in lower insurance premiums; and
- allowed for greater productivity and efficiency,

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[291] W.D. Irwin & Sons Limited (2018). *Group of companies' accounts made up to 1 April 2018*. Available at: https://beta.companieshouse.gov.uk (last accessed 22 August 2019).

[292] Ibid.

[293] Food Processing Technology. *WD Irwin and Son Bakery.* Available at: www.foodprocessing-technology.com (last accessed 23 May 2019).

[294] Sysco Software Solutions. *Irwin's Implements Microsoft Dynamics NAV with Sysco*. Available at: www.sysco-software.com (last accessed 23 May 2019).

Have any policy supports been availed of?
Irwin's have benefitted from R&D tax credits and grants and previously gained a Carbon Trust loan. They have also worked with Fast Technologies and NITC to design and test new technology. They are also working with QUB to work with data as part of developing a line control system.

Are there any policy suggestions that may help to automate further in future?
Irwin's expressed they would benefit from increased knowledge and expertise for automation in their industry. This could possibly be done through workshops to provide guidance and assist with testing and problem solving.

8.2.2. Hospitality

Who?
Ormeau Baths is a co-working and technology community space, based in Belfast.

What automated processes/machines have been implemented?

- Co-working platforms and online software systems for admin duties such as contracts, room booking and parcel deliveries.
- Doordeck- virtual key allowing 24/7 access for members.

What were the driving factors behind implementation?
To create a 24/7 working facility to generate ease of working for customers to allow them to work at a time which best suits their needs. Automation enables Ormeau Baths to provide a modern hospitality service.

What have been the consequences of introducing automation?
Automation has enabled Ormeau Baths to offer a flexible working environment to suit the needs of their customers. However human workers are still required to work alongside automated procedures, skilled staff are needed to solve problems that arise due to automated procedures and to provide a human face with softer skills which are still demanded by customers.

Have any policy supports been availed of?
Ormeau Baths have not availed of any policy support from InvestNI, however they do have partnerships with Business in the Community to help promote life skills as well as working with Ulster University. Through these partnerships Ormeau Baths offer internships so that people can develop their hospitality skills.

Are there any policy suggestions that may help to automate further in future?
Ormeau Baths highlighted the great opportunities which are available in NI as a result of FDI, however there is a concern about the pool of talented workers for these organisations being limited and so this could cause an increase in wages as skilled workers run in short supply. Therefore, future policy could help to prepare and develop the labour supply needed to meet FDI and more local company needs.

Ormeau Baths did state that often policy support has a lengthy application process which can be off putting, this is an area which future policy support could aim to address.

8.2.3. ICT/Software Services

Who?
Kainos Software Ltd. develop digital technology and innovative software solutions for private and public sector organisations across the world and are based in Belfast.
Turnover: £63,405,000[295] (2018) **Employee Numbers:** 450[296] (2018- average monthly number of employees in Belfast)

What automated processes/machines have been implemented?
Kainos develop bespoke automated solutions for clients and so automation is a natural aspect already embedding in to their organisation, they foresee that machine learning will be the next step in the automation revolution.

What were the driving factors behind implementation?
Automation was an opportunity for Kainos to develop automated software solutions for clients, it has allowed their demand to grow, resulting in Kainos increasing from 400 staff to 1,600 in 4 years.

What have been the consequences of introducing automation?
Kainos' automated and digital solutions have helped to remove mundane tasks for their clients, allowing staff to work on higher value-added activities. Whilst automation has not reduced staffing numbers for Kainos clients, it has reduced their person burden. They continue to foresee that automation will complement humans.

Automated processes have also helped to decrease unnecessary inefficiencies and to better utilise data. Ultimately the user (customer) experience has been increased, for instance passport renewal services can now be completed using a mobile phone therefore government services are more accessible and user friendly due to automation.

Kainos developed their own experts in house as they could not gain skilled and experienced staff in NI for intelligent automation. They have also recruited staff in other parts of the UK such as Birmingham, Kainos have found that university teachings in this area have been very responsive to emerging industry demands.

Have any policy supports been availed of?
Kainos have benefitted from Invest NI's R&D tax credits and grants as well as training supplied by Invest NI.

They have also engaged with Ulster University for some courses and have found these are responding to industry needs. However there still remains a gap between academic teachings and industry needs.

Kainos have engaged with the CBI's Digital Forum to help inform NI policy needs.

Are there any policy suggestions that may help to automate further in future?
To equip future workers for working environments which involve machine learning, Kainos expressed the benefits of increased mathematics teachings in ICT and related courses. Additionally, it would be greatly beneficial for NI universities to develop a machine learning course or include this as a module in related courses.

[295] Kainos Software Limited (2018). *Full accounts made up to 31 March 2018*. Available at: https://beta.companieshouse.gov.uk/company/NI019370/filing-history (last accessed 05 September 2019).

[296] Ibid.

Kainos see great potential in the 'Earn as you Learn' scheme and would like to see this continued as well as the yearlong industry placements which some university students undertake.

Regarding Invest NI, Kainos would like a reinforced focus on the supply of skills and talent for local companies. It may also be beneficial for there to be a focus on developing AI experts as this is an area in short supply in NI, potentially this could create an AI Consultant role for Invest NI.

Kainos would also urge there to be intervention with females to increase their participation in this industry, possibly this would need to start with girls selecting subjects at school like physics and maths to allow them to avail of different career choices in future.

Who?
Flowlens, based in Belfast, offer business process automation software to help companies undertake digital transformations to integrate systems.

What automated processes/machines have been implemented?
Automated processes are an integral feature of Flowlens and they help to supply automation software to a variety of industries.

What were the driving factors behind implementation?
Flowlens' product aims to better utilise data and business resources for their clients, allowing their clients to increase efficiency, quality and value of roles within their organisation. For Flowlens the development of their product is aimed at growing their business through smart workings, they have a focus on growing their organisation outside of NI.

What have been the consequences of introducing automation?
The integration of their product in to various organisations have allowed some of their clients to save 1-day worth of work per week. Automated business processes help to reduce wastage of resources and allow staff to better utilise their workday. Ultimately, automation allows companies to work smarter and help to eliminate inefficiencies.

Flowlens expressed that for automation to further increase in NI, a culture shift is needed from school through to the workforce to develop an environment of entrepreneurship, innovation and learning.

Have any policy supports been availed of?
Flowlens have benefited from Invest NI's R&D tax credits and grants as well as training. Flowlens also attended a trade fair with Invest NI in Scotland and felt this to be hugely beneficial as they were able to engage with potential future clients and promote their product to a different market. They expressed that attending this event with Invest NI was an effective use of a small amount of public resources and led to practical results for companies.

Are there any policy suggestions that may help to automate further in future?
To futureproof the NI economy, Flowlens would encourage future policy to have a reinforced local approach, to support growing indigenous organisations. Whilst for future policy support to be considered by smaller organisations it needs to have a speedy application process as often smaller organisations do not have the resources to dedicate to a lengthy administration process.

Meanwhile for smaller organisations who wish to collaborate with career guidance at schools, but are unable due to resources, it would be beneficial if there was an incentive

for these organisations to be involved so that career guidance recognises the opportunities in smaller, home grown companies.

Additionally, increased commercial literacy is needed across NI to drive ambitious entrepreneurship, automation and growth which would also help to promote a culture shift and reduced the fear and risk that is often associated with automation.

8.2.4. Retail

Who?
Supermarket retailer[297], with stores across the UK.

What automated processes/machines have been implemented?
Technology is a feature within the strategy of this popular retailer and has been implemented so far in these forms:

- virtual reality glasses for training;
- Scan and Go;
- self-checkouts;
- Self-replenishment system which generates a pick order for warehouse staff as a result of data being sent from checkouts to the warehouse;
- continuous use of data to increase efficiency;
- development of an automated warehouse in GB; and
- a concept store (located in GB).

What were the driving factors behind implementation?
The implementation of technology within the retail sector is a result of the pressure on the traditional retail experience. This retailer is driven towards automation due to:

- the need to maintain a low-cost operating model;
- remain competitive on price;
- enhance the customer experience;
- increase efficiency; and
- remove mundane, low-value tasks.

What have been the consequences of introducing automation?
The retailer notes that whilst the headcount of retail staff is down across the UK this is not as a result of automation, instead this is due to restructures and increased competition within the sector. This retailer still has a requirement for labour due to the relationship customers have with store staff, whilst the customer experience can often be benefited through a human workforce. For instance, customer feedback continues to indicate that the store journey is largely determined by the experience when paying for products and so any decision to automate this area further must be carefully considered.

Automation results in the removal of mundane, low value-added tasks, consequently staff are required to possess a higher skill set. This retailer does foresee that more automation could be implemented to remove further mundane tasks, for instance the implementation of electronic shelf edges, however the high investment costs involved with automation require resources to be carefully managed and ensure a return on investment. Furthermore, it has been found that customers are technology resistant therefore retailers have been adopting automation where suitable to benefit the customer experience.

Furthermore, due to the pace of social change and public opinion retailers are aware of the benefits of advanced automation. For instance, the recent 'refill revolution' to cut down on plastic packaging may result in resources being allocated to investigate the

[297] This consultee wished to remain anonymous.

feasibility of implementing this. Therefore, resources must be managed and at times reallocated to keep up with society demands from social trends.

An additional consequence of investment in warehouse automation has significantly improved the ergonomics for workers.

Have any policy supports been availed of?
This retailer has not availed of any policy support within NI, due to the use of their own resources to implement automation and training for their staff.

Are there any policy suggestions that may help to automate further in future?
This retailer suggested that future policy support could be directed to assist SMEs with the cost of automating. Automation would also help these SMEs to overcome uncertainties regarding Brexit and the tightening of the labour market. The products these SMEs generate stock this retailer's supply chain and so automated workings would help to guarantee local supplies for retailers.

The retail sector would not be supportive of any increase in tax or rates that have been suggested as a tool to overcome lost income from taxes if jobs are lost as a result of automation. The various costs imposed on their business and supply chain already such as the sugar tax, plastic bag levy and the apprenticeship levy as well as the current potential for a 'plastic tax' was noted. Instead they would be supportive of decreased tax and rates burdens for retailers to remain competitive.

Additionally, this retailer expressed the need for the apprenticeship levy to be changed so that NI organisations benefit from paying into this scheme.

8.2.5. Stakeholder Consultation- Invest NI[298]

Automation in the current business environment

- Automation[299] in NI has mainly been implemented by larger firms who have the resources in finance, data and staff to support the development of innovative automated solutions.
- Some smaller firms are buying 'off the shelf' automated solutions which have been tried and tested thereby minimising the risk associated with investing.
- For many firms the price of labour does not yet exceed the cost of the capital investment required to automate and/or they do not have the technical know-how to begin automating thereby restricting their ability to automate.
- The paybacks of automation can also be difficult to quantify, organisations can struggle to understand the rate of return of investing in automation causing investment to be held off. Thus, automation paybacks need to be better understood to encourage investment.

Expert Consultants

- A key theme of this discussion was the demand for expert automation consultants in NI to provide the technical know-how and practical advice to organisations, currently expert advice is being recruited from around the world.
- Regional Deals support the development of Advanced Manufacturing Hubs in NI therefore there is the potential for a number of these across NI. However, resources could also be allocated to develop a 'Regional Hub' which would provide automation expertise for all of NI in one location.

Skills

- The skills demanded by automation go beyond the basic level of digital skills including coding and programming, instead skills for roles such as an 'AI Engineer' are needed.
- Significant reskilling and upskilling will be required as a result of automation however, reskilling needs to be clearly defined so that there is a universal understanding as to what is expected for organisations preparing to reskill staff.

Policy Support

- R&D grants have benefitted various organisations however, there is a need for this form of funding to be diversified to support further automation uptake. The discussion suggested that the 'Manufacturing Tool Kit', which is used to assess manufacturing businesses nationally and to develop areas for policy focus, could become a mainstream tool for all relevant sectors to provide more specific assistance.

[298] UUEPC met with Invest NI as a key stakeholder for this project to discuss the level of support currently available to help companies automate.

[299] Invest NI highlight that automation goes beyond digital workings, instead automation is in reference to AI, machine learning, big data usage and advanced robotics.

- There was the recognition that employment-based targets for policy support may need to be addressed to develop different targets to support the outcomes of automation.
- Invest NI have addressed the policy support available outside of NI such as Enterprise Ireland's Business Innovation project, which provides support for organisational or process innovation that transforms current workings. The funding can support the salaries of staff working on the project as well as cost of materials, consultancy costs and overheads[300].

[300] Enterprise Ireland (2019). *Business Innovation*. Available at: enterprise-ireland.com (last accessed 01 October 2019).

Annex 3- Country Policy Review

Country	Policy Theme	Policy and Key Points
Germany	**Context**	Germany has a strong manufacturing history in areas such as automobiles, electrical engineering and chemicals, with a total of 15 million jobs linked to the production of goods[269]. It is also one of the leading nations in AI research[270] and is currently ranked Number 2 overall in the Automation Readiness Index[271]. Germany's robotic and automation industry had an average growth rate of 10% from 2010 to 2017, the sector turned over €14.5 billion in 2017[272]. This has led to Germany holding a leading position in the progress of automation. This has been achieved through policies such as **I40**, which other countries have aimed to replicate, and their **High-Tech Strategies** (HTS, 2006 and 2010)[273]. These policies are directly linked to automation and so Germany has created for itself a leadership position in the development of technology, therefore it was essential that Germany's policies have been included in this review. Also, Germany's strategies have heavily focused on the support for SMEs, which make up 99.6% of companies in Germany[274], NI has over 132,000 SMEs[275] and so it will be important to review the support available for these businesses in other countries. I40 was developed from the High-Tech Strategies and aims to create smart factories by achieving digitalised manufacturing over the next 10 to 15 years; this is with the goal of increasing the interconnection of people, products, machines, value chains and business models. This will be done using cyber-physical system technology, the internet of things and the internet of systems as well as automated machines[276].

[269] Klitou, D et al.
for the European Commission. (2017). *Digital Transformation Monitor- Germany: Industrie 4.0*.

[270] The Federal Government. (2019). '*World-class intelligence in action'*. Available at: www.bundesregierung.de (last accessed 28 May 2019).

[271] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[272] Grune, C. for Germany Trade and Invest (2018). *The Robotics & Automation Industry in Germany.* Available at: www.gtai.de (last accessed 5 June 2019).

[273] Federal Ministry of Education and Research. (2010). *Ideas. Innovation. Prosperity. High-Tech Strategy 2020 for Germany*. Available at: www.bmbf.de (last accessed 28 May 2019).

[274] The Legislative Council Commission. (2015). *Fact Sheet: Development of Innovation and Technology in Germany*.

[275] Department for Business, Energy & Industrial Strategy (2018). *Business Population Estimates for the UK and Regions 2018.* Available at: https://www.gov.uk/government/statistics/business-population-estimates-2018 (last accessed 5 June 2019).

[276] Klitou, D et al. for the European Commission (2017). *Digital Transformation Monitor- Germany: Industrie 4.0*.

		Limitations are present in evaluating I40, because whilst the physical technology to be implemented does exist, its new ways of working with data to streamline processes is still being developed[277] and is something of the future.
	R&D, Skills and Education	Both the HTS and I40 place a heavy focus on R&D, I40 particularly aims to do this by increasing collaboration amongst industries, policy makers and academics. I40 has led to the development of **Plattform Industrie 4.0** (PI40) which provides different aspects such as a governance role, working groups and a steering body made up of business representatives, Federal Ministries, chairs of working groups and companies. These groups will help to enable ideas and research to be put into practice through the share of information and expertise[278]. PI40 reports that more than 300 stakeholders are involved in their work and they have also held over 50 events to increase their awareness for companies and to provide training[279]. I40 carries out research activities and provides testbeds for SMEs through funding from the Ministry of Education and Research. The use of testbeds has been further developed through 'Labs Network Industrie 4.0', which PI40's members have developed to enable companies to gain access to relevant test centres before they commit to an investment in technology[280]. This highlights how collaboration is being put in to practice to achieve I40. Germany has also recognised that skills will need to be adapted to meet the future of work and so a dual system for vocational training was developed in 2005, updated from the **1969 Vocational Training Act**. This involves student's time being split between a classroom and an organisation, the 2005 update introduced the closer working of the government, industries and teaching institutions to ensure that quality and accredited training is being provided. As a result, one in five German companies are involved in the dual vocational training scheme as the companies can see the benefits of developing an apprentice into a

[277]Drath, R. and Horch, A. (2014). *Industrie 4.0: Hit or Hype?* IEEE Industrial Electronics Magazine (p56-58)

[278]Federal Ministry for Economic Affairs and Energy (nd). *The background to Plattform Industrie 4.0.* Available at: www.plattform-i40.de (last accessed 4 June 2019).

[279]Federal Ministry for Economic Affairs and Energy (nd). *A consistent focus on the needs of SMEs.* Available at: https://www.platform-i40.de (last accessed 5 June 2019).

[280]Ibid.

		specialist. In 2018 more than 1.3 million young people were in vocational training[281], this has helped with youth employment and to develop skills demanded by employers[282]. Additionally, the **'Central Innovation Programme for SMEs' (ZIM)** offers grants for R&D projects for SMEs. The policy objective of ZIM is to increase the innovative capacity and competitiveness of SMEs, via development and commercialisation of new and innovative technological products and services. The Programme has been complimented for its easy to access nature due to: reduced bureaucracy; swift procedures; pre-application support; the openness of the programme to all technologies; availability to all in Germany; and the ability for SMEs to be able to undertake a project specifically linked to their own industry[283]. Due to the easy application process, 78% of applications succeed[284]. On review, ZIM was the first programme that offered broad support for SMEs and cooperation with other industries was also a feature of the programme as was the ability to work with research institutions[285] which have helped the programme to succeed. Overall, ZIM added value in the policy mix in Germany as 68% of companies reviewed did not apply another programme outside of ZIM[286].
	Business Support	ZIM has introduced the 'ZIM Cooperation Networks International' which allows for German companies to work with foreign companies to share ideas and best practices to develop projects in the technological sector[287]. This development shows programmes may be updated to suit new requirements.

[281] Grune, C. for Germany Trade and Invest (2018). *The Robotics & Automation Industry in Germany.* Available at: www.gtai.de (last accessed 5 June 2019).

[282] Federal Ministry for Economic Affairs and Energy (nd). *A consistent focus on the needs of SMEs.* Available at: https://www.platform-i40.de (last accessed 5 June 2019).

[283] INNO-Partnering Forum (2010). *ZIM, the Central Innovation Programme for SMEs- Part of Deliverable D2.2 INNO-Partnering Forum*. Available at: www.taftie.org (last accessed 5 June 2019).

[284] Ibid.

[285] Ibid.

[286] Ibid.

[287]Dorucon, Dr. Rupp Consulting (2019) *ZIM promotes cooperation projects with international partners*. Available at: www.dorucon.de (last accessed 5 June 2019).

Federal Ministry for Economic Affairs and Energy (2019). *International Cooperation Projects & Networks in ZIM.* Available at: www.zim.de (last accessed 5 June 2019).

		Whilst I40 suggests that digitalised manufacturing generates new ways of creating value, there may be limitations to digitalisation in practice. Organisations face high investments costs, data security concerns, the need to adapt management styles and a limited supply of skilled workers, which may limit the feasibility or attractiveness of increased digitalisation[288]. Additionally, The Ministry for Economic Affairs and Energy contributed funding to aid I40's work on standardisation and regulation[289]. However, continual uncertainty associated with the development of industrial standards remains, which has led to a slow uptake of investments in new systems due to fear that these systems may be unsuitable in future[290]. New companies in Germany also have low risk capital preventing them from developing their business in line with I40. Consequently, adoption of recommendations under I40 has been limited to pioneering organisations, resulting in larger companies setting standards[291].
	Lessons for NI	In order to replicate successful outcomes in Germany, R&D should continue to be developed and invested in, in NI. For R&D to take place it will require support both financially and in expertise, particularly for SMEs, to implement new technology. Key lessons learnt from the ZIM programme include: The efficient application process. Openness of the programme, whilst also maintaining accountability. Fast pace of the project. The R&D projects are applicable to the individual SME, this makes it an attractive and accessible scheme for SMEs[292]. A factor limiting the success of I40 has been the standardisation process, therefore helping with standardisation for new technology in NI will help to give industries confidence to invest in new technology allowing for automation to occur.
Estonia	**Context**	When Estonia regained independence from the USSR in 1991, President Meri's leadership set about creating Estonia's unique selling point through digitalisation and ICT. This focus has led to Estonia becoming one of

[288] UNIDO. (2018). *What Can Policymakers Learn From Germany's Industrie 4.0 Development Strategy?.*

[289] Klitou, D., Conrads, J., Rasmussen, M., CARSA, Probst, L., Pedersen, B. and PwC for the European Commission. (2017). *Digital Transformation Monitor- Germany: Industrie 4.0*. Available at: https://ec.europa.eu/growth/tools-databases/dem/ (last accessed 24 June 2019).

[290] Commission of Experts for Research and Innovation in Schroeder, W. (2016). *Germany's Industry 4.0 strategy: Rhine capitalism in the age of digitalisation*. Friedrich Ebert Stiftung.

[291] Schroeder, W. (2016). *Germany's Industry 4.0 Strategy- Rhine Capitalism in the Age of Digitalisation.* Friedrich Ebert Stiftung.

[292]INNO-Partnering Forum (2010). *ZIM, the Central Innovation Programme for SMEs- Part of Deliverable D2.2 INNO-Partnering Forum*. Available at: www.taftie.org (last accessed 5 June 2019).

		the most digitalised countries in the world. In 2001, X-Road was created allowing for the interconnection of private and public sector so that information could be exchanged safely with the e-Identification process. E-Estonia estimated that this saves 800 years of working time for the state and citizens annually[293]. 99%[294] of all government services are now completed online through **e-Estonia.com** (the state portal), saving citizens and government time and money. Estonia's digital polices, whilst not directly linked to automation have helped to prepare the country for the future. Estonia is currently ranked 6th overall in the Automation Readiness Index[295] and so they have been incorporated into this review to provide analysis of how NI can prepare for automation.
	R&D, Skills and Education	**The Estonian R&D and Innovation Strategy 2014-2020** has created R&D and innovation targets including that 3% of the GDP will be invested in R&D and the share of employment in high and medium-high technology sectors to rise to 9% by 2020, in 2010 this share was 6%[296]. Automation is not directly mentioned in this strategy, however it does aim to increase Estonia's knowledge economy, helping to continue their development and leadership in new technologies. Estonia is ranked Number 2 in Education Policies by The Automation Readiness Index[297], this again highlights the importance of skills and education development in preparation for automation. ICT has been given great prominence in the Estonian education system, originally this was through the **Tiger Leap programme** in 1996, which was funded by the government and 11 private IT companies[298]. Tiger Leap's success led to 84% of schools providing computer science classes, Tiger Leap is linked to having helped to create Estonia's IT start-up sector as the children who benefitted from the Programme grew up with the digital skills allowing

[293] E-Estonia (nd). Available at: https://e-estonia.com (last accessed 12 June 2019).

[294] E-Estonia.com (nd). Available at: e-estonia.com (last accessed 11 June 2019).

[295] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[296] Estonian Research and Development Council, Ministry of Economic Affairs and Communications and Ministry of Education and Research (2014). *Estonian Research and Development and Innovation Strategy 2014-2020 "Knowledge-based Estonia".* Available at: https://rio.jrc.ec.europa.eu/en/library/rdi-strategy-knowledge-based-estonia-2014-2020 (last accessed 13 June 2019).

[297] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[298] Kattel, R. and Mergel, I. (2018). *Estonia's Digital Transformation: Mission Mystique and the Hiding Hand.* Institute for Innovation and Public Purpose. Available at: www.ucl.ac.uk (last accessed 24 June 2019).

		for these successes[299]. This has helped Estonia to be ranked top of Europe's Hidden Entrepreneurs[300] therefore due to a focus on digital skills in education it has helped to drive Estonian innovation. Further developments in education include the **Education Information System** which is a state database containing a variety of information on education institutions, teachers, students and study materials. It is also used as a method of monitoring the educational system so that educational authorities can ensure that the subjects and skills being taught are preparing people for the future of work[301]. These policies do not directly mention automation however they will help to develop teachers' and children's digital skills. **The Estonian Lifelong Learning Strategy 2020** aims to encourage lifelong learning for adults aged 25-64, the Estonian government has a target in place to have a 20% participation rate in education and training by 2020[302]. In 2017 the Estonian participation rate for adults was 17%, the EU average was 10.9%[303]. The Lifelong Learning Strategy recognises issues such as a mismatch of skills and aims to overcome this through increased collaboration between the education system and employers so that skills needs are addressed. Additionally, the Strategy notes that there needs to be more information regarding the labour market for students and so it aims to improve career counselling[304] so that students are more aware of skills and jobs demanded.

[299] Mets, T. (2017). *From the Educational Tiger Leap Program to the ICT Startup Booming in Estonia*. University of Tartu. Available at: http://ieeexplore.ieee.orb 9last accessed 24 June 2019).

[300] WEF (2016). *Europe's Hidden Entrepreneurs- Entrepreneurial Employee Activity and Competitiveness in Europe*. Available at: www3.weforum.org (last accessed 24 June 2019).

[301] E-Estonia. Estonian Education Information System. Available at: https://e-estonia.com (last accessed 21 May 2019).

Detail not available on how appropriate skills for the future of work are identified in Estonia.

For further details on Estonian Education see E-Estonia- Estonian Education Information System. Available at: https://e-estonia.com (last accessed 21 May 2019).

[302] Ministry of Education and Research (2014). *The Estonian Lifelong Learning Strategy 2020*. Available at: www.hm.ee/sites/default/files/estonian_lifelong

_strategy.pdf (last accessed 24 June 2019).

[303] European Centre for the Development of Vocational Training (2018). *Vocational education and training in Europe: Estonia 2018*. Available at: www.cedefop.europa.eu (last accessed 13 June 2019).

[304] Ministry of Education and Research (2014). *The Estonian Lifelong Learning Strategy 2020.* Available at: www.hm.ee/sites/default/files/estonian_lifelong

_strategy.pdf (last accessed 13 June 2019).

	Business Support	Due to low wages in Estonia there has been low incentive for businesses to invest in automation, to overcome this grants and credit has been made available to allow companies to test new technologies, as well as funding being provided for retraining employees[305]. Estonia's small domestic market has forced companies to think globally[306]; they aim to increase exports of high-technology and service goods to 15% by 2020, in 2010 10.4% of these items were exported[307]. The e-residents programme[308] is encouraging immigrants to set up businesses in Estonia. This may help to tackle Estonia's brain drain as they aim to attract highly educated and skilled immigrants[309], who can help to maintain an innovative environment that is technology focused.
	Inequality and Taxation	Estonia is ranked in the bottom third of OECD for high inequalities in income, wealth and adult skills. Gender inequality is also high as women are more likely to be in low paid work, but whilst these issues are noted there is no current tax reform to overcome these[310]. However, Estonia is trying to overcome inequalities in other ways such as by increased participation in education to allow people to gain higher skilled and higher paid jobs through the Estonia Lifelong Learning Strategy 2020[311].
	Lessons for NI	Estonia's strong data security has enabled citizens to support and trust the digital processes[312]. Data security is a factor which should be considered in any future policy as without strong data security users will not feel confident in switching to new procedures and technology.

[305] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[306] The Economist. (2013). *How Did Estonia Become a Leader in Technology?* Available at: www.economist.com (last accessed 10 May 2019).

[307] Estonian Research and Development Council, Ministry of Economic Affairs and Communications and Ministry of Education and Research (2014). *Estonian Research and Development and Innovation Strategy 2014-2020 "Knowledge-based Estonia".* Available at: https://rio.jrc.ec.europa.eu/en/library/rdi-strategy-knowledge-based-estonia-2014-2020 (last accessed 13 June 2019).

[308] Anthes, G. (2015*). Estonia: A Model for e-Government*. Communications of the ACM, 58 (6), 18-20.

[309] Estonian Research and Development Council, Ministry of Economic Affairs and Communications and Ministry of Education and Research (2014). *Estonian Research and Development and Innovation Strategy 2014-2020 "Knowledge-based Estonia".* Available at: https://rio.jrc.ec.europa.eu/en/library/rdi-strategy-knowledge-based-estonia-2014-2020 (last accessed 13 June 2019).

[310] OECD Better Life Initiative. (2017). *How's Life in Estonia?.* Available at: www.oecd.org (last accessed 30 May 2019).

[311] Ministry of Education and Research (2014). *The Estonian Lifelong Learning Strategy 2020*. Available at: www.hm.ee/sites/default/files/estonian_lifelong

_strategy.pdf (last accessed 24 June 2019).

[312] Ilves, T.H. (2018). *E-stonia Takes Off*. Finance & Development, Vol 55(1), pgs. 38-39.

		Much of Estonia's early digital development was ad-hoc rather than strategy led, however digitalisation's success has also been attributed to the cross-party support it has received[313]. It will be important for NI to have cross-party and cross-departmental consensus so that automation policies are understood and implemented across education, industries and public services. This may also allow for consistency across sectors which will also be important to the overall success of automation and provide a constant, long-term approach. Estonia's Lifelong Learning Strategy could continue to provide guidance as to how NI can increase lifelong participation rates. NI can learn from Estonia's updated and mandatory career counselling at schools as well as updating all curriculum to ensure students of all ages have basic digital skills.
Singapore	**Context**	Singapore is ranked Number 3 overall in the Automation Readiness Index[314]. This ranking has been aided by programmes such the **Industry Transformation Programme** (announced in 2016) and the Singaporean Government committed an investment of SGD$4.5 billion[315]. The Industry Transformation Programme aimed to have an industry focus to address issues associated with disruption from technological development, rising competition as well as land and manpower constraints. This programme aims to help strengthen government and industry partnerships. The Industry Transformation Programme will be driven by **Industry Transformation Maps (ITMs)**, which are tailored programmes for 23 industries aimed to promote growth and competitiveness[316]. The 4 pillars of ITMs include: productivity, jobs and skills, innovation, and trade and internationalisation[317].
	R&D, Skills and Education	The **SkillsFuture for Digital Workplace** (2017) is a publicly ran, digital training scheme, aiming to benefit 100,000 Singaporeans over 3 years. It involves a 2-day programme, that has been developed with 7 training

[313] Kattel, R. and Mergel, I. (2018). *Estonia's digital transformation: Mission mystique and the hiding hand*. Institute for Innovation and Public Purpose.

[314] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[315] Singapore Government. (2016). *Media Factsheet- Industry Transformation Maps*. Available at: www.mti.gov.sg (last accessed 24 June 2019).

[316] Ibid.

[317] Yin, C.H. (2017). *Singapore Unveils Industry Transformation Map for Wholesale Trade.* Available at: www.businesstimes.com.sg (Last Accessed: 10 May 2019).

		partners who have helped customise training to accommodate different industry needs. For instance, the Asian Culinary Institute and the Singapore University of Social Sciences have been involved in developing curriculum for participants[318]. SkillsFuture goes in partnership with **SkillsFuture Credit** which give those aged 25 and above SGD$500 credit to incentivise citizens to develop their skills independently of the workplace[319]. This credit scheme aims to place the ownership of the training on to the individual, rather than SkillsFuture being an employer driven programme. The Committee on the Future Economy reviewed Singapore's economic strategies, observing the need to link skills to future job requirements and maintain a life-long learning approach. The Committee recommended the establishment of a digital portal for education and career guidance[320] to help enable lifelong learning.
	Business Support	The Committee on the Future Economy suggested that support is needed for SMEs to adopt digital technology. The Committee recommends that this can be achieved through pilot projects which would involve financial assistance from the government to pay for initial investment costs in digital solutions to be piloted for testing and then later deploy to SMEs[321]. The Committee further recommends that partnerships be developed between large and smaller businesses as well as with research institutions, unions and education providers to address issues regarding the future economy[322]. This partnership approach would particularly help smaller businesses gain access to R&D resources and best practices which would assist with their implementation of automation.
	Lessons for NI	Singapore's success in training of the workforce has been achieved through collaboration of the government, industries and educators who have worked together to develop curriculum and customised courses to meet

[318] Helkkula, K. (2018). AI for all: How Finland (and other countries) are delivering free, accessible digital skills training. Nesta Available at: www.nesta.org.uk (last accessed 23 May 2019).

SkillsFuture. (2017). Factsheet on SkillsFuture for Digital Workplace. Available at: www.ssg-wsg.sg (last accessed 30 May 2019).

[319] Helkkula, K. (2018). AI for all: How Finland (and other countries) are delivering free, accessible digital skills training. Nesta Available at: www.nesta.org.uk (last accessed 23 May 2019).

SkillsFuture Credit (2016). *Skills Future Credit*. Available at: www.skillsfuture.sg/Credit (last accessed 30 May 2019).

[320] Committee on the Future Economy (2017). *Report of the Committee on the Future Economy- Pioneers of the Next Generation.* Available at: www.gov.sg (last accessed 11 June 2019).

[321] Ibid.

[322] Ibid.

		different industries' needs[323]. Therefore, a one-size fits all approach for skills and education development is not suitable to meet the differing needs of industries. Also, Singapore's SkillsFuture aims to tackle the uncertainty associated with new technology in the workplace, giving citizen's confidence with new technology which will then help gain public support for technology. The monetary incentive attached to this programme will help increase participation, but this incentive will also be beneficial for SMEs who may not have the resources to train staff themselves and so this incentive allows for individuals to self-fund the development of their skills. Singapore's pilot projects which enable technology to be tested before an investment is made helps to give all business, particularly SMEs the confidence to adopt and invest in new technology. Further support to SMEs will be important such as assistance with financial support and expertise knowledge.
UK		The UK has a strong history in previous industrial revolutions, and it is currently ranked Number 8 overall in the Automation Readiness Index[324]. The UK is preparing for the AI revolution through the 2017 **UK Industrial Strategy**. This Strategy covers AI, R&D, education, the business environment, construction and energy to help provide high quality and high paid jobs as well as turning research in to new products and industries, to develop a future economy. In total the strategy covers more than 200 policies across government[325] and the projects it discusses have significant investment costs such as a £400million infrastructure investment to support electrical vehicles, increasing the National Productivity Investment Fund to £31billion to help support investment in housing, transport and digital infrastructure[326]. The Strategy has five foundations of productivity, these are: ideas, people, infrastructure, business environment, and places[327].

[323] Tend, A. (2017). *Big push to equip workers with basic digital skills*. Available at: www.straitstimes.com (last accessed 11 June 2019).

[324] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[325] Gordon, S., Pfeifer, S. and Pooler, M. (2018*). Is the UK's new Industrial strategy starting to work?* Available at: www.ft.com (last accessed 12 June 2019).

[326] HM Government (2017) *Industrial Strategy- Building a Britain Fit for the Future.*

[327] Ibid.

		The large scope of this Strategy helps to convey the collaboration and overlapping that is required for new technology to be fully immersed across the UK economy, creating an environment where businesses can thrive. However, the strategy was met with some criticism due to the large amount of funding pledges and the overlapping of initiatives which may become confusing[328]. The UK Industrial Strategy has already impacted NI such as the development of the **Belfast City Deal**. The Belfast City Deal has already enabled the collaboration of six councils, NI's two universities and Colleges. A pillar of the City Deal is based on innovation and digital enhancement, this has already involved QUB and UU working together on AI and data analytics and advanced manufacturing this will help to further develop the knowledge economy in NI and develop Regional Innovation Centres, technology testbeds, Smart districts and digital connectivity[329]. This is a positive step towards preparing NI for the automation revolution and attract investment here.
	R&D, Skills and Education	In 2016 the UK spent 1.7% of GDP on R&D[330], The Industrial Strategy has a target is in place for public sector investment in R&D to reach 2.4% of the GDP across the whole of the economy by 2027, then increase investment to 3% in the long term[331]. The Industrial Strategy Challenge Fund has also been created to help bring together industry and researchers, enabling research to be deployed in to industries[332]. In 2017 £68million was awarded to four research projects and innovation projects[333]. The Industrial Strategy included various methods of helping to develop citizen's skills such as the creation of a **National Retraining Scheme** beginning with a £64 million investment for digital and construction retraining, in 2018 £100 million was committed to this National Retraining Scheme in the UK budget[334]. This

[328] Gordon, S., Pfeifer, S. and Pooler, M. (2018*). Is the UK's new Industrial strategy starting to work?* Available at: www.ft.com (last accessed 12 June 2019).

[329] Belfast City Council (nd). Belfast City Region Deal- it's a big deal. Available at: www.belfastcity.gov.uk (last accessed 27 June 2019).

[330] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[331] HM Government (2018). *Forgoing Our Future- Industrial Strategy- The Story So Far*.

[332] UK Research and Innovation (nd). Industrial Strategy Challenge Fund. Available at: www.ukri.org (last accessed 14 June 2019).

[333] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[334] HM Government (2018). *Forgoing Our Future- Industrial Strategy- The Story So Far*.

		Scheme specifically targets the retraining of workers who may be displaced by automation, manufacturing industries have commented on the high costs of up-skilling workers for jobs which new technologies may create and have urged for the Scheme to aid with these up-skilling costs[335]. Continuing professional development is to play a role in the future of work and so the UK Government will work with industries to prepare training and conversion courses so that AI can be applied across different specialist areas[336]. The Industrial Strategy also aims to develop skills in accredited, industry specific programmes by working with universities and businesses to develop an industry-funded master's programme. Since the Industrial Strategy was published, 47,000 people started a higher-level apprenticeship in the UK in 2018. To further develop apprenticeships a new system entitled the **'T level'** is being developed to streamline technical qualifications. T Levels aims to give participating students an accredited qualification whilst gaining industry skills. Employers will work with Further Education (FE) colleges to develop new qualifications to better meet the demands of the workforce. T Levels aim to ensure qualifications are adding value, the first programmes are expected to be delivered in 2020[337]. In terms of school education, the Strategy intends to upskill 8,000 computer science teachers with £84 million committed to improve the teaching of this subject and increase student participation[338]. Since 2017 there has been a 25% increase in A level computer science entries[339]. In the long term these R&D and education and skills development approaches will help enable citizens to be confident in working alongside machines and so these approaches may also help to manage citizen anxiety surrounding automation.
	Business Support	The **Business Basics Programme** encourages SMEs to test and adopt technologies, £2million has been made available to support this through the Business Basics Fund in 2019[340]. Sub-programmes have also

[335]Davidge, V. at MAKE UK The Manufacturers Organisation (nd). *Insights- National Retraining Scheme*. Available at: www.makeuk.org (last accessed 13 June 2019).

[336] HM Government (2017) *Industrial Strategy- Building a Britain Fit for the Future.*

[337] Department for Education (2018). *Implementation of T Level Programmes. Government Consultation Response.* Available at: www.gov.uk (last accessed 30 May 2019).

[338] HM Government (2017) *Industrial Strategy- Building a Britain Fit for the Future.*

[339] HM Government (2018). *Forgoing Our Future- Industrial Strategy- The Story So Far*.

[340] Department for Business, Energy & Industrial Strategy (2019). Business Basics Programme. Available at: www.gov.uk (last accessed 30 May

		been developed such as **Be the Business**; which aims to increase productivity through the development of a national business mentoring scheme, helping businesses to share best practices[341]. **A Scale Up Taskforce and a Scale Up Champion** have been appointed by the government to help understand the difficulties businesses face in scaling up and to provide help to overcome these[342]. Also, a **New Industrial Strategy Council** was appointed including the Chief Economist of the Bank of England, academics and business representatives[343] to help oversee the Industrial Strategy.
	Citizen Engagement	The Industrial Strategy included a **Good Work Plan** which sets out to improve work practices and protect workers' rights[344] this should help ease the anxiety associated with automation.
	Inequality and Tax	Whilst no taxation policy has been created as a direct consequence of automation, in 2016 the UK Government introduced the National Living Wage to increase pay for citizens aged 25 and over. Whilst low paid workers have seen a pay rise, critics argue that this wage is not reflective of actual living costs and so this is not enough to help tackle inequality[345]. Universal Credit has been introduced to replace other Credits such as Child Tax Credit, Housing Benefit, Income Support and Jobseekers' Allowance, this is available for citizens not in employment, or on a low income. Universal Credit has been established to help encourage more people in to work as the Credit will not be removed immediately if a person begins work or takes on a temporary job[346]. However, Universal Credit has been widely criticised for increasing poverty and hardship, particularly during the five-week wait for the first payment to be received[347]. From 2005 to 2014, 60% of households in the UK had flat or falling incomes, this is compared to less than 2% of households for 1993 to 2005[348]. Automation has the potential to increase inequality due to capital

2019).

[341] Be the Business (nd). *About Be the Business*. Available at: www.bethebusiness.com (last accessed 30 May 2019).

HM Government (2018). *Forgoing Our Future- Industrial Strategy- The Story So Far*.

[342] HM Government (2017). *Industrial Strategy- Building a Britain Fit for the Future.*

[343] Parker, G. (2018). *Andy Haldane tapped to tackle UK's productivity puzzle.* Available at: www.ft.com (last accessed 12 June 2019).

[344] Ibid.

[345] Living Wage Foundation (nd). What is the Real Living Wage? Available at: www.living wage.org.uk (last accessed 12 June 2019).

[346] NI Direct (nd). *Before you claim Universal Credit*. Available at: www.nidirect.gov.uk (last accessed 12 June 2019).

[347] Bounds, A. (2019). *Universal credit scam leaves vulnerable UK families penniless*. Available at: www.ft.com (last accessed 12 June 2019).

[348] Dobbs, R., Madgavkar, A., Manyika. J., Woetzel, J., Bughin, J., Labaye, E. and Kashyap, P. (2016). *Poorer than their parents? A new perspective on income inequality*. McKinsey & Company. Available at: www.mckinsey.com (last accessed 12 June 2019).

		ownership as discussed in Section 1.5.1. Therefore, inequality and taxation are issues which need to be addressed and whilst NI has no tax setting powers, data collection could begin regarding wages, inequality, taxation and automation so that this can be used for future tax lobbying purposes. Corporation Tax has been reduced from 28% to 19% to help drive business start-ups and competition[349].
	Lessons for NI	The Industrial Strategy is extremely wide ranging in its scope, this helps to convey how wide-ranging automation and its impact will be. Future NI policies will require collaboration, with cross-party and cross-departmental backing so that the policies can withstand any changes in government or policymakers, and so that it is foreseen as a long-term project[350]. Also, NI automation policy may aim to be inclusive so that all aspects of society are brought in to the automation revolution. Engagement with small businesses will be important for NI, particularly in helping smaller organisations to retrain their workers. Commenting on the UK's Industrial Strategy, SMEs said that they were able to receive financial support for purchasing new equipment (such as loans), but less was available to help with the cost of training needs for staff[351]. Programmes such as Be the Business and Business Basics Programme are beneficial to help mentor and provide support for SMEs to test and adopt new technology. The workings of the Scale Up Taskforce and New Industrial Strategy Council may help to provide future guidance for how businesses are overcoming challenges associated with technology disruption.
Scotland	**Context**	In 2011, the Scottish Government first published their **Digital Strategy** which focused on new ways of delivering a digital economy through the digitalisation of public services, digital participation by citizens and improving broadband access. The Digital Strategy led to successes such as Revenue Scotland which enabled 98% of tax returns to be completed online, whilst elsewhere the Scottish Government has invested £1million to aid 127 local projects supporting skills development, helping over 15,000 get online[352]. The 2011 Strategy helped to lay the groundwork for the 2017 **Digital Strategy for Scotland (DSS)** which covered the importance of preparing Scotland for new technologies such as AI, machine learning and cloud

[349] Ibid.

[350] Gordon, S., Pfeifer, S. and Pooler, M. (2018*). Is the UK's new Industrial strategy starting to work?* Available at: www.ft.com (last accessed 12 June 2019).

[351] Gordon, S., Pfeifer, S. and Pooler, M. (2018*). Is the UK's new Industrial strategy starting to work?* Available at: www.ft.com (last accessed 12 June 2019).

[352] Scottish Government (2017). *Realising Scotland's Full Potential in a Digital World: A Digital Strategy for Scotland*. Available at: gov.scot/digital (last accessed 31 May 2019).

		computing[353]. The DSS aims to incorporate these new technologies by having digitalisation at the heart of every industry and discusses the need for digital experts to be involved in developing economic policy. This strategy aims to create a collaborative and partnership approach to help generate the conditions that are welcoming to technology.
	R&D, Skills and Education	In 2014, only 37% of businesses surveyed said that they are fully equipped with sufficient technology skills[354]. To overcome low levels of technology skills and increase skills development, The **Digital Growth Fund** was launched in 2017, aiming to provide £36 million worth of loans to companies to enable them to provide digital training for their staff[355]. Additionally, The Enterprise and Skills Strategic Board's 2018 **Working Collaboratively for a Better Scotland: Strategic Plan**, discusses the need to ensure there is a demand-led skills system[356]. To enable the progression of skills, the Plan includes the development of a one system approach for learners, employers and the economy to be established by the Scottish Funding Council and Skills Development Scotland. The Plan also notes the development of a sustainable funding model to ensure that funding can meet demand for work-based and work-integrated learning as well as creating more effective pathways from education to productive employment[357]. Skills Development Scotland has invested £8.5 million to target digital skills, this includes programmes such as **Digital Xtra Fund** which organises extra-curricular clubs and activities designed to increase skills in young people regardless of their gender, background or where they are from[358]. Also, to incentivise people to take part in developing their own digital skills, a marketing campaign entitled **Digital World** was launched to inform individuals of the career opportunities that the development of skills can lead to[359]. Additionally, the DSS highlights the importance of 'meta skills', which are the social and emotional skills that machines cannot perform and emphasises a life-long learning approach in their development[360]. Overall, the

[353] Scottish Government (2017). *Realising Scotland's Full Potential in a Digital World: A Digital Strategy for Scotland*. Available at: gov.scot/digital (last accessed 31 May 2019).

[354] Office of the Chief Economic Advisor (2014). *Digital Economy Business Survey 2014*. Available at: www.gov.scot (last accessed 13 June 2019).

[355] Scottish Government (nd). *Digital Support for Businesses*. Available at: www.gov.scot (last accessed 31 May 2019).

[356] Enterprise and Skills Strategic Board (2018). *Working Collaboratively for a Better Scotland*.

[357] Ibid.

[358] Scottish Government (nd). *Digital support for business*. Available at: www.gov.scot (last accessed 14 June 2019).

[359] Skills Development Scotland (2016) *Discovering Digital World*. Available at: www.skillsdevelopmentscotland.co.uk (last accessed 13 June 2019).

[360]Scottish Government (2017). *Realising Scotland's Full Potential in a Digital World: A Digital Strategy for Scotland*. Available at: gov.scot/digital

		development of skills in the present will be crucial to enabling a smooth transition for automation to be incorporated in the workplace in the near future.
	Business Support	To support businesses a '**Digital Scotland Business Excellence Partnership'** has been set up, including digital businesses and Scotland's Enterprise and Skills agencies. The Partnership has invested £15.5 million in programmes such as **Digital Boost** which gave one-to-one support, online advice and workshops to help businesses grow and improve[361]. Also, a **Digital Vouchers** scheme has helped companies meet the costs of investing in digital technology. Successful applicants were awarded up to £5,000 which can be used to purchase project and management software for an ICT or digitally related project[362].
	Citizen Engagement	The DSS incorporates a societal aspect too, aiming to create an inclusive and understanding approach towards digitalisation from the public, the development of skills will help citizens to be less fearful of automation as they may have more confidence working alongside machines.
	Lessons for NI	The continued development of digital skills will be vital to lay the ground work for a smooth transition towards automation. In NI, digital skills therefore should continue to be developed in schools, colleges, universities and the workplace to provide inclusivity and to help convey the need for lifelong learning. Scotland's Digital
		World also helps to convey the importance of training to individuals so the understand the benefits to themselves and are a willing participant. In the 2014 Digital Economy Business Survey in Scotland some businesses stated that they were too small to adopt technology[363]. Small businesses are vital to the NI economy and so policy for these businesses will be important to help them adopt new technology, potentially this could be through a partnership-based approach between businesses; so that expert advice can be given to help guide businesses into automation. Financial support is also important to help with initial investment and training costs, particularly for smaller businesses.
South Korea	**Context**	South Korea is ranked Number 1 overall in the Automation Readiness Index and has become a world leading industrial power through government led, export-oriented strategies[364]. This has been achieved through

(last accessed 31 May 2019).

[361] Scottish Government (nd). *Digital support for businesses.* Available at: www.gov.scot (last accessed 13 June 2019).

[362] Digital Impact (2015). *Digital Scotland Voucher- Up To £5000*. Available at: www.digitalimpact.co.uk (last accessed 7 May 2019).

[363] Office of the Chief Economic Advisor (2014). *Digital Economy Business Survey 2014*. Available at: www.gov.scot (last accessed 13 June 2019).

[364] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

		investment in R&D to generate innovation, in 2016 South Korea spent 4.23% of its GDP on R&D, the highest amount of all countries in the Index[365]. Earlier policies which have aided automation include the **Five-Year Economic Development Plans** from 1962-1992. These Plans were continually updated to upgrade targets and industries with increasing knowledge content were initially targeted and there was also import restrictions and export incentives[366] to help grow South Korea industries and their competitiveness.
	R&D, Skills and Education	The South Korean government has invested heavily in R&D since the 1980s and provided incentives for private R&D. This has led to Korean conglomerates being committed to R&D[367]. Additionally, in 2017 the Ministry of Science and ICT committed funding of USD$150million for AI related R&D to be conducted by both the public and private sector[368]. The **2019 Budget Proposal** also aimed to increase the R&D budgets to KRW[369]20.4trillion with KRW1.7trillion dedicated to basic research on future technologies and KRW3.7trillion on SME R&D support[370]. These actions may help to maintain South Korea's leading position in automation. South Korea has recognised that automation leads to increased inequality and have aimed to overcome this through education. This has been driven from the Five-Year Economic Development Plans which included policies for human capital firstly focusing on developing literacy and then training and research[371]. As a result of the continued focus on education, 67.7% of the population aged 25-34 have post-secondary education; from this there is an estimation that only 6% of jobs in South Korea are deemed to be at risk of being displaced by automation[372]. More recently, South Korea reformed teacher training, assessments and updated the curriculum to incorporate the development of soft skills[373].

[365] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[366] OECD Development Centre (2012). *Industrial Policy and Territorial Development: Lessons from Korea*.

[367] OECD Development Centre (2012). *Industrial Policy and Territorial Development: Lessons from Korea*.

[368] Ibid.

[369] South Korean Won (KRW).

[370] Budget Proposal 2019 (2019). Available at: http://english.moef.go.kr/popup/180830/popup20180830.html (last accessed 9 July 2019).

[371] OECD Development Centre (2012). *Industrial Policy and Territorial Development: Lessons from Korea*.

[372] Choi, Y. and Baker, B. (2017). *The Impact of Automation on Business and Employment in South Korea*. IUP Journal of Supply Chain Management, 14 (4), p22-37.

[373] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at:

		Further support for skills and SMEs has been provided by the government offering university scholarships to students who will join an SME after graduation. The government aims to support SMEs utilising skilled workers to provide on the job training for new starts as well as using R&D centre retirees to provide expertise for SMEs facing technical difficulties thus allowing for knowledge transfer in a variety of ways[374].
	Business Support	The **2019 Outlook** also predicts a slowdown in exports due to concerns with trading partners such as Japan, the US and China[375] in order to maintain growth, welfare has been increased and investment policies developed. Whilst there has been a previous focus on export-led growth this has favoured the Capital Region and coastal areas leading to Gyeonggi and Seoul contributing the most to GDP resulting in regional imbalances. Regional development therefore has become a priority with a particular focus to increase education and business opportunities in rural regions through a bottom-up approach to address regional policies, allowing them to become more suitable and specific to each region[376]. This has included grants to local governments for education and has increased these grants by 11% in the 2019 Budget Proposal[377]. The renewed regional focus aims to increase social acceptance across the country towards automation as well as help to promote the 2019 goal of producing an economy that works for all[378]. The 2018 **Measures to Promote Investment and Support the Job Market** by the Ministry of Economy and Finance, which aim to help the economy gain momentum by increasing its private sector investments and increase employment. To achieve this the Measure include: funding to support projects suspended due to financial or regulatory difficulties; increasing public investment through projects such as infrastructure projects to improve transportation and distribution as well as projects to help local economies develop their own investments; support for struggling manufactures for instance promoting smart manufacturing in the textile industry and low interest loans for small merchants; aiming to create of 59,000 public sector jobs such as roles for young adults to gain experience;

www.automationreadiness.eiu.com (last accessed 3 June 2019).

374 Ministry of Strategy and Finance (2012). *Measures for Productivity Enhancement of SMEs to Build a 'Creative Economy'*. Available at: www.mosf.go.kr (last accessed 25 June 2019).

375 Ibid.

376 OECD Development Centre (2012). *Industrial Policy and Territorial Development: Lessons from Korea*.

377 Budget Proposal 2019 (2018). Available at: http://english.moef.go.kr/popup/180830/popup20180830.html (last accessed 25 June 2019).

378 Ministry of Economy and Finance (2018). *2019 Economic Policies*. Available at: http://english.moef.go.kr/popup/27_PolicyFocusBanner/popup.html (last accessed 25 June 2019).

		increasing job training support for unskilled workers[379]. The 2018 Measures have been supported by the 2019 Budget Proposal which included policies such as increasing job creation budgets by 22% with a look to continue increasing public sector jobs and the promotion of work-study and job training[380]. To support SME productivity the Ministry of Strategy and Finance increased funding for technology development of SMEs to be 18% of the R&D budget by 2017 and aimed to make it mandatory for government funded institutions to commit a percentage of their budget to R&D for SMEs to aid technology advisory and transfers and joint research[381].
	Inequality and Taxation	A limitation has been placed on previous tax incentives for businesses with automated machines. This limitation will downsize the tax deduction benefits that businesses have been receiving for infrastructure investment. Currently businesses can deduct 3-7% of an investment in automation from their corporate taxes; this new policy will decrease this by up to 2% points[382]. This deduction will help to make up for lost income taxes from human workers as well as aid welfare recipients[383]. The 2019 Economic Policies will increase tax incentives for investments for SMEs affected by restructuring[384] and continuing the reshoring project which aims to attract business with parts of their business based abroad back in to the country by providing investment support, corporate tax reductions and tariff reductions for capital goods imports.

[379] Ministry of Economy and Finance (2018). *Measures To Promote Investment And Support The Job Market*. Available at: www.moef.go.kr (last accessed 25 June 2019).

[380] Budget Proposal 2019 (2018). Available at: http://english.moef.go.kr/popup/180830/popup20180830.html (last accessed 25 June 2019).

[381] Ministry of Strategy and Finance. (2012). *Measures for Productivity Enhancements of SMEs to Build a 'Creative Economy'*. Available at: http://english.moef.go.kr/pc/selectTbPressCenterDtl.do?boardCd=N0001&seq=3300 (last accessed 25 June 2019).

[382] Abbott, R. and Bret, B. (2018). *"Should Robots Pay Taxes: Tax Policy in the Age of Automation."* Harvard Law & Policy Review, vol. 12, no. 1, pp. 145-176. Available at: https://heinonline.org/HOL/P?h=hein.journals/harlpolrv12&i=151 (last accessed 22 May 2019).

[383] Sung-Won, Y. (2017). *Korea Takes First Step to Introduce 'Robot Tax'*. Available at: www.koreatimes.co.kr (last accessed 20 May 2019).

[384] Ministry of Economy and Finance (2018). *2019 Economic Policies*. Available at: http://english.moef.go.kr/popup/27_PolicyFocusBanner/popup.html (last accessed 25 June 2019)

		The 2019 Budget Proposal included increasing welfare budgets by 12%, further support for employment protection and small business support[385]. These have not been developed as a direct result of automation but will help to deal with associated challenges that automation can bring.
	Lessons for NI	South Korea has achieved its leading position due to a long-term and sustained approach, this approach will be important to automation's implementation in NI. A major focus on R&D will help to develop automation technology and learning, helping to develop best practices and the most productive uses of this technology within NI. To ensure regional imbalances do not occur, it will be important that future policies understand the needs of local councils and that there are widespread opportunities in education and business across NI. Throughout the 2012 Measures to Enhance Productivity of SMEs a variety of approaches were taken to help SMEs gain skills, collaboration was cited continually throughout as a measure to aid the sharing of best practices with the overall goal to increase productivity[386].
Ireland	**Context**	Ireland does not have a direct automation strategy however it is preparing for a changing economy with a larger population through **The National Development Plan 2018.** This Plan involves commitments such as €116billion investment towards Ireland's infrastructure and investment needs over 10 years[387]. The success of this plan will help to generate an environment where new technology can prosper. The development of skills is further supported by the **National Skills Strategy 2025** including the **National Digital Strategy (NDS).** This National Skills Strategy involves steps towards creating a digitally enabled society with emphasis placed on increasing the use of the internet[388]. There is also an **eGovernment Strategy** which aims to use technology to improve the delivery of Government services to customers[389].
	R&D, Skills and Education	The Expert Group on Future Skills Need (EGFSN) recommends a co-ordinated and multisector approach across the private and public sector. EGFSN notes that Ireland currently has a lifelong learning participation

[385] Budget Proposal 2019 (2018). Available at: http://english.moef.go.kr/popup/180830/popup20180830.html (last accessed 25 June 2019).

[386] Ministry of Strategy and Finance (2012). *Measures for Productivity Enhancement of SMEs to Build a 'Creative Economy'*. Available at: www.mosf.go.kr (last accessed 25 June 2019).

[387] Government of Ireland (2019). *National Development Plan 2018-2027*. Available at: www.gov.ie (last accessed 31 May 2019).

[388] Department of Education and Skills (2016). *National Skills Strategy*. Available at: www.education.ie (last accessed 31 May 2019).

[389] EGFSN. (2018). *Digital Transformation: Assessing the Impact of Digitalisation on Ireland's Workforce.* Available at: www.skillsireland.ie (last accessed 23 May 2019).

		rate of 8.9%, Ireland is trying to increase this participation rate through further education and training programmes[390]. This is supported by programmes in the National Skills Strategy 2025 such as: **SOLAS 2018-2021**- This was developed in 2013 under the Further Education and Training Act and is responsible for managing, supporting and co-ordinating Further Education and Training (FET). SOLAS aims to develop programmes to meet the needs of learners, employers and the changing economy. SOLAS delivers online courses through eCollege Online Learning, this provides distance learning courses online to employer and adults, regardless of the individual's employment status[391]. SOLAS also conducts research to guide policy related to further and higher education. **Springboard+-** This programme offers 285 courses to 9151 participants for free. It is targeted at adults who need to reskill or upskill, courses are provided in conjunction with accredited partners such as Maynooth University who provide a Higher Diploma in Data Analytics[392]. Springboard+ is co-funded by the Government and European Social Fund. In 2019, Dublin City University's (DCU) Institute of Education launched a STEM Teacher Internship programme to equip student teachers with STEM industry skills and knowledge which can benefit their teaching practices. Internships are available in the Bank of Ireland, Microsoft, Intel and PwC[393], it is anticipated that by experiencing work outside of the classroom, student teachers may better understand how they can prepare children for the future of work.
	Business Support	The National Digital Strategy aims to encourage small businesses to get online through the **Doing More With Digital** policy. This includes a variety of measures, such as a 'trade-on-line' voucher scheme for small businesses with up to 10 employees, providing them with financial assistance of up to €2,500 along with training and advice[394]. Further support for businesses can be accessed through organisations such as the National Research Centre and Digital Hub Development, which can provide skills training, research and financial support[395].

[390] Ibid.

[391]SOLAS (nd). *What We Do*. Available at: www.solas.ie (last accessed 31 May 2019).

[392] Springboard+ Website (2019). Available at: spingboardcourses.ie (last accessed 1 June 2019).

EGFSN. (2018). *Digital Transformation: Assessing the Impact of Digitalisation on Ireland's Workforce.* Available at: www.skillsireland.ie (last accessed 23 May 2019).

[393]Dublin City University (2019). *STEM Teacher Internship programme connects teachers and industry at DCU*. Available at: www.dcu.ie (last accessed 3 June 2019).

[394] Department of Communications, Climate Action & Environment (nd). *Trading Online Voucher Scheme*. Available at: www.dccae.gov.ie (last accessed 23 May 2019).

[395] Department for Communications, Energy and Natural Resources (2013). *Doing more with Digital- National Digital Strategy for Ireland*. Available

		In 2013, Ireland appointed a **Digital Champion**, this person was to provide leadership and advice to stakeholders. The role also involved reviewing best practise from other Digital Champions and hosting workshops for key stakeholders to help deliver the National Digital Strategy[396].
	Lessons for NI	Ireland's skills development should be noted for its availability with opportunities available across the whole region as well as being accessible in terms of times and place. Programmes such as SOLAS and Ireland's eCollege[397] have helped to reskill or upskill individuals in remote locations and enable users to learn at their own speed as well as providing accredited training. Irish skills policies reiterate the need for curriculum to be developed in collaboration with government, industries and the education system. NI Universities can learn from DCU's STEM Teacher Internship programme[398] as it allows student teachers to learn industry skills that they would not gain in a classroom setting. This will be important to prepare future generations for the world of work.
Canada	**Context**	Canada is ranked Number 8 overall in the Automation Readiness Index[399] however a Deloitte survey found that only 16% of Canadian businesses have used AI technology since 2014, whilst only 4% of Canadians surveyed felt confident to explain what AI was and how it works[400]. Canada aims to be leader in AI and so in 2017 the **Pan-Canadian Artificial Intelligence Strategy** was launched to increase Canadian research capabilities through a partnership between the Canadian Institute for Advanced Research and three centres of excellence which will provide resources, support and talent for AI innovation and investment. Overall the Strategy's four goals are: to increase the number of AI researchers and skilled graduates in Canada; to develop scientific excellence in Canada's three centres for AI; to develop global thought leadership on the economic, ethical, policy and legal implication of advances in AI; and to support a national research community on AI[401].

at: www.dccae.gov.ie (last accessed 23 May 2019).

[396] Ibid

[397] SOLAS (nd). *What We Do*. Available at: www.solas.ie (last accessed 31 May 2019).

[398] Dublin City University (2019). *STEM Teacher Internship programme connects teachers and industry at DCU*. Available at: www.dcu.ie (last accessed 3 June 2019).

[399] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[400] Deloitte (2018). *AI adoption among Canadian businesses stagnant: Only 16 per cent of companies use AI, which remains unchanged since 2014*. Available at: www.deloitte.com (last accessed 14 June 2019).

[401] Canadian Institute For Advanced Research (CIFAR) (nd). CIFAR Pan-Canadian Artificial Intelligence Strategy. Available at: www.cifar.ca (last

		Canada's 2017 **Innovation and Skill Plan**[402] acts as a starting point to providing the right landscape in which automation can succeed through the growth of an innovative society as it focuses on the development of people and their skills. Therefore, the Innovation and Skills Plan will help to provide citizens and industries with a better understanding of technology and how it can benefit them to increase its usage in Canada.
	R&D, Skills and Education	The Innovation and Skills Plan aims to support Canadians with the development of their skills at every stage of their life. The Plan aims to achieve this through programmes such as CanCode which has worked with over 1 million students and 61,000 teachers to teach young people coding skills, these figures exceed the original target to reach 500,000 students by March 2019[403]. **The Innovation Superclusters Initiative** is investing CAN$950 million in five industry-led superclusters to help bridge the gap between research to commercialisation, to investment and business scale-up. These Superclusters represent businesses, post-secondary education institutions and investors with the overall aim to drive industry-led R&D and innovation as well as creating a link between larger firms and SMEs, to help SMEs scale up[404]. Additionally, **The Future Skills Centre** is a research-based centre which has been set up to help test and measure innovative approaches to identify Canada's future skills need. It has committed funding worth CAN$11.6million over two years, for six initial projects centred around innovation in collaboration with businesses and research organisations[405]. This Centre will help to maintain a constant focus on skills by providing up to date results of skills demanded, this information can be used to help inform policymakers, educators and businesses so they can develop skills in their sector for the future needs of the economy.
	Business Support	The Innovation and Skills Plan notes a continuous problem with businesses scaling-up, to overcome this **Innovative Solutions Canada** has been set up which involves the government contributing up to CAN$150,000 to support the development of an idea and later up to CAN$1million to develop a prototype

accessed 14 June 2019).

[402] Innovation, Science and Economic Development Canada (2019). *Building a Nation of Innovators*. Available at: www.canada.ca.innovation (last accessed 22 May 2019).

[403] Government of Canada (2019) *CanCode*. Available at: www.ic.gc.ca (last accessed 22 May 2019).

[404] Innovation, Science and Economic Development Canada (2019). *Building a Nation of Innovators*. Available at: www.canada.ca.innovation (last accessed 22 May 2019).

[405] Future Skills Centre (2019). *Innovation Projects*. Available at: https://fsc-ccf.ca (last accessed 20 May 2019).

		as well as the government being the first customer for of the product to assist with commercialisation[406]. This is specifically targeted at small businesses and innovators. Late stage capital has also been made available to help existing businesses grow through **Venture Capital Catalyst Initiative** with aims to increase CAN$1.5billion for venture capital[407]. These methods of helping businesses to grow are linked to automation because the Plan recognises that larger business invest more in R&D which may help to encourage more automotive practices and they also pay higher wages, have higher exports and have higher productivity[408]. The development of six **Economic Strategy Tables** aim to support innovation in advanced manufacturing, agri-food, health/bio-sciences, clean technology, digital industries and resources for the future. These tables have been established to improve industry and government collaboration to drive Canadian innovation to a global level by setting growth targets and identifying weaknesses with road maps being established to achieve goals[409] therefore helping to drive automation. **Futurepreneur Canada** is an organisation which supports business owners aged 18-39 through mentoring from a business expert. Support is given through financial assistance, pre-launch coaching to develop ideas in to practice and an online platform to help develop a business plan[410]. This type of policy will be beneficial for entrepreneurs to take the next step to develop their business idea, helping to encourage innovation.
	Inequality and Taxation	The Innovation and Skills Plan has a substantial focus on those currently under-represented in employment and training. The Prime Minister Trudeau aims to expand access to grants and interest free student loan to make it easier for people to upskill, particularly adults with children who financially need to remain in work but wish to learn new skills[411].
	NI Best Practices	From the Pan-Canadian Artificial Intelligence Strategy highlights the need for any future automation strategy to have a strong R&D element. A consistent and constant approach to R&D will help to create a culture of innovation as well as continued learning approach to automation and its best practices.

[406] Government of Canada (2019*). Innovative Solutions Canada*. Available at: www.ic.gc.ca (last accessed 20 May 2019).

[407] Innovation, Science and Economic Development Canada (2019). *Building a Nation of Innovators.* Available at: www.canada.ca.innovation (last accessed 20 May 2019).

[408] Ibid.

[409] Government of Canada (2017). *Economic Strategy Tables*. Available at: www.ic.gc.ca (last accessed 31 May 2019).

[410] Futurepreneur Canada (nd). Who We Are. Available at: www.futurpreneur.ca (last accessed 31 May 2019).

[411] Vanian, J. (2017). *Canada is preparing for automation. Here's how.* Available at: www.weforum.org (last accessed 20 May 2019).

		Further, The Innovation and Skills Plan identifies that a culture of innovation cannot be solely government driven and so policy aims to generate innovation through increased industry and citizen participation which has been incorporated through the development of skills. The constant development of skills at all stages of life will also be important to ensuring that there is citizen buy-in of automation. Canada has a good variety of support available for new and existing businesses, this indicates that a one-size fits all approach is not suitable when trying to drive innovation. Therefore, to help with the adoption of new technology a degree of flexibility is required in policies to suit the needs and sizes of different businesses.
Japan	**Context**	Japan is ranked Number 4 in the overall Automation Readiness Index[412], this achievement reflects Japan's social need to implement automation as a method of preparing to support its population's declining birth rate and ageing society[413]. Japan has developed **Society 5.0,** which aims to use data solutions to provide humans with a better quality of life by targeting the areas of healthcare, infrastructure, mobility and fintech[414] with the overall goal of creating a smart society. Additionally, directly linked to automation is the **New Robot Strategy** which prepares to integrate robots in to the daily part of people's lives and aims for Japan to set international standards in this area[415]. Japan is also ranked Number 1 for creating an Innovative Environment in the Automation Readiness Index[416], the achievement of this ranking has been supported by the creation of the Strategic Council for AI Technology in 2016 who have created the **Artificial Intelligence Technology Strategy[417]**.
	R&D, Skills and Education	Both the New Robot Strategy and Society 5.0 incorporate a focus on the development of human talent to produce industry specialists using a medium to long-term approach. This includes the involvement of businesses in the education process as well as aiming to increase the size of the labour force by promoting

[412] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[413] The Headquarters for Japan's Economic Revitalization (2015). *New Robot Strategy*. Available at: www.meti.go.jp (last accessed 24 June 2019).

[414] Keidanren (Japan Business Federation) (2016). *Toward realization of the new economy and society- Reform of the economy and society by the deepening of Society 5.0.* Available at: www.keidanren.or.jp (last accessed 20 May 2019).

[415] The Headquarters for Japan's Economic Revitalisation (2015). *New Robot Strategy*. Available at: https://www.meti.go.jp (last accessed 20 May 2019).

[416] The Economist (2018). *The Automation Readiness Index: Who is Ready for the Coming Wave of Automation?* Available at: www.automationreadiness.eiu.com (last accessed 3 June 2019).

[417] Future of Life Institute (nd). *AI Policy- Japan*. Available at: https://futureoflife.org (last accessed 21 June 2019).

		female participation and the acceptance of foreign workers[418]. The New Robot Strategy cites how technology will enable more women, elderly and young workers to find work in industries such as agriculture and construction as they perceive the working environment to be more attractive with the integration of technology to take over labour-intensive tasks[419]. In terms of school education, Japan aims to increase the integration of science and the arts, with a focus on STEAM subjects (Science, Technology, Engineering, the Arts and Mathematics). Recommendations by the Ministry of Economy, Trade and Industry include the need to allow children to think more which would change the role of a teacher to become more diversified[420]. Additionally, Japan aims to introduce **EdTech** which would increase the use of technology in schools allowing children to be connected to the international community and the economy[421]. Overall, EdTech foresees classrooms changing in to 'Class Labs' to increase science participation. For EdTech to be achieved some issues for review that have been noted include the need for support for school management and developing new teaching staff, organising information security rules in municipalities, ICT investment in schools and developing connection between schools and the 'real world' by increasing company involvement in education[422]. The AI Technology Strategy notes the shortage of AI technology researchers and personnel (data scientists/engineers) and so focus has been placed on fostering Human Resources. The Strategy aims to develop people through educational programmes to develop society already engaged in AI to improve their value creation in their current role/workplace. Also, by promoting joint research projects with global universities and industries; and continuing with previous approaches such as the retention of young researchers both from Japan and abroad by making Japan workplaces as an attractive place to remain and by increasing collaboration with joint research partners and exchanges with graduate schools and external researchers[423].

[418] Keidanren (Japan Business Federation) (2016). *Toward realization of the new economy and society- Reform of the economy and society by the deepening of Society 5.0.* Available at: www.keidanren.or.jp (last accessed 20 May 2019).

[419] The Headquarters for Japan's Economic Revitalisation (2015). *New Robot Strategy*. Available at: https://www.meti.go.jp (last accessed 20 May 2019).

[420] Ministry of Economy, Trade and Industry (2018). *The Study Group for Learning Innovation- "Future Classroom" and EdTech- Key Points of the Primary Recommendations*. Available at: www.meti.go.jp (last accessed 24 June 2019).

[421] Ibid.

[422] Ibid.

[423] Strategic Council for AI Technology (2017*). Artificial Intelligence Strategy (Report of Strategic Council for AI Technology).* Available at: www.nedo.go.jp (last accessed 21 June 2019).

		Additionally, the Strategic Council is responsible for co-ordinating three national R&D centres and five National R&D Agencies, overall helping to increase the cooperation of R&D by industry, academia and government. They noted the insufficient investment by both the private and public sector in R&D, having compared to the amount of research carried out by other countries such as Canada[424]. Additionally, The Research Coordination Council was created to develop linkages in R&D carried out by the government ministries; also established was the Industry Coordination Council to conduct surveys and investigations such as on developing the roadmap for industrialisation and areas such as data maintenance to aid towards R&D by the ministries and social implementation of other businesses[425],[426]. There are also distinct projects which are helping to prepare Japan for automation such as **Humanoid Robot Prototype (HRP-5P)** that has been developed to perform heavy labour or work in hazardous environments. The development of HRP-5P at this stage includes a R&D platform to continue the collaboration of industry and academia to help encourage R&D towards practical application of using robots at further working locations to help compensate for labour shortages and allow for humans to focus on high-value-added work[427].
	Business Support	The New Robot Strategy aims to create an innovation hub where domestic and foreign users can work together to test new robots and lead to further exploration[428]. The Strategy sets out a schedule of regulation reform for different sectors such as for medical automation, transport and consumer safety. These schedules aim to set standards and laws regarding the use of robots and technology as well as encourage the adoption of robots in to sectors[429]. The AI Technology Strategy incorporates the need for support for start-ups by creating an environment of open innovation and encourage collaboration of large and new companies to share best practices.

[424] Strategic Council for AI Technology (2017*). Artificial Intelligence Strategy (Report of Strategic Council for AI Technology).* Available at: www.nedo.go.jp (last accessed 21 June 2019).

[425] Future of Life Institute (nd). *AI Policy- Japan*. Available at: https://futureoflife.org (last accessed 21 June 2019).

[426] The Government of Japan (2018). *Artificial Intelligence: A Rival for Humans, or a Partner?* Available at: www.japan.go.jp (last accessed 21 June 2019).

[427] National Institute of Advanced Industrial Science and Technology (AIST) (2018). *Development of a Humanoid Robot Prototype, HRP-5P, Capable of Heavy Labor.* Available at: www.aist.go.jp (last accessed 24 June 2019).

[428] The Headquarters for Japan's Economic Revitalisation (2015). *New Robot Strategy*. Available at: https://www.meti.go.jp (last accessed 20 May 2019).

[429] Ibid.

		Approaches to this already include the **Japan Open Innovation Council** and the **Organisation for Small & Medium Enterprises and Regional Innovation**. There also needs to be the development of management know-how for start-ups because whilst personnel with technical/AI skills exist they may not have the management know-how to transfer this knowledge in to an organisation successfully. Further challenges facing companies include commercialisation using new technology and funding at early stages. Programmes already in place to overcome these challenges include the AI Challenge Contest and Technology-based Startup Support Program[430].
	Citizen Engagement	Society 5.0 has a social acceptance section which addresses social and ethical implications with technology, this is important to promote job mobility and new flexible ways of working[431]. There is already a high Cultural acceptance of technology in place due to Japan's previous history in developing technology and so technology usage has become a norm in society[432].
	Lessons for NI	Due to Japan's advancement in technology due to their social needs, NI policymakers should continue to monitor how Japan uses technology to help its ageing society, this will be important to guide policy as to how older workers can be incorporated in to the automation process. EdTech used in schools will help develop children's thinking skills and allow them to gain a wider perceptive of the world, again this highlights the need to adapt school curriculum to meet future technology needs and prepare children now as they are the workforce of the future. This preparation of children and their skills will be crucial to automation's long-term success. The Strategic Council for AI Technology notes the importance for continuous development of AI because AI will require a medium to long-term approach to be fully implemented and so development should not be stopped during a period of temporary boom[433]. Therefore, an oversight group such as the Strategic Council is beneficial to maintain momentum and update polices.
Finland	**Context**	Finland is not currently ranked on the Automation Readiness Index however, it has created an **Artificial Intelligence Programme** aiming to make Finland a leader of AI application. The Programme has been

[430] Strategic Council for AI Technology (2017*). Artificial Intelligence Strategy (Report of Strategic Council for AI Technology).* Available at: www.nedo.go.jp (last accessed 21 June 2019).

[431] Keidanren (Japan Business Federation) (2016). *Toward realization of the new economy and society- Reform of the economy and society by the deepening of Society 5.0.* Available at: www.keidanren.or.jp (last accessed 20 May 2019).

[432] Moss, D. (2017). *Graying Japan wants automation, not immigration*. Available at: www.japantimes.co.jp (last accessed 21 June 2019).

[433] Strategic Council for AI Technology (2017*). Artificial Intelligence Strategy (Report of Strategic Council for AI Technology).* Available at: www.nedo.go.jp (last accessed 21 June 2019).

		prepared by a steering group which was made up of industry leaders, government representatives and researchers. Sub-groups have also been developed focusing on expertise, innovations, ethics, society, work and data[434]. The steering group have analysed how other countries are preparing for AI and have used this to develop recommendations for Finland.
	R&D, Skills and Education	The AI Programme's steering group positively noted the co-ordinated nature of the education system which made it possible for Finns to react quickly to educational needs, this will be important as technology and skills need develop. The steering group suggested the need for different teaching methods in future such as online courses, virtual qualifications and virtual educational institutions. However, in terms of R&D a weakness noted was the slow nature of research to commercialisation and a reduction in R&D and innovation investments has led to a decline in private investments[435]. To support the demand for future skills free online course have been made available entitled 'The Elements of AI'[436]. Industries can partake in these year-long programmes to upskill their workers, on completion workers receive two academic credits from the Open University of Helsinki. In terms of skills development there is the digital school for entrepreneurs and AI encoding course offered by the Federation of Finnish Technology Solutions for companies and a Massive Open Online Course on AI by the University of Helsinki allowing course participants to learn AI basics[437].
	Business Support	AI development and its application in Finland has been industry led so far. To incentivise AI usage for SMEs Tekes innovation vouchers[438] are available which can be used for testing out AI and data solutions for a new product/service that requires external expertise[439]. Furthermore, the **AI Accelerator** model allows an organisation to identify an AI case within their organisation, they then work with academia, service providers and start-ups to develop AI-solutions to this case. This approach to testing technology allows the involved organisations to share learnings and pitfalls

[434] AI Finland (2017). Background. Available at: www.tekoalyaika.fe/en/ (last accessed 23 May 2019).

[435] Ministry of Economic Affairs and Employment in Finland (2017). *Finland's Age of Artificial Intelligence*.

[436] Helkkula, K. (2018). AI for all: How Finland (and other countries) are delivering free, accessible digital skills training. Nesta Available at: www.nesta.org.uk (last accessed 23 May 2019).

[437] Ibid.

[438] Ibid.

[439] Business Finland (nd). *Innovation Voucher*. Available at: www.businessfinland.fi (last accessed 25 June 2019).

		publicly[440]. This will be particularly useful to smaller organisations who may gain access to larger organisations and academic research which they may otherwise not have been able to.
	Inequality and Taxation	Finland has tried to tackle unemployment partially associated with automation through a **universal basic income trail**. This trail selected 2,000 unemployed people who were receiving unemployment benefits to receive a basic income instead for two years. The trail aimed to test if these individuals were incentivised to gain employment as they would continue to gain their basic even if they were receiving income from employment[441]. So far this trial has been deemed somewhat disappointing as the income and hours worked of those on the trail remained largely unchanged even though those on the trail had a higher incentive to gain more money, there was no significant difference between those who gained the new basic income and those who remained on unemployment benefits. Out-of-date skills were cited as a reason contributing to the results of this basic income trial as skills still prevented these individuals from gaining employment[442].
	Lessons for NI	The development of Finland's AI Programme again highlights the importance of collaboration and oversight required in implementing a large strategy which will ultimately impact the whole of society. Therefore, a collaborative approach ought to be taken from the outset so that all government agencies, industries and society understand how automation will impact the economy and the future of work leading to support. In terms of inequality, NI policymakers could continue to monitor countries such as Finland to better understand how automation impacts society and any negative consequences associated with automation so that these can be successfully dealt with.

[440] Finland's AI Accelerator (FAIA) (nd). *Finland's AI Accelerator*. Available at: https://faia.fi (last accessed 25 June 2019).

[441] Hiilamo, H. (2019). *Heikki Hiilamo: 'Disappointing results from the Finnish basic income experiment'.* University of Helsinki. Available at: www.helsinki.fi (last accessed 23 May 2019).

[442] Ibid.