Digitizing Canada's Advanced Manufacturing Sector: Reshaping Jobs & Skills

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About Future Ready

The Future Ready program is a $19 million program funded in part by Employment and Social Development Canada's Sectoral Workforce Solutions Program to support companies in onboarding new and diverse workers to Canadian manufacturing. The initiative will also aid Canadian manufacturers in identifying their critical skills gaps to support the future profitability and growth of their organization through NGen's highly regarded Transformation Leadership Program. Through these approaches, the program aims to provide demand-driven solutions for the manufacturing sector, one of the sectors hardest hit by the pandemic, and a key to the recovery of the Canadian economy.

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Introduction

Beginning in the 1970s, developments in computer technology, programmable logic controllers, and early automation paved the way to what is known as the Third Industrial Revolution in manufacturing. These technologies also laid the foundations for the Fourth Industrial Revolution (4IR), commonly referred to as Industry 4.0 (I4.0). I4.0 is in the process of transforming the manufacturing industry through digitization and interconnectivity between multiple parts of the supply chain, from production floors to administrative offices. Key technologies driving this transformation include autonomous robotics, advanced data analytics, Artificial Intelligence (AI), and the use of smart sensors. These innovations are not just changing how products are designed, produced, and consumed, but also how they are maintained and accessed by consumers. I4.0 is also enhancing transparency across the supply chain by integrating and connecting suppliers, manufacturers, customers and the product itself within its ecosystem[1].

I4.0 combines both mechanical and digital technologies to improve the flow of operations in manufacturing. It uses advanced technologies and AI for real-time data driven decision-making to optimize production and improve customer satisfaction. As with previous major industrial technological shifts, the digitization and automation accompanying I4.0 has the potential to increase productivity, alter skills and labour demands, improve the quality of goods, and reduce costs. In a time where manufacturers need to be able to adapt quickly to market changes and disruptions, and compete both regionally and globally, these emerging technologies can enable increased operational efficiency and greater product customization.

Canada's manufacturing sector has historically been a strong source of national economic growth and employment. In 2021, the sector accounted for more than 10% of Canada's gross domestic product (GDP)[2]. Over the past two decades, the sector has faced significant challenges due to events such as the Global Financial Crisis (2008 - 2009) and Covid-19, among other economically impactful events. Throughout these challenges, manufacturers worked to adapt to changes in economic and labour market conditions. More recently, the COVID-19 pandemic led to supply chain disruptions, pressuring manufacturers to innovate in order to operate within challenging conditions, and global competition. Amidst all these challenges, the sector is also dealing with an acute labour shortage driven by an aging workforce and retiring skilled workers. This has been impacting the sector's ability to operate and remain competitive. As a result, Canadian manufacturers will need to be forward-looking and anticipate their future employment needs as their operations adapt to new technologies and the shift in skills they require[3].

The adoption of emerging technologies amongst Canadian manufacturers has been slower than many other global manufacturing sectors[4]. A 2017 industry survey found that only 3% of Canadian businesses have fully implemented I4.0 projects, with another 36% partway through the process1[,5]. Other countries whose position at the forefront of digital technology in production is enabling them to far outpace other less advanced manufacturers worldwide. According to the Organization for Economic Co-operation and Development (OECD), Canada's gross fixed capital formation (GFCF)[6] only rose 6% between 2017 – 2022 which is significantly below the OECD average of 24.6%. GFCF in the United States grew at 26%, and 30% in the EU in the same time period5. Companies which have invested in implementing I4.0 technologies are seeing operational and productivity improvements throughout their organization. According to a survey conducted by McKinsey & Co., companies reported that undertaking their digital transformation was essential to improving efficiency and responding to disruptions. One example includes Infineon, a semiconductor products manufacturer in Singapore, which increased personnel efficiency by 50% using advanced analytics[7].

As I4.0 technologies reshape manufacturing operations, they bring forth significant changes to the nature of manufacturing jobs, the flow and type of tasks, and skills required, as the shift to digitization and automation machines introduces changes to the way work is performed. The implications of this shift are manifold. On one hand, there is a growing demand for advanced technical skills — such as programming, systems analysis, and technological troubleshooting — to manage and maintain sophisticated machinery and data systems. The integration of these technologies demands higher-level cognitive skills, including critical thinking, creativity, and problem-solving, to leverage the potential of I4.0 fully. On the other hand, these technologies may significantly affect labour-intensive occupations, altering the nature of their tasks or, in some instances, leading to the partial or full elimination of certain tasks.

This report delves into the core I4.0 technologies transforming manufacturing operations. It highlights the areas within the manufacturing sector that are being most impacted by these technological advancements, such as production lines, supply chain management, and product development. Subsequently, the report explores the evolving tasks and skill requirements of some manufacturing occupations with this adoption. By analyzing current trends and projecting future developments, the report aims to provide insights into how to prepare the workforce for the changing demands of an advanced manufacturing environment. Through this exploration, the report not only presents the challenges posed by these new technologies, but also the opportunities they present for innovation, job creation, and the upskilling of the workforce.

Technologies of Industry 4.0

I4.0 is the digitization and automation of production systems. Under I4.0, production systems are designed to sense, predict and interact with the physical environment in order to make decisions about production, maintenance, and process optimization[8]. The shift towards automation and data exchange involves collecting and processing data in real-time. This data then informs autonomous decisions aimed at optimizing the production process and enhancing customer satisfaction. The technologies associated with I4.0 consist of both physical and digital technologies. Physical technologies may include autonomous robots, smart sensors and microprocessors. Digital technologies include data analytics, the use of artificial intelligence (AI), and cloud computing. By integrating physical and digital technologies, companies can collect and use real-time data from a variety of sources to manage and enhance manufacturing operations and processes[9].

To assess the impact of I4.0 technologies on manufacturing operations, it's essential to first comprehend the emerging technologies of digitization and automation. Understanding these technologies is crucial for identifying the changes they will bring to the tasks and skills required in manufacturing occupations and how they integrate into the production process. I4.0 encompasses a range of technologies and systems that enable interconnection between the physical and digital manufacturing landscape. The following technologies are most commonly associated with I4.0 systems and are considered to have had significant impact within the manufacturing sector:

1. **Artificial Intelligence:** Artificial Intelligence (AI) empowers machines to learn from data and improve over time, enabling them to execute tasks and make decisions akin to human intelligence and reasoning. It's particularly advantageous in manufacturing for its rapid, precise decision-making, which is crucial for forecasting, outlier analysis, and efficiency improvements such as predictive maintenance and inventory management[10, 11].
2. **Smart Sensors:** Smart sensors are advanced electronic components that transform physical data into digital signals, enabling on-site processing and analysis for immediate decision-making. Unlike basic sensors, they integrate digital sensors, processors, and communication tech to relay actionable insights, enhancing supply chain visibility and optimizing production and distribution[12].
3. **Internet of Things (IoT):** The Internet of Things (IoT) connects diverse devices over the internet, facilitating interaction and decentralized, real-time decision-making through built-in computing. In manufacturing, IoT boosts productivity by harnessing data from production, aiding in predictive maintenance, and integrating customer feedback into

design, enhancing the customer experience[1,13].

4. **Big Data and Analytics:** Industry 4.0 digitization enables the accumulation and management of large datasets throughout the supply chain. Big Data and Analytics involve analyzing these vast datasets to uncover patterns and insights, thus enhancing error detection, production quality, and supply chain efficiency. Sharing data across firms further refines AI algorithms and ensures the peak performance of data-driven applications[1,14,15].

5. **Cyber Security:** Digital transformation in manufacturing brings the risk of cyber-threats, which can damage systems, products and jeopardize important data. Cybersecurity safeguards systems against these threats. In manufacturing, cybersecurity extends to Operational Technology (OT), which is critical to plant and product security. Increasing threats necessitate real-time intrusion detection and often require external support for incident response[16, 17].

6. **Autonomous Robotics:** Robots in manufacturing are becoming increasingly adept and collaborative. Equipped with smart sensors and with access to AI capabilities, these robots are able to make autonomous decisions and learn from their surroundings, thus enhancing efficiency, precision, and safety. By assisting humans, they reduce the need for manual labour and minimize the risk of injuries. In certain scenarios, tasks can be fully automated, leading to increased productivity[17, 18, 19].

7. **Cloud Computing:** The cloud centralizes data management and services for manufacturing, streamlining processes and supply chain integration. Its full business potential, beyond just tech and security, remains largely untapped. Cloud adoption facilitates scaling, IoT, and AI-enhanced operations through varied service models[20, 21, 22].

8. **Simulation:** Simulation modeling streamlines design and testing, offering cost savings and process optimization in manufacturing. It helps reveal pinpoint bottlenecks and optimize labour input. Despite the challenges of time and expertise needed to develop valid models, simulations significantly boost performance and accelerate new product introduction[23, 24].

9. **Virtual Reality (VR)/Augmented Reality (AR):** 2D and 3D graphics via AR on devices like tablets and glasses enhance production by providing real-time data and instructions to workers. This technology is key for error-sensitive industries like automotive and aeronautics, boosting productivity, accuracy, and decision-making quality[25, 26].

10. **Additive Manufacturing:** Computer-aided manufacturing (CAM) processes create parts or components by adding layers of materials. A common method is 3-D printing, which has advantages in small batch production, as well as prototyping and customized products. As an efficient and cost-effective method, additive manufacturing is being utilized in many industrial contexts[1].

Industry 4.0: Areas of Impact on Manufacturing

The list of technologies most commonly associated with I4.0 provide an overview of the main types of technologies that are currently employed by manufacturers and those predicted to become widespread in the sector. These technologies help manufacturers stay on the cutting edge of production processes while improving the product, customer experience, and economic gain. Below are some of the main areas of the production that I4.0 can impact:

Decarbonization

Advanced technologies can help Canadian manufacturers work towards national decarbonization goals. Combined, all I4.0 technologies contribute to higher accuracy and improved process efficiency. For example, additive manufacturing can improve sustainability by enhancing quality, conserving resources, and increasing efficiency as it reduces waste and enables customization. Simulations, big data analytics and AI optimize production efficiency and reduce energy use by predicting production outcomes and detecting defects. IoT bridges OT-IT (operational technology and information technology), enhancing quality and inventory management, while cloud computing powers machine learning and AI, enabling dynamic, market-responsive manufacturing. Finally, VR/AR in training cuts errors and assembly time, improving energy efficiency. Altogether, these advanced I4.0 technologies enhance efficiency, quality, and sustainability, playing a crucial role in steering manufacturers towards achieving decarbonization goals while maintaining competitive and responsive production systems[20, 27].

Automation

I4.0 technologies in automation, including autonomous robotics, smart sensors, and AI, are transforming production by enhancing customization, increasing speed and accuracy, and reducing labour costs and errors. Flexible automation employs intelligent robots to handle increasingly complex tasks, thereby reducing the physical labour required while boosting both speed and accuracy. The ability to make real-time adjustments in production is crucial for modern manufacturing, as it minimizes downtime and speeds up the output of customized products. Central to this are AI and machine learning, which analyze data to make strategic decisions and optimize performance. In an era where markets demand rapid scalability, I4.0-driven automation not only supports growth, but also maintains quality and eases workforce strain, signaling a shift from traditional automation to a more adaptive, economically beneficial model[20, 28, 29].

Supply Chain

In a global market, flexible supply chains with I4.0 technologies enhance connectivity, responsiveness, and coordination from raw materials to delivery, ensuring quality and demand fulfillment. By aligning front, middle, and back-office operations, manufacturers are able to meet market demands with efficiency and accuracy. Packaging, customization, and overall experience now drive customer loyalty, necessitating that companies monitor customer perceptions via direct customer-production interaction and social media to maintain authenticity. Aligning all company aspects with customer promises balances expectations and profitability. I4.0 digitizes supply chain management through real-time data and data analytics for advanced planning and predictive analytics for accurate forecasting and responsive production. Industry 4.0 creates a supply chain management system that is transparent, responsive, dynamic, and able to meet the demands of the current and future markets[30].

Customer Experience

Customers are no longer simply expecting a product; they are interested in and drawn towards companies that provide an experience. I4.0 technologies enable efficient response to queries, customization, and trend prediction. Using big data analytics, customer preferences are gathered from online purchases to inform AI, IoT, and machine learning-driven production scaling, ensuring that in-demand products remain readily available. Digital automation and AI handle customer interactions, turning feedback into actionable insights. VR/AR can also create virtual product trials and offer immersive and interactive experiences that allow customers to engage with products in a simulated environment to foster customer trust and product transparency. IoT advances also enable the detection of potential product defects early in the production cycle[31].

Product Development and Customization

The evolving landscape of I4.0 significantly enhances product development and customization. As consumer demand shifts towards personalized products and expedited delivery, the role of flexible supply chains and cutting-edge manufacturing techniques becomes crucial. A key technology driving this change is additive manufacturing, which facilitates the creation of products such as custom-made medical implants. This integration of operational and information technology allows for more complex and customer-specific solutions[9].

Labour

As parts of the manufacturing process become increasingly digitized and automated, many existing jobs will change as the associated tasks are altered, or in some cases eliminated. Demand for highly-skilled occupations will arise out of the need to support and maintain the new technologies incorporated through the manufacturing processes. New job skills may be required to perform certain tasks and will result in the need for re-skilling and up-skilling of the existing labour force. The emphasis placed on highly-skilled workers can potentially lead to higher wages for those with the requisite skills. The shift away from physical demanding jobs may also open up the manufacturing to appeal to a more diverse workforce which will require companies to ensure environments are equity and inclusion focused. The introduction of advanced robotics, AI and data analytics will also lead to increased safety and reduced workplace hazards[3,4].

Industry 4.0: Areas of Impact on Manufacturing

All the advantages and benefits offered by I4.0 technologies suggest an exciting future for the Canadian manufacturing landscape. However, these changes to manufacturing production processes will also impact its labour force. Many current occupations will adapt to include the use of new technologies. Production will also require highly-skilled workers with training to operate and maintain I4.0's advanced technologies. In order to make a smooth transition to utilizing new technologies, understanding the potential impact on the labour force and preparing for evolving worker demands is crucial. On one hand, despite the current labour shortage in manufacturing, a common concern is that increased automation and digitization may result in significant job losses, as some occupations may become entirely automated and cause manufacturing jobs to be eliminated[32]. On the other hand, a more optimistic perspective is that few jobs will be lost but work activities will change with varying impact across occupations. These variations in outlook are made clear by two commonly cited studies on the future of occupational automation (Figure 1. & Figure 2., Appendix A). Frey & Osbourne analyzed the probability of different occupations being automated in the future, suggesting that as machine learning and automation become more feasible, jobs will become increasingly automated, with some jobs being phased out. McKinsey & Co conducted a similar analysis which showed that almost all occupations will be impacted by the introduction of I4.0 technologies but the degree of impact will vary among occupations (Appendix A)[30, 33]. McKinsey predicts that occupations which will be potentially significantly impacted are those that involve routine and repetitive physical tasks, simple calculations and data processing, as these tasks are easily automatable with existing technologies. Jobs in unpredictable environments or highly variable tasks such as social interactions, managing people, and applying expertise such as engineering, will be less impacted as the constituent tasks are more difficult to automate. The impact on employment will vary by occupation, with certain roles seeing significant transformation and others less so due to factors such as technical feasibility and cost.

As some manufacturing tasks are potentially altered to operate and maintain some more advanced technologies, the skills required by manufacturing jobs under I4.0 will also be impacted and will potentially change. This implies that manufacturers will need to identify the upskilling and reskilling needs to equip their workforce with the necessary skills and knowledge to operate I4.0 technologies. New entrants into the manufacturing sector may also see the required skills for positions change to include new skills, and training and education programs will need to adapt to prepare students and workforce entrants for new skill demands. Understanding the required skills and identifying who needs them will enable companies to develop strategies for facilitating in-house learning and development.

Methodology

To assess the impact of I4.0 technologies and their potential to automate tasks in Canada's manufacturing sector, data was drawn from two studies on job automation. Frey & Osbourne analyzed the susceptibility of entire occupations to automation. They used a machine learning model, combined with data from the O*NET database, to evaluate jobs based on factors like routine, creative and social intelligence requirements, and perception-manipulation tasks. Their study highlighted that occupations with routine tasks were highly automatable, while those needing creative and social skills were less so[33]. Another McKinsey & Co. study on job automation adopted a task-based approach, analyzing the proportion of work activities across various occupations that could be automated with existing technology. It highlighted the evolving nature of work and skill requirements, emphasizing that while some jobs may be fully automated, many will change as certain tasks within them become automated, thereby reshaping the work landscape[29].

While both the Frey & Osborne and the McKinsey studies used the United States Standard Occupational Classification System (SOC) in their analyses, a detailed study or analysis on the automation susceptibility of jobs using Canada's National Occupational Classification (NOC) has not been performed. Frenette & Frank (2020) examined the potential impact of automation on Canadian workers by applying a task-based methodology similar to the one used by Arntz, et. al. and Frey & Osbourne[34], [33]. Their analysis provided an overview of the potential impact on jobs looking at variables such as education, age, and general occupation types but did not provide the granular examination of specific occupations within the manufacturing sector. The findings of Frey & Osbourne and McKinsey & Co, were employed in this report utilizing a crosswalk methodology to map occupations from the SOC system onto Canadian NOC system, allowing for the application of analyses findings to the Canadian occupational framework[35]. This approach can provide a general understanding of the potential impact of automation on various Canadian manufacturing occupations.

To select which manufacturing occupations from the NOC system to include in this study, the proportion of occupations in each manufacturing industry within the manufacturing sector was calculated. This analysis utilized the North American Industry Classification System (NAICS) at the 4-digit level. The proportion of people employed in each of the 516 NOC occupations within each manufacturing 4-digit NAICS was calculated to determine which NOC occupations accounted for the largest number of people employed in each industry. The cut off for inclusion was at least 1 % of total number of employed in each NAICS category, this resulted in a list 184 occupations found in Appendix B. Automation scores from Frey & Osbourne and McKinsey were applied to the list of 184 using the crosswalk methodology described above. To examine the relationship between automation and different types of work, occupations were sorted based on NOC occupational categories, designated by the first digit of the NOC code[36]. In this analysis, the second and third NOC digit level codes were used for some categories to better capture the variation of manufacturing occupations (Appendix C). These broad occupational categories reflect the type of work performed or the sector of activity. In addition, they reflect the training, experience or education required for entering the occupation. This includes the educational background, and in some cases, the specific industry experience required, especially where progression through an internal job hierarchy is involved. These categories provide a way to distinguish between different segments of the type of work performed throughout the advanced manufacturing sector. By grouping occupations this way, the relationships among different types of occupations with similar skills levels and training requirements can be examined. Data on employment and wages was applied to examine the relationship between the automation potential of various occupations and their respective employment numbers and wage levels in the Canadian manufacturing sector. The median hourly wage was obtained from 2022 Statistics Canada Labour Force Survey data from[37]. Median was used as opposed to average as it is less sensitive to outliers and provides a more unbiased representation of wages. Employment data was retrieved from Canadian CENSUS data. Overall, this information can also assist in planning for future workforce challenges with the introduction of new technologies, and the changes to the tasks and skills of the workforce under advanced manufacturing systems.

To better understand the necessary skills for these evolving occupations under advanced manufacturing and I4.0, this study employed job data scraping as a tool to identify these key technical skills and competencies. Job data scraping is the automated process of collecting jobs posting data from websites such as career sites or company job postings. The data is then cleaned and categorized to provide better insight into current job requirements and trends in manufacturing. For this study, the analysis was applied to job postings for 10 key jobs for advanced manufacturing and I4.0 within Canada's manufacturing sector. The jobs selected for this analysis included jobs which fall under production, skilled trades, engineering and supervisory occupations. These jobs were chosen based on current job postings for positions that indicate the requirement of new skills related to Industry 4.0 technologies and to represent the range of skill level and type as well as training and education required by occupations within the sector. The selection was aimed to capture jobs that are directly tied to industry 4.0 technologies (Data Scientist, Cyber Security Specialist and Cloud Engineer), as well as jobs that currently exist and will be impacted by industry 4.0 technologies. The skills for each job were then sorted into skills categories as outlined by the O*Net database and system. The result of the job data scraping analysis is an up-to-date and comprehensive list of the skills that are key for advanced manufacturing and I4.0 technologies.

Results

The assessment of the impact of I4.0 technologies and their potential of automating tasks in Canada's manufacturing sector, drawing from both the Frey & Osborne and McKinsey studies, provide significant insights into understanding automation's potential impact on various manufacturing occupations. The results of this study are summarized in Figures 1 and 2. The detailed findings of this report can be found in Table 1 in Appendices A and B.

Frey & Osborne's research provides an important perspective on the susceptibility of certain occupations to automation, particularly highlighting the vulnerability of jobs involving routine tasks. Their analysis indicates that roles characterized by repetitive and predictable processes, such as those in production, transportation, logistics, and office support, face a high risk of automation. This trend suggests a decreasing demand for routine skill sets and an increasing need for skills centered around creativity, problem-solving, and social intelligence. Jobs that require these more complex and nuanced abilities appear less prone to automation, indicating a shift in the manufacturing workforce towards more innovative and interpersonal skill sets[33].

McKinsey's task-based approach offers additional granularity, revealing that a substantial proportion of tasks within various manufacturing occupations could be automated with currently available technology. This finding does not necessarily signal the complete elimination of these jobs but points to a significant transformation in their nature. Particularly, tasks that are manual, repetitive, and predictable are identified as more susceptible to automation. This shift is likely to result in a change in job roles and responsibilities, emphasizing tasks that require human judgment, creativity, and social interaction[18].

In their analysis, Frey & Osborne concluded that 47% of occupations were at risk of being automated in the future. They identified that occupations involving a large number of routine tasks were at higher risk, while those requiring creative intelligence, social intelligence, and perception and manipulation skills were at lower risk. This assessment aligns with the findings of McKinsey & Co., which estimated that 45% of work activities could potentially be automated using current technology. It is important to note that some of the discrepancies in the automation and computerization impact scores of individual occupations between these two studies can be understood by the divergence in method of analysis of each study. Frey and & Osbourne analyzed the likelihood of entire occupations being automated whereas McKinsey & Co. looked at the proportion of tasks within an occupation that could be automated. It is also important to note that both of these studies were conducted prior to the most recent advances in artificial intelligence language models which are capable of performing tasks beyond what had previously been anticipated, yet they remain the best source of data on occupational automation to date.

In the context of manufacturing, both studies predict that, Technical Trades (73% impacted tasks according to McKinsey & Co. and 82% according to Frey & Osbourne), Manufacturing Assemblers and Operators (82% according to McKinsey & Co. and 85% according to Frey & Osbourne) and Manufacturing Labourers (98% according to McKinsey & Co. and 75% according to Frey & Osbourne) will be among the top three most potentially impacted occupational categories. Both occupational groups of

Manufacturing Assemblers and Operators, and Manufacturing Labourers encompass a significant portion of the manufacturing workforce, and are characterized by tasks that are highly susceptible to automation. Manufacturing Assemblers and Operators include occupations such as Foundry workers and Machining tool operators, both with over an 85% potential impact according to both studies. Similarly, Manufacturing Labourers include occupations such as Labourers in metal fabrication and Labourers in rubber and plastic products manufacturing which will also be significantly impacted by digitization and automation technologies.

According to both studies, management occupations, which includes Senior Managers, Managers in Engineering, and Manufacturing managers and supervisors are among the least impacted by digitization and automation technologies. The overall impact for these occupations is below 35% according to both studies. However, the results show that even the highest earning occupations such as Chief executive officers can have estimated 20% of work activities that can be automated.

For the occupational group of Sciences and Engineering occupations, automation probability ranges between 8% and 30%, while automation probability for Sciences and Engineering Technical occupations ranges between 35% and 45%. These two groups include occupations such as Electrical engineers, Industrial engineers, Mechanical engineering technologists and technicians, and information systems testing technicians which face a more moderate impact compared to production and trades occupations.

Appendices A and B provide further details on the impact of automation and digitization on individual occupations. In Appendix A, 24 charts summarize the results of the impact of new technologies on individual occupations per Frey & Osborne, and McKinsey & Co. Impact by occupation data are also presented along with the median hourly wage of each occupation. This data presentation allows for an exploration of the correlation between the potential impact of automation and digitization on specific occupations and their respective wage levels. In examining the general trend, it becomes clear that jobs with a higher potential for automation are typically associated with lower median hourly pay rates.

The task-based approach of McKinsey's analysis reaffirms the importance of upskilling and reskilling, and preparing the workforce with the adequate technical skills to perform the new tasks required. For this reason, the second part of this study employs job data scraping and analysis to present a snapshot of the key skills and competencies crucial for roles in Canada's advanced manufacturing sector within the context of Industry 4.0, providing an up-to-date and comprehensive overview of the technological and system competencies required (Appendix D). The findings, categorized per O*Net job skills classifications, indicate a wide spectrum of proficiencies spanning basic, social, system, resource management, and technical skills.

For roles such as Data Scientists and Cloud Engineers, there is emphasis on data management, programming, cloud services, and infrastructure development. Skills like SQL, NoSQL, Python, machine learning, cloud services, and cloud security are highly emphasized in job postings, underlining the digital and analytical orientation of these positions. Similarly, Cybersecurity Specialists are expected to possess a deep understanding of information security practices, network and IT infrastructure, and proficiency in operating systems and platforms, highlighting the importance of safeguarding digital assets in an increasingly interconnected manufacturing landscape.

Industrial and Mechatronic Technicians, on the other hand, exhibit a need for robust systems knowledge, hands-on experience with automation, robotics, and comprehensive understanding of control systems and operational technology, including PLC programming and CNC machinery. For jobs falling under trades and production occupations, Motor Vehicle Assemblers and Robotic Welders are characterized by a mix of manual dexterity, quality control, and familiarity with automation programming and robotic processes, indicating the integration of traditional manufacturing skills with new technologies. It is important to note that Motor Vehicle Assemblers is the one occupation that is traditionally not associated with high levels of digital literacy however, as the results of job data scraping and analysis shows, over half of the sought-after skills involve computer literacy. This indicates that throughout the manufacturing process there is already a demand for workers to have digital skills that go beyond basic office productivity software.

Figure 1. Probability of Automation by Occupational Categories (McKinsey & Co. 2016

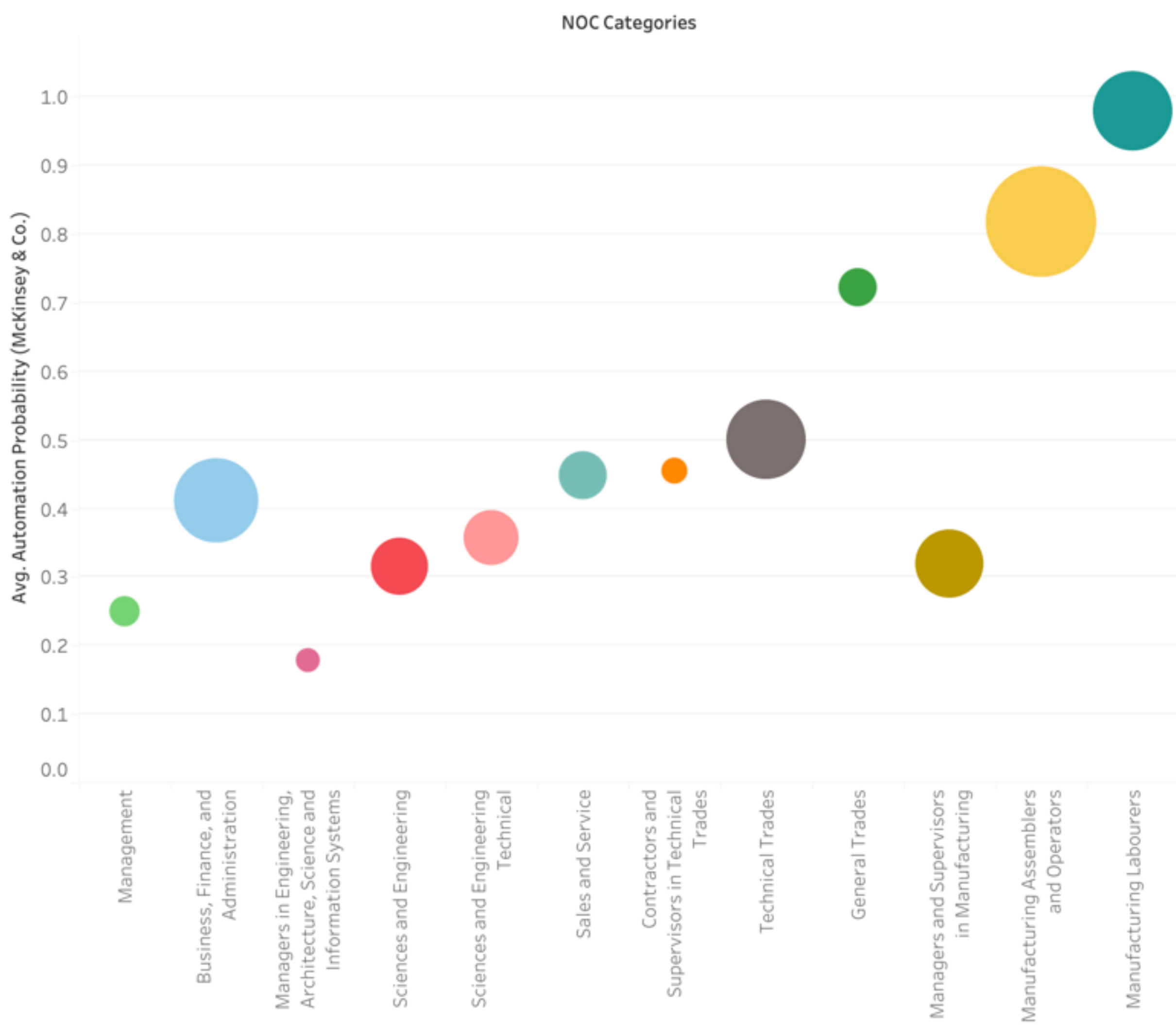
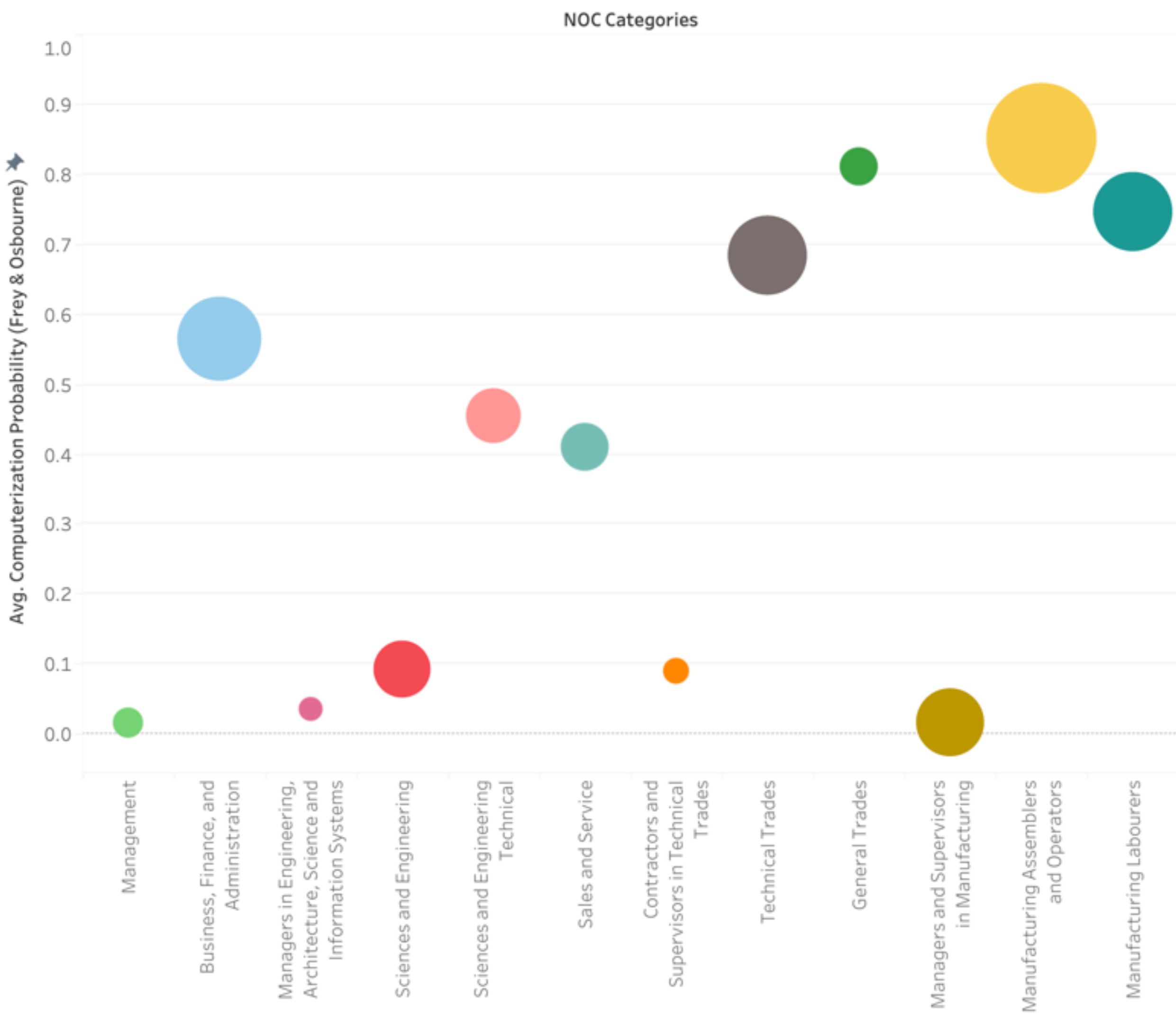


Figure 2. Probability of Automation by NOC (Frey & Osbourne, 2013)



Discussion: Automation and Job Skills

The assessment of the impact of automation and digitization, drawing insights from both studies by Frey & Osborne and McKinsey & Co., provides a comprehensive overview of how I4.0 technologies might affect various occupations and their individual tasks within Canada's manufacturing sector. The integration of new digital technologies and increased automation associated with I4.0 will affect a wide range of roles in the manufacturing sector with the degree of impact differing across occupations. While these studies laid the groundwork in assessing the impact of automation on occupations, they fell short in detailing how specific I4.0 technologies can potentially reshape the tasks of individual occupations. The data drawn from the job data scraping analysis performed in this study assists in detailing some of the changes introduced by I4.0 to manufacturing jobs.

Industrial, mechanical, and electrical engineering roles, for instance, are increasingly pivotal in the advanced manufacturing sector, especially with the integration of I4.0 technologies. Their role now extends beyond traditional engineering tasks, as they are central to embedding smart sensors and predictive analytics into manufacturing processes. This integration is key to enhancing production efficiency and anticipating maintenance needs. Engineering roles are now required to have a dual expertise: a deep understanding of fundamental engineering principles, along with proficiency in data analytics and their software. Engineers now are tasked to analyze data from sensors to optimize machine performance and anticipate potential breakdowns, thereby reducing downtime and increasing productivity. Their skills in data interpretation and application are crucial in making real-time adjustments to manufacturing processes, leading to smarter, more efficient production lines. This shift in their role signifies a move from purely mechanical or electrical work to a more data-driven approach in engineering, reflecting the increasingly interconnected nature of modern manufacturing systems.

Welders, traditionally known for their manual dexterity and precision, are also adapting to the new manufacturing environment. The introduction of robotic welding arms has transformed their job role from one that is purely manual to one that blends manual skills with technical know-how. This change means that welders now need to be skilled in programming and operating these robotic arms, which involves a deep understanding of the machine's interface, its capabilities, and the software that controls it. Their ability to adapt to this technology is critical in ensuring high-quality welding in automated production lines.

Similarly, tool and die makers are undergoing a transition in their skillset due to the integration of additive manufacturing technologies. With the increasing use of CAD/CAM (Computer-Aided Design and Computer-Aided Manufacturing) software, these professionals are now required to design and manufacture tools and parts using these digital platforms. This shift demands not only proficiency in the software but also an understanding of the principles of additive manufacturing. This includes knowledge of materials, design for additive manufacturing, and the operation of 3D printing machinery. The ability to quickly produce prototypes and tools using these methods is revolutionizing the way tool and die makers contribute to the manufacturing process, allowing for greater flexibility and efficiency in production.

Mechanical assemblers in the advanced manufacturing sector are also experiencing a significant shift in their roles due to the introduction of I4.0 technologies. Historically focused on manual assembly tasks, they are now finding themselves in charge of overseeing and maintaining automated and digitized assembly lines. This new role requires them to be proficient in operating and troubleshooting robotic systems, and to have a strong understanding of quality control systems to ensure the products meet the required standards. As automation becomes more prevalent, their expertise in these areas is becoming essential for the smooth operation of manufacturing processes. Quality control inspectors will also be adapting to new technologies. Automated systems powered by AI are expected to take over routine checks for defects, requiring inspectors to manage and interpret the results of these systems.

Even senior management roles are also being reshaped by I4.0 technologies. Beyond strategic oversight, there is an increasing emphasis on data-driven decision-making and the ability to understand and leverage insights from big data analytics, transforming senior managers into leaders who can navigate both the physical and digital fields of manufacturing.

While some existing jobs will change dramatically, new job titles created by emerging technologies will require new skillsets and training. For this reason, the role of human resources and training specialists will be crucial in identifying the new skills needed within their organizations. They must develop training programs that equip the current workforce with the necessary skills to thrive in advanced manufacturing.

These trends indicate a clear shift in job descriptions and the potential emergence of new job titles that reflect the blend of technical, digital, and problem-solving skills necessary for advanced manufacturing. As manufacturing processes become more intertwined with digital technologies, the workforce is expected to adapt, highlighting a need for upskilling and reskilling initiatives tailored for emerging and existing roles. The job data scaping analysis reveals a demand for workers who are not only proficient in the use of office productivity software but also capable of engaging with specialized applications and tools, underscoring the shifting baseline of skills required across the manufacturing sector.

The benefits of integrating emerging technologies are not limited to improving cost and production efficiency but can also help manufacturers work towards decarbonization goals. The transition to more sustainable practices with the help of I4.0 technologies will likely lead to the emergence of new skills and specialized roles. To meet Canada's net-zero targets, there will be a demand for skilled tradespeople such as electricians, mechanics and plant operators who will employ the skills of testing, installing, maintaining, repairing and decommissioning various areas of industrial facilities. Project managers who specialize in decarbonization will be needed to coordinate and supervise the transformation of the production process. As the focus shifts to alternative energy sources, there will be a growing demand for experts in fields like bioenergy, biomanufacturing, carbon management, energy efficiency and hydrogen. These clean energy specialists will be involved in research and development, as well as implementation of clean energy technologies [27]. Decarbonization in manufacturing represents a significant shift in industrial practices and will also offer new job opportunities and the development of new skills.

Barriers in Adopting Industry 4.0 in Canada's Manufacturing Industries

As Canadian manufacturing industries strive to integrate I4.0 technologies, they face multiple barriers that can impede their progress. Adopting I4.0 is financially demanding for Canadian manufacturers, particularly small and medium-sized enterprises (SMEs). The costs associated with modernizing machinery, integrating advanced IT systems, and establishing robust cybersecurity are significant. This not only involves procuring new equipment but also updating existing systems to become 'smart' and interconnected, as well as investing in cybersecurity to safeguard against increasing digital threats. Such investments can be a substantial financial burden for SMEs with limited capital, posing a significant barrier to embracing Industry 4.0 and its associated benefits.

Another key obstacle is the skills gap. The rapid advancement of technology in some cases might also have outpaced the development of a skilled workforce capable of managing and maintaining I4.0 systems. Educational institutions are challenged to update curricula and training programs quickly enough to meet the demand for skills such as data analytics, machine learning, and advanced robotics. Finding candidates with the appropriate skills and retraining current workers might be a challenge. Canada's sectors and industries are already challenged by labour shortages and are already grappling with a limited pool of skilled candidates who possess the advanced technical competencies necessary for I4.0 roles. This shortage is exacerbated by an aging workforce and the difficulty in attracting younger generations to manufacturing careers.

Technological and technical barriers, such as connectivity and integration issues, can also pose significant barriers when adopting I4.0 technologies. The transition to a smart factory requires seamless communication between devices and systems, which can be difficult to achieve, particularly in older facilities with equipment that may not be compatible with new, smart technologies.

Overcoming these barriers will require coordinated efforts across the industry, including investment in technology and training, updates to educational curricula, and a focus on attracting skilled workers. To bridge the gap, public-private partnerships will be key, leveraging government support and a strategic approach to technology adoption, focusing on critical improvements and shared experiences. As I4.0 becomes increasingly essential for competitiveness on the global stage, the ability of Canada's manufacturing industries to navigate these challenges will be critical to their success. To stay competitive, Canadian manufacturers must embrace advanced technologies, necessitating government-facilitated support and information exchange for technology adoption and workforce training. Without this, Canadian manufacturing risks falling behind in the global market

The introduction of I4.0 and its associated technologies in Canada's manufacturing sector is set to introduce significant changes to a multitude of areas including operational efficiencies, product innovation, supply chain management, and environmental sustainability. This shift also involves changes, which in some cases are significant, in the nature of occupations within manufacturing. This may involve altering job tasks and skill requirements, and introducing new opportunities for innovation, job creation, and workforce upskilling. Furthermore, as some operations become increasingly automated and digitized, there is a growing demand for skills in areas such as autonomous robotics, data analysis, and digital fluency.

The adoption of I4.0 technologies, while slower in Canada compared to other global counterparts, is progressively enhancing operational efficiency, product customization, and supply chain transparency. This shift is not without its challenges, such as the acute labour and skills shortage and the need for significant investments in training and technology. However, the potential benefits, including increased productivity, quality improvement, cost reduction and meeting decarbonization goals, are substantial.

As the sector adapts to new technologies, the workforce must also evolve. There is a growing demand for advanced technical skills alongside higher-level cognitive abilities like critical thinking and problem-solving. The shift away from labour-intensive occupations is opening the manufacturing sector to a more diverse workforce.

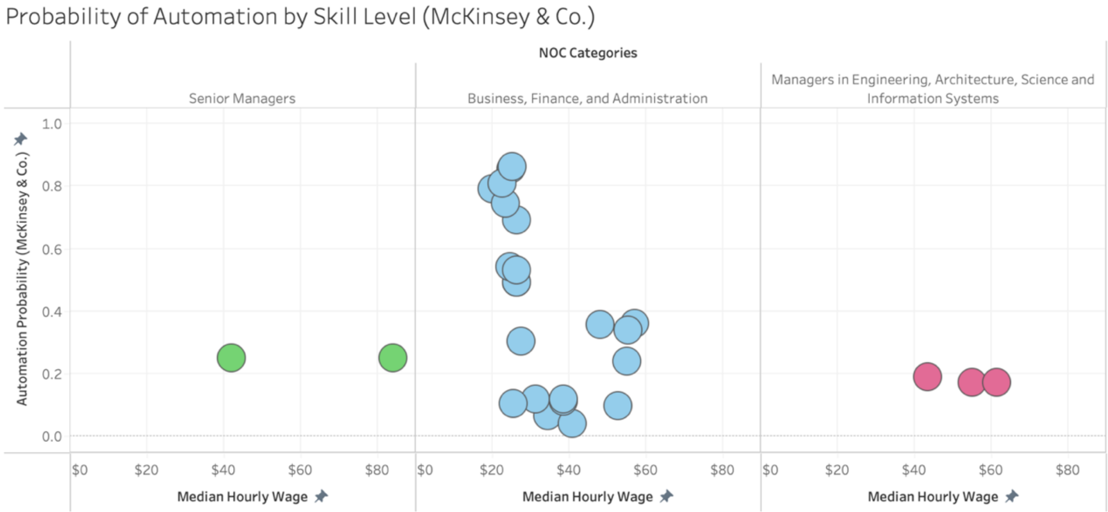
One of the fundamental differences between the so-called fourth industrial revolution versus prior industry shifts is the need for organizations to take a wholistic approach to transformation. Only in this way can an organization realize the true potential benefits of digitalization, as Industry 4.0 will not only change the way of work, but it may also change the content of the work performed, eliminating some functions, and adding all new roles and responsibilities. The fundamental thesis of NGen's highly regarded Transformation Leadership Program is that companies need to take this integrated approach to transforming operations, including rationalizing workflows for Industry 4.0, achieving internal and customer alignment, and preparing the organization and the individual workers with the processes and skills required for successful implementation. The Transformation Leadership Program provides tools to support organizations in accomplishing this.

Digitization and automation represent a significant shift in industrial practices, offering new opportunities for Canada's economy, and more specifically, its manufacturing sector. This shift offers a compelling opportunity for growth, innovation, and leadership in the global manufacturing landscape. It paves the way for enhanced competitiveness through advanced technologies and data-driven decision-making, positioning Canada to be a leader in advanced manufacturing. These changes also demand a proactive approach in workforce development and education, ensuring that Canadian workers are equipped with the skills necessary to thrive and progress.

Appendix A.

Probability of Automation of NOC by Skill Level

Tables 1 – 3



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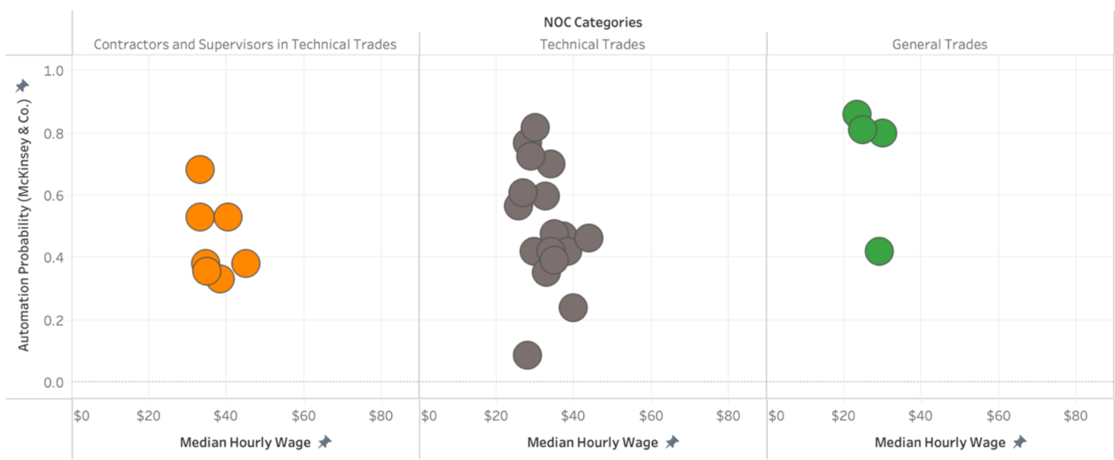

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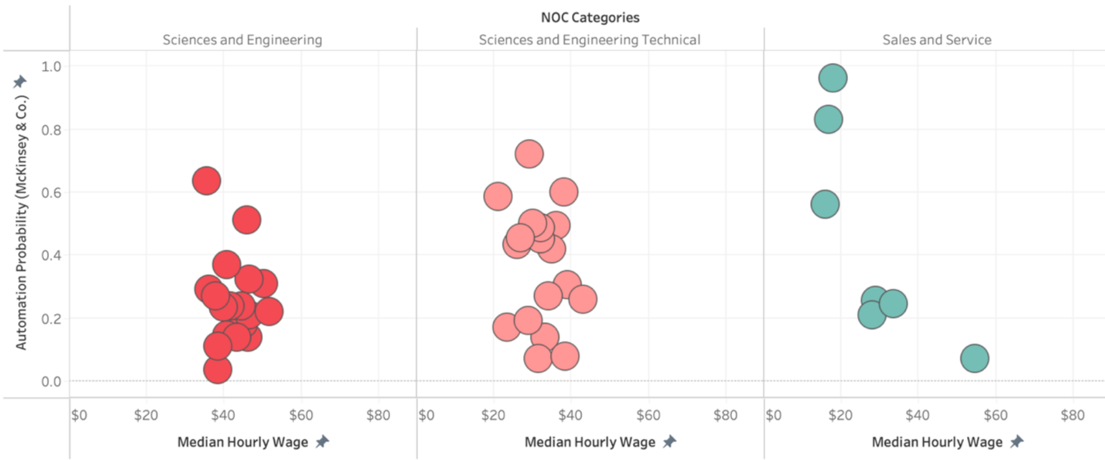
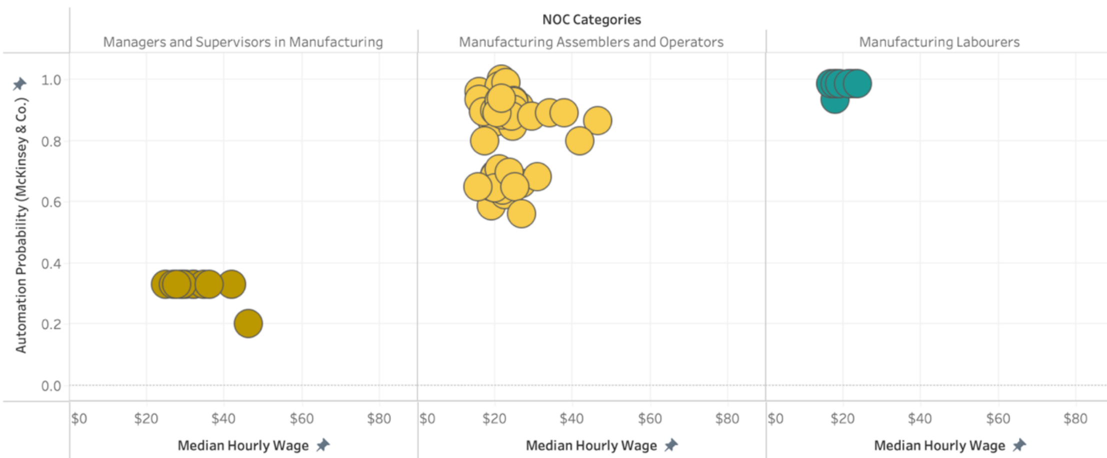
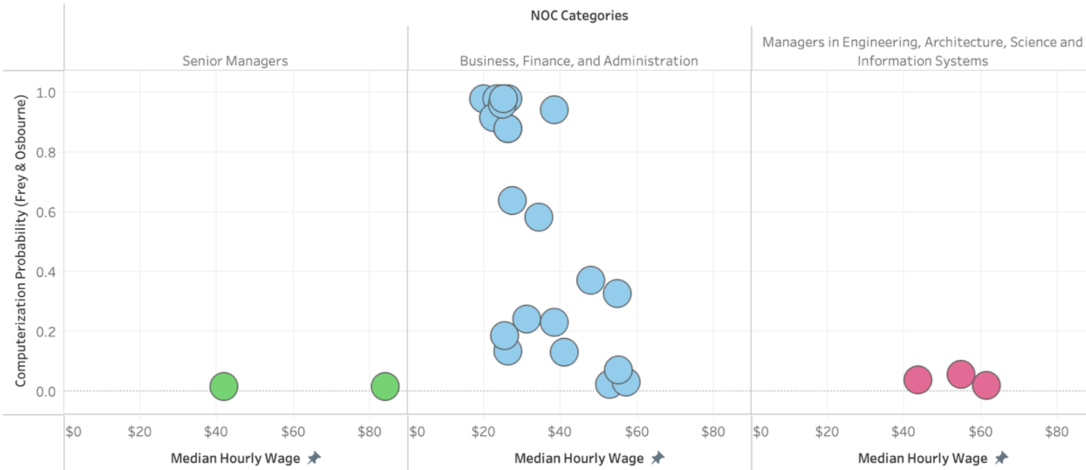


Tables 10 – 12



Tables 13 – 15

Probability of Automation by Skill Level (Frey & Osbourne)



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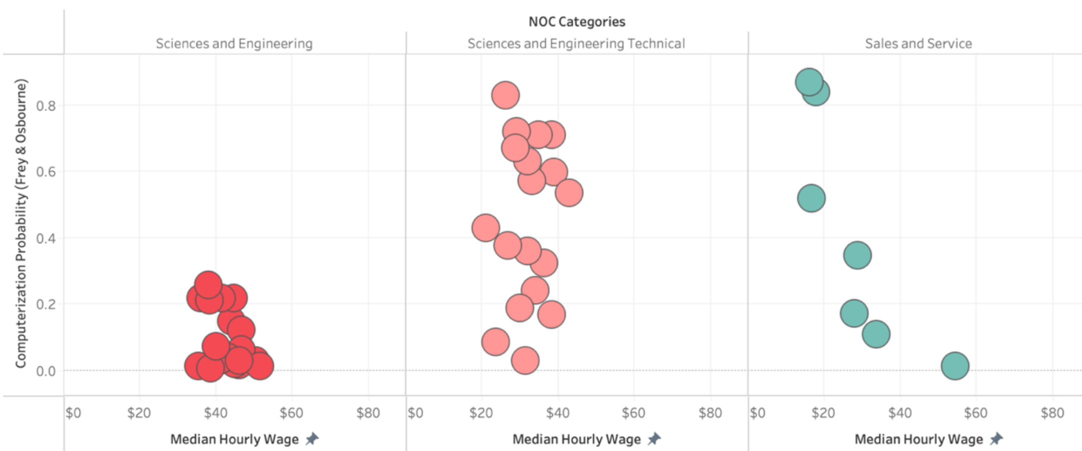

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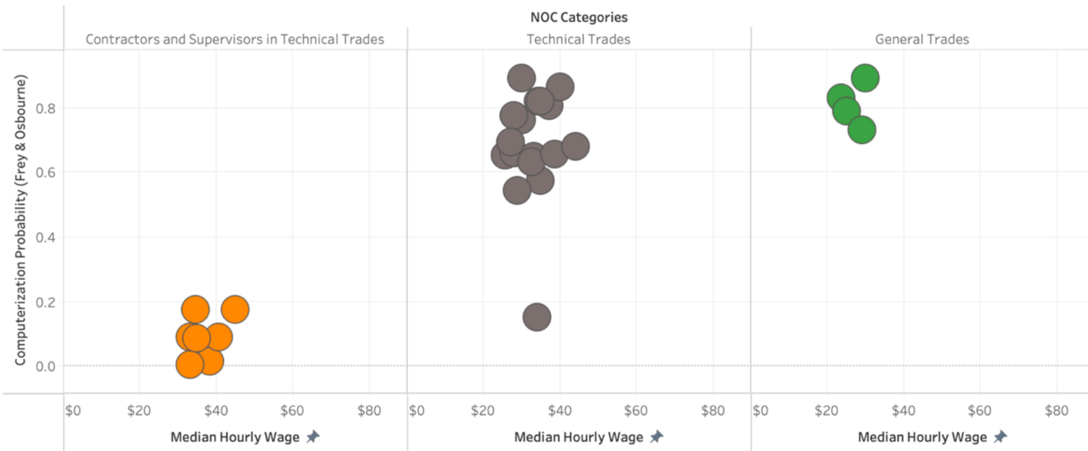

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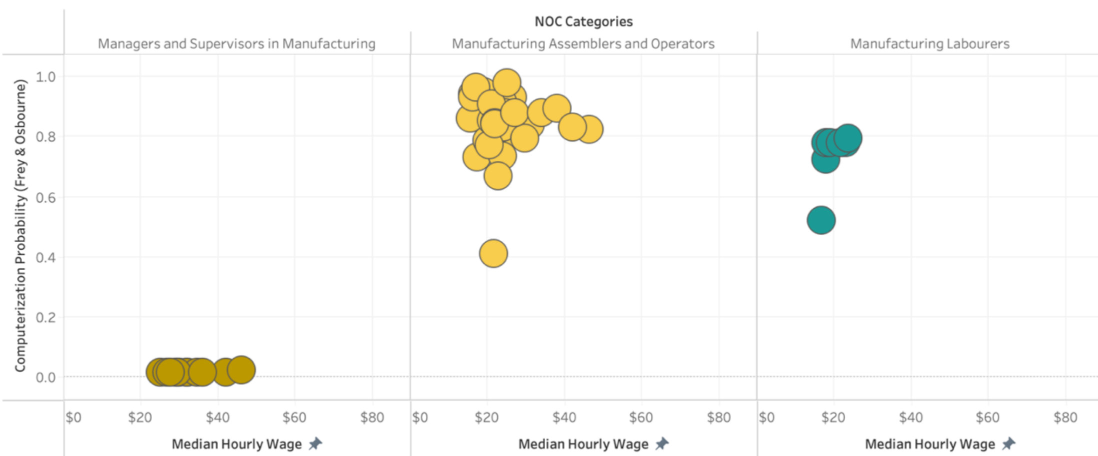

Appendix B.

List of NOC manufacturing Occupations with automation scores from Frey & Osbourne (2013) and McKinsey & Co. (2016). * Gaps in data are the result of in-equivalencies between the SOC and NOC codes.

NOC	Occupation	Frey & Osbourne	McKinsey & Co.
12	Senior managers - financial, communications and other business services	2%	25%
15	Senior managers - construction, transportation, production and utilities	2%	25%
10010	Financial managers	7%	34%
10011	Human resources managers	32%	24%
10012	Purchasing managers	3%	36%
10019	Other administrative services managers	37%	36%
10022	Advertising, marketing and public relations managers	2%	10%
11100	Financial auditors and accountants	94%	12%
11101	Financial and investment analysts	23%	11%
11200	Human resources professionals	19%	10%
11201	Professional occupations in business management consulting	13%	4%
11202	Professional occupations in advertising, marketing and public relations	24%	12%
12013	Supervisors, supply chain, tracking and scheduling coordination occupations	13%	53%
12102	Procurement and purchasing agents and officers	58%	7%
12200	Accounting technicians and bookkeepers	98%	86%
13100	Administrative officers	64%	30%
13110	Administrative assistants	96%	54%
13201	Production and transportation logistics coordinators	88%	49%
14100	General office support workers	92%	81%
14200	Accounting and related clerks	98%	74%
14400	Shippers and receivers	98%	79%
14401	Storekeepers and partspersons	98%	86%
14402	Production logistics workers	88%	49%
14403	Purchasing and inventory control workers	98%	69%

NOC	Occupation	Frey & Osbourne	McKinsey & Co.
20010	Engineering managers	2%	17%
20011	Architecture and science managers	6%	17%
20012	Computer and information systems managers	4%	19%
21101	Chemists	26%	27%
21110	Biologists and related scientists	7%	23%
21111	Forestry professionals	1%	11%
21112	Agricultural representatives, consultants and specialists	1%	64%
21120	Public and environmental health and safety professionals	21%	4%
21211	Data scientists	3%	51%
21220	Cybersecurity specialists		65%
21221	Business systems specialists		65%
21222	Information systems specialists		65%
21223	Database analysts and data administrators	3%	37%
21230	Computer systems developers and programmers	22%	24%
21231	Software engineers and designers	2%	22%
21232	Software developers and programmers	22%	24%
21233	Web designers		54%
21234	Web developers and programmers	22%	29%
21301	Mechanical engineers	4%	14%
21310	Electrical and electronics engineers	6%	21%
21311	Computer engineers (except software engineers and designers)	12%	32%
21320	Chemical engineers	3%	31%
21321	Industrial and manufacturing engineers	3%	15%
21322	Metallurgical and materials engineers	2%	18%

NOC	Occupation	Frey & Osbourne	McKinsey & Co.
21390	Aerospace engineers	2%	14%
21399	Other professional engineers	15%	16%
22100	Chemical technologists and technicians	38%	46%
22101	Geological and mineral technologists and technicians	19%	50%
22110	Biological technologists and technicians		48%
22211	Industrial designers		3%
22212	Drafting technologists and technicians	67%	19%
22220	Computer network and web technicians	36%	49%
22221	User support technicians	72%	72%
22222	Information systems testing technicians	9%	17%
22230	Non-destructive testers and inspectors	24%	27%
22231	Engineering inspectors and regulatory officers	54%	26%
22232	Occupational health and safety specialists	17%	8%
22301	Mechanical engineering technologists and technicians	63%	45%
22302	Industrial engineering and manufacturing technologists and technicians	3%	7%
22303	Construction estimators	57%	14%
22310	Electrical and electronics engineering technologists and technicians	71%	42%
22311	Electronic service technicians (household and business equipment)	83%	43%
22312	Industrial instrument technicians and mechanics	60%	31%
22313	Aircraft instrument, electrical and avionics mechanics, technicians and inspectors	71%	60%
32129	Other medical technologists and technicians	32%	49%
33109	Other assisting occupations in support of health services	43%	59%
41402	Business development officers and market researchers and analysts	61%	13%
52111	Graphic arts technicians	34%	30%

NOC	Occupation	Frey & Osbourne	McKinsey & Co.
52121	Interior designers and interior decorators	22%	12%
53123	Theatre, fashion, exhibit and other creative designers	14%	19%
53124	Artisans and craftspersons	28%	64%
60010	Corporate sales managers	1%	7%
62100	Technical sales specialists - wholesale trade	11%	25%
62101	Retail and wholesale buyers	17%	21%
63220	Shoe repairers and shoemakers	52%	83%
64100	Retail salespersons and visual merchandisers	87%	56%
64101	Sales and account representatives - wholesale trade (non-technical)	35%	26%
64200	Tailors, dressmakers, furriers and milliners	84%	96%
70012	Facility operation and maintenance managers	59%	31%
72010	Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations	9%	36%
72011	Contractors and supervisors, electrical trades and telecommunications occupations	9%	53%
72012	Contractors and supervisors, pipefitting trades	17%	38%
72013	Contractors and supervisors, carpentry trades	17%	38%
72014	Contractors and supervisors, other construction trades, installers, repairers and servicers	9%	53%
72020	Contractors and supervisors, mechanic trades	0%	68%
72022	Supervisors, printing and related occupations	2%	33%
72100	Machinists and machining and tooling inspectors	54%	73%
72101	Tool and die makers	89%	82%
72102	Sheet metal workers	82%	39%
72103	Boilermakers	68%	46%
72104	Structural metal and platework fabricators and fitters	69%	61%
72105	Ironworkers	87%	24%

NOC	Occupation	Frey & Osbourne	McKinsey & Co.
72106	Welders and related machine operators	78%	9%
72200	Electricians (except industrial and power system)	15%	42%
72201	Industrial electricians	66%	42%
72400	Construction millwrights and industrial mechanics	63%	60%
72401	Heavy-duty equipment mechanics	58%	48%
72402	Heating, refrigeration and air conditioning mechanics	65%	35%
72404	Aircraft mechanics and aircraft inspectors	81%	47%
72405	Machine fitters	82%	70%
72410	Automotive service technicians, truck and bus mechanics and mechanical repairers	66%	77%
72422	Electrical mechanics	76%	42%
72999	Other technical trades and related occupations	65%	56%
73111	Glaziers	73%	42%
73300	Transport truck drivers	79%	81%
73400	Heavy equipment operators	89%	80%
73401	Printing press operators	83%	86%
74203	Automotive and heavy truck and equipment parts installers and servicers	78%	48%
75101	Material handlers	86%	56%
75110	Construction trades helpers and labourers	74%	46%
75119	Other trades helpers and labourers	80%	28%
75201	Delivery service drivers and door-to-door distributors	84%	80%
80020	Managers in agriculture	50%	34%
85100	Livestock labourers	41%	47%
90010	Manufacturing managers	2%	20%
92010	Supervisors, mineral and metal processing	2%	33%

NOC	Occupation	Frey & Osbourne	McKinsey & Co.
92011	Supervisors, petroleum, gas and chemical processing and utilities	2%	33%
92012	Supervisors, food and beverage processing	2%	33%
92013	Supervisors, plastic and rubber products manufacturing	2%	33%
92014	Supervisors, forest products processing	2%	33%
92015	Supervisors, textile, fabric, fur and leather products processing and manufacturing	2%	33%
92020	Supervisors, motor vehicle assembling	2%	33%
92021	Supervisors, electronics and electrical products manufacturing	2%	33%
92022	Supervisors, furniture and fixtures manufacturing	2%	33%
92023	Supervisors, other mechanical and metal products manufacturing	2%	33%
92024	Supervisors, other products manufacturing and assembly	2%	33%
92100	Power engineers and power systems operators	83%	80%
93100	Central control and process operators, mineral and metal processing	90%	89%
93101	Central control and process operators, petroleum, gas and chemical processing	82%	87%
93102	Pulping, papermaking and coating control operators	88%	89%
93200	Aircraft assemblers and aircraft assembly inspectors	88%	56%
94100	Machine operators, mineral and metal processing	80%	88%
94101	Foundry workers	84%	94%
94102	Glass forming and finishing machine operators and glass cutters	77%	89%
94103	Concrete, clay and stone forming operators	83%	88%
94104	Inspectors and testers, mineral and metal processing	98%	65%
94105	Metalworking and forging machine operators	85%	88%
94106	Machining tool operators	84%	90%
94107	Machine operators of other metal products	91%	93%
94110	Chemical plant machine operators	86%	93%

NOC	Occupation	Frey & Osbourne	McKinsey & Co.
94111	Plastics processing machine operators	85%	93%
94112	Rubber processing machine operators and related workers	88%	85%
94120	Sawmill machine operators	86%	93%
94121	Pulp mill, papermaking and finishing machine operators	84%	68%
94122	Paper converting machine operators	67%	99%
94123	Lumber graders and other wood processing inspectors and graders	92%	70%
94124	Woodworking machine operators	79%	90%
94129	Other wood processing machine operators	73%	88%
94130	Textile fibre and yarn, hide and pelt processing machine operators and workers	97%	90%
94131	Weavers, knitters and other fabric making occupations	73%	80%
94132	Industrial sewing machine operators	93%	94%
94133	Inspectors and graders, textile, fabric, fur and leather products manufacturing	86%	65%
94140	Process control and machine operators, food and beverage processing	87%	91%
94141	Industrial butchers and meat cutters, poultry preparers and related workers	77%	98%
94142	Fish and seafood plant workers	94%	96%
94143	Testers and graders, food and beverage processing	41%	100%
94150	Plateless printing equipment operators	83%	86%
94151	Camera, platemaking and other prepress occupations	93%	91%
94152	Binding and finishing machine operators	95%	87%
94200	Motor vehicle assemblers, inspectors and testers	81%	66%
94201	Electronics assemblers, fabricators, inspectors and testers	88%	65%
94202	Assemblers and inspectors, electrical appliance, apparatus and equipment manufacturing	93%	64%
94203	Assemblers, fabricators and inspectors, industrial electrical motors and transformers	86%	71%
94204	Mechanical assemblers and inspectors	88%	62%

NOC	Occupation	Frey & Osbourne	McKinsey & Co.
94205	Machine operators and inspectors, electrical apparatus manufacturing	89%	65%
94210	Furniture and fixture assemblers, finishers, refinishers and inspectors	89%	69%
94211	Assemblers and inspectors of other wood products	86%	65%
94212	Plastic products assemblers, finishers and inspectors	92%	59%
94213	Industrial painters, coaters and metal finishing process operators	91%	95%
94219	Other products assemblers, finishers and inspectors	92%	69%
95100	Labourers in mineral and metal processing	80%	99%
95101	Labourers in metal fabrication	78%	99%
95102	Labourers in chemical products processing and utilities	78%	99%
95103	Labourers in wood, pulp and paper processing	78%	99%
95104	Labourers in rubber and plastic products manufacturing	78%	99%
95105	Labourers in textile processing and cutting	78%	99%
95106	Labourers in food and beverage processing	78%	99%
95107	Labourers in fish and seafood processing	52%	99%
95109	Other labourers in processing, manufacturing and utilities	72%	94%

Appendix C.

Occupational Categories

NOC Broad Occupational Category

First Digits of NOC code	Occupational Category	Examples
0	Senior Managers	00012 Senior managers - financial, communications and other business services
1	Business, Finance and Administration	10011 Human resources managers
20	Managers in Engineering, Architecture, Science and Information Systems	20011 Architecture and science managers
21	Sciences and Engineering	21110 Biologists and related scientists
22	Sciences and Engineering Technical	22100 Chemical technologists and technicians
6	Sales and Service	62100 Technical sales specialists - wholesale trade
720	Contractors and Supervisors in Technical Trades	72012 Contractors and supervisors, pipefitting trades
721	Technical Trades	72100 Machinists and machining and tooling inspectors
73	General Trades	73400 Heavy equipment operators
92	Managers and Supervisors in Manufacturing	92010 Supervisors, mineral and metal processing
93	Manufacturing Assemblers and Operators	92100 Power engineers and power systems operators
95	Manufacturing Labourers	95100 Labourers in mineral and metal processing

Appendix D.

Job Skills Tables

Data Scientist			
Basic Skills	Oral Communication Communication	Data Manipulation Data Integrity	Data Quality
Complex Problem Solving	Commercial Analysis Customer Intelligence Sales Strategy	Quality Analysis Data Analytics Forecasting	Root Cause Analysis Business Insights Product Requirements
Social Skills	Workplace Relations Social Influence	Labor Relations Teamwork	Meeting Facilitation
System Skills	IT Governance Market Research	Supply Chain Management Strategy Implementation	Business Intelligence (BI)
Resource Management Skills	Key Metrics	Key Performance Indicators	
Technical Skills	• Database Management and Administration: SQL, NoSQL, Teradata Database, Microsoft Access, Apache Hive, Data Warehousing, Microsoft Dynamics	• Data Analysis and Processing: Data Modeling, Data Profiling, Robotic Process Automation (RPA), Machine Learning, XGBoost, PySpark, Apache Spark, MapReduce big data software, Apache Hadoop, Snowflake	• Programming and Development: VBA Excel, C, Ruby, R, Scala, Bash, JavaScript, Docker, GitHub, Git, Jenkins CI, RESTful API, Kubernetes
	• Data Visualization and Reporting: Microsoft Power BI, Data Visualization, Dashboard Building, Reporting software, Qlik Tech QlikView, Tableau, Microsoft (Excel, Office, PowerPoint)	• Business Intelligence and Analytics: Business Intelligence Tools, Web Analytics, Analytical or scientific software (IBM SPSS, SAS…), StataCorp Stata, The MathWorks MATLAB, Splunk Enterprise, Geographic information system GIS systems	• Cloud and Infrastructure Services: Amazon Web Services AWS software, AWS SageMaker, Google Cloud software, Microsoft Azure software, Linux, UNIX
	• Project and Workflow Management: Atlassian JIRA, Apache Airflow, Atlassian Confluence, Management information systems MIS	• Data Interchange and Communication: JavaScript Object Notation JSON	• Advanced Analytics and Big Data: Apache MXNet, TensorFlow, Keras, C++, Oracle Java

Industrial Instrument Technician			
Basic Skills	Oral Communication	Problem Solving	
System Skills	Compensation	Preventative Maintenance	
Resource Management Skills	Facilities	Work Orders	
Technical Skills	• Systems Knowledge and Maintenance: Control Systems, HVAC (Heating, Ventilation, and Air Conditioning), Hydraulics, Pump Repair, SCADA (Supervisory Control and Data Acquisition), Boilers, Industrial Equipment, Mechanical Systems • Communication and Network Systems: Network Communications (understanding of communication protocols and network configurations)	• Advanced Technical Skills: Robotics (knowledge of robotic systems and their applications) • Software Proficiency: Minitab, Computer-aided design (CAD) — Autodesk AutoCAD, Autodesk AutoCAD Civil 3D, Bentley MicroStation, Dassault Systemes SolidWorks, National Instruments LabVIEW, Apple macOS, Linux, Microsoft Project	• Electrical Skills and Instrumentation: Electrical Design, Electrical and Instrumentation Engineering (EIE), AC/DC (Alternating Current/Direct Current knowledge), Electricity, Schematic (ability to read and interpret) • Problem-Solving and Analysis: Troubleshooting (diagnosing and resolving equipment malfunctions)

Mechatronic Technician

Basic Skills	Communication	Follow Written Instructions	Digital Literacy
Complex Problem Solving	Root Cause Analysis	Operations Management	Quality Control Analysis
Social Skills	Customer Service	Inter-Departmental Collaboration	Self-Directed
System Skills	Equipment Evaluation		
Resource Management Skills	Reduce Machinery Downtime	Automated Equipment Upkeep	
Technical Skills	• Regulatory and Safety Compliance: Knowledge of CSA, OSHA, and Electrical Safety Code • Technical Documentation: Technical document literacy (schematics, prints, pneumatic diagrams) • Programming and Software Skills: Experience in PLC programming, troubleshooting, and modifications (specifically for platforms listed), ANSYS Mechanical, Autodesk AutoCAD, CNC Mastercam, Computerized numerical control CNC programming software, Microsoft PowerPoint, Follow procedures for software & firmware setup on systems	• Robotics and Automation: Experience in robot programming, Knowledge of servos, sensors, smart actuators, etc., PLC, robot, and HMI programming, implementation, and troubleshooting, Setup, changeover, and PM various automation equipment and systems (e.g., Enfield Automation cells) • Troubleshooting and Maintenance: Basic electrical, mechanical, and pneumatic troubleshooting ability, Diagnose and solve basic pneumatics, Assemble & test of electrical, mechanical, and optical systems (including specifics like wiring, crimping & soldering, connector assembly, camera focusing & calibration)	• Machinery and Equipment Knowledge: Knowledge of injection moulding machines and process, Electrical controls setup, changeover, and Preventative Maintenance of equipment (e.g., Sonic Welders, Barcode Machines), Setup and PM resin pellet receivers and blenders, Clean valve stack filters • Quality Control and Inspection: Perform optical calibration procedures on cameras and laser systems, Inspect & test incoming components according to QC instructions

Supply Chain Supervisor

Basic Skills	Literacy Oral Communication Forecasting	Attention to Detail Multitasking Managerial Finance	Problem Solving Analytical Skills General Management
Complex Problem Solving	Continuous Improvement Site Visits	Conflict Management Industry Training	Stress Management
Social Skills	Leadership Skilled Multi-tasker Coaching	Customer Service Supervisory Skills Positive Employee Relations	Interpersonal Communication Interviewing
System Skills	Key Performance Indicators Supplier Evaluation	Development Approvals	Procurement
Resource Management Skills	Time Management Warehouse Management Logistics Management	Inventory Management Supply Chain Management	Production Planning Stock Management
Technical Skills	• Office and Communication Software: Microsoft (Excel, Outlook, Office suite, Word. PowerPoint) • Electronic Data Management: Electronic Data Interchange (EDI), Radio-Frequency Identification (RFID) • Enterprise Resource Planning (ERP) and Supply Chain Management: Infor Enterprise Resource Planning (ERP), SAP Electronic Data Interchange (EDI), SAP Products, SAP ERP, Materials requirements planning logistics and supply chain software — Warehouse management system WMS, Inventory management software — Inventory control software, Inventory management systems, Warehouse management system WMS	• Inventory and Quality Control: BOMs (Bill of Materials), Cycle Counting, Enterprise Resource Planning (ERP), Inventory Control, Material Requirements Planning (MRP), Physical Inventory, SAP Products, SAP ERP, APICS, CPIM (Certified in Production and Inventory Management), Six Sigma • Project Management and Team Collaboration: Project management software — Contract management software, HCSS HeavyJob, Microsoft Project, Microsoft Teams • Equipment and Machinery Operation: Forklift Operation, Precision Measuring, RF Scanners, Radio-Frequency Identification (RFID)	• Logistics and Material Handling: Sawmill, Timber, Warehouse Management Systems, Material Handling, Truck Driving, Packing, Shipping & Receiving, Damage, Cleansing, Purchase Orders • Database Management and Interface: Data base user interface and query software — Blackboard software, Microsoft Access, Oracle Database, Yardi software • Compliance and Safety: Customs Regulations, Safety Committee, Statutory Accounting Principles (SAP)

Process Engineer

Basic Skills	Oral Communication	Report Writing	Research and Development
Complex Problem Solving	Spec Sheets		
Social Skills	Customer Presentations		
Resource Management Skills	Workload Prioritization	Performance Motivation	
Technical Skills	• Engineering and Design: Chemical Engineering, Engineering Documentation, Fixtures, Flow Charts, Process Design, Process Engineering, Process Flow Charts, process flow diagram (PFD), Process Integration, Process Simulation, Processes Development, Proof of Concept, Piping and Instrumentation Drawing (P&ID)	• Manufacturing and Operational Processes: Automation, Computer Simulations, Data Driven Testing, Dehydration, Electric Vehicles, Gas Metal Arc Welding (GMAW), HAZOP Study, Manufacturing Processes, Mass & Energy Balance, Material Handling, Modelling, Resistance Welding	• Software Development and Database Management: Data base user interface and query software (Amazon Web Services AWS software, Microsoft Access, PySpark, Structured query language SQL), Development environment software (C, Microsoft Azure software, Ruby, XGBoost), Object or component oriented development software (C++, Oracle Java, R, Scala)
	• Industry-Specific Knowledge: Oil and Gas Industry	• Software and Modeling Tools: 3D Modeling Software, AutoCAD, JMP, Minitab, Statistical Software, Traditional Animation, Analytical or scientific software (IBM SPSS Statistics, SAS, StataCorp Stata, The MathWorks)	• Presentation and Documentation: Presentation software (Microsoft PowerPoint)

Cloud Engineer			
Complex Problem Solving	Knowledge Acquisition	Defining Requirements	Root Cause Analysis
Social Skills	Focus Groups	Service Work	Technical Advisory
System Skills	Design Documents Computer Science	Systems Analysis	Systems Thinking
Resource Management Skills	Skills Development		
Technical Skills	• Cloud Infrastructure Management and Design: Decommissioning, architecture, cloud migration, migration projects, implement and manage cloud infrastructure components, including load balancers, caching, web servers, application servers, databases, and networking, deploy and maintain Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) resources to support hosted products and solutions • Protocols and Standards: OPC Unified Architecture (OPC UA), open Platform Communication (OPC), protocol Buffers • Project and Team Collaboration Tools: project Management software (e.g., Atlassian Confluence; Microsoft Project; Microsoft Teams; Oracle Primavera Enterprise Project Portfolio Management)	• Networking and Communications: Internet of Things (IoT), wireless networking, network monitoring tools, participating in the implementation of AWS Cloud VPCs, AWS Networking policies • Database Management and Integration: Databases, NoSQL, data base management system software (e.g., Amazon DynamoDB; Apache Hive; Elasticsearch; Redis) • Operating Systems and Scripting: operating system software (e.g., Bash; Microsoft Windows Server; Shell script; UNIX Shell) • Web Development and Platforms: Web platform development software (e.g., Django; Google Angular; React; Spring Framework) • Cloud Service Providers: involving in AWS Cloud, Cloud Networking, and IAM	• Software Development and Engineering: Software development, microservices, algorithms, data structures, object oriented design, Python (Programming Language), acceptance testing • Development Tools and Environments: CircleCI, Terraform, development environment software (e.g., Apache Kafka; Apache Maven; Go; Oracle Java 2 Platform Enterprise Edition J2EE) • Protocols and Standards: OPC Unified Architecture (OPC UA), open Platform Communication (OPC), protocol Buffers • Cloud Security and Identity Management: Identity federation, Okta Identity Cloud, Security Assertion Markup Language (SAML), single Sign-On (SSO), AWS Cloud, Cloud Networking, and IAM

Motor Vehicle Assembler			
Basic Skills	English Manuals Drawing	Handbooks Communication Schematics	Manual Dexterity Attention to Detail
Complex Problem Solving	Quality Control	Total Productive Maintenance	Quality Assurance
Social Skills	Attitude Change Coordinating Skills	Teamwork	Service Work
System Skills	Product Quality	Continuous Improvement	
Resource Management Skills	Multitasking	Construction Site Inspections	
Technical Skills	• Analytical and Design Tools: Analytical or Scientific Software (e.g., Harris Technologies BassBox; LinearTeam WinISD; True Audio WinSpeakerz; Yield - Werx) • Quality Assurance and Maintenance: Quality Control, Zero Defects, Total Productive Maintenance (TPM) • Visual and Technical Aids	• Software Proficiency: Micrsoft (Outlook, Office, Powerpoint, Excel, Word, Enterprise resource planning ERP software (e.g., SAP software), Computer aided design CAD software (e.g., WHE Term-PAK; Autodesk AutoCAD), Database user Interface and Query Software (e.g., Installalogy Access Client; MobileToys MAIDXL) • Assembly and Mechanical Skills: Mechanical Assembly, Automotive Repair	• Industrial Control and Manufacturing Software: Industrial Control Software (e.g., Camstar Systems Camstar Semiconductor Suite; Eyelit Manufacturing) • Project and Workflow Management: Atlassian JIRA, Apache Airflow, Atlassian Confluence, Management information systems MIS

Software Developer

Basic Skills	Analytical Reasoning	Communication	
Complex Problem Solving	Debugging	Root Cause Analysis	Agile Development
Social Skills	Constructive Feedback		
System Skills	Computer Science Design Documents Industry standards	Data Models Technical Architecture	Integrated Systems Product Requirements
Resource Management Skills	Building Performance	Operational Excellence	Agile Development
Technical Skills	• Programming and Markup Languages: C#, Java, JavaScript, Cascading Style Sheets (CSS), HTML, SQL, Scala, TypeScript, Objective C • Business and Data Analysis: Business Intelligence (BI), Data Science, Datasets, Extract, Transform, Load (ETL) • Frameworks and Libraries: .NET, Spring Framework, Apache Spark • Configuration and Integration Tools: Configure Price Quote (CPQ) Software	• Database Management: Microsoft SQL Server, Database management system software, Database user interface and query software, Database Procedures • Cloud Computing and Services: Azure Data Factory, ServiceNow, Web platform development software • Web Development and Front-End Technologies: Front-End Development, React.js, Redux.js, Web Applications, Web Services, Representational State Transfer (REST), Bootstrap, Vue.js	• Development Tools and Environments: Development environment software, Object or component-oriented development software, Powerbuilder • Software Development Practices: Application Development, Technical Architecture, Ops • Testing and Quality Assurance: Test Scripts

Cyber Security Specialist

Basic Skills	Writing English	Communication	Analytical Skills
Complex Problem Solving	Risk Analysis Corrective Actions	Root Cause	Incident Response
Social Skills	Teamwork	Peer Team Partnering	
System Skills	Business Analysis Risk Mitigation	Solution Integration Security Trends	Data Analytics Malicious Factor Management
Technical Skills	• Cybersecurity and Information Security Practices: Cybersecurity, Information Security, ISO Standards, Security Controls, Anti-spam, Encryption, Vulnerability, Vulnerability Assessment	• Networking and IT Infrastructure: Computer Networking, Networking, NT Client/Server Platform or Unix Client/Server Platform, system architecture components	• Operating Systems and Platforms: Great operating systems knowledge (both Microsoft and *NIX), Skills and Experience in at least two Platforms
	• Cloud Technologies and Security: Cloud Computing, Cloud Infrastructure, Cloud Security, Amazon Web Services (AWS)	• Project and IT Management: IT Projects, installing and managing complex security solutions	• Web Development and Front-End Technologies: Front-End Development, React.js, Redux.js, Web Applications, Web Services, Representational State Transfer (REST), Bootstrap, Vue.js
	• Industrial Control and Systems • General IT Skills: Information Technology	• Database Management and Systems: Knowledge of MySQL, SQL or Oracle DBs	• Technical Troubleshooting:

Robotic Welder

Basic Skills	Written and Verbal communication Skills	Communicate with internal and external parties.	Mathematical, analytical, and organizational skills
Complex Problem Solving	Weld defect solutions	Carry out kaizen projects.	
Technical Skills	• General Computer Applications: Microsoft (Excel, Office, PowerPoint, Outlook), IBM Notes • Robotic Welding Processes: Robotic MIG, Resistance, Drawn Arc, and Projection Welding processes • Welding Equipment Operation: Servo Weld Guns operation, Line robots set-up • Process and Quality Management: MIG weld Process Tuning, Weld Schedule Optimization (GMAW), weld tooling PMs & quality checks, weld schedule audits	• Automation Programming: OCTOPUZ Robot Programming and Simulation Software, Yaskawa Programming/Practical Experience, • Sensor Technologies: Yaskawa Touch Sense Experience, Wire or Laser • Safe Operations and Material Handling: safe material handling equipment operation • Control Systems and Troubleshooting: weld control troubleshooting (Bosch, WTC, Emhart, and Lincoln Weld controller), Allen Bradley PLC & HMI programming	• Training and Skill Development: train manual weld operators, manual welding parameter development • Enterprise and Data Management Software: enterprise resource planning (ERP) software usage, data base user interface and query software (e.g., Oracle Database; Recordkeeping software), calendar and scheduling software (e.g., OmniFleet Equipment Maintenance Management), analytical or scientific software (e.g., Fred's Tip Cartridge Picker; Scientific Software Group Filter Drain FD; Value Analysis), industrial control software (e.g., Tool center point TCP setting software) • Design Tools: AutoCAD, Karmax Software usage

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