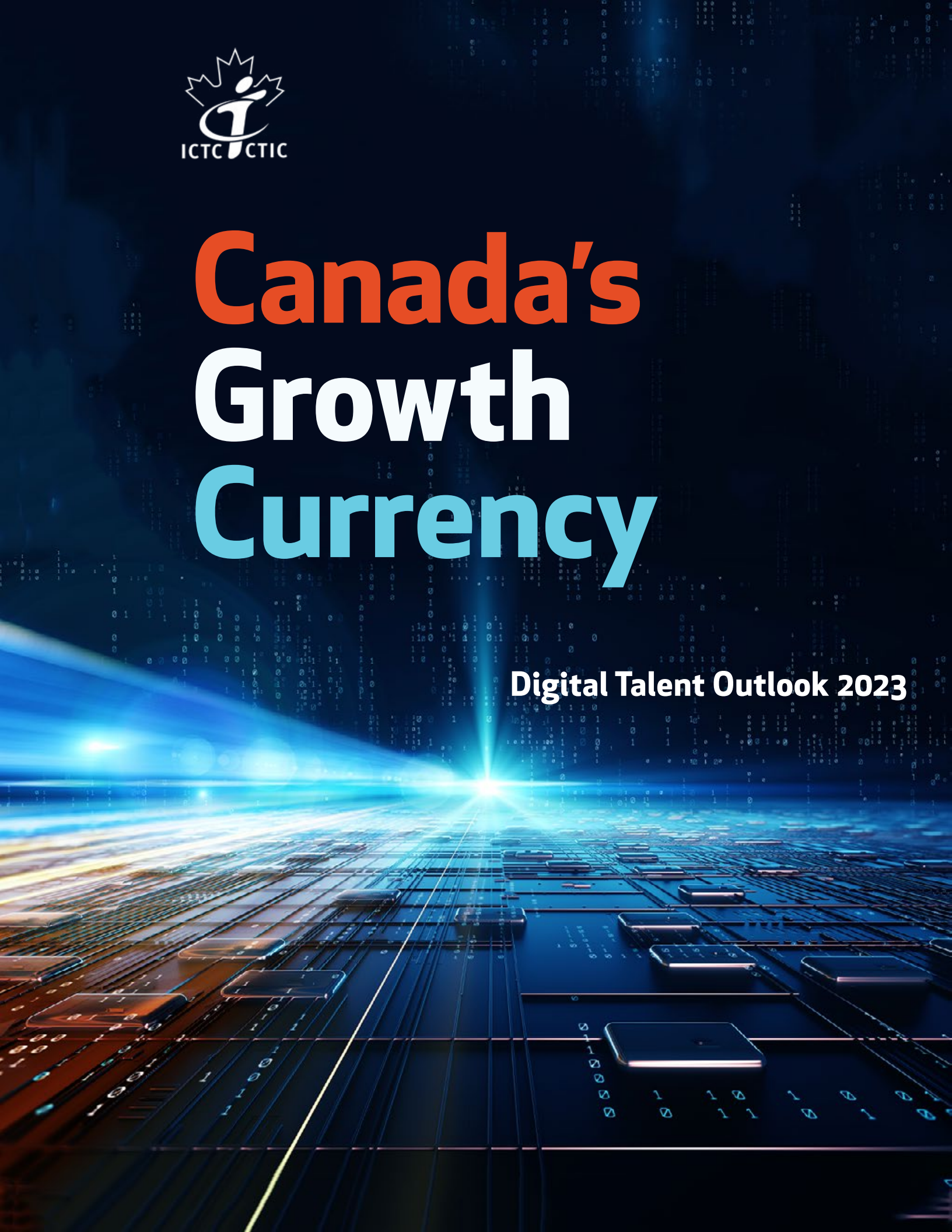

Canada's Growth Currency

Digital Talent Outlook 2023

Research by

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Preface

ICTC is a national centre of expertise for the digital economy. With over 25 years of experience in research and capacity building related to technology, ICTC has the vision of strengthening Canada's digital advantage in the global economy. Through forward-looking research, evidence-based policy advice, and creative capacity building programs, ICTC fosters innovative and globally competitive Canadian industries, empowered by a talented and diverse workforce.

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Foreword

It is my pleasure to contribute to the Information and Communications Technology Council's report, *Canada's Growth Currency: Digital Talent Outlook 2023*, and offer my perspective on how technology is shifting the labour landscape. As a founder and CEO in the agtech sector, Semios uses key technologies to offer digital solutions for growers, ultimately with the purpose of improving the efficiency and effectiveness of their operations.

In several ways, it's Canada's innate innovative spirit that has given us many of the technologies we couldn't imagine living without today. Advances in energy, transportation, farming, communication, and healthcare have not only allowed us to thrive, but are also keeping us alive.

With the population set to grow to 10 billion by 2050, we will be adding nearly 2 million people on earth, every week, for the next 30 years. As we've seen with the impact of climate change, supporting our needs is extremely taxing on the planet. Technology-enabled innovation is our only hope to sustain this growing population.

Yet, in today's connected world, it is becoming less meaningful to classify a company as 'tech'. As we witness the permeation of technology in all industries and the rise of emerging sub-sectors like agtech, fintech and cleantech, the driving factor behind success in all of these arenas is data.

One of the last industries to join the tech revolution, agriculture boasts a wealth of unmined data that holds the answers to some of growers' most complex challenges. Managing a farm is not easy. Farms are made up of millions of connected organisms which make for highly complex biosystems. Yet, most of these interactions are governed by a relatively small number of factors, such as exposure to heat and water.

At Semios, we've built a business around the deployment of millions of sensors that measure heat and water every 10 minutes, on every acre of land we manage. As we move further along the axis of time and space, our Internet-of-things (IoT) network gains further insight into the relationships at play between these organisms and their environment. The combination of big data, machine learning, and artificial intelligence will become essential to farmers, allowing them to determine how environmental and agronomic factors influence yield (quantity) and grade (quality).

On the labour front, the challenges that growers face are two-fold. While enrolment in post-secondary agriculture programs declines and labour costs increase, growers are increasingly looking for ways to scale their resources, including labour, across more acres. Having mobile access to granular farm data that would normally take hours of manpower to obtain allows growers and their consultants to act quickly and precisely, helping them to optimize water use, and reduce chemical inputs.

As technological developments become more complicated and interwoven, customers are naturally gravitating towards services over products. In traditional sectors like agriculture, tech adoption isn't always second nature. Investing in customer support, for the installation, maintenance, and upgrading of technologies can reduce much of the implementation burden and make it easier to leverage the power of data.

While we have a strong pool of talent in Canada, I believe more people, with a wide range of technical and leadership skills, will be needed to leverage the vast amounts of data that are growing every day. I commend the ICTC for undertaking this research to understand the human capital needed for this quickly-scaling digital economy, and for highlighting opportunities to ensure that Canada continues to be a leader in applying technology and using data to solve global problems.

– Michael Gilbert, Founder & CEO of Semios

Executive Summary

Around the world, digital disruption, shifting international dynamics, and emerging markets are changing economic structures and business models. At the same time, transformative technologies like AI, 5G, Blockchain and a handful of others have already begun to play a substantive role in our current economy and communities; and they will continue create new opportunities, generate potential, and cause robust change across many sectors. For instance, even the most traditional industries like forestry are changing and adapting to new business needs, oftentimes doing so via experimenting with new technologies. Finland's CollectiveCrunch uses AI to identify and model various characteristics of forest inventory[1]. In Canada, the forestry industry has long been a pillar of economic strength, with provinces like BC and Alberta playing pivotal roles. New start-ups are emerging to tackle forest management across the country, and in BC, well-established companies like TimberWest are experimenting with technology such as LiDAR to better evaluate microhabitat diversity and improve outcomes.

Although only one example showcasing the permeation of technology in the forestry industry, increasingly all sectors of the economy will have a digital touch. The ICT (technology) sector has traditionally played a major role in reshaping productivity in Canada, through transforming production processes, fostering efficiencies, and spurring innovation. The sector is also an important contributor to the Canadian economy, with total GDP reaching nearly $89 billion[2] in 2018. Representing more than 4.5% of Canada's total economic output, its growth was nearly double that seen across the overall Canadian economy that year. Yet, despite its economic strength, the growth of technology across other sectors is shifting the boundaries of the digital economy, with scaling numbers of ICT workers employed outside of the ICT sector. In 2009, the sector's total share of digital economy employment was more than 52%; but fast-forward to 2019 where the ICT sector made up under 48% of all digital economy employment.

Our near-term future may point to uncertain international trade dynamics, potentially stalling overall job growth[3], along with pressing environmental considerations among other factors. However, Canada is afforded with the opportunity to create, innovate and expand our digital economic footprint despite these realities, and Canadian businesses are already leading in some critical technology areas. One need look no further than Montreal's robust presence in AI research, or Vancouver's digital media stronghold to understand that we are in a position to grow. Moreover, with novel initiatives like the Innovation Superclusters, or trade agreements like CETA opening the door to the world's largest marketplace, the demand for homegrown goods, services, and innovations can quickly scale. With this comes the continued need for a competent digitally-skilled workforce that can develop, implement, utilize and enhance transformational technologies to support Canada's digital economy.

[1]"How it works", Collective Crunch, 2019. https://www.collectivecrunch.com/how-it-work/
[2]"Table 36-10-0434-01: Gross domestic product (GDP) at basic prices, by industry, monthly", Statistics Canada, September 1, 2019. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610043401
[3]"Unemployment rate jumps to 5.7% in July as more people look for fewer jobs", CBC News, August 9, 2019. https://www.cbc.ca/news/business/canada-jobs-july-1.5241385

Digitally-skilled talent is at the cornerstone of our economic success, and like Canada, many countries around the world are and will continue to experience the crunch for this crucial supply stream in the future – particularly as key technologies like AI continue to drastically impact the way we do business. Under a **moderate growth scenario, ICTC foresees the demand for digitally-skilled talent in Canada to reach more than 305,000 by 2023.**

If filled, total employment in the Canadian digital economy will scale to more than 2.1 million. Even when taking into account the possibility of longer-term economic slowdown, the need for digital talent remains significant. **Under a contractionary growth scenario, Canada will still see a demand for digitally skilled talent that will total approximately 250,000 by 2023.** If filled, this will bring digital economy employment to over 2.05 million, with the economic impact[4] of these jobs reaching $160 billion by 2023.

To be certain, our digital journey is not without challenges – some of which may be spurred by global trends that are beyond our control. However, as a nation, our path to success in this connected economy remains squarely anchored in our ability to fully embrace digital technologies in the coming years. They will change the way we work, live, how we interact with one another, how business is conducted, and our relationships with global markets. As a country, turning this impending disruption into opportunities will be pivotal; and our focus must rest with developing, training, and attracting the skilled talent that will facilitate sustainable economic progress, drive our competitive advantage, and ultimately safeguard our continued future success.

[4]Estimated using average annual wages for overall digital economy talent, forecasted to 2023.

The Canadian Digital Economy at a Glance

2018 was a significant year for the global economy with technological developments, changing trade relations and shifting economic priorities making headlines. The new Canada-United States-Mexico Agreement (CUSMA) was signed, replacing the North American Free Trade Agreement (NAFTA) that existed for 25 years prior. Around that same time, the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) also entered into force, ratified by six initial countries, including Canada. By 2018, the Comprehensive Economic and Trade Agreement (CETA) was already provisionally operational, opening up new connections between Canada and the European Union. Although impacts of CUSMA and CPTPP remain to be seen, the effects of CETA are already evident, and by the second quarter of 2018, exports from Canada to the EU were beginning to climb.

2018 also brought forward other significant developments, such as a slowdown in the global economy. Both global and Canadian economic activity began to stall during the latter part of 2018, and particularly in sectors tied to energy. Overall, the Canadian economy showed its slowest growth in the fourth quarter of the year. While expected to pick up in the medium term, the Bank of Canada (BoC) announced its expectation for continued modest growth in 2019, with its most recent projections totaling 1.2% across the entire economy from 2019 to 2020.

However, recent data suggests that Canadian businesses not directly impacted by or tied to the energy sector reported expectations of growth. Many of these businesses stated intentions to actually increase capital spending in order to fulfill scaling market demand and boost productivity. Much of this spending can be attributed to an increase in efficiency-producing and productivity-enhancing tactics like digitization, along with the use of key technological practices such as machine learning or predictive analytics.

This report was created using a combination of primary and secondary research of both a quantitative and qualitative nature. Primary research included: a Canada-wide employer survey focused on a number of aspects related to employment demand; key informant interviews (KIIs) with experts from industry, academia, industry associations and others; and an advisory committee to review and validate results. The data was used to suggest potential trends related to talent and skill needs for the digital economy and the “innovation areas”; to highlight roles that were seen as in-demand by employers across sectors; and to draw parameters (scale) around the “innovation areas”. The “innovation areas” are created by aggregating relevant industry codes and normalizing the results using qualitative data from the survey and KIIs as well as available secondary data. This was done to generate estimates of these sub-sectors given that there is currently no commonly-accepted definition of these “innovation areas”. It should be noted that these categories are not mutually exclusive. For example, a company producing plant-based meat alternatives can be categorized as both biotech and agri-foods and, depending on the processes they undertake, possibly even cleantech. Therefore, it is not appropriate to simply sum employment across the “innovation areas” to generate an estimated size of the “innovation economy”. Employment in these categories should be compared longitudinally, rather than cross-sectionally.

Web scraping was completed to support the identification of in-demand roles, determine the volume and availability of these roles, and determine their competencies and skill needs across the digital economy and in key growth areas. Secondary analysis was undertaken using a variety of data sources ranging from Stats Canada, O*NET and OECD to specialized industry data sets. For a more detailed understanding of the research and forecasting methodology employed in this study, along with limitations of research, please see Appendices I to III.

Based in this research, this study will highlight Canada's current and future pathways in the digital economy, including changing sectors, and provincial considerations until 2023. It will highlight the demand for talent, including top jobs and critical skills; shine a spotlight on Canada's key innovation areas; and underline the essential supply streams that will need to be leveraged to fill this demand.

This report is organized into five key sections:

I

Section I of this report will provide an overview of the important drivers, changes and influencing factors that are shaping the Canadian and global digital economy of the future, paving the way for emerging growth sectors and areas of innovation, and shifting the demand for talent.

II

Section II of this report provides an introductory overview of the (6) key innovations areas that are expected to see the fastest growth and employment potential for Canada, along with the ICT sector that is the cornerstone for their success. These areas are increasingly influencing the Canadian digital economy and driving the demand for digital talent.

III

Section III provides labour market forecasting analyses (contractionary, moderate and expansionary scenarios) from 2018 to 2023 across the Canadian digital economy. This section also highlights the top 15 in-demand occupations in the digital economy as expressed by employers, along with their corresponding skill needs.

IV

Section IV showcases labour market forecasts (contractionary, moderate and expansionary scenarios) for the 6 innovation areas. This section also underlines technology use cases and examples in these fields, as well as two key in-demand occupations for each, and their corresponding critical skills.

V

Section V offers a snapshot of supply needed to fill those roles in Canada. This section discusses youth and new grads, women, people with disabilities, immigrants and other critical talent streams that will support the digital economy of tomorrow.

Section I

The Changing Nature of Employment and the Central Drivers that Will Shape our Future Digital Economy

What do we mean when we say that business models and economic structures are changing? Which factors drive these shifts and how are they influencing the strength of our markets, or our ability to compete internationally? How are they bringing new nuances to labour and skill needs, generating opportunities and enshrining the need for lifelong learning and continuous skill development?

There are many intricacies impacting and reshaping our relationships with global markets and ultimately, changing the nature of work itself. Despite the interwoven nature of these variables, ICTC has identified the following global disruptors and movements that can be seen as anchors of future economic growth and meaningful employment opportunities for Canadians.

Growing Automation

Increasingly, businesses around the world are looking to automation as a solution for enhancing efficiencies, boosting productivity, and ultimately, growing profit margins in an increasingly competitive global marketplace. While it is not necessarily true that all jobs which can be automated will be, a recent report identified that automation driven by technologies like AI and robotics can lead to more than 350 million workers globally needing to acquire new skills or even shift occupational categories by 2030[8]. In a future shaped by such changes, the need for a workforce that is agile and adaptable is essential. This means not only understanding which jobs will see demand, but taking the necessary steps to gain the skills needed for those roles. Whether it be an engineer in the oil and gas industry upskilling for a job as a data scientist[9], or an automotive technician training to work on electric and eventually autonomous vehicles, impending automation across industries creates a strong need for a nimble workforce that can be revectored into the jobs of the future.

Demographic Shift

The most recent Canadian census confirmed a long-anticipated reality: our society is ageing rapidly, creating notable consequences for the workforce. The 2016 census found that for the first time ever, seniors (aged 65+) made up a bigger portion of the Canadian population than youth (aged 14 and under)[10]. While some seniors are choosing to take on part-time work during their retirement[11], an ageing population means that many who are currently working-age will be exiting the workforce themselves in the next number of years. This makes it pertinent to prepare youth from an early age, guiding them into the career pathways that will drive our future economy. This means attracting more students into STEM and other increasingly critical study areas like business, psychology, and marketing among others; while also ensuring that the foundational blocks needed to build interest and confidence in these areas are developed from an early age – particularly among underrepresented groups.

The Diversity Dividend

Further to attracting more underrepresented groups such as women, Indigenous youth, or youth with disabilities to critical study areas, we must also ensure that our future economy is inclusive, accessible, and diverse at all levels. The recent census highlighted that Indigenous population growth is four times that of non-Indigenous populations in Canada[12], however on a national level, fewer than 2% of Indigenous peoples were employed in top tech roles[13]. Although only a snapshot of one province, in Alberta, roughly 17% of the population identified as having a disability in 2017[14], with many expressing challenges finding work in general, let alone in high-growth areas like tech. These are only a few examples of critical supply streams that can play an essential role in supporting and advancing Canada's future economy, while simultaneously creating meaningful opportunities and long-term impacts for their communities.

[7]Excluding the ICT sector, which cuts across all innovation areas.
[8]James Manyika, Susan Lund, Michael Chui, Jacques Bughin, Jonathan Woetzel, Parul Batra, Ryan Ko, Saurabh Sanghvi, "Jobs lost, jobs gained: What the future of work will mean for jobs, skills, and wages", McKinsey Global Institute, November 2017. https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages.
[9]Alexandra Cutean, Robert Davidson, "Mapping Calgary's Digital Future: Tech Employment Opportunities for Displaced Workers" Information and Communications Technology Council, August 2018. https://www.calgaryeconomicdevelopment.com/dmsdocument/252
[10]Terra Ciolfe, "What the census tells us about Canada's aging population" MacLean's, may 3, 2017. https://www.macleans.ca/news/canada/what-the-census-tells-us-about-canadas-aging-population/
[11]Myriam Hazel, "Labour Statistics at a Glance: Reasons for working at 60 and beyond", Statistics Canada, December 14, 2018. https://www150.statcan.gc.ca/n1/pub/71-222-x/71-222-x2018003-eng.htm

The Rise of Non-Traditional Education and Work

Although traditional educational and employment pathways continue to play an important role in our current and future economy, unignorable are the changes that are taking place across the workforce. Increasingly, more people are opting for alternative forms of employment, whether to replace fulltime work or simply supplement it. Developments like remote working, or the rise of the gig economy[15] and sharing economy[16] are creating new opportunities for the labour force, while bringing with them additional considerations on issues like fair wages and benefits. This fluidity among methods of working is also translating to pathways for obtaining employment. Traditional education will always play an important role in supporting and preparing the talent supply of the future, however more and more are looking to alternative methods like short-duration training, bootcamps, and even MOOCs[17] to obtain the education needed for future careers. Whether upskilling themselves, or transitioning their careers altogether, Canadians are increasingly embracing the growing need for lifelong learning and continuous skill development.

Broadening of the Digital Value Chain

Roles like software developers, data scientists, cybersecurity analysts and a number of other highly-skilled jobs will play critical roles in building, supporting and safe-guarding not only our digital economy, but our future communities as well. The growing emergence of smart cities for example, will bring to the forefront questions related to governance, infrastructure, mobility needs, environmental considerations and many others[18]. With this, new opportunities will emerge and be generated not only for the digitally skilled software developers and data scientists of the world, but for a number of lower-skilled roles as well. Take for instance the case of the automotive technician: increasing electrification is already impacting automotive roles like these, requiring them to obtain new skills to be able to work on and fix vehicles as needed. Unlike gas-powered engines, electric engines do not require oil changes, and have fewer parts that can break down[19]. While this means that repairs may be needed less frequently, they will nonetheless still be needed. Technicians with deep automotive knowledge and expertise will not be rendered obsolete by technology, yet they will increasingly require at least some degree of digital competency. Many of the most progressive auto shops are already utilizing technology like iPads and Google Hangouts to streamline work, and some are even offering animated repair videos to customers, visualizing repairs needed[20]. An increasingly digital future that is properly planned for will not supplant roles like the automotive technician – but it will undoubtedly tweak them. This further enshrines the need for continuous learning across occupations as our economies and societies become more connected and digitally-enhanced.

[15]"Labour, Employment and Human Rights Bulletin: HR Space" Fasken, April 4, 2019. https://www.fasken.com/en/knowledge/2019/04/hr-space---the-canadian-gig-economy/
[16]Jim Chappelow, "Sharing Economy", Investopedia, June 25, 2019. https://www.investopedia.com/terms/s/sharing-economy.asp
[17]"Mooc.org", edX, 2019. http://mooc.org/
[18]Holly Brown, Alexandra Cutean, Trevor Quan, "Smart City Priority Areas and Labour Readiness of Canadian Cities" Information and Communications Technology Council, August 2019. https://www.ictc-ctic.ca/wp-content/uploads/2019/08/ICTC_Smart-City-Priority-Areas_Brief_ENG-8.19.19.pdf
[19]Peter Holly, "Will electric vehicles doom your neighborhood auto mechanic?" The Record, December 12, 2017. https://www.therecord.com/news-story/7993971-will-electric-vehicles-doom-your-neighbourhood-auto-mechanic-/
[20]"5 Ways How Technology Changed Automotive Repair Shops", AutoBarn, 2019. https://autobarn.ca/technology-changed-automotive-repair-shops/

Section II

Digital Economy Zoom-In:
6 Key Innovation Areas

With technology saturating many aspects of our economy, it is increasingly difficult to definitively distinguish between emerging sectors and industries. For example, does a business that specializes in the 3D printing of organs classify as a biotechnology company, or as an advanced manufacturing company? Likewise, is the field of bioinformatics better thought of as biotechnology, information technology, or even artificial intelligence? All the emerging sectors – or "innovation areas" – discussed in this report inevitably contain some element of Information and Communications Technology (ICT).

Although not necessarily mutually-exclusive as evidenced by the example above, the following section provides defining guidelines and an introductory overview of Canada's emerging innovation areas.

Information and Communications Technology (ICT): A Pillar of Innovation

The ICT sector includes a variety of subsectors, and combined, is responsible for substantial increases in productivity over the past few decades. Manufacturing in this sector focuses on the production of equipment for industry, including computers, audio and video machinery, magnetic and optical media, and other electronic components. The ICT wholesaling subsector is responsible for the purchase and sale of both ICT equipment and services. The ICT software subsector includes the development of systems and network design, software engineering, and data processing; and finally, the telecommunications subsector includes wired and wireless carriers, Internet Service Providers (ISPs), and other program distributers.

Industry Canada currently estimates a total of 40,000 businesses operating in the ICT sector across Canada.[21] The vast majority, 86%, were micro-businesses[22], employing ten or fewer employees. However, while small businesses currently dominate this sector in Canada, employment is growing substantially faster than the economy as a whole, with the software subsector largely responsible for this expansion.

INNOVATION AREA I

Cleantech: Carbon-neutral and climate-positive energy and services

The cleantech industry is comprised of businesses that are predominantly engaged in the development and sale of environmentally-friendly goods and services, and/or environmentally-friendly energy alternatives. Cleantech companies focus on generating efficiencies through the use of technology, while simultaneously minimizing the impact on the environment. Examples of top Canadian cleantech leaders include BC's *Axine Water Technologies*, Toronto's *ecobee*, or Halifax's *CarbonCure*.

INNOVATION AREA II

Clean Resources: The next generation of natural resource extraction

Clean resources refers to the blend of the natural resources sector and clean technology. In short, clean resources companies use technology to extract or utilize natural resources in ways that are carbon-neutral. Even with these changes, the natural resources sector is a long-standing pillar of the Canadian economy, accounting for 17% of total economic output,[23] or $377 billion in GDP during 2017. Examples of top clean resources companies in Canada include Quebec's *Dundee Sustainable Technologies* and Alberta's *Questor Technology Inc.*

[21] *"Canadian ICT Sector Profile 2017", Government of Canada, October 12, 2017.https://www.ic.gc.ca/eic/site/ict-tic.nsf/eng/h_it07229.html*
[22] *"Definitions" Microbusiness Research Portal, 2019. http://microbusiness.ac.uk/definitions/*
[23] *"10 Key Facts on Canada's Natural Resources", Natural Resources Canada, 2018. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/files/pdf/10_key_facts_NatResources_2018_e.pdf*

INNOVATION AREA III

Advanced Manufacturing: Kickstarting production with technology

Advanced manufacturing refers to new and often digitally-enabled processes and technologies that disrupt the manufacturing sector and generate efficiencies. These processes often depend on the use and coordination of information, automation, computation, software, sensing, and networking. They can be applied to pioneer new ways of manufacturing existing products or create entirely new products. Examples of top advanced manufacturing companies in Canada include Quebec's *AON3D*, or Alberta's *ATTAbotics*.

INNOVATION AREA IV

Interactive Digital Media: Tuning in and experiencing design

The interactive digital media industry is an intersection of ICT, digital and creative industries, and businesses that display data or information in creative or innovative ways. Some digital media sub-sectors, such as the video game industry, are growing significantly across Canada. The sub-sector grew by 24% from 2015 to 2017 alone, according to the Entertainment Software Association of Canada[24]. Other examples of businesses in this space include those based on animation, visual effects, or even data visualization. Examples of top interactive digital media companies in Canada include BC's *Yeti Farm Creative* or Alberta's *VizWorx*.

INNOVATION AREA V

Health and Biotechnology: Innovative well-being

Health and biotechnology can be broken down into several subsectors. While many healthcare-based companies increasingly utilize technology to improve processes or expand access to products and services, Bioinformatics is focused on using big data to identify correlations between gene sequences and diseases, to aid in the design of novel drugs, and to tailor treatments to individual patients based on their DNA sequences (pharmacogenomics).[25] Green Biotech is biotechnology related to agricultural or environmental processes, including genetically modified organisms. Industrial Biotech focuses on the production of organic enzymes for use as industrial catalysts or cleaners. Industrial biotechnicians manufacture products useful for the chemicals, food and feed, detergents, paper and pulp, textiles, and biofuels industries.[26] Finally, Red (health) Biotech, making up the majority of biotech firms in Canada, relates to biotechnology for medical purposes, including the engineering of genetic cures, or designing organisms which create antibiotics.[27] Examples of top health and biotech companies in Canada include BC's *Zymeworks*, or Manitoba's *DiaMedica*.

[24]"Essential Facts about The Canadian Video Game Industry", The Entertainment Software Association of Canada, October 2017. http://theesa.ca/wp-content/uploads/2017/10/ESAC2017_Booklet_13_Digital.pdf
[25]Arthur M. Lesk, "Bioinformatics", Encyclopaedia Britannica. https://www.britannica.com/science/bioinformatics
[26]Mayara C S Barcelos, Fernanda B Lupki, Gabriela A Campolina, David Lee Nelson, Gustavo Molina, "The colors of biotechnology: general overview and developments of white, green and blue areas", FEMS Microbiology Letters, Vol.365, No.21, September 25, 2018. https://academic.oup.com/femsle/article/365/21/fny239/5106815
[27]Paul Arnold, "What is Red Biotechnology? Biopharmaceuticals is the Application of biotechnological Research in the Medical Field", Bright Hub, 2019. https://www.brighthub.com/science/genetics/articles/2196.aspx

INNOVATION AREA VI

Agri-foods and Food-tech: Tech-based nutrition and production

Agri-Foods and food-tech cross over several subsectors, including animal genetics, industrial bioproducts, crops, dairy, and many others.[28] This area shades substantially into biotechnology, with a number of technologies overlapping. For example, the industrial bioproducts subsector contains over 200 Canadian firms[29] performing services such as transforming hemp and flax fibre into biomaterials for the automotive and construction industries, or using crop residues to produce bio-based chemicals for household cleaning products. Ultimately the agri-foods and food-tech innovation area focuses on the use of technology for environmentally-friendly and sustainable food production. Examples of agri-foods and food-tech companies in Canada include Saskatchewan's *Agimatics*, or BC's *Teramerra*.

[28] *"Canadian agri-food sector intelligence", Agriculture and Agri-Food Canada, July 24, 2019. http://www.agr.gc.ca/eng/industry-markets-and-trade/canadian-agri-food-sector-intelligence/?id=1361290241756*
[29] *"Bioproducts", Agriculture and Agri-Food Canada, July 5, 2017. http://www.agr.gc.ca/eng/industry-markets-and-trade/canadian-agri-food-sector-intelligence/industrial-bioproducts/?id=1361906627801*

Canada's Future Digital Economy:
Forecasting the demand for talent 2018-2023

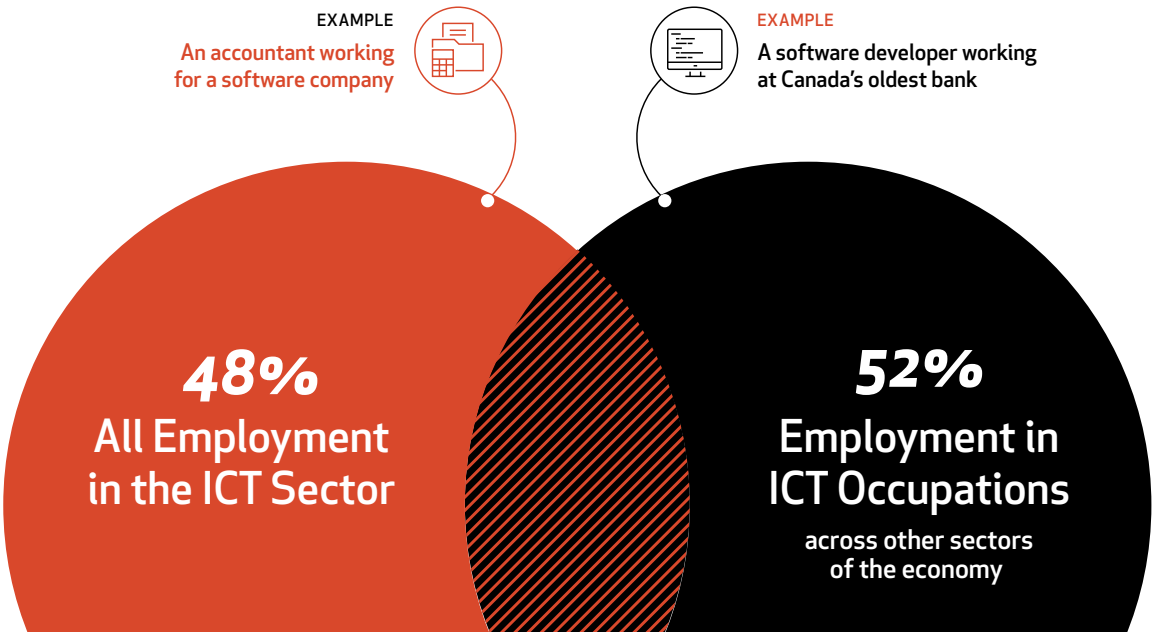
The ICT sector vs. the digital economy – what's the difference?

While the ICT sector refers to businesses that fall under certain digital based industries, the digital economy represents the sum of total employment of ICT workers across all sectors, as well as the sum of non-ICT workers within the ICT sector. This is both the accountant working for a software company (employment in the ICT sector), and the software developer working at Canada's oldest bank (employment in ICT occupations, but not in the ICT sector). In simple terms, the digital economy can be visualized by Figure 1, below.

While the ICT sector remains a critical component of the digital economy, its parameters are increasingly shrinking. The permeation of technology across industries is broadening the scope of the digital economy, meaning that more and more ICT workers are employed in other sectors of the economy. In fact, over the last 10 years, the ICT sector's total share of digital economy employment dropped by nearly 4%, going from more than 52% in 2009 to less than 48% in 2019.

Figure 1: *Visualization of the Digital Economy*

Source: ICTC, 2019



From 2001 to 2018, employment in Canada's digital economy saw a CAGR of 2.5%. Growing almost twice as fast at the overall economy, by the end of 2018 nearly 1.8 M people were employed in the Canadian digital economy. Seeing a CAGR of slightly more than 2% during this period, approximately 870,000 were employed in the ICT sector in 2018. Although the general economy is expected to see slow growth from 2019 to 2020, over the next five years, the Canadian digital economy is forecasted to continue on an upward trajectory. A contractionary growth scenario, where economic uptick stalls past 2020, will mean that employment growth in the digital economy will remain relatively constant. However, if economic conditions improve from 2020 onward, a moderate growth scenario forecasts digital economy employment to scale significantly by 2023.

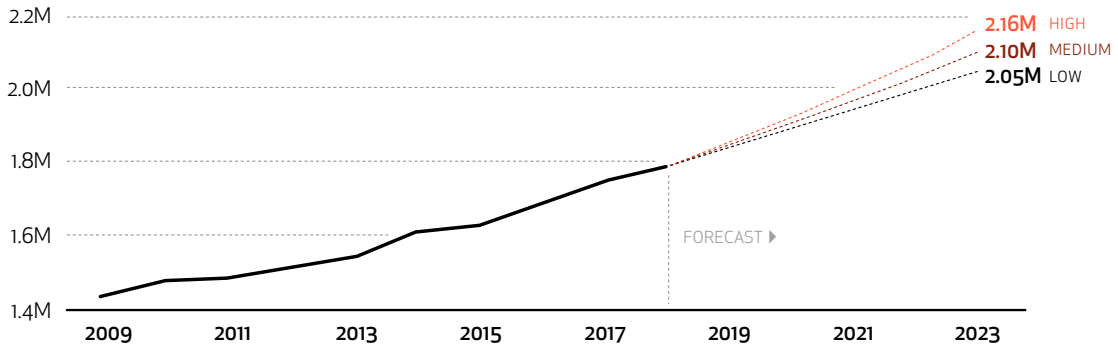
Employment in the Digital Economy: Moderate, Contractionary and Expansionary Growth Forecasts until 2023

What does this mean for Canadian employment prospects? By 2023, under the moderate growth scenario, the Canadian digital economy will see a demand for more than 305,000 digitally-skilled workers. If filled, employment will total slightly more than 2.1 million. Slightly more than 46% of this figure, employment in the ICT sector (all employment in ICT companies) is expected to reach approximately 982,000.

However, the possibility of longer-term economic slowdown resulting from an emerging and lingering recession is a notable consideration. Despite substantial advancements in areas like AI, AR/VR, blockchain and a number of others, intensifying international political dynamics and accelerating trade tensions can function to slow economic activities and curtail exports. Under a contractionary growth scenario, Canada will see demand for slightly more than 250,000 digitally-skilled workers across all sectors. Still significant, this will bring total potential digital economy employment to more than 2.05 million, with employment in the ICT sector totaling nearly 935,000 (approximately 45%).

Lastly, the potential of technology-based efficiencies across sectors, coupled with improvements in trade liberalization near the tail end of 2020 may result in a situation of economic uptick and even full upswing by 2023. Economic conditions such as these tend to act as catalysts for heightened productivity, increased output, and the accelerated trade of goods and services. Under an expansionary growth scenario, the demand for digitally-skilled workers can reach upwards of 360,000 by 2023, bringing total employment in the Canadian digital economy to more than more than 2.16 million. Under this scenario, the ICT sector's share of employment would total approximately 47% or 1.02 million.

Figure 2: *Canadian Digital Economy Forecast 2018 to 2023*



Source: ICTC, 2019

Most in-demand

Top 15 occupations across the Canadian digital economy

Under all potential growth scenarios, the demand for digital talent remains high – but which jobs will be most needed in Canada? At the heart of a discussion like this must always be engagement with industry; with the employers that are paving the way for innovation and opportunity in Canada. Consultations with employers across the digital economy identified a demand for both digital roles as well as supporting business roles that will guide and shape the country's future economy. A total of 15 top occupations were uncovered.

The most in-demand digital roles were:

- Software Developers
- Data Scientists
- Data Analysts
- UX/UI Designers
- Full stack Developers
- Cybersecurity Analysts
- DevOps Engineers
- Machine Learning Engineers
- Database Administrators
- IT Support Specialists

On the business side, the most in-demand jobs were:

- Business Development Managers
- Project Managers
- Business Analysts
- Digital Marketers
- Researchers

The following provides an in-depth description of these roles and the critical skills needed to fill them.

Digital Roles in Demand: Responsibilities & Skillsets

- **Software Developer:** Software developers build applications and programs, then test and maintain those developed products. They work with build automation and version control tools to automate and validate applications based on source code and create consistent processes. They have knowledge of a variety of programming languages including but not limited to Java, JavaScript, C++, C#, Python and SQL. Software developers possess at least a basic level of comfort with machine learning principles and practices, and increasingly, must be proficient with building and using APIs.

- **Data Scientist:** Data scientists collect, clean and analyze data from various sources, using it to build algorithms, models, and machine-learning tools that automate and optimize processes. Data scientists have a strong background in data mining, statistical analysis, as well as creating and running simulations. They possess competency with machine learning principles, and are proficient with programming languages like SQL and Python. Data scientists also tend to use and manage cloud products and data pipelines on platforms like AWS, Microsoft Azure or Google Cloud.

- **Data Analyst:** Data analysts are responsible for tasks ranging from data cleaning, to data analysis, to data visualization. They use statistical methodologies including descriptive statistics, labeling and regression, to extract valuable information from data sources. Data analysts also visualize data, create and implement databases and develop collection strategies for efficient capture and use of incoming data for optimal quality. Data analysts are proficient with programing languages for data analysis like R, Python, SQL, and also have familiarity with database management platforms like Hadoop or Apache Spark.

- **UX/UI Designer:** UX/UI Designers are often a hybrid blend of software development and design. They possess an understanding of usability, ease in navigation, accessibility, and other skills related to creating effective user interfaces and designs for desktop and mobile devices. UX/UI designers are utilized in anything from web design, game design, visual effects, and even graphic design. While UX/UI designers do not in all cases need to be proficient with a variety of programming languages like a software developers do, they do require knowledge of design platforms like InDesign, and cloud computing platforms like AWS, Azure or Google Cloud. UX/UI designers also tend to possess proficiency with web development tools like Google Chrome Developer Tools, jQuery or Angular.js.

- **Full Stack Developer:** Full stack developers are proficient with both the back and front end of software development. This means they can manage IT infrastructure like databases or servers, and develop and manage APIs along with other elements that focus on the functionality of the product. At the same time, full stack developers are also proficient with the front-facing parts of a website that operate according to the principles of user design and user experience. This includes architecture that monitors responsiveness of applications, design features and usability. Full stack developers are proficient with a number of programming languages like C/C++, HTML, Python, Java, JavaScript, and Ruby on Rails. They are also proficient with database management tools and platforms like MySQL or MongoDB.

- **Cybersecurity Analyst:** Cybersecurity analysts design, test, and implement security systems and protocols that are intended to protect an organization's networks from attack. Analysts must have knowledge of relevant cybersecurity standards, as well as the ability to recommend specific and preventative measures that improve an organization's security capabilities. Cybersecurity analyst should have the skills to conduct vulnerability or penetration testing, risk analysis, perform security audits, and analyze security breeches to identify the cause(s) of attack(s). Cybersecurity analysts possess experience with Windows and Linux operating systems, IP networks, DNS, and proxy servers.

- **DevOps Engineer:** DevOps Engineers are a merger between software development, planning, testing and troubleshooting. They provide guidance on system opportunities, risks and cost-benefit analyses – all of which contribute to effective strategic organizational and project planning. They also develop and implement IT solutions, upgrades, and troubleshooting for system maintenance. DevOps Engineers possess an understanding of various programming languages like Python and JavaScript, and can work with a number of development platforms such as Node.js, or React Native. DevOps Engineers often possess proficiency with Git and Jira, and are experienced with cloud computing platforms like AWS. Lastly, DevOps Engineers also have experience with deployment technologies like Kubernetes, OpenStack or Jenkins.

- **Machine Learning Engineer:** Machine Learning Engineers create machine learning models and systems, with the ultimate goal of developing and maintaining efficient self-learning applications and products. They perform data science tasks including collecting, cleaning, and labeling data to prepare it for analysis (e.g. a Data Engineer) and create and test models. Lastly, machine learning engineers train and retrain the systems and models built according to overall objectives, and keep abreast with developments in the field of AI. Machine learning engineers are often proficient with a number of programming languages like Python, C/C++, SQL and Java, use open-source libraries like TensorFlow, and possess experience with natural language processing and IoT applications.

- **Database Administrator:** Database administrators are responsible for the integrity, security, usability and performance of a database. They plan and develop the database, troubleshoot issues, and ensure that data is clearly tagged. They create permission guidelines and ensure that access permissions are appropriately assigned. Database administrators must work to minimize downtime of the database and increasingly require familiarity with cloud database platforms like AWS, Azure or Google cloud.

- **IT Support Specialists:** IT Support Specialists are responsible for providing assistance to users across IT platforms, as well as performing maintenance on those platforms. They are often tasked with installing, configuring or updating software and providing user support on issues or challenges that occur. This includes running diagnostic testing on malfunctioning software or hardware. IT support specialists possess knowledge of SQL and are familiar with ITIL (Information Technology Infrastructure Library) frameworks. They also possess knowledge of LAN, VMWare and VPNs.

Business roles in demand: Responsibilities & Skillsets

- **Business Development Manager:** Business development managers are responsible for managing and developing relationships with clients, customers or other stakeholders that are of strategic interest to an organization. These activities are completed with the intent of expanding customer bases, targeting and reaching new markets and increasing sales and revenue – both in the short and long-term. Business development managers are often responsible for setting growth strategies, conducting research on new markets and consumer needs, leading business meetings with clients, and promoting the business' products and services. They must possess strong leadership and interpersonal skills, a strong groundwork of domain knowledge (e.g. a BD manager for a cleantech company will possess different knowledge than a BD manager for a manufacturing company). Domain knowledge is critical to the success of a business development manager in any field, and in particular tech or science-based verticals. Lastly, business development managers need to be proficient with a variety of CRM platforms like Salesforce or Hubspot.

- **Project Manager:** Project managers are needed across industry verticals and organization types. Typically, project managers are responsible for planning, budgeting, resource allocation, and the tracking of projects in their lifecycles. This includes communicating with stakeholders to identify changes or shifts in project plans, and acting as the main point of contact for clients. Often working with tight deadlines, project managers must exercise robust time management skills. While this can be a general role that is in-demand across many types of sectors, technical project managers work specifically on ICT projects. In these cases, project managers will require the above-noted skills, as well as training or knowledge of ICT practices and principles like software installation and upgrades, site maintenance, and familiarity with relevant technologies, programs or models. Project managers often require proficiency with CRM tools like Salesforce, along with management tools like MS Project, Wrike, or Asana.

- **Business Analyst:** Business analysts work with and analyze a variety of data that are relevant to the overall profitability and productivity of a business. They also develop data quality metrics and measure them across a period of time to ensure that business needs are met. Business analysts must identify problems, opportunities and solutions, and possess familiarity with financial modeling and forecasting, variance analyses, reporting and data visualization. Business analysts often possess proficiency with data analysis and visualization tools like Microsoft PowerBI or Tableau, along with a working knowledge of scripting languages like R.

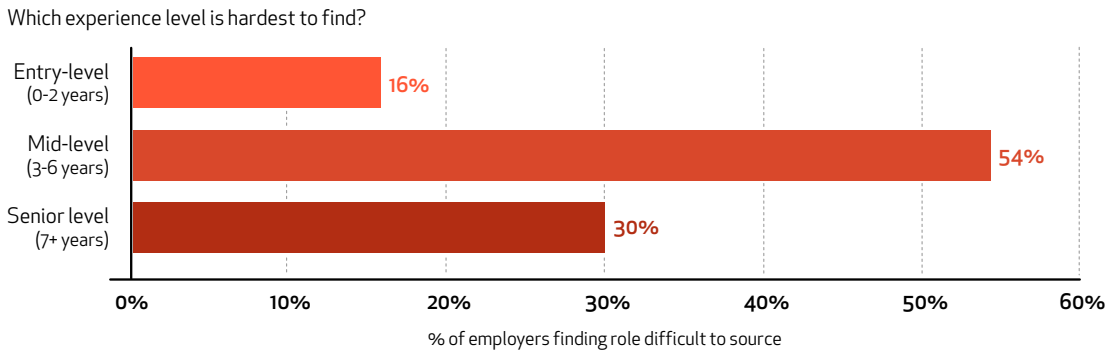
- **Digital Marketer:** Digital marketers are responsible for planning and managing marketing activities and campaigns that function to promote a business' products or services. They often create marketing campaigns, both general and targeted, and utilize user metrics to refine strategies as needed. Digital marketers are in charge of not only attracting users to a business or product, but actively managing "conversions" – that is turning visitors of a website into paying customers. Digital marketers should be proficient with social media, as well as analytics tools like Google Analytics or Hootsuite.

- **Researcher:** The role of a researcher is one that can be applied across a variety of industry verticals, sectors, or types of organizations. For example, economic researchers can be considered in-demand in the financial sector, with their tasks being to perform economic analyses, forecast modeling, and probability analyses. Similarly, researchers can also be considered in-demand in the healthcare and biotech sectors, needed to perform research on human genetics, gene expression or disease, chemical structure review, or even pharmaceutical analysis. While the skills for such a role can differ vastly depending on the subject matter or field, increasingly researchers in the areas of agtech, biotech, and in relation to emerging technologies like artificial intelligence, 5G and blockchain are in-demand. At the core, all researchers must be able to investigate and analyze data, synthesize information, utilize relevant methodology, run tests, and generate and communicate findings in a manner that is understandable and relevant to a given audience. While competency with platforms or tools depends on the type of research role, many researchers working with statistics are competent with programs like STATA, SPSS, and R.

Experience Matters: The mid-level crunch

While all of these occupations were found to be in-demand across the Canadian digital economy, employers further highlighted an important nuance of this talent crunch. More than half (54%) stressed that overall, mid-level employees with 3-6 years of experience were very difficult to source. Of course, senior-level talent was also underlined as very challenging to source – when needed – however were required much less frequently than mid-level employees.

Figure 3: *Experience levels most difficult to source*



Source: ICTC, 2019

Overall, approximately 45% of employers stated that they were able to source the talent they needed – whether within Canada or abroad – in 2 to 3 months. For mid-level and senior employees, this figure averaged between 4 to 6 months.

Snapshot on Tech: 8 Key Digital Roles & Their Critical Skills

Although the below digital roles will be broken down according to specific digital and technical (or "hard") skills, employers are increasingly looking for workers across the board and in digital occupations that are equipped with a blend of business or even "soft" skills. Most commonly cited as "must-haves" for the digital roles below were: knowledge of Agile development and project management, exceptional critical thinking and problem-solving skills, ability to work in teams and other collaborative environments, strong task and time management skills, business acumen and client relationship management, awareness of financial metrics tied to deliverables, and strong communication and interpersonal skills.

The following offers a snapshot of 8 digital occupations seeing high-demand across Canada, along with their top 10 critical "hard" skills. These skills were sourced via a combination of consultation with employers along with analyses of skills most emphasized in job postings.

Software Developer

TOP 10 CRITICAL HARD SKILLS

- Proficiency with Java
- Proficiency with SQL
- Proficiency with Python
- Proficiency with CSS
- Proficiency with JavaScript
- Ability to work with and create APIs
- Proficiency with HTML
- Ability to use cloud platforms like AWS
- Proficiency with C/C++
- Proficiency with open-source version control platforms like Git

Full Stack Developer

TOP 10 CRITICAL HARD SKILLS

- Proficiency with CSS
- Proficiency with HTML
- Proficiency with JavaScript
- Ability to use cloud platforms like AWS
- Proficiency with SQL
- Proficiency with Python
- Proficiency with Java
- Ability to work with and create APIs
- Proficiency with PHP
- Ability to work with open-source platforms like Node.js

UX/UI Designer

TOP 10 CRITICAL HARD SKILLS

- Proficiency with JavaScript
- Proficiency with HTML
- Ability to work with and create APIs
- Expert use of InDesign
- Ability to work with open-source front-end web frameworks like AngularJS
- Expert use of design toolkits like Sketch
- Expert use of Photoshop
- Proficiency with open-source version control platforms like Git
- Familiarity with JavaScript libraries like jQuery
- Familiarity with product design platforms like InVision

Data Scientist

TOP 10 CRITICAL HARD SKILLS

- Proficiency with Python
- Proficiency with JavaScript
- Proficiency with SQL
- Expert use of Excel
- Strong understanding of Machine Learning
- Familiarity with open-source data libraries like TensorFlow
- Familiarity with data visualization programs like Tableau
- Familiarity with SAS
- Ability to use and manage cloud platforms like AWS
- Strong knowledge of AI for data science

DevOps Engineer

TOP 10 CRITICAL HARD SKILLS

- Extensive experience with continuous integration
- Proficiency with Java
- Proficiency with SQL
- Ability to use cloud platforms like AWS
- Proficiency with container management tools like Docker
- Proficiency with open-source automation software like Jenkins
- Ability to work with and create APIs
- Proficiency with open-source container orchestration systems like Kubernetes
- Familiarity with open-source deployment tools like Ansible
- Proficiency with automation products for software infrastructure like Puppet

Machine Learning Engineer

TOP 10 CRITICAL HARD SKILLS

- Proficiency with Python
- Deep knowledge of Machine Learning
- Proficiency with C/C++
- Proficiency with SQL
- Proficiency with Java
- Familiarity with open-source neural-network libraries like Keras
- Proficiency with open-source data libraries like TensorFlow
- Ability to use and manage cloud platforms like AWS
- Familiarity with open-source software utilities for networks like Hadoop
- Deep knowledge of natural language processing

Database Administrators

TOP 10 CRITICAL HARD SKILLS

- Proficiency with SQL
- Proficiency with database management systems like SQL Server
- Proficiency with database management software like Oracle
- Familiarity with open-source relational database management systems like MySQL
- Familiarity with data migration processes performed by SSIS
- Proficiency with report-generating software like SSRS
- Familiarity with cloud computing and virtualization software like VMWare
- Proficiency with CRM tools like Microsoft Dynamics
- Ability to use cloud platforms like AWS
- Ability to use cloud platforms like Azure

IT Support Specialist

TOP 10 CRITICAL HARD SKILLS

- Expert use of Excel
- Proficiency with SQL
- Proficiency with ITIL practices
- Deep knowledge of local area networks (LAN)
- Familiarity with cloud computing and virtualization software like VMWare
- Deep knowledge of virtual private networks (VPN)
- Familiarity with DNS
- Familiarity with programming languages like Java
- Familiarity with protocols used on IP networks like DHCP
- Proficiency with SharePoint

Snapshot: 3 Key Business Roles & Their Critical Skills

While digital roles are the foundational pillar of the digital economy, business roles are also increasingly in-demand, particularly as businesses move from R&D or early-stage development, to late-stage development, deployment and commercialization. In later stages of business growth, occupations like the below are critical to the ability of the organization to market products and reach new markets, track sales and other success metrics, as well as highlight barriers and launch strategies to overcome them.

The following offers a snapshot of 3 business occupations seeing high demand across Canada, along with their top 5 critical "hard" skills and top 5 business skills. Similar to the digital roles above, these skills were sourced though a combination of employer consultation and analyses of job postings.

Business Analyst

TOP 5 CRITICAL HARD SKILLS

- Proficiency with SQL
- Proficiency with Microsoft PowerBI
- Proficiency with Salesforce
- Familiarity with flowchart applications like Microsoft Visio
- Familiarity with multi-capability business management software like SAP

TOP 5 CRITICAL BUSINESS SKILLS

- Proficiency with project and task planning
- Knowledge of project management practices and principles
- Proficiency with statistical analysis
- Strong capacity for problem-solving
- Familiarity with report writing, including strategy-based and financial reports

Project Manager

TOP 5 CRITICAL HARD SKILLS

- Proficiency with flowchart applications like Microsoft Visio
- Familiarity with multi-capability business management software like SAP
- Proficiency with project management tools like Wirke or Asana
- Knowledge of various elements of enterprise resource planning (ERP)
- Proficiency with bug and issue tracking tools like Jira

TOP 5 CRITICAL BUSINESS SKILLS

- Proficiency with Agile project management practices and principles
- Proficiency with budgeting
- Expert scheduling and tracking skills
- Expert time and resource management skills
- Proficiency with writing requests for proposal (RFPs)

Business Development Manager

TOP 5 CRITICAL HARD SKILLS

- Proficiency with collaboration software like Confluence
- Proficiency with SharePoint
- Expert use of Salesforce
- Proficiency with software-centric sales and marketing platforms like Hubspot
- Proficiency with project management tools like Wrike

TOP 5 CRITICAL BUSINESS SKILLS

- Familiarity with business-to-business (B2B) sales
- Strong leadership skills
- Familiarity with negotiation and dispute resolution practices and procedures
- Proficiency with project management
- Expert relationship and client management skills

Section IV

Canada's 6 Key Innovation Areas:

A Strategy for Leadership in the Digital Future

Cleantech | Clean Resources | Advanced Manufacturing | Interactive Digital Media | Health & Biotech | Agri-foods & Food-tech

In 2017, the Federal Budget announced a vision for Canada to become a global leader in innovation.

Grounded in the Innovation and Skills Plan[30], six (6) Economic Strategy tables were created to track, understand, and support the needs of businesses in key areas of the economy. Modeled after these growing industries, ICTC's 6 key innovation areas are: Cleantech, Clean Resources, Advanced Manufacturing, Interactive Digital Media, Health & Biotech, and Agri-foods & Food-tech.

The following will offer an expanded background on these critical areas of technology-development and innovation, highlight in-demand and unique employment opportunities along with their skill needs, and forecast total employment from 2018 to 2023 according to moderate, contractionary and expansionary growth scenarios. While these innovation areas will contribute substantially to overall digital economy employment in Canada, they are not synonymous – that is, these forecasts represent the sum of total employment in these areas, including occupations that fall outside of the digital economy.

[30] *"Economic Strategy Tables", Government of Canada, October 23, 2018. https://www.ic.gc.ca/eic/site/098.nsf/eng/home*

Cleantech in Canada

Background and Employment Forecast, 2018-2023

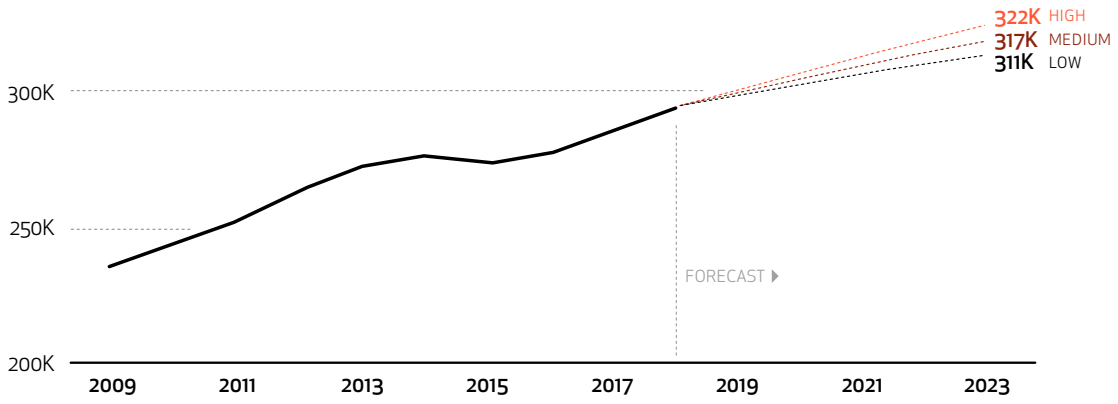
With an estimated 850 firms operating in the country,[31] cleantech is considered to be a relatively young industry, but has already proven to be an important source of job creation for Canadians. In 2017, a little over 3% of Canada's GDP was attributed to the production of clean technology and environmentally-friendly goods and services,[32] and that same year, cleantech accounted for more than 250,000 jobs.[33]

Total cleantech exports from Canada were estimated to be worth more than $11 billion in 2016,[34] with the United States being the main export market.[35] While the outlook for future export growth has the potential to be positive depending in large part on investment, regulation, and movement on international commitments such as the Sustainable Development Goals, Canada's position in the global cleantech market remains relatively small at this stage.[36] Recently, Canada's market share of global clean technology goods totaled 1.4%, ranking us 16th among the world's top 25 exporters.[37]

Therefore, although a key area for innovation, cleantech's role in employment generation will be gradual while carbon and emission policies are further solidified, investments scale, and businesses commercialize their products. Compounding these factors with overall economic conditions, a moderate growth scenario estimates that cleantech employment in Canada will see a demand for approximately 25,500 workers by 2023, bringing total potential employment to more than 316,500. And while the possibility of a further slowing economy can dull growth for most industries, a continued or even growing crunch in the energy sector specifically can prove further problematic for cleantech. With many energy companies being the main purchasers of cleantech products, a further slowdown in this sector will inevitably impact employment growth for this innovation area. According to a contractionary growth scenario, the demand for cleantech workers will be slightly more than 19,500 by 2023, taking total potential employment to slightly more than 310,500.

[31] *"Environmental and Clean Technology Products Economic Account, 2017", Statistics Canada, December 17, 2017. https://www150.statcan.gc.ca/n1/daily-quotidien/181217/dq181217d-eng.htm*
[32] *"Environmental and Clean Technology Products Economic Account, 2007 to 2016", Statistics Canada, December 13, 2017. https://www150.statcan.gc.ca/n1/daily-quotidien/171213/dq171213g-eng.htm*
[33] *"Canada's clean technologies poised to lead sustainable future", The Canadian Trade Commissioner Service, October 4, 2018. https://www.tradecommissioner.gc.ca/canadexport/0003164.aspx?lang=eng*
[34] *"Exporting Canadian Technology and Know-how", The Future Economy. https://thefutureeconomy.ca/spotlight-interviews/carl-burlock/*
[34] *Mia Rabson, "Canada's clean tech industry falling behind", The Record, March 16, 2018. https://www.therecord.com/news-story/8331512-canada-s-clean-tech-industry-falling-behind/*
[35] *"2017 Canadian Clean Technology Industry Report", Analytica Advisors Inc., 2017. http://analytica-advisors.com/sites/default/files/2017%20Canadian%20Clean%20Technology%20Industry%20Report%20Synopsis%20FINAL.pdf*
[36] *Mia Rabson, "Canada's clean tech industry falling behind", The Record, March 16, 2018. https://www.therecord.com/news-story/8331512-canada-s-clean-tech-industry-falling-behind/*
[37] *"2017 Canadian Clean Technology Industry Report", Analytica Advisors Inc., 2017. http://analytica-advisors.com/sites/default/files/2017%20Canadian%20Clean%20Technology%20Industry%20Report%20Synopsis%20FINAL.pdf*

Figure 4: *Cleantech employment in Canada, 2018-2023*



Source: ICTC 2019

A core blend of technology and energy-based roles, cleantech is a unique combination of job and skill needs. Consultations with cleantech employers highlighted that overall, the greatest employment demand rested within the engineering field. Employers noted a number of in-demand engineering occupations including biocomposite engineers, process engineers, manufacturing engineers, and power engineers – these roles were in addition to data science roles that were regarded as extremely in-demand. On the business side, employers also stated a variety of talent needs ranging from financial analysts to project managers.

While the software developer was the most commonly cited in-demand digital role, a few cleantech employers highlighted the need for newly-emerging occupations like blockchain developers. Although the application of blockchain in cleantech or energy may be a recent use case for the technology, blockchain is increasingly regarded as a potential solution for green energy innovations like smart grids, energy trading, and even renewable energy sources to power cryptocurrency trading.

Snapshot: Cleantech Jobs & Skills

The following offers a snapshot of two (2) key occupations seeing high-demand among cleantech businesses, along with their top five (5) critical "hard" skills. These skills were sourced though a combination of employer consultation and analyses of job postings.

Chemical Engineer

TOP 5 CRITICAL HARD SKILLS

- Proficiency with building process flow diagrams (PFDs)
- Proficiency with simulation software for chemical reaction models like AspenPlus
- Knowledge of good manufacturing practices (GMP)
- Knowledge of relevant engineering standards administered by organizations like the ASME
- Familiarity with programmable logic controllers (PLC)

Mechanical Engineer

TOP 5 CRITICAL HARD SKILLS

- Proficiency with design and drafting software like AutoCAD
- Proficiency with modeling/engineering-based design software like SolidWorks
- Familiarity with building modeling software like Revit
- Proficiency with C++
- Familiarity with human-machine interfaces (HMI) and dashboards

Clean Resources in Canada

Background and Employment Forecast, 2018-2023

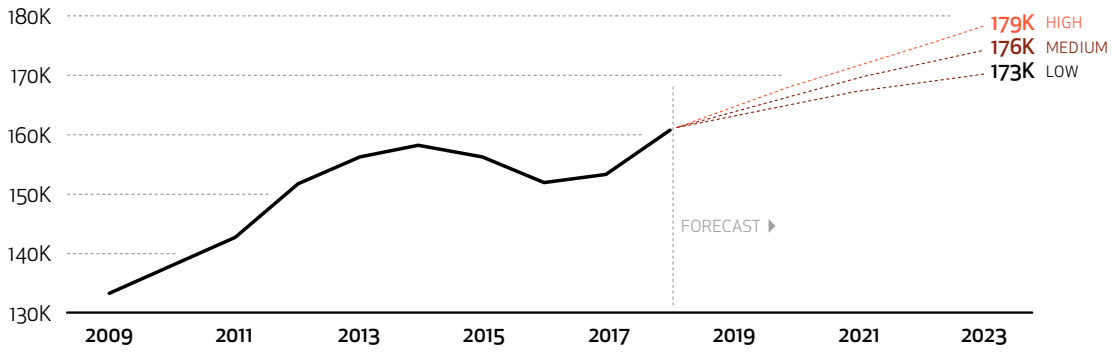
While similar to cleantech, the clean resources area represents businesses that focus on the extraction or use of natural resources in ways that are environmentally-friendly, carbon neutral, or climate-positive. A pillar of the economy, in 2018, over 1.5 million Canadians were either directly or indirectly employed by the natural resources sector.[38] However, estimates suggest that the development and use of natural resource-based products account for over 90% of Canada's greenhouse gas emissions.[39] The need to mitigate environmental damage via the use of alternative solutions within this sector is clear.

Canadian artificial intelligence firms like *Ambyint*,[40] are among those leading the way in the "greening" of the natural resources sector. Developing industrial IoT methods capable of detecting leaks in drilling equipment and reducing the energy inputs required to extract petroleum, Ambyint aims to reduce the environmental impact of commodity extraction, while maintaining the economic strength of the sector.

However, similar to cleantech, external factors such as global and national environmental commitments, energy sector trends, and other influencers, play a key role in the employment prospects of companies operating in the clean resources field. Under a moderate growth scenario, clean resources is forecasted to see modest employment demand totaling approximately 10,500 workers by 2023. If filled, this will bring total clean resources employment to nearly 176,000. Similarly, should economic conditions – particularly in the energy and natural resources sectors – continue to slow, a contractionary growth scenario highlights a further dulling of demand for clean resources talent. In this instance, demand will total approximately 7,500, bringing total clean resources employment to slightly below 173,000 by 2023.

[38] *Idem.*
[39] *"Greenhouse gas emissions", Statistics Canada, December 6, 2007. https://www150.statcan.gc.ca/n1/pub/16-251-x/2007000/findings-resultats/4074170-eng.htm*
[40] *"Ambyint: Artificial Lift Meets Artificial Intelligence", Ambyint, https://ambyint.com/*

Figure 5: *Clean resources employment in Canada, 2018-2023*



Source: ICTC 2019

Given the strong overlap between cleantech and clean or green applications to the natural resources sector, the occupational needs of clean resources employers and cleantech employers tend to be similar. In clean resources, employers noted a slight inclination to technician roles vs. engineers in some cases, and placed a heavier emphasis on geospatial or mapping roles like GIS analysts.

GIS applications and workers can play important roles in the natural resources sector. For example, GIS analysts are essential to forest management and in particular, emergency management in the forestry sector. One pertinent application of these skillsets is in relation to the migration and containment of forest fires. Spatial analysis tools are utilized in these cases to analyze the extent of fires, locations of facilities, and to map areas that may fall in the fire's range. Geospatial analysis, coupled with predictive analytics and wind-force estimates can even be used to automate the processes utilized to identify facilities at risk in future instances[41].

Snapshot: Clean Resources Jobs & Skills

The following offers a snapshot of two (2) key occupations seeing high-demand among clean resources businesses, along with their top five (5) critical "hard" skills. These skills were sourced though a combination of employer consultation and analyses of job postings.

Process Engineer

TOP 5 CRITICAL HARD SKILLS

- Proficiency with Python
- Proficiency with CAD
- Proficiency with SQL
- Proficiency with modeling/engineering-based design software like SolidWorks
- Familiarity with open-source operating systems like Linux

Embedded Software Engineer

TOP 5 CRITICAL HARD SKILLS

- Proficiency with C/C++
- Proficiency with Python
- Possession of relevant software and hardware engineering designations like ARM
- Familiarity with communication interfaces for embedded systems like Serial Peripheral Interface (SPI)
- Familiarity with TI Embedded software products

[41] *"Ambyint: Artificial Lift Meets Artificial Intelligence", Ambyint, https://ambyint.com/.*

Advanced Manufacturing in Canada
Background and Employment Forecast, 2018-2023

The Advanced Manufacturing supercluster is one of five under the Government of Canada's $950-million Innovation Superclusters Initiative. Based in Ontario, the Advanced Manufacturing Supercluster is expected to contribute to the development of "next-generation" manufacturing capabilities, by incorporating technologies like advanced robotics, IoT sensors, artificial intelligence, and 3D printing into the manufacturing process.

Next Generation Manufacturing Canada, the industry-led non-profit organization established to lead Canada's Advanced Manufacturing Supercluster initiative, already points to skill gaps in the existing manufacturing sector. They estimate that future jobs in the manufacturing sector will be expected to have a greater capacity to handle quality control, logistics, process management, and planning.

Additionally, the global move towards automation and efficiency-generation in manufacturing processes has contracted in recent decades, and from 2000 to 2017, total Canadian employment in manufacturing fell from 15% to 9.3%. New technologies have been developed that automate previously labour-intensive processes, and growing globalization and new free trade deals have functioned to create competition. While developments in advanced manufacturing may not bring low-skilled manufacturing jobs back to Canada, new and higher-quality occupations are likely to emerge, bringing with them the demand for new skills and competencies.

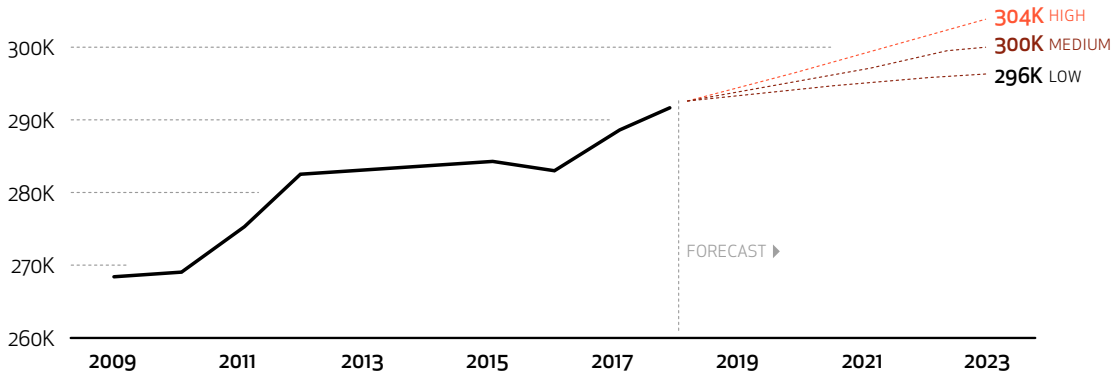
However, despite the potential for novel innovation, advanced manufacturing in the current and near-term is still a small component of the overall manufacturing industry. ICTC estimates suggest that the advanced manufacturing sector accounts for just under 20% of all manufacturing in Canada . Moreover, much of the job growth that will propel this industry forward will still require substantial research and development in relation to technological advancements like Industrial IoT (IIoT), enhanced data transmission capabilities that will be enabled with 5G, and further exploration and commercialization of artificial intelligence and robotics. Taking this into account, the near-term growth of advanced manufacturing occupations will remain modest. A moderate growth scenario in this area suggests a demand for approximately 8,000 workers by 2023, brining total potential employment to over 300,000.

Similarly, should economic conditions slow further, functioning to curtail advancements in trade and international collaboration needed for innovation in key areas like IIoT and AI, the demand for advanced manufacturing workers will dampen further.

[38] *Idem.*
[39] *"Greenhouse gas emissions", Statistics Canada, December 6, 2007. https://www150.statcan.gc.ca/n1/pub/16-251-x/2007000/findings-resultats/4074170-eng.htm*
[40] *"Ambyint: Artificial Lift Meets Artificial Intelligence", Ambyint, https://ambyint.com/*

In cases like this, a contractionary growth scenario points to a demand for just over 4,000 workers. Here, total potential employment in advanced manufacturing will reach slightly more than 296,000 by 2023.

Figure 6: *Advanced manufacturing employment in Canada, 2018-2023*



Source: ICTC 2019

With advanced manufacturing primarily being a combination of manufacturing and technology occupations, consultations with employers have identified a mixture of engineering and digitally-centered roles as in-demand. Among these are jobs like applications engineers, mechanical engineers, software engineers, data scientists, and drafting technicians. While 3D printing of consumer products is one well-known application of advanced manufacturing, notable inroads are being created in sectors like aerospace, healthcare, and transportation. In aerospace for example, weight reduction is a critical concern[45], and advanced manufacturing has been utilized in combination with lean manufacturing processes to create light-weight yet high-performance products and components. Alternatively, in the healthcare sector, medical manufacturers are increasingly exploring developing biocompatible 3D printing solutions, to the point of even being able to utilize bioprinters[46] that can eventually create functional 3D printed organs.

Snapshot: Advanced Manufacturing Jobs & Skills

The following offers a snapshot of two (2) key occupations seeing high-demand among advanced manufacturing businesses, along with their top give (5) critical "hard" skills. These skills were sourced though a combination of employer consultation and analyses of job postings.

Production Technician

TOP 5 CRITICAL HARD SKILLS

- Knowledge of good manufacturing practices (GMP)
- Familiarity with standard operating procedure (SOP) for manufacturing
- Familiarity with hazard analysis and critical control points (HACCP)
- Proficiency with CAD
- Expert use of Excel

Control Engineer

TOP 5 CRITICAL HARD SKILLS

- Proficiency with design and drafting software like AutoCAD
- Proficiency with Java
- Familiarity with programmable logic controllers (PLC)
- Ability to work with and create APIs
- Familiarity with open-source operating systems like Linux

[45] *"5 Places Additive Manufacturing is Unstoppable", Stratasys Direct Manufacturing, 2019. https://www.stratasysdirect.com/manufacturing-services/3d-printing/unstoppable-industries-using-additive-manufacturing*
[46] *Ed Gent, "New Progress in the Biggest Challenges with 3D Printed Organs", Singularity Hub, May 7, 2019. https://singularityhub.com/2019/05/07/new-progress-in-the-biggest-challenge-with-3d-printed-organs/*

Interactive Digital Media in Canada
Background and Employment Forecast, 2018-2023

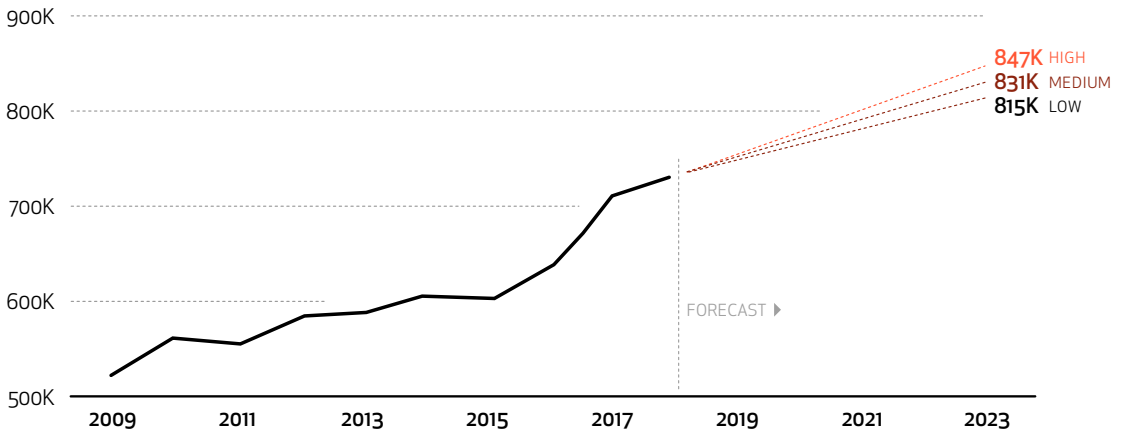
The digital media sector is an increasingly important pillar of the Canadian economy. With particular strength in Quebec, BC, and Ontario, a recent study by Indeed.com found that 74% of jobs in the video game industry were located in Montreal, Vancouver, or Toronto.[47] The development of new technology like Augmented and Virtual Reality (AR/VR) will continue to bolster clusters like gaming and visual effects, while propelling the rise of new growth industries and opportunities. With real life examples materializing rapidly in the video game industry – the Oculus Rift, Pokémon Go – AR is gaining widespread awareness as an increasingly popular method of interacting with the physical world.

Moreover, the applications of AR extend far beyond the gaming sector or even the creative industries. AR glasses for example, can be used in the energy sector to indicate the location of underground pipelines, guide workers through difficult tasks, and offer new training opportunities for occupations ranging from drillers to mine safety inspectors. All of these developments can prove valuable for finding efficiencies, creating mechanisms for bolstering safety, and even creating new employment opportunities.

As a result of its existing strength and future promise, the interactive digital media sector is one that is expected to see substantial growth in Canada. Here, a moderate growth scenario points to a demand for more than 95,000 workers by 2023. If filled, this will bring total employment to more than 830,000. Conversely, even slow overall economic conditions will not drastically curtail employment prospects in the area of digital media. A contractionary growth scenario still points to a demand for more than 80,000 workers, bringing total potential employment to nearly 815,000 by 2023.

[47]Amira Zubairi, "Report: Canada's Gaming Industry Contributes $3.7 billion to Economy", BetaKit, May 23, 2018. https://betakit.com/report-canadas-gaming-industry-contributes-3-7-billion-to-economy/.

Figure 7: *Interactive digital media employment in Canada, 2018-2023*



Source: ICTC 2019

Categorized broadly, interactive digital media workers can specialize in anything from graphic design and media, to gaming, to TV and film, to the visualization of data and more. These roles are already seeing heightened demand across many industry verticals. Consultations with employers have underlined roles such as data analysts, web developers, compositing artists, UX/UI designers and a number of others as in-demand. Additionally, with the maturation of AR/VR technology, more and more businesses are seeing potential use cases for VR-specialized developers. Augmented and virtual reality is increasingly changing and challenging the way we interact with the world. From the Air, Land & Sea AR experience at the Toronto Zoo[48], to the use of VR to train future surgeons[49], interactive digital media is quickly expanding beyond just the creative industries, and into all facets of our economy and daily life.

Snapshot: Interactive Digital Media Jobs & Skills

The following offers a snapshot of two (2) key occupations seeing high-demand among interactive and digital media businesses, along with their top five (5) critical "hard" skills. These skills were sourced though a combination of employer consultation and analyses of job postings.

Animator

TOP 5 CRITICAL HARD SKILLS

- Proficiency with Maya
- Proficiency with cross-platform game engines like Unity
- Proficiency with 2D production animation software like Harmony
- Proficiency with gaming tool suites like Unreal Engine
- Proficiency with 3D character animation software like Motion Builder

VFX Artist

TOP 5 CRITICAL HARD SKILLS

- Proficiency with Maya
- Proficiency with node-based digital compositing applications like Nuke
- Proficiency with 3D animation software applications like Houdini
- Proficiency with cross-platform game engines like Unity
- Proficiency with digital sculpting tools like Zbrush

[48] *"Toronto Zoo Launches New Innovative Exhibit", Toronto Zoo, June 27, 2015. http://www.torontozoo.com/press/releases.asp?pg=20150627.*
[49] *"OssoVR: The Leading Virtual Reality Surgical Training & Assessment Platform", OssoVR. https://ossovr.com/.*

Health & Biotech in Canada

Background and Employment Forecast, 2018-2023

With demographic trends such a rapidly ageing population and low birth rates in Canada, the cost of healthcare is set to increase. Currently, government expenditures on healthcare already exceed 10% of GDP and are expected to rise in the coming years.[50] Innovations in healthcare and biotechnology will be of critical importance to keep healthcare costs down and quality of life high for Canadians.

Particularly in light of this context, there has been a renewed interest in biotechnology over the past decade and a half. Since 2003, the NASDAQ Biotech stock index has risen in value by over 500%,[51] with many prominent investors like Peter Thiel of PayPal and Facebook focusing on the industry.[52]

A number of new technologies are also driving innovation in this space. 3D-Printed organs are approaching applicability, with real-life examples including San Diego-based Organovo that prints tissue and organs for use in pharmaceutical testing.[53] In the field of genomics, the cost of sequencing a human genome has fallen precipitously over the past 30 years from $100 million in 2001 to under $1000 today.[54] These are but a few examples of how growth in the health and biotech areas can produce substantial opportunities for Canada.

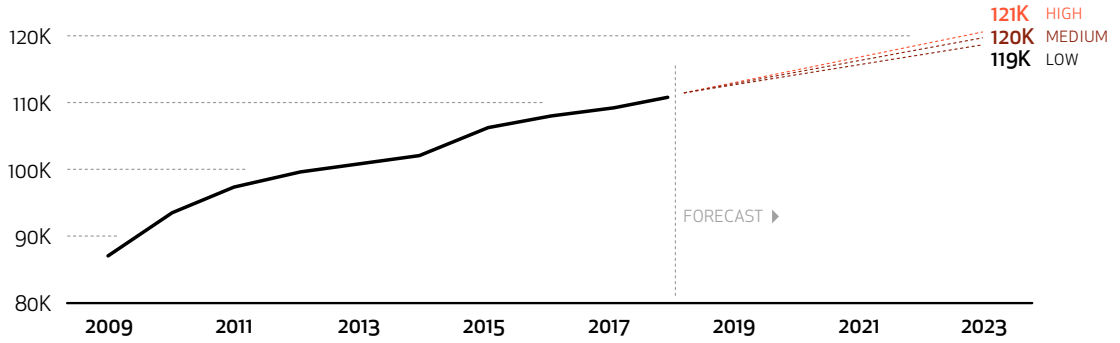
Both employment and economic strength emerging from this space are likely to pay dividends more towards the long-term. The quickly developing field of e-health is ripe with promise of effective and efficient solutions by linking technology, medical informatics[55] and patient demand for digital health solutions. However, developments in this field necessitate the use and exchange of data, oftentimes personal health information. This is something that requires concerted cross-collaboration not only within the health sector, but among legislators and regulators to set guidelines for use, access, storage and portability of data beyond simply compliance with PHIPA and PIPEDA. Similarly, with biotech, putting aside typically long R&D periods, the industry is heavily wrapped in regulatory considerations and compliance needs that impact commercialization, and ultimately, employment.

As a result, a moderate growth scenario points to a demand for roughly 9,000 workers by 2023. This would bring total employment in this area to nearly 120,500 in Canada.

[50]"National Health Expenditure Trends, 1975 to 2017", Canadian Institute for Health Information, 2017. https://secure.cihi.ca/free_products/nhex2017-trends-report-en.pdf
[51]Corey Renauer, "These 3 Biotech Stocks Are Up More Than 500% Over the Last 3 Years", Nasdaq, April 13, 2018. https://www.nasdaq.com/article/these-3-biotech-stocks-are-up-more-than-500-over-the-last-3-years-cm947537
[52]Antonio Regalado, "Peter Thiel Explains Biotech Investing Rationale: Get Rid of Randomness", MIT Technology Review, September 15, 2015. https://www.technologyreview.com/s/541226/peter-thiel-explains-biotech-investing-rationale-get-rid-of-randomness/
[53]Hasan Chowdhury, "Liver success holds promise of 3D organ printing", The Financial Times, March 4, 2018. https://www.ft.com/content/67e-3ab88-f56f-11e7-a4c9-bbdefa4f210b
[54]"The Cost of Sequencing a Human Genome", National Human Genome Research Institute, July 10, 2019. https://www.genome.gov/about-genomics/fact-sheets/Sequencing-Human-Genome-cost
[55]G Eysenbach, "What is s-health?", Journal of Medical Internet Research, V.3(2), June 18, 2001. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1761894/

A situation of long-term economic crunch can further compound employment need in this sector. Here, a contractionary growth scenario places the demand for workers in this space at just over 7,500, bringing total employment to slightly more than 119,000.

Figure 8: *Health & biotech employment in Canada, 2018-2023*



Source: ICTC 2019

Recent shifts in the biotech industry are creating new labour and skill needs, including a renewed demand for data scientists and statisticians. Key occupations highlighted by consultations with employers found a number of roles including big data engineers, gene engineers, software developers, and biologists as essential to this field, along with AI-skilled professionals. Increasingly, AI can be used for genetic analysis and diagnosis determinations. The Swiss company Sophia Genetics can extract a patient's DNA via a blood test or biopsy, then later use it for DNA sequencing. The data is then entered into the Sophia platform which uses AI to identify mutations in a patient's genome[56]. Coupling AI with healthcare in this way can create revolutionary outcomes for the sector in the long-term. The provision of long-range data and varied samples means that an AI system can continuously evaluate and learn from those samples – the more it does this, the better able it will be to draw accurate conclusions. Toronto's own Deep Genomics is charting a similar course to Sophia. Via AI and data analytics, the company attempts to use machine learning in order to better detect and treat genetic diseases[57].

Snapshot: Health/Biotech Jobs & Skills

The following offers a snapshot of two (2) key occupations seeing high-demand among advanced manufacturing businesses, along with their top give (5) critical "hard" skills. These skills were sourced though a combination of employer consultation and analyses of job postings.

Lab Technician

TOP 5 CRITICAL HARD SKILLS

- Knowledge of standard operating procedures (SOP) for lab testing
- Knowledge of good manufacturing practices (GMP)
- Strong knowledge of data analytics
- Knowledge of relevant testing standards administered by organizations like ASTM international
- Knowledge of analytical techniques for chemical detection like inductively coupled plasma optical emission spectrometry (ICP-OES)

Biostatistician

TOP 5 CRITICAL HARD SKILLS

- Knowledge of clinical research standards administered by organizations like the Clinical Data Interchange Standards Consortium (CDISC)
- Proficiency with the standards for human clinical trial data like the study data tabulation model (SDTM)
- Proficiency with XML
- Proficiency with STATA
- Knowledge of standards and procedures for pharmaceutical development set out by organizations like the International Council for Harmonisation (ICH)

[56]*Berenice Magistretti, "Swiss data analytics company Sophia Genetics could be Switzerland's next unicorn", TechCrunch, January 2, 2017. https://techcrunch.com/2017/01/02/swiss-data-analytics-company-sophia-genetics-could-be-switzerlands-next-unicorn/*
[57]*"Deep Genomics: Creating a New Universe of Genetic Medicines", Deep Genomics, 2019, https://www.deepgenomics.com/*

Agri-foods & Food-tech
Background and Employment Forecast, 2018-2023

According to recent estimates, the average Canadian household spends about $950 per month on food.[58] This figure amounts to over 15% of average household income.[59] Technological developments in agriculture aim to make food more nutritious, easily producible and less costly. Prior innovations in food-tech include pasteurization, powdered milk, freeze-drying, heat-treated sterilization, and other techniques to optimize the food production process.[60] These innovations enabled the development of fresher and more nutritious food, new flavours, and novel products.

Bio-fabricated animal products is another promising technological use case within this sector, particularly with increasing consumer awareness related to ethical and nutritional implications of factory farming, or the mass production of animal products. Meat consumption also has significant implications for the environment, with beef generating 105kg of greenhouse gasses per 100g of meat.[61] New products, such as the *Beyond Meat Burger*[62], promise the taste and nutritional content of meat while being plant-based.[63]

Genetically modified organisms (GMOs), while not without controversy, may become a promising means of increasing quality and reducing cost in the food sector. By modifying the genes of organisms, scientists can create crops with more nutrients, disease or drought-resistance, or greater robustness. Examples include blight-resistant potatoes in South America,[64] or Roundup-Ready soybeans that are herbicide and insect resistant, necessitating the use of fewer pesticides.[65] While accurate that the long-term effects of such modifications are not known, innovations in food technology can have promising implications for both human and environmental welfare.

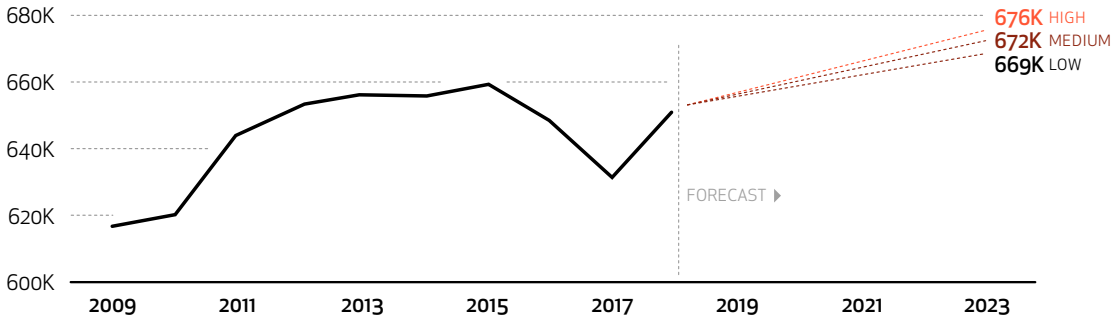
ICTC estimates that combined, employment in agri-foods and food-tech represents approximately one quarter of all employment in the agricultural sector. While also subject to a variety of ethical, regulatory and compliance considerations, agri-foods & food-tech is expected to see a considerable demand for employment in the short-term, particularly if coupled with growing consumer demand for new and improved methods of farming and meat production.

[58]"Table 11-10-0125-01: Detailed food spending, Canada, regions and provinces", Statistics Canada, September 9, 2019. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110012501
[59]Household income in Canada: Key results from the 2016 Census", Statistics Canada, September 13, 2017. https://www150.statcan.gc.ca/n1/daily-quotidien/170913/dq170913a-eng.htm
[60]"20th century marks achievements in food science and technology", Institute of Food Technologists, December 28, 1999. https://www.eurekalert.org/pub_releases/1999-12/IoFT-2cma-281299.php
[61]David Carrington, "Avoiding meat and dairy is 'single biggest way' to reduce your impact on Earth", May 31, 2018. https://www.theguardian.com/environment/2018/may/31/avoiding-meat-and-dairy-is-single-biggest-way-to-reduce-your-impact-on-earth
[62]"Beyond Burger", Beyond Meat.com, 2019. https://www.beyondmeat.com/products/the-beyond-burger/
[63]Laura Brehaut, "Canada loved the Beyond Meat Burger; now A&W is trying out a vegan sausage patty on its breakfast sandwich", National Post, March 4, 2019. https://nationalpost.com/life/food/canada-loved-the-beyond-meat-burger-now-aw-is-trying-out-a-vegan-sausage-patty-on-its-breakfast-sandwich
[64]Matt McGrath, "Genetically modified potatoes 'resist late blight'", BBC News, February 17, 2014. https://www.bbc.com/news/science-environment-26189722
[65]Amy Maxmen, "GMOs May Feed the World Using Fewer Pesticides", PBS.org, July 24, 2013. https://www.pbs.org/wgbh/nova/article/fewer-pesticides-farming-with-gmos/

This is in addition to the new possibilities that data science and predictive analytics can offer to the farming industry.

A moderate growth scenario points to a demand for approximately 20,000 workers by 2023. If filled, this will bring total employment to more than 672,000. Similarly, even with the possibility of continued overall economic slowdown, the impact on food-production and food-based innovation is not expected to dull too drastically. Under a contractionary growth scenario, the demand for workers is expected to be nearly 16,500, still bringing total potential employment to nearly 668,500 by 2023.

Figure 9: *Agri-foods & food-tech employment in Canada, 2018-2023*



Source: ICTC 2019

The agri-food and food-tech field combines roles related to agriculture, biology, and technology. As a result, the types of roles highlighted as in-demand by employers in this sector varied, ranging from pasteurizers and brewers, to data scientists and GIS analysts. Some companies, like BC's *Semios*[66], may rely more heavily on technology and data-driven roles like data scientists, whereas businesses like Edmonton's *Aurora* may see a demand for a variety of occupations, including roles like breeding technicians[67], responsible for plant breeding, management and harvesting.

Snapshot: Agri-food & Food-tech Jobs

The following offers a snapshot of two (2) key occupations seeing high-demand among agri-foods & food-tech businesses, along with their top five (5) critical "hard" skills. These skills were sourced though a combination of employer consultation and analyses of job postings.

Entomologist

TOP 5 CRITICAL HARD SKILLS

- Proficiency with scientific writing
- Knowledge of environmental science
- Proficiency with experimental design practices and procedures
- Proficiency with data analysis procedures and tools
- Strong knowledge of entomology

Scientist, food science

TOP 5 CRITICAL HARD SKILLS

- Familiarity with food and chemical safety mechanisms, like hazard analysis and critical control points (HACCP)
- Proficiency with SQL
- Knowledge of green public procurement (GPP)
- Familiarity with analytical chemistry techniques like high-performance liquid chromatography (HPLC)
- Familiarity with gas chromatography (GC)

[66] *"Semios: We Help Growers Worry Less", Semios, 2019. https://semios.com/.*
[67] *"Technician, Breeding", Aurora Jobs, 2019, https://careers.auroramj.com/job/Vancouver-Technician%2C-Breeding-Brit/535854817/*

Section V

The Pathway to Filling Industry Demand:
The supply of digitally-skilled talent in Canada

With the demand for digitally-skilled talent continuing to accelerate, it is critical to consider and engage various supply streams in order to solidify Canada's competitive advantage in the global digital space.

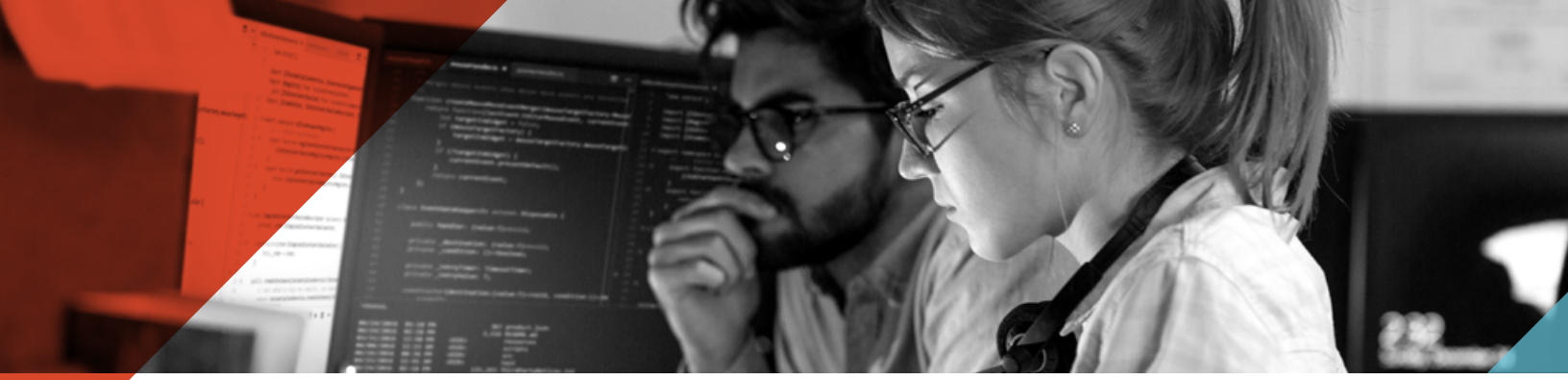
This means concerted efforts to engage not only the computer science graduate with 3-6 years of experience, but a variety of groups including women, youth, internationally-educated professionals, career transitioners, Indigenous communities, people with disabilities, and more. Only through an approach that is diverse, inclusive and transparent can we ensure the continued and sustainable success of our future digital economy.

Women in Tech

The Canadian digital economy has evolved substantially over the past few years, with new developments taking place frequently in verticals tied to healthcare, natural resources, and a number of others. When analyzed though a lens of "traditional" tech jobs like software developers, women continue to make up approximately 25% of employment in these roles. Unfortunately, this along with the gender wage gap[68], are dials that have seen little movement over the last 10 years, and a mission that must continue to be worked on.

However, when considering the growing intersection of industry verticals like healthcare, biotech, creative industries and others, we find that women currently represent approximately 32% of this "new" digital workforce. Although the breaking down of systemic barriers that prevent women from engaging with roles in software development or data science at a rate similar to their male counterparts is key, a digital economy that continues to evolve and merge with other sectors may play a crucial role in accelerating the representation of women in technology.

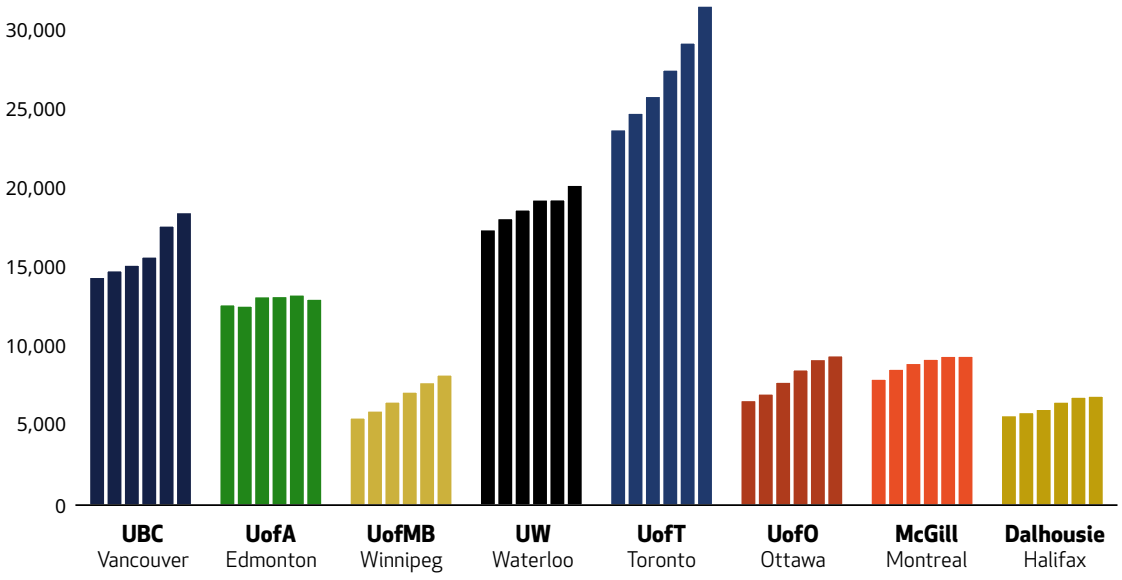
[68]*Women employed in ICT occupations in 2018 earned on average, 76% of male counterparts.*



Youth and New Grads

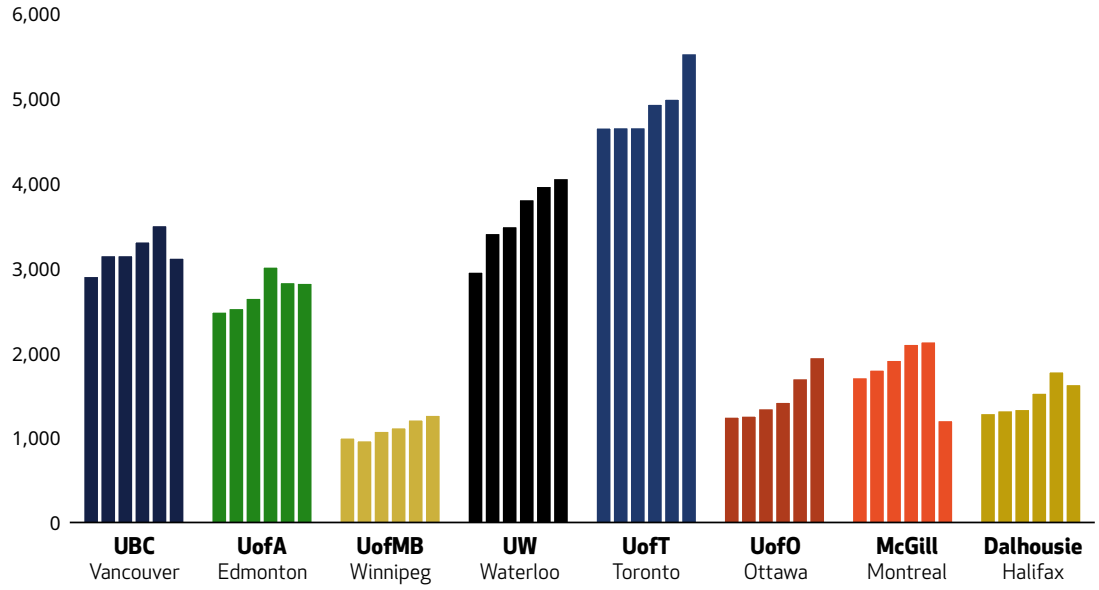
It is no secret that the Canadian population and workforce are rapidly ageing[69]. In 2015, one of five Canadians aged 65 and older were working, a figure that is trending upward.[70] However, with retirements quickly looming, it is increasingly important to attract and retain youth into in-demand fields of study, and eventually, in-demand roles in the digital economy. Among major universities across Canada, both graduation and enrolments have seen a rise in STEM fields in recent years. When it comes to STEM graduations, the University of Ottawa saw some of the highest growth in new grads from 2010 to 2015, scaling by a CAGR of nearly 10%. In terms or enrolment, some of the highest growth rates were seen among STEM programs at the University of Manitoba, growing by more than 8% from 2010 to 2015.

Figure 10a: *STEM Enrolments by Institution*



Source: Universities Canada, 2016

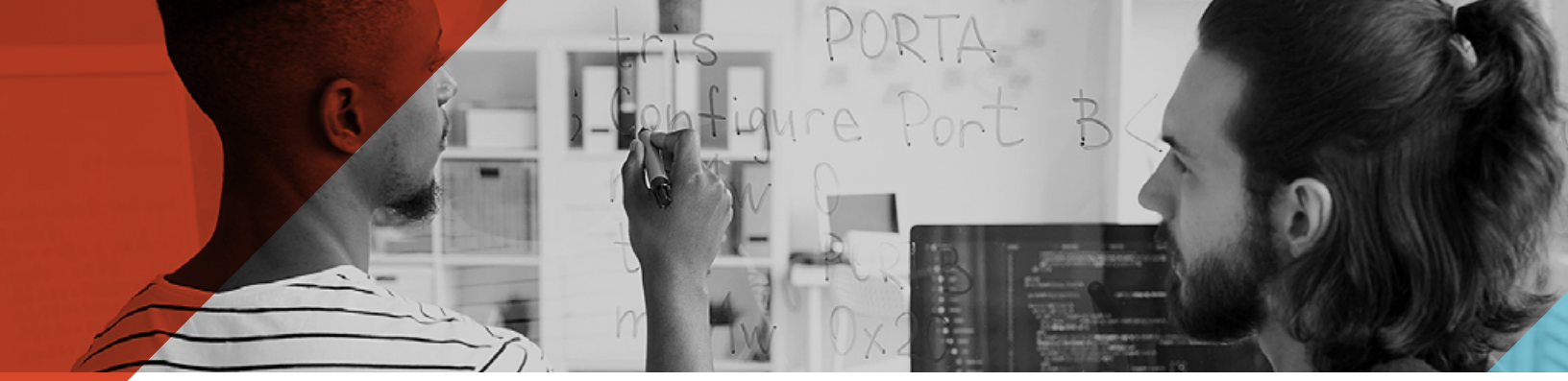
Figure 10b: *STEM Degrees Awarded by Institution*



Source: Universities Canada, 2016

Although enrolment trends in STEM-related fields appear to be flatter among Canadian colleges for the time being, the development of new programs may function to attract new students. At BCIT, the school of Health Sciences recently developed the SIM Lab, a place where students can learn and attempt medical procedures with the *Microsoft Hololens* headset. Similarly, Lethbridge college has recently become the first in Canada to offer a Virtual and Augmented Reality certificate. Developments like these, along with the growth of programs like WIL Digital[71] that can provide students with practical training in areas like cybersecurity and AI, will be essential in attracting, training and supporting Canadian youth on their journey into the future digital economy.

[71] *"Work Integrated Learning Program (WIL DIGITAL): Employers", e-Talent Canada, 2019. https://www.etalentcanada.ca/work-integrated-learning-program-wil-digital-employers/*



Immigrants

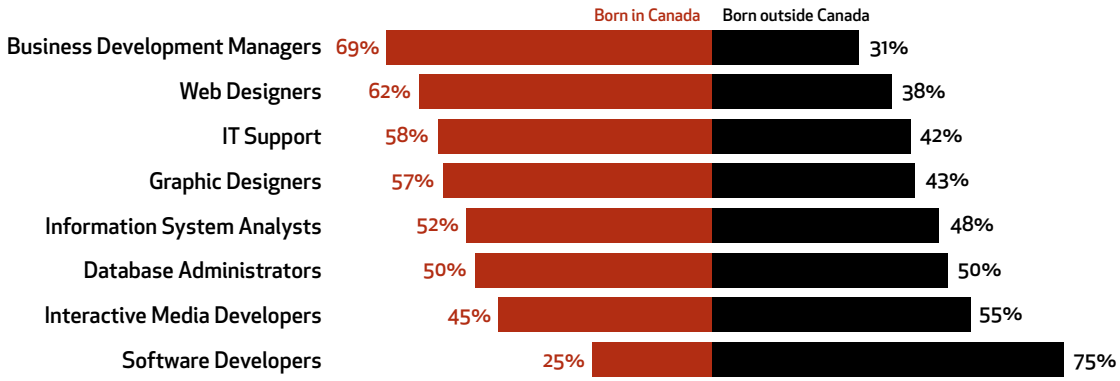
In Canada, immigrants[72] represent more than one-fifth of the total population, with an average of nearly six in ten recent immigrants admitted under the skilled worker or entrepreneur category each year. Within the past decade, the influx of immigrants to Canada has increased substantially, from 245,290 in 2009, to 303,260 per year in 2018[73].

Workers born outside of Canada are a remarkably important source of employment for all sectors in Canada, and particularly for the digital economy. In 2009, roughly 30% of workers in ICT roles were foreign-born. Today, two in five workers in ICT roles were born outside of Canada.

When examined more closely for some of Canada's most in-demand roles in the digital economy, the importance of attracting digitally-skilled immigrants is even further accentuated.

During 2018, 30% of workers in business development manager roles were foreign-born. This increases to nearly 50% for information system analysts or cybersecurity analysts, and more than 70% for software developers.

Figure 11: *Immigrants in Key Roles*



Source: Statistics Canada, 2018

While this analysis encapsulates both the individual who immigrated to Canada with his family 30 years ago, as well as the developer who arrived to Canada with her partner 3 months ago, an analysis of employment obtained by recent newcomers through ICTC immigration programs like GO Talent and Coach Connect still showcases a talent base with both a strong tech background and employment pathways to in-demand digital roles. A sample of new arrivals under these programs found that approximately 50% came under Information systems analyst or Software engineer classifications, with nearly 35% obtaining employment in software development roles[74], followed by another 20% in IT Support roles.

[72] *Those born outside of Canada.*
[73] *"Number of immigrants in Canada from 2000 to 2018 (in 1,000s)", Statista, 2019. https://www.statista.com/statistics/443063/number-of-immigrants-in-canada/*
[74] *Includes roles like junior to senior software developer or engineer, full stack developer, back end developer, etc.*

Career Transitioners, Indigenous Peoples and Persons with Disabilities

As technology continues to permeate all sectors of the economy and global economic shifts challenge employment prospects in a number of traditional areas from oil and gas to forestry and others, more and more Canadians are seeking pathways into the digital economy. Upskilling and retraining, along with lifelong learning are quickly becoming common terms, and the development of short-duration training programs, tech bootcamps and MOOCs[75] are increasingly seen as contenders or effective alternatives to traditional post-secondary education.

From 2013 to 2017, Lighthouse Labs graduated more than 1,500 students from their Web and iOS bootcamps, alone[76]. Of those students, 93% were able to find employment within their first three months of graduation[77]. More and more, alternative educational programs, and new education models and methods are acting as pathways for Canadians who are seeking to transition from a previous career into tech, as well as for a variety of other talent streams for which traditional routes may not be accessible or desired.

Currently, it is estimated that there are more than 140,000 people working in the Canadian ICT sector who identify as having a disability[78], a figure that has increased steadily over the last decade. People with disabilities can act as a critical supply stream to fill a number of in-demand digital and business roles across the economy, but they often face challenges finding meaningful employment. Among Indigenous communities, approximately 1.5% were employed in the ICT sector in 2018, and when analyzed from the perspective of ICT roles specifically, this figure was slightly more than 1%[79]. Indigenous peoples are a crucial source of talent and innovation for Canada as a whole. With culturally-relevant and community-driven approaches to training and upskilling, Indigenous peoples will develop sustainable employment opportunities and economic growth prospects that empower their communities.

In the same way that educational alternatives like bootcamps or other short-duration training programs can help increase the engagement of Canadians with in-demand digital roles, incorporating accessible technology and diverse and inclusive hiring practices in the workplace will not only soften the transition to an increasingly digital future, but will also assist in creating a welcoming environment for underutilized talent streams[80]. Upskilling, retraining and continuous skill development, coupled with inclusive, accessible and diverse hiring practices are essential to ensuring that all Canadians have the opportunity to be plugged in to our rapidly-developing digital economy.

[75] *Massive open online courses.*
[76] *"Lighthouse Labs 2016 Student Outcomes Report", Lighthouse Labs, 2017. https://www.lighthouselabs.ca/student_outcomes_report_2016.pdf*
[77] *Idem.*
[78] *"Canadian Survey on Disability", Statistics Canada, 2017.*
[79] *Alicia Cameron, Alexandra Cutean, "Digital Economy Talent Supply: Indigenous Peoples of Canada", Information and Communications Technology Council, June 2017. https://www.ictc-ctic.ca/wp-content/uploads/2017/06/Indigenous_Supply_ICTC_FINAL_ENG.pdf*
[80] *"Rethinking DisAbility in the Private Sector", Government of Canada, August 5, 2013. https://www.canada.ca/en/employment-social-development/programs/disability/consultations/rethinking-disabilities.html*

Conclusion

Fostering, building, and supporting a Canadian digital ecosystem that can offer robust and high-quality employment opportunities is essential.

It is necessary to support our growth prospects as a country and to shape an economy that can not only compete, but lead on a global scale. However, as important as it is to create opportunities, our focus must also rest on matching workers to those opportunities: on opening doors for all Canadians to gain the education, skills, training, and access to pathways that will prepare them for a future that is increasingly digital.

Technological pivots, increasing automation, evolving trade dynamics, and new economic structures are redefining our economy. At the same time, demographic shifts, changes in the way we work, and new labour needs across a number of occupations – both high and lower-skilled – are accentuating the need to shape and enable a robust and diverse talent base. Couple this with the increasing permeation of transformative technologies like AI, 5G, Blockchain and many others across industry verticals, and this need is even more accentuated. This multitude of factors will continue to usher in a strong demand for skilled talent across all sectors. A moderate economic growth scenario for Canada highlights a demand for more than 305,000 digitally-skilled workers by 2023. This demand, even at a moderate level, is substantial. Cross-stakeholder collaboration, with a focus on diversity, upskilling, and lifelong learning in the development and attraction of talent is necessary to tackle this new reality.

Technology will continue to grow and scale regardless of whether or not we embrace and grow with it. However, our goal of meeting industry demand must rest within our responsibility to prepare Canadians for the digital future. The future of the Canadian digital economy is ripe with opportunities, although of course, there will be challenges along the way. What should guide the Canadian approach to a digital future are the same values that should guide us as a country: fairness in opportunity, diversity and inclusivity, sustainability, and community. The Canadian digital economy of today, of 2023, and of the indefinite future should be one that everyone has a chance to be a part of.

Appendices

I. Research Methodology

II. Forecast Methodology

III. Limitations of Research

IV. Digital Economy Forecast 2018-2023

V. Digital Economy by Province in 2018

I Research Methodology

The research methodology used in the development of this report consisted of a combination of **primary** and **secondary** research.

Primary Research: The primary research portion of this study was comprised of four main elements. These are: an employer survey, key informant interviews, a project steering committee, and an LMI Consortium.

The employer survey was targeted at businesses across a variety of sectors in Canada, yet was primarily focused on employers in the following areas: ICT, interactive digital media, cleantech, clean resources, health & biotech, agri-foods & food-tech, advanced manufacturing. The survey was useful in highlighting important trends witnessed by employers in a number of different sectors. Key findings uncovered in the survey were: perceptions on the demand for talent, in-demand roles and skills, talent attraction strategies, the perceived importance of transformative technologies like AI and 5G, and others. The survey was kept open for approximately 9 months, in that time receiving 112 responses. The portion of the survey specifically tied to in-demand jobs received nearly 300 (289) responses. Here, employers stated which roles they felt were most needed and in-demand, and these results were then analysed to identify the frequency with which they were identified (e.g. businesses were asked to state their top 5 in-demand digital/technical roles, sometimes stating the same multiple times).

Key informant interviews played another important role in gathering primary insights on trends and needs as they relate to digital employment in Canada both currently and in the future. A total of 22 key informant interviews were completed with employers, industry associations, and academic institutions across Canada. Interviews took place either in person or over the phone and lasted an average of 1 hour, each. Interview questions focused primarily on gaining an in-depth understanding of business plans and prospects for future growth, in-demand roles and skillsets, current and anticipated talent needs, and the perception of supply availability and quality.

Lastly, the project and its findings were assessed and validated by a project steering committee, along with an ICTC-created *Consortium* that validates and discusses the research across a variety of projects, including this one. The steering committee was made up of 20 members from industry, academia, industry associations, economic development agencies, and government. The committee was key in providing review, guidance and validation of the research. The *Consortium* is comprised of 15 members from industry, academia and industry associations all related to digital economy and/or innovation areas covered in this study. The *Consortium* was engaged during the production of this report to discuss the labour market and policy impacts of emerging technologies on the Canadian labour market, as well as the six innovation areas.

Secondary Research: The secondary research component of this study focused on an analysis of existing data and literature, as well as the use of advanced analytics for the purpose of identifying trends on job vacancy, skill needs, and skill availability.

The first method utilized was a literature review and analysis of secondary data. Complementing primary research findings, an analysis of available and relevant literature and data sets (e.g. Statistics Canada, O*Net database, OECD, etc.) were used to formulate the background upon which the primary research findings would be based. An analysis of the mentioned datasets was useful in tracking economic and employment trends, supply trends, business growth of innovation areas, and others.

Once in-demand occupations were identified using primary research, ICTC used advanced analytics to extract job vacancies, and in-demand skills of both digital/technical roles and business roles. The jobs that were scraped were the ones identified via qualitative feedback from the survey and KIIs as most in-demand. The levels of demand identified in the survey were cross-checked with the frequency with which they appeared on job boards. This was done via 1) web scraping of in-demand jobs from job boards; and 2) text mining for critical skills. Web scraping was completed in order to obtain a comprehensive idea of the volume of in-demand jobs on monthly basis – this was done in order to confirm perceived "demand". Text mining was completed to identify the most prominent skills for those jobs.

II Limitations of Research

While ICTC had attempted to ensure that the research process for this study was as exhaustive as possible, a few limitations exist. These include:

Lower than desired survey response rate: ICTC had benchmarked a survey response rate of 200+. However, while the survey was kept open for a longer than average period (9 months, vs. 4-6 on average), and was outreached several times via the ICTC newsletter, social media, and even direct communication to relevant stakeholders, survey response rates were low. However, the quality of survey responses was very high, with most respondents completing all questions in detail. ICTC supplemented the lower than desired survey response rate with key informant interviews, steering committee and Consortium feedback, conferences attended on relevant innovation areas, and other methods of secondary research.

Measuring "size" of innovation areas: Because the innovation areas (e.g. advanced manufacturing, health and biotech, agri-foods & food-tech, etc.) worked with in this report are not documented by historical data, ICTC utilized a combination of secondary and primary research to estimate the size of these areas (sub-sectors) in Canada. While ICTC will continue to track these over time, it is possible that the overall size of these areas may be smaller or larger than the initial estimates.

Supply trends: While the scope of this study focused on identifying the demand for talent in the Canadian digital economy and the innovation areas, ICTC also provided an analysis of critical supply streams that will fill this demand. More extensive research is required to eventually forecast supply availability over the coming years, both in terms of volume as well as skills and competencies.

III Forecast Methodology

The forecasting methodology involves the fitting of Vector Autoregressive (VAR) and Autoregressive Integrated Moving Average (ARIMA) Models under various specifications (various time lags and variables are included to maximize fit while maintaining model parsimony, generating stable forecasts, and manifesting other favorable characteristics). Several models were created and compared, and forecasts were compared with those made by other research organizations. For each innovation area (that is, sub-sector) the models included endogenous variables like historical employment, wages, and the unemployment rate (obtained from Statistics Canada). The real GDP growth rate for Canada is obtained from the IMF: low-, medium-, and high-growth variations are included exogenously into the model.

The "innovation areas" are created by aggregating relevant Statistics Canada NAICS (which are mutually exclusive categories of employment), and normalizing the result to an estimate of sector size based on key informant interviews, estimates from secondary research, and qualitative understanding of the sector. Indeed, there is no canonical definition in the literature for any of these innovation areas. Looser or broader definitions may incorporate more or fewer economic activities and technologies under the umbrella of 'Cleantech of 'Advanced Manufacturing', for example.

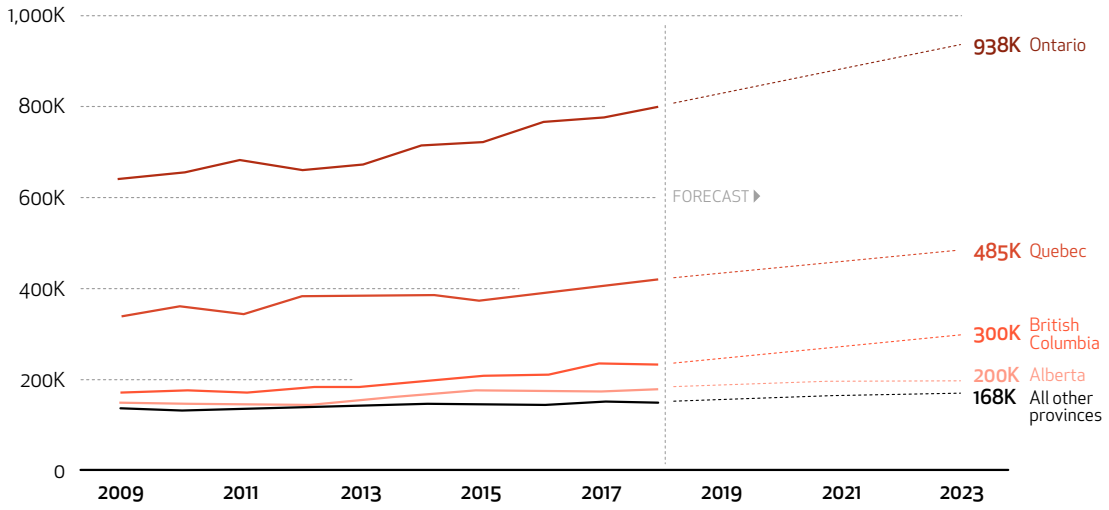
At the same time, these categories are not mutually exclusive – a company manufacturing sophisticated wind turbine blades may be said to work in both Advanced Manufacturing and Clean technology. For this reason, it is inappropriate to sum the employment level across all of these innovation areas to arrive at an estimated size of the "innovation economy". Employment in these categories are designed to be compared longitudinally, rather than cross-sectionally. That is, the historical and forecast growth rates in a given innovation area is more meaningful than a comparison of the level of employment between innovation areas.

As always, forecasts should be treated as estimates. Historical patterns between economic variables are identified, and are assumed to continue to hold. A structural shift in the relationship between variables under consideration can have an effect on forecasts, and such structural shifts are relatively common in a rapidly changing world, particularly when examining novel industries and technologies. White noise means that a range of estimates are plausible, and only point estimates have been reported.

VI Digital Economy Forecast 2018-2023: Ontario, Quebec, BC, Alberta and All Other Provinces – Moderate Growth Scenario

The following provides a breakdown of demand for total employment in the Canadian digital economy primarily across four major provinces, from 2018 to 2023. These forecasts showcase demand according to a moderate growth scenario. By far, Ontario will see the greatest demand for talent in the digital economy, totaling nearly 135,000 (nearly 45% of total digital economy demand) by 2023. Under this scenario, total digital economy employment in Ontario will reach nearly 938,000 by 2023. Next is Quebec, where the demand for digitally-skilled talent will total nearly 65,000 by 2023, bringing total possible employment to approximately 485,000. In BC, the demand for digitally-skilled talent will reach nearly 67,000 by 2023, brining total potential employment to 300,000; and in Alberta, the demand will reach more than 20,000 by 2023, bringing total possible employment to approximately 200,000. For all other provinces, the demand for digitally-skilled talent will reach approximately 18,000, bringing total employment to more than 168,000 by 2023.

Figure 12: *Digital Economy Employment Growth Forecast*

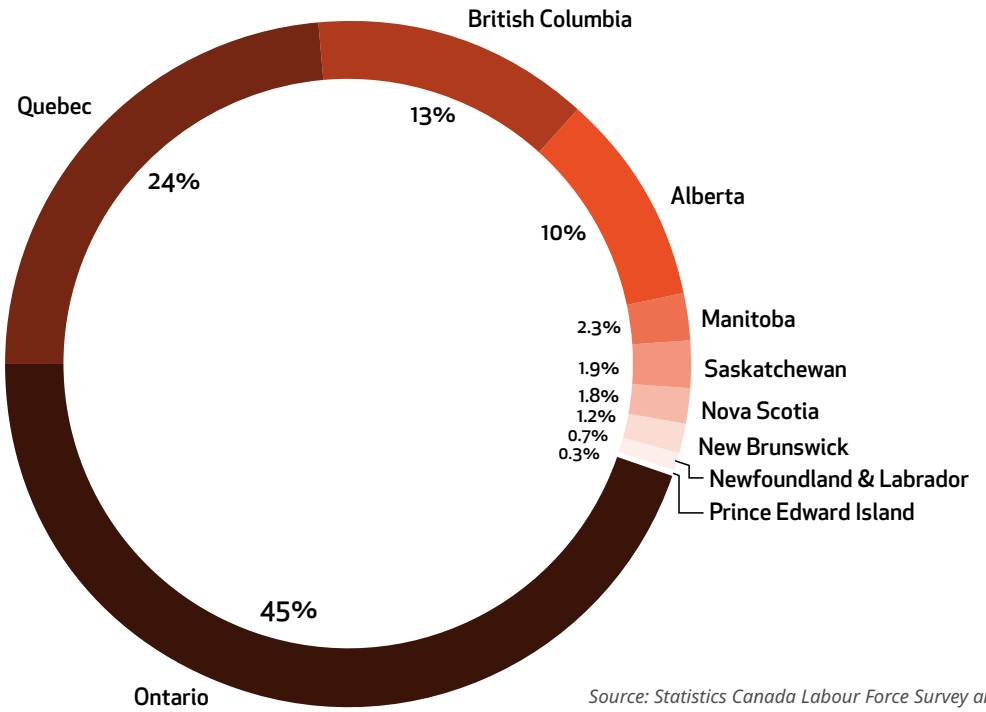


Source: Statistics Canada Labour Force Survey and ICTC Forecast

V Digital Economy by Province in 2018

The following showcases the portion of the digital economy occupied by each province in 2018. Combined, Ontario, Quebec, BC and Alberta made up nearly 92% of all labour in the Canadian digital economy in 2018. This was followed by Manitoba (2.3%), Saskatchewan (2%), Nova Scotia (1.9%), New Brunswick (1.2%), and Newfoundland & PEI (1% combined).

Figure 13: *Provincial Share of Digital Economy Employment in 2018*



Source: Statistics Canada Labour Force Survey and ICTC Forecast